Jitariuc Vitalie **Rusu Vitalie**

JUDICIAR TRACELOGY AND ITS EXPERTISE

Monographs

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ABBREVIATIONS

DNA – deoxyribonucleic acid
c/s – cycles per second
Ed. – publishing house
et. al. – and others
IR – infra red
LCV – leucocrystal violet
mm – millimetres
p. – page
pp. – pages
TMB – tetramethylbenzene
and others
vol. – volume
UV – ultraviolet rays

WORD AHEAD

The achievement of the tasks of the criminal process, which relate to the identification and punishment of persons who have committed criminal acts, is inextricably linked to the restoration of the truth in criminal cases. Only on the basis of comprehensive and thorough investigations of all aspects of socially dangerous acts can we determine the role of each person involved in the crime and establish with sufficient certainty the circumstances in which the crime was committed.

The basic function of forensic science, as the science of the reasons for the appearance of information about crimes and the procedures and means of discovering, collecting, investigating, assessing and using this information for the effective investigation of criminal offences, is to scientifically provide law enforcement officials and experts with specially developed technical means, tactical procedures and methods of investigating and examining certain categories of crime.

In the system of means of evidence, a special place is given to the corpus delicti. Traces play a very important, and in some cases even decisive, role, as they reflect, in real time and spatial dimensions, certain individual objects in the material environment of the event under investigation.

The perpetrators' actions lead to certain changes in the surrounding material environment. They correspond to the character of certain facts, reflecting the particularities of the impact (influence) of a person or object. In forensic science, these changes are known as “material traces”, and are one of the main sources of evidence used in the investigation and detection of crime.

By refining existing and developing new methods, methods and means of discovering, collecting and investigating traces, forensic scientists have made a substantial contribution not only to the development of forensic science, but also to the many practical issues related to the use of traces in crime investigation.

The scientific development of techniques and methods for detecting, fixing and investigating material traces, the analysis of the laws and mechanisms of their formation on the basis of the achievements of technical and natural sciences led to the emergence of a specific field of forensic science – tracing (the science of traces).

Traceology is a branch of forensic science that studies the mechanism and theoretical basis of the formation of traces, the laws of the appearance of traces, which reflect the mechanism of criminal acts. It also develops and provides us with many recommendations on the application of methods and means of discovering, collecting and investigating traces in order to establish the relevant circumstances for the investigation of criminal cases. Forensic tracing provides us with knowledge of the following: the theoretical bases of tracing; the reasons for and specifics of the appearance of traces reflecting the mechanism of crimes; the methods and means of discovering, collecting and investigating them in order to establish the circumstances relevant to the investigation of criminal acts; the basic provisions of the methodology of tracing examinations; the system of tracing expertise, etc.

Trace investigations, according to the frequency of the forensic examinations ordered and carried out, are the most widespread area of forensic expertise, since the range of objects targeted during their disposal is quite large: human footprints, traces of clothing, traces of means of transport, traces left by tools, mechanisms, etc. Their use to solve certain identification and forensic diagnostic tasks allows us to obtain information of significant evidential and indicative value.

In recent years, trace specialists have developed new procedures and methods for discovering and fixing traces, much more efficient methods of tracing them have been implemented, and remarkable practical experience has been gained in using traces in the process of investigating and discovering crimes. All of these factors have made it necessary to produce a work that corresponds to the current level of development of tracing.

In this paper we focus on the general considerations concerning crime scene traces, we talk about their classification, we explain the specifics of forensic investigation of certain categories of traces (hand traces, foot traces, biological traces of a human nature, etc.) and, last but not least, we focus on several relevant aspects related to the specifics of the arrangement and performance of certain categories of trace analysis. Forensic transcription and trace analysis are two components which, in their unity, are determined by a single task: to support the prosecution and the courts in identifying evidence that would ensure a complete, objective and objective investigation of crimes and the proper examination of criminal cases.

Studying these aspects shapes the scientific vision of forensic experts (future and present), activates their creativity, initiates them in the issues examined and solved by tracing. The work provides the reader with general scientific provisions and specific techniques for tracing different categories of traces, and reflects the importance and timeliness of arranging and carrying out certain categories of tracing expertise necessary for the investigation and detection of criminal acts.

Authors

Chapter I

Theoretical Considerations on Crime Scene Evidence

Wherever he steps, whatever he touches, whatever he forgets by mistake will serve as a silent witness against him. Not only fingerprints, but hair, textile fibres, glass he has broken, tool marks, blood or collected semen can all be silent witnesses against him. This is evidence that should not be overlooked.

They are not influenced by the circumstances of the moment. They exist even in the absence of human witnesses. They cannot be totally absent.

Only their interpretation can be wrong. Only human failure to find, study and understand them can diminish their value (Kirk, 1974, p. 2).

1.1 General concepts

As the famous Locard Edmond said ,,No one can act with the intensity that criminal action implies without leaving multiple traces of his passage, sometimes the offender has left traces of his activity at the scene, sometimes, by a contrary action, he has imprinted on his body or on his clothes clues of being at the scene of the crime or of his action" (Locard, 1948, p. 68).

The study of traces is the most important research topic in forensic science. Some researchers in this field admit that there is even an autonomous science, traceology, whose object of study is the entire activity of discovering, fixing, lifting and recovering traces (Ciopraga et. al., 1996, p. 12).

Traces are the most relevant and irreplaceable element in the investigation and discovery of criminal acts of any kind.

In the process of investigating criminal offences, the discovery and investigation of traces occupies a special place. Several people are involved in the crime, bringing changes to the material environment of the crime scene, leaving various traces on different objects. Forensic trace investigation allows us to determine the specific object that left the trace, either by assigning it to a particular class, genre or type. With the help of traces, the anatomical, physiological, functional and dynamic characteristics of the person can be established. At the same time, identification and diagnostic tasks are solved (Rusu et. al., 2023, p. 260; Derevyanko, 2007, p. 35).

Since prehistoric times, the need to find food has forced hunters to recognise the marks left by the feet of animals on the ground to be discovered, tracked and caught. Rock paintings found in many places around the world show animal silhouettes, hunting scenes and hand and footprints (Drîmbă, 1984, p. 31). The need for them to study the tracks in order to learn about some of the events that had taken place enabled them to acquire everything they needed to survive (food, water, shelter). Later on, as experience and knowledge of the mechanism of trace formation were gained, the skills of these subjects began to be used in the legal sphere to search for people who had committed antisocial acts, and sometimes also to establish how they had been committed (Golubenco, 2015, p. 22).

Most offences involve the presence of the offender at the place where the crime is committed and the offender taking actions that cause changes to the environment. These changes are known generically as traces, which may remain on the perpetrator's body, the victim's body, their clothes, the ground, various objects, etc., and are of significant importance in investigating the case and establishing the truth (Ruiu et. al., 2016, p. 9).

The investigation of these traces, known in the field of forensic science as crime traces, helps to ensure:

- the reconstruction of the picture of the environment in which the crime was committed;
- the direct identification of the perpetrator and other persons participating or involved;
- the identification of the objects, in one way or another, exploited during the criminal acts;
- the establishment of concrete data on the circumstances of the place, time, mode of action and other circumstances of the crime committed (Doraș, 2011, p. 124).

In the framework of the trace forensic examination, particular attention is paid to the study of traces as impressions of the external structure of the creative object in order to identify it and reconstruct the whole according to its component parts. There are, however, two notable exceptions in this field: forensic dactyloscopy expertise, which deals with the identification of persons on the basis of papillary traces, and forensic ballistics expertise, which focuses on the identification of firearms through the analysis of traces left on tubes and projectiles (Ruiu et. al., 2016, p. 10).

The experience of trace work, combined with a sufficiently developed sense of observation and the ability to generalise systematically, can lead to the art of

„reading” traces. This art of trace tracing is possessed not only by experienced criminal investigation officers and investigators, but also by hunters, natural scientists and military scouts (Golunski, 1961, p. 82).

In the literature (Golunski, 1961, p. 82; Suciu, 1972, p. 200; Mircea, 1999, p. 56; Stancu, 2001, p. 111; Cîrjan, 2004, p. 52), the notion of trace has been defined in two senses: broadly and narrowly.

In the broad sense, traces are the result of changes in the environment caused by human action (intervention), and in the narrow sense, traces are only those changes produced in the environment during the commission of criminal offences (Ciopraga et. al., 1996, p. 37).

Most authors consider trace as any material change produced at the scene and in the process of committing a crime (Pășescu, 2000, p. 34). Some authors define traces as the most varied changes that may occur in the environment as a result of the action of the offender (Golunski, 1961, p. 82), or the totality of the material elements whose formation is determined by the commission of the crime (Suciu, 1972, p. 200), or any material change occurring in the conditions of the commission of a criminal act, between the act and the change produced there is a causal relationship (Stancu, 1992, p. 118).

Other authors, wishing to make more comprehensive and precise distinctions, define by the trace any material change produced as a result of the interaction between the offender, the means used by him and the elements of the environment in which he carries out his criminal activity, changes which, examined individually or in their entirety, may lead to: the establishment of the crime, the identification of the perpetrator, the means used and the clarification of the circumstances of the case (Anghelescu et. al., 1976, pp. 117-118), the trace representing a change created at the place and in the process of committing the crime, by the physical movements carried out at the time by the persons involved in the activity in question; the change produced, by its general appearance, by its specific or positive characteristics, is useful for forensic investigation (Mircea, 1996, p. 15).

In turn, traces, viewed in the forensic sense, have the following general characteristics:

- they necessarily appear in the process of committing a criminal act;
- their creation is the result of the interaction of factors that occur during the commission of the act;
- over time, traces undergo a series of transformations that may lead to their value being diminished in the identification process. For this reason

it is necessary to discover, fix, preserve and exploit them as quickly as possible (Ruiu et. al., 2016, p. 11; Anghelescu et. al., pp. 117-118).

As different as the traces themselves are, so too is the nature of their appearance. The formation of traces may be due to the action of an infinite number of physical, chemical and biological phenomena (Golunski, 1961, p. 82) such as:

- mechanical influences of some objects on other objects (handprints, break-ins, transport, animal tracks, etc.);
- the breaking or fragmentation of objects in the course of committing crimes (destruction of an obstacle, detachment of parts from the means of transport following a traffic accident, etc.);
- the disappearance of objects or substances from their usual place, the appearance of new objects at the scene (shell casing, bullet, instrument, other objects lost or left by the perpetrator at the scene, including micro-objects of a mechanical nature);
- physico-chemical processes, which take place in the course of the crime and which, for the most part, remain invisible (thermal, electrical, magnetic, radioactive traces);
- biological processes (body stains, rigor mortis, hangman's noose, etc.).

The importance of their study is determined by the possibility of solving identification tasks aimed at establishing the identity of the object on the basis of the traces created, including the determination of generic belonging, and diagnostic tasks aimed at establishing the mechanism of trace formation, the condition of the objects, the determination of causal links between certain actions and their consequences (Golubenco, 2015, pp. 25-27).

The great variety of traces left after the commission of a crime has conditioned the emergence, within forensic science, of traceology – a field intended to ensure the implementation of the achievements of the various sciences in the investigation of traces left at the scene or in other similar circumstances (Doraș, 2011, p. 124).

The name ,,traceology" comes from the combination of the words ,,trace" (of French origin, which translates as trail, trace) and ,,logos" (of Greek origin, which translates as order, idea) (Ruiu et. al., 2016, p. 9).

In its early stages, traceology focused exclusively on the traces left by the contact between an object and the surface or interior of another object. In the literature, it is emphasised that the main objective of tracing is to identify material objects by analysing their external features reflected in the environment.

Subsequent research has already led to the forensic exploitation of new categories of traces, which has broadened and modified the scope of tracing. Today, tracing is a well-defined field of forensic science, the aim of which is to understand the laws governing the formation of material traces of crime and to develop the methods and technical-scientific means needed to discover, fix and examine these traces in order to establish the crime, identify the perpetrator and determine all the circumstances of the case (Doraș, 2011, pp. 124-125; Granovsky, 1974, pp. 25-26; Shevchenko, 1975, p. 11; Artamonov et. al., 1977, p. 48).

In this context, the following tasks can be identified as tasks of traceology:

- the identification of the object that created the trace is the main task of tracing. In situations where the object in question is not available for direct comparison, detailed analysis of the trace can provide information on the type and characteristics of the object that created it;
- another important responsibility of tracing is to elucidate the circumstances in which the trace was formed and to explain the mechanism of its formation (Ruiu et. al., 2016, p. 11);
- the development of the technical-scientific methods and techniques necessary for the discovery, documentation and collection of criminal traces is another vital direction in tracing. The ability of the prosecution authorities to carry out their work effectively depends to a large extent on adequate technical and technological equipment. The development and refinement of the means necessary to carry out these activities is a fundamental task in forensic tracing;
- the development and application of forensic tracing methods is the final stage in the forensic trace investigation process. The aim is to evaluate and properly interpret the information obtained from the traces analysed (Doraș, 2011, p. 125; Gheorghiță, 2006, p. 288).

1.2 Classification of Traces at the Crime Scene

The diversity of changes that take place in the material world as a result of human intervention means that traces also take on many different forms and appearances, and their classification becomes very difficult. Therefore, for didactic reasons, the classification of traces is based on multiple criteria (Ciiopraga et. al., 2001, p. 37; Suciu, 1972, p. 200; Stancu, 1994, p. 137).

Obtaining a unified view of the track system and highlighting the interdependencies between the different categories, groups and subgroups of tracks leads to the use of several classification criteria. These criteria make it possible to determine the source, form, size and content of the traces and to assess their quality and possible use in the judicial process. By applying such criteria, a deeper and more detailed understanding of the traces can be obtained, which facilitates investigation and makes an important contribution to the resolution of criminal cases (Ruiu et. al., p. 2016, p. 11).

From a gnostic point of view, the classification of these traces is a prerequisite for the process of learning about them. As is well known, knowledge of a phenomenon, whether natural or social, presupposes the establishment of the system to which it belongs (Doraș, 2001, p. 126; Averianov, 1976, p. 51).

In an earlier view, promoted by French criminologists, classification was made in fingerprints (fingerprints, body prints, clothing prints, animal prints, etc.), among which the papillary prints of the human body occupied a privileged position and, in traces, extremely varied (objects left by the offender, burglary tools, hairs, etc.). A distinction is also made between traces and smudges (Stancu, 2015, pp. 114-115; Locard, 1931, p. 9; Locard, 1948, p. 68).

The author, Suciu C., classifies traces in two broad categories: „traces formed by reproducing the external construction of objects (traces of hands, feet, clothing, burglary tools)" and „traces formed as remains of objects and organic and inorganic matter (remains of clothing, food, smoking, paint, organic stains, etc.)". In turn, they are classified according to the process of movement in which they were formed and the changes made to their support (Suciu, 1972, pp. 200-201).

From practical forensic work, the criteria for classifying traces amount to five:

- according to the factor creating the traces;
- according to the factor receiving the traces;
- according to the essence of the traces;
- according to the size of the traces;
- according to the possibilities they offer in the forensic identification process (Ruiu, et. al., 2016, p. 12).

Other authors use the identification value criterion to classify traces into two categories: indeterminate traces and determinant traces. Indeterminate traces may be chemical, biological or non-biological (such as soil, paint, metal, etc.) and are characterised by the fact that they do not directly indicate a relationship with the perpetrator. On the other hand, determining marks, which are of a physical nature and are produced by pressing, rubbing or pulling, retain an interpretable relationship with the person or object to which they belong, thus allowing identification (Stancu, 2015, p. 115; Chevet et. al., 1980, p. 2).

In essence, classification involves dividing phenomena (whether material or logical) into groups based on the common characteristics they share. Therefore, the identification of these criteria characteristics is the fundamental aspect of classification (Doraș, 2011, p. 127).

Taking into account the interconnection between the trace-forming objects (the offender, the material situation, the victim (the subject of the crime), the instruments and the environment of the crime and the protection), the traces of the crime are usually: firstly, distinguished in the form of traces on the offender, the victim, individual elements of the material environment (the scene of the incident, the instruments and means used to commit the crime and the protection against it, and secondly, in the form of traces on the offender, the victim, the material environment (the scene of the incident), on the instruments and means of the crime and the protection. As a result of the interaction and impact of the main objects on each other, each of them may have multiple traces from the rest of the objects. For example, on the victim there are traces of the offender (teeth, saliva, microparticles, textile fibres in clothes, etc.), material conditions, tools and means used (damage to body and clothes, metal microparticles, paints, etc.), and on the victim there are traces of the victim (damage to body and clothes, metal microparticles, paints, etc.).), on the instrument of the crime – traces of the offender (sweat, traces of smell, traces of hands, microparticles from pockets of clothing, etc.), traces of the victim (textile fibres, microparticles from clothes, hair, blood, cells of internal organs, etc.), traces of the material situation (broken barrier, etc.). Such interaction leads to the formation of the so-called cross of traces (Jitariuc, 2023, p. 56; Yablokov, 2001, p. 214).

There is a wide variety of traces left by criminals, making it impossible to formulate a single criterion for an exhaustive classification. This impossibility is highlighted by an analysis of the literature, where the criteria used for classifying footprints vary according to the perpetrator, both in terms of content and number of criteria used (Doraș, 2011, p. 127; Krylov, 1961, p. 106; Selivanov, 1975, p. 3; Goncharenko, 1984, p. 119).

1.3 Classification of Traces by Mode of Formation

According to this criterion, tracks are divided into three categories, namely: breeding tracks; tracks formed by objects or various substances; tracks produced by fire or explosion.

All these categories are examined below in separate chapters. As regards the category of reproduction marks, they are formed by the direct contact between two objects: the first, called the trace-creating object, leaves part of its contact characteristics on the surface or substance of the second, called the trace-receiving object (Ciopraga et. al., 2001, pp. 37-38; Mitrichev, 1953, p. 105).

Reproduction traces, also known as shape traces, are created by the direct contact of two objects, resulting in a negative representation of part of the characteristics of the contact area of one object on the surface or in the volume of the other object.

For the creation and preservation of reproduction marks over a longer period of time it is necessary that the two objects – the creator and the receiver of the marks – have certain properties. First, both objects must have a certain consistency, without which the formation of reproduction marks is not possible. An object without sufficient consistency, in contact with another object, does not leave on its surface or in its volume the characteristics of the trace, but only a simple stain, without a determined shape, without details, in such a situation we are not in the presence of a reproduction trace, but of a stain, which falls into another category of traces. In the reverse situation, a highly consistent object in a fluid mass produces, at the moment of contact, a deformation of the fluid in question, which will take the form of the creative object, but immediately after its removal, the receiving fluid mass returns to its previous state. In addition to this feature, the trailing object must be at least as hard as the receiving object or harder, otherwise its characteristics on the contact side do not imprint themselves on the receiving object. Thus, if the creative object is a viscous paste, in contact with another object it leaves on its surface a certain amount of substance which does not meet the requirements of a reproduction trace. The receiving object, for its part, must have such characteristics that it can receive the impression of the creative object and, at the same time, retain it for an appreciable length of time with the characteristics impressed on its surface or in its volume. When the receiving object is as hard as the creative object, or even harder, it can receive the trace of the creative object if it has a smooth surface to receive and preserve its shape and the details of the contact surface, by the deposition of substance in that area. In the case of the receiving object of lower hardness than the creating object, in order to receive and retain the trace, it is necessary for it to have a molecular construction such that, on contact, it changes its volume in the target area, taking on the shape and size of the creating object, which it retains for a longer period of time (Mircea, 1999, pp. 60-61).

In turn, reproduction traces are classified and sub-classified according to certain criteria, namely:

- the mode of action of one object on the other: into static traces and dynamic traces;

– the nature of the receiving object: depth traces and surface traces;
– the nature of the creating object (Ciopraga et. al., 2001, p. 38).

According to the mode of action of one object on the other, reproduction traces are classified into static traces and dynamic traces.

Static traces are created by contact between two objects at right angles to each other, without any slippage occurring at the time. These include handprints, footprints created in the normal human gait, vehicle tracks in the natural rolling of wheels, impressions of stamps on written documents, etc. These marks primarily reproduce the shape and dimensions of the contact part of the creative object. In addition, they show the characteristics of the contact surface of the object in such a way, sometimes so clearly, that they can be used to determine the type or group of objects to which the object belongs. In more favourable cases, these traces may even enable the creator object to be precisely identified. For example, a footwear print in clay soil: by its shape and dimensions, it helps to determine the number of the shoe, whether it is worn by a man or a woman; by the nature of the tread pattern, the origin of the sole, possibly the factory that produced it; individual characteristics, such as wear, if any, even lead to the identification of the specimen that created the print (Mircea, 1999, pp. 61-62).

Dynamic traces are formed by the sliding of an object on the object with which it comes into contact. This is how sledge and ski tracks are created on snow, braking or skidding tracks on vehicle wheels, cut marks created by various breaking tools, etc. Because of the way they are formed, these tracks do not reproduce the shape of the object that created them on the surface or in the volume of the receiving object. However, the projections on the contact surface of the object of creation are reproduced in the negative as parallel striations on the surface or in the volume of the receiving object. When they reproduce characteristics of mass-produced objects, according to master molds, they are useful in determining the group to which the object belongs. If such marks also reproduce individual characteristics of the maker object, they lead to its identification. Thus, depending on the nature of the two objects, dynamic traces may achieve such perfection, reproducing clear individual details, as to lead to the identification of the creative object (Mircea, 1999, pp. 61-62).

According to the consistency or degree of plasticity of the receiving object, reproduction traces are classified into: depth traces and surface traces.

Depth marks are formed when the maker object is harder than the receiver object and reproduce the outer structure of the maker object. The accuracy of the reproduction of the external shape of the object in the depth trace is influenced by several factors: plasticity of the receiving object material.The more plastic the material of the receiving object, the more accurately the depth trace will reproduce the surface of the forming object. For example, in the case of clay, the creative object will imprint better than in sand; the structure of the material of the receiving object. The finer the material of the receiving object, the more faithfully the microrelief of the creative object will imprint in the depth trace. These factors determine the accuracy and level of detail of the depth traces and may influence the possibility of identifying the creative object by analysing these traces (Ruiu et. al., 2016, p. 14).

Surface traces are formed when the trace maker and the trace receiver have a nearly similar degree of plasticity and the trace maker object imprints its outline and detail on the surface of the trace receiver. These traces are further divided into layering traces and destratification traces (Ciopraga et. al., 2001, p. 38).

Layering traces are formed by the removal of substance from the object and its adhesion to the surface of the receiving object. This reproduces on the surface of the receiving object many of the characteristics of the contact surface of the creative object. Most surface traces are created at the scene by substance layering. The substance removed from the creative object may come from its contents, as in the case of handprints created by the deposition of sweat on objects touched with the hands. At other times, the substance may be foreign to the creative object, deposited on its surface on another occasion, such as mud on the soles of shoes. Such traces include wheel marks created by vehicles on the road, footprints created by the deposition of dust or mud on the floor, as a substance removed from the soles (Mircea, 1999, pp. 62-63). Such tracks that reproduce the shape of the object created by means of a foreign supporting substance are called mixed traces (Ruiu et. al., 2016, p. 13).

The destratification traces are created by detaching the substance from the surface of the receiving object and adhering it to the surface of the trace-creating object. As the substance is detached from the receiving object and deposited on the creating object only within the limits of the contact part and in different amounts depending on its relief, the trace thus formed reproduces the shape, dimensions and some characteristics of that part of the creating object. These traces are usually formed when the surface of the receiving object is covered with a thin smear of foreign matter, such as freshly painted objects or those covered with a small amount of fine-grained dust. Traces of destratification are created by hands in contact with the surface of freshly painted furniture, with objects covered with a thin layer of dust (Mircea, 1999, p. 63).

Layering and stripping traces can be: visible, when detected by the human eye; invisible (or latent), which cannot be detected unless viewed under certain angles of light, through transparency, for which visibility requires the use of directed light sources or ultraviolet radiation (Cîrjan, 2005, p. 181).

Most layering marks are at least faintly visible, even when the colour of the layered substance is close to the colour of the object receiving the mark. So we rarely come across invisible or latent traces, as they are called, imprinted on various objects at the scene. However, in very rare cases, invisible traces are also discovered at the scene. Such traces are created in two situations: when the substance deposited is colourless, as in the case of handprints created by sweat adhering to the surface of the receiving object; when the substance deposited is the same colour as the receiving object. In both cases the traces can be observed even with the naked eye, in ordinary daylight, if the objects bearing such traces are examined very carefully. What is difficult to see in these traces is their detail. Therefore, in order to be studied, latent traces must be highlighted beforehand by various methods and means (Mircea, 1999, p. 63).

According to the nature of the creative object.

According to this criterion, we can find as many traces as there are objects in the material world. In forensic science, only those traces that are of interest for the truth in criminal proceedings are studied: handprints, footprints, teeth marks, etc.(Ciopraga et. al., 2001, p. 39).

In addition to the criteria given, the literature also distinguishes between local and peripheral (negative) traces, which represent the outline of objects. The possibilities offered by the traces in terms of identifying the object or establishing its membership of a particular group are also examined (Drăghici et. al., 2018, p. 87).

Local traces are formed when the surface or volume of the receiving object undergoes changes in the area of contact with the creative object, reproducing the general and in some cases individual characteristics of the contact part of the creative object. Examples of such marks are footprints, handprints and similar. These traces contain specific information that can be used in their identification and analysis in the context of forensic investigations (Mircea, 1999, p. 63).

Peripheral traces show the configuration, the outline of an object, the position of which has changed as a result of the crime in the place where it has been located for a long time (Doraș, 2011, p. 128).

This is the case with an object left in an open place, when rain, snow, fire, dust, etc. act on the whole space (including the object) and, if the object is lifted, the area occupied by it remains untouched by these factors and its boundaries and contours can be seen. The identification value of this category of traces has been confirmed by numerous cases encountered in criminal prosecution and commented on by forensic experts (Ciopraga et. al., 2001, p. 40; Andrei, 1997, p. 219).

Another category of trace can be found, called positional. This category of traces represents changes in the original positions of bodies, objects or their sub-assemblies observed at the scene of a crime and which are directly related to the crime. Positional traces can provide relevant information about the dynamics of the events and help to reconstruct the chronology of the crime. These include, for example, partially opened drawers, doors ajar with the lock in the „secured" position, clocks broken and stopped at certain times, engine coupling handles or dashboard devices locked in specific positions, etc. By carefully analysing these positional traces, forensic experts can obtain important information about the activities during the crime and the associated events (Stancu, 2015, p. 117; Gayet, 1973, p, 7; Ruiu et. al., 2016, p. 13).

1.4 Classification of Traces According to the Nature of the Factors Involved in the Formation Process

Depending on the creative factor, the following main groups of traces can be distinguished:

Human traces represent the totality of changes resulting both from the simple contact of the human body with the components of the environment and from complex movements of the human body initiated, deliberated and coordinated by brain activity. These traces include all the changes resulting from contact of the hands, feet, face and other parts of the body with the elements of the place where the crime was committed (Ruiu et. al., 2016, p. 12) and are classified in two categories:

- created by reproducing the external construction of various body parts and clothing (hands, feet, teeth, lips, clothing objects) on the surface or in the depth of objects in the environment;
- created in various forms of biological substances, belonging to the human body (hairs, bloodstains, tissues, saliva deposits, semen, odor, etc.);
- created in the form of a trace of the body (hair, bloodstains, tissues, saliva deposits, semen, odor, etc.). (Doraș, 2011, p. 128).

Animal traces. Animals can create tracks with different body parts: claws, hooves, horns. Also of interest in forensic science are hairs, biological products and the specific odor of animals, as they can be used to identify them (Ciopraga et. al., 2001, p. 39).

Plant traces, comprising various changes resulting from contact and interaction of plants or plant products with the environment. These traces may be in the form of leaves, branches, stems, seeds, spores or other biological products of plant origin. Also included are traces of processed plant products such as coffee, tobacco, jelly and the like (Ruiu et. al., 2016, p. 12). Vegetable traces may indicate where people involved in a conflict or crime have passed: vegetation specific to the marshland, mountainous area, etc. (Ciopraga et. al., 2001, p. 39).

Traces of objects and instruments used in the commission of the crime, which include all the changes produced at the scene during the commission of the crime by the presence or action of the objects (Cîrjan 2005, p. 181). Traces given reproduce the external construction of solid objects. In forensic science, they are divided into traces of tools and traces of mechanisms (means of transport or means of production, etc.) (Doraș, 2011, p. 128).

Traces created by various phenomena, such as fires, explosions, catastrophes or exposure to radiation, are visible changes to objects. These traces can be observed in the form of characteristic features that reveal the consequences of these events. For example, the traces of fires may include obvious changes in the appearance of materials or structures affected by the fire, while the marks left by high-voltage leakage currents may be observed as distinctive marks on surfaces exposed to such leakage. Phenomena such as explosions can also cause complex modifications to machinery, installations, buildings or means of transport, which can provide important clues for forensic analysis and investigation of these events (Ruiu, 2016, p. 12).

1.5 Classification of Traces by Size

Traces can also be classified according to other criteria, which are of less interest. Thus, according to size, traces are classified into macro-urms and micro-urms.

Macro-urms are all categories of traces, whether of form or matter, which are large enough to be perceived and examined directly with the human sensory organs. These traces are visible and can be manipulated without the use of special instruments or apparatus. They can be subjected to ordinary chemical and physical processing, examination and analysis without danger of complete destruction of their substance. This type of trace offers greater opportunities for identification and analysis in forensic investigations as it can be examined in detail using standard methods and techniques (Drăghici et. al., 2009, p. 169; Drăghici et. al., 2018, p. 42).

Micro-urms are very small in size, which cannot be perceived with the human sense organs and require special technical means to be discovered. This category includes paint particles or glass powder resulting from the breaking of windscreens, mirrors, etc. on impact of the vehicle with an obstacle (Ciopraga et. al., 2001, p. 40).

1.6 Classification of Traces According to the Possibilities They Offer in the Identification Process

According to the possibilities they offer in the identification process, the author Cîrjan L., classifies the traces into:

- suitable traces, which allow the identification of the creative object;
- unsuitable traces, which do not allow identification but contribute to the establishment of gender (Cîrjan, 2005, p. 181).

In a work intended for police specialists, the criteria for classifying traces according to the possibilities they offer in the identification process are defined as follows:

- traces which provide elements for clarifying the various circumstances of the crime. This category includes traces which, although they do not contain elements for identification or for establishing that they belong to a particular genus, group, species or category, help to determine the nature of the activities carried out by the offender, to understand their sequence and duration and to explain the various negative circumstances. This category includes in particular positional traces, which provide information on how objects, bodies or persons were placed or left in the course of criminal activity. Also included in this category are conceptual traces, which reflect the conception of the commission of a crime and which may vary from individual to individual. A well-known example of such conceptual traces is modus operandi, which refers to the specific way in which an offender plans and carries out a crime, including characteristic methods, techniques and patterns of behaviour;
- traces, which contribute to the establishment of gender, are characterised by the lack of individual characteristics necessary for the identification

process, according to the forensic approach. However, the general characteristics of these traces make it possible to distinguish gender from the factors that created them and are of particular importance in establishing the circle of suspects. In this category, the most important are traces with a dynamic shape (with the exception of striations), destratification traces, negative traces, some material traces, micro traces and certain associated phenomena;

- traces that allow the identification of the creative factor. This category includes traces containing a number of sufficient individual characteristics (traces left by hands, feet, lips, teeth, clothing, footwear, transport rolling parts, as well as voice and speech traces) (Anghelescu et. al., 1976, p. 122-123).

The literature also classifies tracks according to the possibilities they offer in the identification process, namely sound traces (voice, speech, sounds of weapons, objects) (Drăghici, 2018, p. 43). These traces represent a distinct category in which the possibility of identification is conditional on the presence of a recording medium or a witness capable of picking up specific characteristics of the voice or speech. However, when we depend on such recording media or the ability of a witness to retain these characteristics, we can no longer consider this information as traces stricto sensu.

Chapter II

Forensic Investigation of Handprints

2.1 General Information

The most commonly used identification activity in forensic science is that which aims to identify the person, also known as ,,forensic identification".

It has emerged as a concern and a necessity since the investigation of the first acts hostile to society organised on a state basis, acts which contradicted the morals of that society and violated the rules of conduct established by it. Two problems have arisen with regard to the judicial identification of the person who has committed a crime:

– identifying the person who has broken the law on the basis of traces (and other elements of the crime);
– registering this person, so that if he commits another crime, his status as a repeat offender is known (Drăghici et. al., 2009, p. 81; Păşescu, 1996, p. 15).

Since the first forensic identification of the perpetrator of a murder carried out by the British Henry Faulds in Tokyo in 1879 (Locard, 1931, pp. 20-26), and in Romania since the identification of the perpetrator of a theft carried out in 1896 by the reputed doctor Nicolaie Minovici (Stancu, 2015, p. 118), dactyloscopy, defined by the great Romanian criminalist Ţurai C., as ,,the science of studying papillary drawings" (Ţurai, 1947, p. 16) at a time when Bertillion's creation, namely ,,bertilionage", was gradually replaced everywhere by dactyloscopy, because of its perceived superiority, was the main scientific method of identifying criminals in the 20th century (Cîrjan, 2015, p. 95).

Dactyloscopy is over five hundred years old as a science and has several millennia of experience (Cîrjan, 2005, p. 186; Pandrea, 1945, p. 458; Mircea, 1978, p. 59). And in fact Bertillon Alphonse is wrongly credited with the discovery of fingerprints, one of the cornerstones of forensic and police identification. Their classification was developed by Francis Galton, who in 1892 published a classification method based on the shape of fingerprints. It was not until the beginning of the 20th century that Bertillon introduced them into his files as an accessory and complement to his anthropometric methods (Buquet, 2001,

p. 33). But as a means of evidence, based on scientific investigation, handprints were recognised in criminal justice much later. According to the accepted opinion of many researchers in this field, the first records of identification of criminals on the basis of handprints found at the scene of the crime were recorded at the end of the 19th century – beginning of the last century. On the basis of great achievements in the fields of medicine and anthropology, a special branch of forensic science was established, known today as dactyloscopy – the science of studying papillary patterns (Doraș, 2011, p. 131; Cîrjan et. al., 2009, p. 112).

The forensic investigation of handprints is a complex process involving detailed examination of the papillary pattern on the palmar surface of the hand, as well as investigation of the pores and papillary ridges. Each of these activities has its own names, established in the literature: dactyloscopy, poroscopy, crestoscopy (Ciopraga et. al., 2001, p. 41).

In one sense, the term dactyloscopy comes from the Greek words dactylos, meaning ,,finger”, and scopy, meaning ,,to look” or ,,to investigate”.

Today, activities such as identifying perpetrators of crime, detecting repeat offenders or identifying unknown bodies are based on the methods of dactyloscopy, a branch of forensic science that deals with the examination and classification of papillary drawings for the purpose of identifying the person (Stancu, 2015, p. 118; Minovici, 1930, pp. 103-104; Constantin et. al., 1975, p. 14).

Dactyloscopy deals with the examination of the fingers, palms and soles of the feet, but not from an anatomical point of view, but only from their external appearance for identification purposes (Drăghici et. al., 2004, p. 77).

Suchiu C., defines forensic dactyloscopy as the branch of forensic techniques that deals with the study of the papillary drawings that are found in the finger, palm and plantar region, as well as the traces left by these regions in the field of crime, for the identification of persons and corpses (Suciu, 1972, p. 202).

The subject of forensic dactyloscopy is the following problems:

– development of procedures and methods for the discovery, identification, fixation, lifting, examination and interpretation of papillary drawing traces left by a person in different places;
– development of rules for coding papillary drawings for the organisation of dactyloscopic records of criminals, with a view to identifying repeat offenders, identifying false names and identifying criminals on the basis of papillary traces found at the scene of crime;

- development of methods for recording the fingerprints left from crimes with unknown perpetrators;
- development of procedures and techniques for fingerprinting persons and corpses;
- development of the methodology for identifying offenders by dactyloscopic expertise on the basis of fingerprints made by them at the scene of the crime;
- identification of unknown corpses (found without identity documents on them) by comparing them with dactyloscopic impressions taken from them. There are two possible situations: – When the person to whom the body belongs has undergone a dactyloscopic process during his or her lifetime; – When the family, relatives or friends of a person who has disappeared in unknown circumstances can provide objects on which the missing person's fingerprints may be present (Drăghici et. al., 2004, p. 78; Drăghici et. al., 2003, pp. 88-89).

Poroscopy studies the characteristics of pores, openings in the sweat glands, which are set on the papillary ridges in the form of a string of beads, and which can be used to identify the person (Ciopraga et. al., 2001, p. 41). In many cases, only fragments of papillary ridges are found at the scene of the crime, insufficient to indicate the shape of the papillary pattern and yet with a sufficient number of characteristic details to draw a definite conclusion. In these cases, the handprint will be lifted under special conditions, enlarged by micro-photography 80-100 times, and the dactyloscopic expertise will also be supplemented with poroscopy data. If, due to the extremely small shape of the handprint, we have to resort to poroscopy, from the first moment of the discovery of the handprint we have to follow some specific rules. It is preferable that handprints to be examined by poroscopic methods are photographed in the latent form in which they were found, using the transparency reflection method, if the object on which the handprint was found allows this, i.e. if it is transparent. The comparative examination of the characteristic points will be carried out as follows:

- the characteristic shape of the pores shall be taken into account;
- the placement of each pore on the papillary ridge and the mutual relationship of position to adjacent pores will be taken into account;
- the size of each pore in relation to the others in the revealed trace will be taken into account;

– the number of pores per mm or per fragment of papillary ridge, such as on the arm of a bifurcation, will be taken into account (Suciu, 1972, pp. 235-237).

Crestoscopy studies the details of the papillary ridges, especially their edges, when the fingerprint is not complete, but contains only fragments of the ridges (Ciopraga et. al., 2001, p. 41). The papillary lines are formed by the fusion of aligned epidermal elements, round or oval in structure and each containing a pore for exudation. Due to this fusion of epidermal elements, papillary ridges acquire their own characteristics. The pore is generally located in the centre of the papillary ridge, but may also be located at the edge of the ridge, creating a kind of fringe, a characteristic lacing of the papillary ridge. This marginal position of the pore will give the characteristics of the ridge edge, characteristics on which the identification of the person by crestoscopy is based. These ridge characteristics have been divided into eight variants: straight; convex; tooth-shaped; table-shaped; pocket-shaped; concave-shaped; angle-shaped and undefined, which includes any other shape except those mentioned above. To apply crestoscopy, rules similar to those in poroscopy must be followed. The removal of latent traces consisting only of fragments of papillary ridges requires the use of crestoscopy by reflex photography in transparency, if the trace-bearing object is transparent, or by iodine or bromine spraying in the case of other objects. During comparative examination, the general shape of the ridge examined, the number, shape and position of the pores and the characteristics of the mucosae shall be taken into account. Impressions shall be taken with a mixture of wax and tar or printing ink in a very thin layer and without pressing the fingers too hard to avoid destroying the marginal fringes of the ridges. For comparison of two patterns, the same figure should be used for coincident features, and examination can be made with a microscope or much enlarged micrographs. Diagram methods and superimposition of two devices can also be used for comparative examination of two papillary ridges in terms of their margins (Suciu, 1972, pp. 237-238).

2.2 Properties of Papillary Design

The formation of the marks on the hands on various smooth objects at the scene or on the victim's human body is due to the permanent presence on the surface of the offender's palms of the substance secreted by the skin, a substance made up of organic and inorganic compounds that do not evaporate so easily over time. These handprints (either finger, palm or sole) are formed by direct contact with the objects in question and have a particular forensic significance which is determined by the possibilities of establishing the various circumstances of the event under investigation. First of all, to determine the mechanism of their formation, as well as to diagnose and then identify the objects creating the traces (Gheorghiță, 2017, p. 185).

Papillary patterns, specific to the skin of the human body, on the fingers, palms and soles of the feet (soles), known as dermatoglyphs, are formed by the system of parallel lines of papillary ridges, separated from each other by papillary grooves. The papillary ridges are the irregular relief of the dermal papillae, which are located at the line connecting the two main layers of the skin, the dermis and the epidermis, of which the latter, on the surface, is constantly desquamating (Stancu, 2015, p. 118; Derobert, 1976, pp. 899-900; Țurai et. al., 1971, pp. 25-26).

The skin is the covering that covers the entire surface of the human body. It is made up of three layers: epidermis, dermis and hypodermis, which in turn are divided into several component layers, each of which has a precisely defined role (Drăghici et. al., 2009, p. 89):

- epidermis is the outer part of the skin, made up of several layers of epithelial cells. The upper cells of the epidermis are dead cells and form a horny layer, which is in a permanent process of desquamation (Cîrjan, 2005, p. 187; Țurai et. al., 1971, p. 25);
- the dermis or skin itself is made up of several tissues. The upper layer of the dermis, also called the papillary layer, consists of a series of conical protrusions called papillae. At the top of the papillae are the pores through which sweat and toxins are removed from the body. The sweat (made up of water, mineral salts and organic substances) secreted by the sweat glands and the fatty substances secreted by the sebaceous glands form a layer of salts and fats on the surface of the epidermis, which on contact with an object are deposited on its surface, reproducing the papillary pattern exactly (in a latent state). The papillae are arranged in a line-like sequence forming the papillary ridges, and the designs formed by these lines are called papillary designs. The distribution of papillary ridges on the surface of the fingers, palms and soles of the feet is not the same for all people, and each person differs in the way they are distributed (Moise et. al., 2020, p. 70).

The fingerprint is formed from the mixture produced by the natural secretions of the sweat glands (Buquet, 2001, p. 33). The sweat secreted by the sweat glands and the fatty substances (sebum) emitted by the sebaceous glands create a layer of salts and fats on the surface of the skin. These substances are deposited on objects they come into contact with, reproducing the details of the papillary pattern in an invisible latent form. The specific papillary skin patterns on the surface of the fingers, palms and soles of the feet, known as dermatoglyphs, are formed by the system of parallel lines of papillary ridges, separated from each other by papillary grooves. The interval between two papillary ridges is called the papillary grooves, which are the same size as the papillary ridges they separate. The distinction between the papillary grooves and the papillary ridges within a trace is very easy to make, if it is borne in mind that the pores are necessarily located along the ridges (Drăghici et. al., 2009, p. 90; Derobert, 1976, pp. 899-900; Țurai et. al., 1971, pp. 25-26);

- hypodermis, the deepest layer, which connects the skin to the internal organs (Cîrjan 2005, 187). The papillary ridges are linked to the sense of touch. So, the more numerous these papillary lines are, the more developed this sense will be. The distribution of the papillary ridges on the surface of the fingers, palms and soles of the feet is not the same for all people, as each person is characterised by their own distribution. The papillary ridges on the three regions mentioned above form the papillary pattern, which is as complicated as it is useful in the physical identification of a person (Drăghici et. al., 2009, p. 90).

In addition to the papillary ridges and grooves, when examining the relief of the palm and sole of the foot, the flexion grooves, which separate different regions of the fingers, palm and sole of the foot, are also studied, as well as the wrinkles of the skin running transversely across the papillary ridges (called white lines) (Drăghici, 2003, p. 107).

Fingerprints found at the scene are called fingerprints. When taken intentionally for identification purposes, they are called fingerprints. In order to record and document the details of the papillary design, photographs of the prints or impressions are taken and these photographs are known as fingerprints. These fingerprints form the object of study in the dactyloscopic identification process (Mircea, 1994, p. 72; Mircea, 1999, p. 65; Sava, 1943, p. 35).

There are two types of papillary patterns printed on the surface of objects, also known in forensic science as fingerprints:

- fingerprints which represent voluntarily printed papillary patterns. In specialist language these are referred to as either papillary impressions, papillary impressions or comparison prints;

– fingerprints which are papillary designs, involuntarily printed on any object. They are referred to as papillary impressions or disputed impressions (Pășescu, 1996, p. 70; Drăghici et. al., p. 91).

The importance of the papillary design for the identification of the person is due to its unique, fixed, unalterable and durable properties. Some authors (Cîrjan, 2005, pp. 188-190; Doraș, 2011, pp. 132-133; Mircea, 1999, p. 59; Stancu, 1986, p. 27; Basarab, 1969, pp. 94-95) consider that the papillary design has only the first two characteristics, others add the characteristic of inalterability, while others consider that it also has the characteristic of longevity. In our opinion, all these properties have their importance in papillary design research and contribute distinctly to person identification.

The uniqueness of the papillary pattern is explained by their variety. They are varied both in general shape and in the details of the construction of the ridges that compose them. This means that each person has his or her own papillary design as a unique existence, unrepeatable in another person. According to several mathematical calculations made by several scientists, the possibility of repeating two papillary drawings with the same coinciding points in a number of four, would theoretically exist only in 64 thousand prints. In practice, however, no such repetitions have been found. And if the number of characteristic details is increased, the result of the calculation reaches astronomical figures, which confirms the principle that each person is identical only to himself and, at the same time, is different from all others (Gheorghiță, 2017, p. 186; Stancu, 2001, p. 109).

Fixity of the papillary pattern is an important feature of fingerprints, which refers to the maintenance of the shape and characteristic details of the papillary pattern from its formation in the 6th month of intrauterine life until the death of the person. However, we must be aware that the fixity of the papillary design does not mean absolute immutability. Throughout life, small changes in fingerprint size may occur as the body develops, but these do not affect the essential characteristics of the papillary ridge and do not jeopardise the identification process. It is important to note that some changes may occur in the papillary pattern without mechanical, chemical or surgical intervention. These changes may be the result of factors such as aging, medical conditions or temporary skin damage. However, these variations are not likely to cause significant differences in the papillary drawings of the same person and do not essentially affect the dactyloscopic identification process. Thus, the fixity of the papillary pattern is a general characteristic of fingerprints, but should not be interpreted in an absolute sense, but in a framework that recognises the possibility of minor changes without significant impact on identification (Stancu 2015, p. 119; Thornton, 1977, pp. 89-95).

The inalterability of papillary design is a fundamental property of papillary design, which indicates that papillary design cannot be altered by the use of currently available scientific and technical means. All attempts to alter or destroy the papillary pattern have so far failed. This is due to the fact that the skin, in particular the dermis, which is the living part of the skin, is a constantly changing tissue. The dermis, unlike the epidermis (the outer part of the skin), consists of living cells with a limited life span. As these dead cells are replaced by new ones, the papillary pattern remains unchanged. Even in superficial wounds, the skin regenerates completely in a relatively short time, leaving no trace of the papillary pattern. However, deep lesions can lead to scarring which can affect the overall appearance of the papillary pattern. Attempts to destroy the papillary pattern using chemical agents or physical methods have shown that, in the case of superficial damage, the skin can regenerate completely within a few days. In contrast, deep lesions leave permanent scars, which can be used in criminal investigations to identify possible offenders. Therefore, the inalterability of the papillary pattern is based on the dynamic nature of the skin, which is constantly regenerating. This property makes the papillary pattern particularly valuable in identifying individuals and is one of the most reliable and stable means of identification used in forensic science (Ciopraga et. al., 2001, p. 42; Thorwald, 1997, p. 178).

The longevity of the papillary pattern lies in the fact that the papillary relief is formed before birth, completed by the sixth month of the intrauterine phase of the fetus, and continues to exist until the skin decomposes in the process of putrefaction (Mircea, 1999, p. 66). Of obvious importance are the papillary patterns on the surface of the phalanges (fingertip region). This is due both to their frequency at the crime scene and to the volume of structural features reflected in the marks. The papillary ridges on the surface of the phalangeal skin form the papillary pattern that is used to establish the identity of the individual (Gheorghiță, 2017, p. 187).

In addition to these basic features of the papillary pattern, some authors list the following:

Advantageous placement, which consists in the fact that these drawings are placed on that part of the body with which the person most often comes into contact with surrounding objects (the offender cannot perform any activity without using his hands).

The ease with which they remain at the scene. The papillary patterns remain easily at the scene of the crime on various objects or surfaces touched by the offender, due to the sweat glands at the base of the pores that form the papillary patterns and through which sweat is removed from the body. The fatty substances deposited in the marks formed by the hands are not the product of the pores, but are taken from other parts of the body (face, forehead, hair) or from various objects with which the hands have come into contact (cutlery, crockery, other objects). This mixture of sweat and grease easily remains on the surface of sticky and smooth objects touched by the hands.

The ease with which it can be detected and its ability to be studied and compared. Touching objects creates papillary surface traces (layering) due to the deposition of substances from the hand on the touched objects. Some traces are latent, i.e. invisible (those of grease and sweat), others are visible when the hand is dirty with dust, blood, paint, lint, etc. In other cases, when the objects touched have a certain plasticity, traces of depth remain (flour, dust, soft chocolate, butter, etc.). These traces, once they have been revealed and picked up, can be easily studied and compared (Drăghici, 2003, p. 110; Drăghici et. al., 2009, p. 93).

In another classification (Cotuțiu, 1998), the main characteristics of papillary ridges (dermatoglyphs) are: fixity, variegation, patterned type and genetic determinism:

- fixity, refers to the stability and constancy of the papillary pattern from its formation, which occurs in the third or fourth month of intrauterine life, until the death of the individual. This property indicates that the papillary pattern remains unchanged both in terms of its characteristics and in relation to the age and environment in which the individual lives;
- the variety of papillary ridges is extremely wide and contributes to the uniqueness of each dactyloscopic configuration. The structural details of the ridge, known as minutiae, include bifurcations, islands, short ridges, anastomoses and others, which interrupt the linear continuity of the ridge in different ways. Taken together, these details create a papillary pattern characteristic of each individual, making it impossible to repeat it in two individuals. It is important to note that the right and left palms of an individual are different even in dermatoglyphic minute appearance. Even monozygotic twins, which have the same genetic material, do not show identical papillary patterns. This aspect of the uniqueness of papillary patterns has had a significant impact in the forensic field and

revolutionised methods of identifying individuals. The discovery of papillary pattern uniqueness has provided a solid basis for personal identification and has become an essential tool in criminal investigations. This is because the papillary pattern cannot be faked or replicated accurately, providing a reliable way of identifying individuals and associating them with traces found at the crime scene;

– in dactyloscopy, papillary patterns can be categorised into distinct types based on the presence or absence of triradius. The triradium is a delta-like formation where three papillary ridges meet and separate. Depending on the presence of the triradium, three main types of patterns can be broadly identified: arches, loops and vertices.

Arcs: These patterns are characterized by the absence of the triradium. In the case of arches, the papillary ridges form a curved, arch-like configuration. This can be a simple shape, in which the papillary ridges flow in a constant direction, or variations can occur, such as arcs ending in loops or vertices.

Loops: These patterns show a single triradius, where three papillary ridges meet and separate. Loop configuration can be categorized into two main subcategories: simple loops and complex loops. Simple loops consist of a single loop, while complex loops involve multiple loops within the same pattern.

Vertices: These patterns have two triradii, where three papillary ridges meet and split at two distinct points. Vertices can have different configurations, such as simple vertices or vertices with loops embedded within them.

It is important to note that these types of papillary patterns offer great diversity, and each individual may have a unique mixture of patterns in both palms. These patterns are used in the dactyloscopic identification process to ensure uniqueness and specificity in the identification of individuals;

– genetic determinism of dermatoglyphs, refers to the influence of genetic factors on the formation and characteristics of these papillary patterns. It has been found that there are striking similarities of patterns between monozygotic twins, who have the same genetic configuration. Thus, these twins show significant concordance in terms of pattern types and specific dermatoglyph details. There is also concordance between dermatoglyphic patterns in parents and offspring, indicating genetic inheritance of these features. However, the exact transmission of the dermatoglyph pattern does not follow a clearly defined universal pattern of inheritance. Dermatoglyph inheritance is considered complex, influenced by several genetic and environmental factors. Multiple genes are involved in the formation and development of papillary structures, and the interaction of these genes can be influenced by external factors. Currently, there is no universal model of inheritance for dermatoglyphs, as the influence of genetic and environmental factors in the formation of these patterns is still under investigation. Studies continue to explore the relationship between individual genetics, embryonic development and the specific formation of dermatoglyphs. However, what is clear is that dermatoglyphs are unique to each individual and can be used for personal identification in dactyloscopy (Cîrjan et. al., 2009, p. 114).

2.3 Classification of Papillary Pattern

Papillary patterns have a very varied and complex construction, particularly in the phalangeal region. With all their great variety, they are distributed in a certain order, forming a series of combinations which can be grouped in certain regions and areas, both within the whole palm and in the region of the phalanges. The distribution of the regions and areas of the palm is as follows:

– the digital region, subdivided into phalanges, phalangins and phalangites (Suciu, 1972, p. 204); the phalanges in turn have papillary ridges in the form of straight lines, parallel to the flexor groove or slightly oblique to it; they are usually interspersed at short intervals by parallel folds of skin perpendicular to the flexor groove. Because of these creases it is very difficult to trace the path of each individual ridge; phalangins are located between the phalanges and phalangites. The phalangeal ridges are also parallel, but some are parallel to the inferior flexor groove and others are oblique. More rarely, they run concave to the upper flexor groove; the phalanges, the last phalanges of the fingers, have the most varied papillary relief, thus opening up the possibility of classifying them into types, groups and subgroups, which makes the process of dactyloscopic identification much easier (Cîrjan, 2005, p. 192);
– the digito-palmar region, located in the upper part of the palm, immediately below the base of the fingers;
– the tenar region, located between the base of the thumb and the centre of the palm;
– the hypotenar region, located in the ulnar part of the palm (Suciu, 1972, p. 204).

Regardless of the region or area in which they are found, papillary patterns are of major importance in the identification process. In this context, phalangeal patterns stand out in that their marks are most frequently found at the crime scene. Due to their particular structure, these patterns are the only ones used in dactyloscopic records (Stancu, 2015, p. 120).

The phalangeal region, which is the most important one from the point of view of dactyloscopic recording and identification, is in turn divided into several areas, namely:

- the central or nuclear area, formed by the lines of the central drawing, in the form of circles, arcs, spirals, loops, etc.,
- the marginal or outer area, consisting of arcuate papillary ridges in the shape of the outline of the phalanx, which is located at the edge of the papillary design and the fingerprint;
- the basal area, consisting of straight or curved lines convex to the centre of the design, located between the central design and the interphalangeal fold (Suciu, 1972, p. 204).

The regions of the papillary design of the fingers and palms are:

- phalangites region;
- phalangins region;
- phalanges region;
- digito-palmar region;
- tenar region;
- hypotenar region (Anghelescu et. al., 1976, p. 128).

The three areas of the papillary pattern on the phalangeal are separated from each other by a papillary ridge which is called the boundary. The papillary ridge (part of the basal area) separating this area from the central area is called the inferior boundary. The papillary ridge (forming part of the marginal zone) which separates the marginal zone from the central zone is called the upper boundary zone (Drăghici et. al. 2009, p. 96).

The meeting point of these three ridge-types of areas bounding a figure is conventionally called the DELTA, and is composed of three lines drawing a triangle (closed or open, with or without the three distinct points) or a star with three often asymmetrical branches. The first traces described are called white deltas and the others black deltas. Delta is the name derived from the resemblance to the Greek letter of the same name, being a triangular formation arising at the point where the two limiting papillary ridges meet. These ridges may join together, or they may pass each other without touching (Cîrjan, 2005, p. 192).

Depending on the length of the arms from which they are formed, black deltas are divided into:

- long black delta, which has two or all three arms extended to five times the thickness of a papillary ridge;
- short black delta, which has two or all three arms shorter than five times the thickness of a papillary ridge, i.e. up to 4.5 mm (Ciopraga et. al., 2001, p. 52);
- equal-armed black delta, which has all arms equal in length (Mihuț, 2004, p. 73);
- two-armed black delta is delta whose two arms are equal and whose third is longer or shorter than these;
- unequal-armed black delta is delta whose arms are of different lengths from each other (Drăghici et. al., 2018, p. 149).

The white delta consists of the triangular space formed at the point of contact of the two boundaries, which is bounded both by these ridges and by a third papillary ridge (in the central region) in close proximity . The white delta can take different forms, depending on the degree of openness of the angles: open at all angles, at two or one angle, or closed at all angles (Ciopraga et. al., 2001, p. 52). The white delta is classified as follows: white delta open at all angles; white delta open at two angles; white delta open at one angle; white delta closed at all angles (Pășescu, 1996, pp. 48-50). The white deltas, although they do not play a role in classifying dactyloscopic records, are nevertheless useful for identifying fingerprints and for detailed fingerprint expert reports (Cîrjan, 2005, p. 193).

The importance of the drawings lies in the fact that in relation to the shape of the ridges in the centre of the phalanx and the position and number of deltas (one, two, three or four, or missing) the papillary drawings are divided into types and varieties, helping in the general identification and organisation of fingerprint records in the monodactyl and dactyl fingerprint record binders (Drăghici et. al., 2009, p. 96).

In the literature, classification systems are very diverse, but all are based on a few fundamental forms of drawings first described by Purkinje (Cîrjan et. al., 2009, p. 116).

When classifying papillary designs by type and variety, the following elements are taken into account: a) the shape of the papillary ridges in the central area of the phalanx; b) the number and placement of the delts within the papillary design on the phalanx (Drăghici et. al., 2018, p. 151).

Types are large groups of papillary designs divided according to the general shape of the ridges making up the central region. According to this criterion, all papillary designs are divided into five basic types, which in turn have many peculiarities that allow some dactylographs to be easily distinguished from others, although they are of the same shape. Taking into account other criteria, such as core, position or number of deltas, each type is further divided into smaller groups, called subtypes and varieties (Stancu, 2015, p. 121; Cîrjan 2005, p. 193; Ciopraga et. al., 2001, p. 53; Drăghici et. al., 2009, p. 98).

Therefore, the criterion imposed by the shape of the design in the central area and by the position and number of deltas, is classified as follows:

- adeltic or arc-like designs, lacking a central area;
- monodeltic or loop-like designs, in which the central area is actually in the shape of a loop starting from the right or left of the design, hence the sub-classification into dextrodeltic and sinistrodeltic;
- bideltic or circle-like designs, the central area being in the shape of a circle, a spiral, twin loops, etc.
- polydelic or combined designs, most of which have three delts and very rarely four delts;
- exceptional or amorphous designs, which do not approximate to the usual papillary designs. The literature thus points to a type of (simian) monkey-like design found in some mentally handicapped people, and a type called lacy (Stancu, 2015, p. 121; Țurai, 1973).

The characteristic feature of the papillary adelgite or arch relief is that it has no delts. Their ridges run across the anterior part of the phalanx, almost parallel to the flexor groove, describing a slight or sometimes more pronounced wave in the central region, outlining, towards the tip of the finger, up to under the nail, in the shape of a nimbus. Although the adelgites have no deltas, there are features that can be subclassified into several groups, which makes identification and dactyloscopic recording much easier. Thus, according to certain group characteristics, adelgites are subclassified into: simple, pinnate, right confluent, left confluent, right loop, left loop, two opposite loops, spiral beginning (Mircea, 1999, p. 76-77; Țurai, 1947, pp. 135-136; Constantin et. al., 1975, p. 34).

Simple adelgites are the most numerous of the adelgite reliefs and are characterised by the fact that all the papillary ridges are approximately parallel to the flexural groove, marking only a slight wave in the central portion of the relief. In simple adelgites no ridge changes direction in relation to the entire papillary relief.

Pinnate adelgites, in the central part of the papillary relief a single ridge changes direction, taking it abruptly towards the tip of the finger, and the ridges immediately above it rise slightly above the tip, from where they descend and continue their course to the other part of the relief. Thus, in the central region, a design reminiscent of the shape of a pine cone is created.

The straight confluence thinners have the same configuration of the papillary relief as the simple ones, except that on their right side they tend to approach each other, either by merging or by the disappearance of some of them. on the right-hand side, the ridges are more pronounced on the flexural groove than on the left-hand side.

The left-confluent thinners have the same general appearance as the previous ones, except that the ridges tend to be closer together and more pronounced on the left-hand side of the dactylogram.

Straight (right) looped (lace) type, with ridges approximately parallel to the flexural groove, of which only one, in the central region, turns to the left, thus creating a loop with a rounded sector on the right.

Left looped (lace) type, with only one ridge turning to the right in the central region. The apex of the loop (rounded sector) thus created is directed to the left.

Opposite-looped adeltics have two loops, one formed on the left and the other on the right of the relief, both with their apexes directed inwards.

Spiral-headed adeltics differ from simple adeltics in that a certain ridge is twisted in the centre of the relief, but this does not change the direction of the other lines (Cîrjan, 2005, p. 153-154).

Monodeltic or ribbon-like designs. In this type of relief the papillary ridges start from one edge of the papillary pattern on the phalanx and move towards the opposite edge, without touching it, curl to form a loop (lace) and return from where they started (Drăghici et. al., 2018, p. 153).

Two subtypes are described according to the position of the deltoid and the opening of the loop: dextrodeltic and sinistrodeltic (Ciopraga et. al., p. 54).

Dextrodelts are subdivided into two groups according to the characteristics of the relief in the central part:

– dextrodelts with loops have a central region formed by loops placed successively one inside the other. The loops of the loops are directed towards the delta, and the open part is to the left;

- dextrodelts with a racket also have a central region also made of loops, but after the return they merge with their starting part or gradually disappear, describing the shape of a tennis racket.

Sinistrodeltic papillary reliefs, in general appearance, closely resemble dextrodelts. The only difference between them lies in the opposite position of the delta. Sinistrodelts have the delta on the left side, and they are divided into looped sinestrodelts and rocket sinestrodelts (Mircea, 1999, p. 78).

Some authors (Drăghici et. al., 2009, p. 99) note that in the case of papillary lace-like patterns (both dextrodeltic and sinistrodeltic), the nuclei in the central area can exhibit a wide variety of shapes, estimated at about 60 different types. We also mention some variants:

- simple lace – the lace does not contain within or on its arms any characteristic detail;
- simple lace with ring or buttonhole – one or both arms of the lace have a ring or buttonhole on their path; – simple left, right or bilateral bifurcated lace, on one or both arms of the lace there is a junction or bifurcation of papillary ridges;
- lace with point is a specific form of papillary design involving the presence of one or more points between the arms of a simple lace. It can be identified by the presence of one or more dots within the papillary pattern in a specific position;
- linear lace is a specific form of papillary pattern in which the nucleus consists of a loop surrounding one, two, three or even more linear ridges. When there is only one straight ridge between the arms of the ribbon, it is called a ,,linear ribbon' or 'wand ribbon”. This refers to the fact that the core of the loop surrounds a single straight ridge with no other branches or forks. If there are several ridges between the arms of the loop, then it may be called a ,,bilinear loop” (when there are two ridges), a ,,trilinear loop” (when there are three ridges) or a ,,multilinear loop” (when there are several ridges). These names indicate the number of ridges involved in the linear loop configuration. These types of papillary patterns, including linear slashes, are analysed and interpreted by dactyloscopic experts in the process of fingerprint-based identification of persons;
- the rocket lace is a special type of papillary pattern in which the core is formed by a slash whose arms, instead of running parallel, join after a short distance and take the shape of a tennis racket. This type of design is so called because of its resemblance to the shape of a tennis racket;

- the question mark lace is a special type of papillary design in which the nucleus contains a papillary ridge which curves at the upper end, taking the shape of a question mark (?). This particular configuration of the papillary pattern can be seen within the lamina and is characteristic of the individual;
- concave lace is a type of papillary pattern in which the nucleus consists of one or more laminae, having a concave shape relative to the flexion groove of the phalanx. This specific configuration of the papillary pattern can be observed within the nucleus and is characteristic of the individual concerned;
- overlapping, simple or linear laces – the papillary ridges in the nucleus are formed by two lakes whose neighbouring arms intersect. within them there is sometimes a papillary ridge with a linear appearance;
- common laces, simple or linear – in the central region two lakes are formed which have a common arm, and within them there may or may not be a papillary ridge;
- double (parallel) laces, simple or linear – in the centre of the design there are two independent, parallel, contiguous lakes surrounded by a larger lace. The interior of the two loops may each contain an isolated papillary ridge;
- irregular nucleus – the general appearance of the nucleus cannot be classified in any of the above varieties (Drăghici et. al., 2018, p. 153; Ionescu, 2008, pp. 104-105; Pășescu et. al., 1966, p. 58; Constantin et. al., 1975, p. 40).

Papillary lacy designs are the most common. As a rule, left-sided lacy designs are found on the fingers of the right hand, except for the index finger, where the dextrodeltic subtype is quite common, and vice versa for the fingers of the left hand (Drăghici et. al., 2009, p. 99).

Bideltic or circle patterns. Bideltic papillary reliefs have ridges unfolded in such a way that a delta is formed on the left and right sides. The central region of the bidellitic, because of its variety, allows them to be divided into different groups and subgroups. The complex configurations of the papillary ridges, such as spirals, concentric circles, ellipses, interlocking loops and whorls, contribute to the classification of bidelites into different categories (Mircea, 1999, p. 78):

- the spiral bidellitis has a central region consisting of a papillary crest twisted like a spiral. The spiral starts from the centre of the papillary relief and continues until the central region is completed. The spiral bidellitis is subdivided into: – dextrogite, with the spiral twisted to the right; – levogite, with the spiral twisted to the left;

- concentric circle bidellitis, with the central region consisting of at least two or three concentrically arranged circles, the rest of the region being filled, in most cases, with papillary ridges in the form of a spiral;
- ovoid bidellitis, with the central region consisting of several oval-shaped ridges enclosed one inside the other. After a few ovoids, the central region is completed with spirals;
- ellipsoidal bidellitids, have a central region consisting of a few concentric elliptical ridges. After a few ellipses, the central region is completed with spiral ridges;
- bidellitids with entwined loops differ greatly in the central region from all the bidellitids mentioned so far. Their central region is made up of two groups of lobes, coming from both sides of the papillary relief, which are coupled by entanglement in the central region. Depending on the direction of twisting of the lobes, these reliefs are subdivided into:
  - bidellitis with right entangled lobes;
  - bidellitis with left entangled lobes. The delta towards which the loops are twisted has a higher position than the other;
  - bidellitic with whorls, with several papillary ridges arranged in a whorl shape in the central region. depending on the direction of twisting, these bidellitic cells may be:
    - right-sided whorled;
    - left-sided whorled (Cîrjan, 2005, pp. 195-196).

Polydelic or combined type designs. In the combined type, at least three deltas are always found in the papillary field of the design. Depending on the number of deltas, there are two varieties in this type:

- papillary reliefs with three deltas, as the name indicates, have three deltas, one of which is usually in the centre of the typeface and two on the sides;
- papillary reliefs with four deltas. These reliefs are particularly rare (Mircea, 1999, p. 80; Drăghici et. al., 2018, p. 160).

Exceptional or amorphous patterns contain papillary ridges with irregular trajectories, which prevent their systematisation into regions. Although the overall image of the design creates the impression of a chaotic design, it can nevertheless be divided into the following subtypes:

- the simian subtype, specific to monkeys and some categories of epileptics and mentally ill people, consists of vertical or oblique papillary lines and a multitude of papillary points and fragments that merge or bifurcate in very different directions (Drăghici et. al., 2018, p. 106);
- the lacy subtype consists wholly or partly of fragments of papillary ridges which fall perpendicular to the flexural groove and have a shape similar to that of a garland or the incomplete links of a chain,
- the undefined subtype consists of dactylograms which, because of damage to the dignified part due to injury or scarring, are indistinguishable from the subtype by the shape of the central region (Ciopraga et. al., 2001, p. 55).

2.4 Characteristic Details of Papillary Design

In addition to the shape features of papillary patterns, which are of limited help in identifying a person, and which are mainly useful for determining gender or finger group, the fingerprint also contains a number of minutiae or details essential for accurate identification of the individual (Stancu, 2001, p. 123).

The main task of dactyloscopy is to determine whether an incriminating print and a comparison print come from the same finger, palm or sole, and on this basis to establish the physical identity of a person. The two prints, reproducing the ,,stamp” of the papillary ridges of the same area, will inevitably, on the basis of the principle of uniqueness, have the same morphological appearance, taking into account, of course, the inherent changes that occur in the process of printing these designs: depending on the maneuvers carried out at the scene of the crime, the type and quality of the instruments used for printing, the degree of pressure, the properties of the material on which the prints remain, etc. The morphological appearance, which is the same, demonstrates the original identity of the print with the impression and, at the same time, distinguishes them from prints and impressions from other fingers (Drăghici et. al., 2009, p. 108; Constantin et. al., 1975, p. 56; Pășescu et. al., 1996, p. 79).

The dactyloscopic identification process goes through two phases. The first phase consists of establishing common type, group or sub-group features, whereby fingerprints of a type, group or sub-group other than the crime scene print are eliminated from the scope of examination, using the classifications presented in the previous pages as a basis for selection. The second phase of the examination process comprises a detailed comparative search of fingerprints of the same type, group and subgroup representing impressions taken experimentally with the fingerprint which is a copy of the crime scene impression. It is only by finding a certain number of identical details in the impression and the spot print that identity is established, when it can be said with certainty that both fingerprints, brought to the same scale, were created by the same finger. The details to be followed by the expert are recommended by forensic science, by explaining the identifying value of each characteristic detail that can be found on the papillary relief (Mircea, 1978, p. 72; Mircea, 1982, p. 66).

Papillary ridges are rendered by continuous lines, but also by broken or divided lines, which form details called minutiae, elements or minutiae points (Cîrjan et. al., 2009, p. 118). The fingerprint contains a series of minutiae or details that allow the individual to be identified with certainty (Moise et. al., 2020, p. 72; Stancu, 1999, p. 123). The details that forensic science dwells on and recommends for use in the fingerprint identification process, studying them on fingerprints in a clockwise or left-to-right direction, when the papillary ridges are parallel to the flexural groove, are as follows (Mircea, 1999, p. 81):

- papillary ridge beginning, the point where a papillary ridge begins its upward course (Drăghici et. al., 2018, p. 163; Popa et. al., 2005, p. 107);
- papillary ridge ending, the point where a papillary ridge ends its downward course;
- papillary ridge bifurcation, the point where a ridge splits into two distinct courses;
- papillary ridge trifurcation, the point where a ridge splits into three distinct courses;
- papillary ridge branching, the point where a papillary ridge divides into two or three distinct ridges which after two or three millimetres divide in turn into two other ridges, having the appearance of a branch (Drăghici et. al., 2009, p. 110);
- papillary ridge junction, the point where two papillary ridges join;
- triple papillary ridge junction, the point where three papillary ridges join;
- papillary ridge fragment, a papillary ridge whose length exceeds several times its thickness and which lies between two papillary ridges of greater length;
- buttonhole is the oval shape which a ridge takes after it bifurcates and at a very short distance the two branches join again under a single path;

- ring is the same as buttonhole, except that it is circular (Pășescu et. al., 1996, p. 83);
- dotted ring is a circle with a papillary point in the centre;
- overlap is considered to be the place where the end of one papillary ridge exceeds by 2-3 mm the beginning of another which has its path adjacent to it;
- adherent ridge or hook is a fragment attached at one end to another longer ridge;
- break is the place where a papillary ridge interrupts its course and then, after 2-3 mm, reappears and continues its course;
- papillary point is a papillary ridge with a point-like shape and is usually located either in a ridge break, in a ridge delta or between two ridges (Drăghici et. al., 2018, p. 164; Constantin et. al., 1975, p. 60);
- ridge cluster when several points or fragments of ridges are located in different positions in a very limited space;
- ridge head triangle is created at the place where two ridges either disappear and between them, before their disappearance, another ridge begins to develop, or two ridges appear and between them, immediately after their birth, a papillary ridge ends;
- anastomosis is formed by a papillary line connecting, like a bridge, two neighbouring ridges. As it always has an oblique position on the two ridges, it can be found in two aspects, taking into account the direction of its inclination, i.e. right anastomosis and left anastomosis;
- the deviation consists in the deviation from the initial direction of the end of the line, the direction of its development being continued by another ridge with a deviated beginning in such a way that it has a position parallel to the deviated end of the preceding ridge (Mircea, 1999, p. 82);
- alternating ridges – the detail consists of an interruption of a papillary ridge through which a continuous papillary ridge passes (Drăghici et. al., 2018, p. 164; Ionescu, 2008, p. 108);
- intersection – the point at which two ridges intersect;
- reentrant – the detail consists of a papillary ridge which curves sharply and reenters on a course approximately parallel to the original one;
- scar is a characteristic detail which may still be considered;
- island is a formation of papillary points which occurs within the papillary pattern (Drăghici et. al., 2009, pp. 111-112).

The order in which these details are described takes into account the frequency with which they are encountered in practice. When examining a phalangeal fingerprint, the characteristic details shall be read in a circular, clockwise direction and the axis of these needles will be considered as the core of the fingerprint under examination (Ciopraga et. al., 2001, p. 57). For a positive conclusion it is necessary to find at least 12 characteristic elements on the disputed papillary design and on the comparison impression (Drăghici et. al., 2018, p. 165).

The 12-point rule was formulated by V. Balthazard and is a quantitative criterion in dactyloscopy. According to mathematical calculations, it has been shown that the identification value of a fingerprint found at the crime scene is proportional to the number of dots (details) it contains compared to the reference fingerprint. In 1911, Balthazard demonstrated that for four types of minutiae (ridge start, ridge end, bifurcation and ridge junction), a number of 12 coincident points is required for the probability of coincidence to be 1 in 16,777,216 million. If 17 coincident points are taken into account, two prints can be found once in a batch of 17,179,869,184 fingerprints (Cîrjan, 2005, p. 200; Constantin et. al., 1975, p. 213).

In terms of quality, Edmond Locard remarked as early as 1929 that ,,a rare feature is 100 times more significant than a series of bifurcations in the marginal zone". Thus, four or five dots well grouped in the centre of the figure, in an exceptional way, have a greater impact than 12 or 15 bifurcations scattered in the periphery of the drawing. This underlines the importance of the relevance and uniqueness of the distinctive features of the papillary design (Cîrjan et. al., 2009, p. 83).

With reference to the mixed method, it takes into account both the quantity and the quality of the characteristic details found (Aron, 2010, p. 20).

2.5 Other Papillary Relief Details

Other details of the papillary relief used in the dactyloscopic identification process are pore features, white lines and some scars (Mircea, 1999, p. 82).

In the process of dactyloscopic identification, pore characteristics along the papillary ridge are used as an aid when the morphological details of the papillary lines present in the crime scene trace are not sufficient for identification. Although a dactylogram may contain around 150 minutiae, sometimes the minimum number required for identification, 12 matching minutiae, is not present in the crime scene prints, especially in the case of trace fragments or faint details of papillary relief. In such cases, microscopic study of the pore traces on the fingerprints examined is used. Pores can be successfully used in the dactyloscopic identification process as an aid because they preserve certain individual features of the papillary relief. However, pore features do not last for the morphological details of the papillary ridges as they can atrophy, change or even disappear during the individual's lifetime. Therefore, the study of pores under the microscope, known in forensic science as poroscopy, can only be applied in the process of dactyloscopic identification as an aid (Mircea, 1999, pp. 82-82; Stancu, 1981, p. 150; Mircea, 1996, p. 66).

The stability of pores is based on two aspects: immutability and topographical distribution (reciprocal spatial relationships), but their identification may be limited due to the clogging of pores with coating substances or dust on the surface of the object (Cîrjan et. al., 2009, p. 128).

The examination of the coincident characteristic points of the pores is carried out following an obligatory sequence, i.e.:

– the characteristic shape of the pores is taken into account, which may be circular, oval, saddle-shaped, crescent-shaped, fringed, etc.;
– the placement of the pore in relation to another, its distance and position on the ridge (central, marginal, etc.) are studied and taken as elements of comparison. the size of the pore is assessed in comparison with neighbouring pores or by measurement, it being known that their diameter is between 80 and 250 microns;
– the number of pores per unit length or per fragment of ridge is taken into account, it being known that 9-18 pores can be found per millimetre (Ciopraga et. al., 2001, p. 57).

The white lines on the dactylograms appear due to the creases which, from place to place, cross the ridges of the papillary relief. These lines have a relatively long but temporary existence compared to the general structure of the papillae. Their number, arrangement, spacing, length and other characteristics they may have are individual features of the papillary relief at a particular period of a person's life. Therefore, when there are such blank lines in the fingerprints under comparative examination, their characteristics can be used as an additional tool in the identification process, together with other morphological details of the papillary ridges (Mircea, 1999, p. 83).

Scars are nothing more than the result of damage to the skin of the dermis, which lasts for life. Their shape, the area in which they are found and their dimensions are imprinted at the same time as the papillary relief on the receiving object, serving in the identification process (Cîrjan, 2005, p. 207).

2.6 Scene of Crime Search for Handprints

The contact of the offender's hands with the various surfaces encountered at the scene of the crime always results in the production of traces.

These marks occur predominantly as a result of the transfer of substances from the surface of the skin (from fingers or palms) to the objects with which it comes into contact. The deposition of substances can be caused by sebum, sweat, dead skin cells and other compounds present on the surface of the skin. These substances can be transferred to objects by touch and create visible or tactile marks. If the object touched is soft, such as a malleable material or a powdery surface, papillary ridges may be recorded in depth, leaving raised marks (Pășescu, 2000, p. 158; Pășescu et. al., 1996, p. 139).

For the identification of handprints, it is initially essential to establish the alleged perpetrator's places of access and the route taken during the commission of the crime (iter criminis). This is necessary in order to delimit the area in which the footprints can be found and to enable an organised and efficient search and discovery (Stancu, 1995, p. 130).

Handprints can provide relevant information that can lead to inferences about the link between the person who left the footprints and the crime, the activities carried out by that person at the scene of the crime and the identification of the persons who left the footprints or the objects they used in committing the crime (pășescu, 2000, p. 166; Țurai, 1984, p. 93; pășescu et. al., 1996, p. 146).

2.7 Classification of Handprints at the Scene

The complex operation of discovering, revealing, fixing and lifting handprints from the crime scene is carried out from the beginning of the investigation, in accordance with the way in which these handprints were formed. Papillary marks, whether from the fingers, palm or whole hand, are formed by direct contact with a surface or object. Depending on how they were formed, these marks may have the following characteristics (Stancu, 2015, p. 122):

– according to the mode of formation, a distinction is made between dynamic and static marks. In terms of forensic identification, dynamic traces are of little value, as they contribute at most to establishing gender identity and not to the individual identification of a person. Static traces, on the other hand, are of particular importance and are carefully researched because their details can be used for identification (Ciopraga et. al., 2001, p. 43);

– depending on the plasticity of the trace receiving medium, a distinction is made between surface and depth traces. These traces represent a reproduction in the negative and in the body of the receiving object of the characteristics of the contact part of the creative object. Depth marks are created by sledges on snow, feet or vehicles in muddy or clayey ground, hands on certain foodstuffs such as butter, marmalade, etc. The quality of these marks depends very much on the construction of the receiving object. When the receiving object is fine-grained and plastic, the traces created in its mass reproduce the smallest details of the contact surface of the creative object, thus making them capable of leading to the realisation of identity (Mircea, 1999, p. 62). In turn, surface traces can be formed by layering, due to the deposition of substance on the hand (sweat, paint, grease, blood, etc.) on the surface touched, and by destratification, due to the lifting of substance previously present on the object (dust, paint) (Stancu, 2001, p. 125);

– visible traces and invisible or latent traces are known according to the identification value. Visible traces are created when hands soiled with coloured substances, such as blood, paint or ink, leave traces on objects with which they have come into contact. In some cases, the features of the papillary pattern are not perfectly retained, due to the soaking of the grooves with the coloured substance, leading to smearing. The degree of soaking of the papillary ridges can vary and lead to different aspects of visible papillary traces. For example, hands soiled with blood or paint, repeatedly applied to different objects, may initially leave smear marks. Later, the coloured substance on the raised papillary ridges thins out until the ridge marks are white and the groove marks are coloured. This is because at first the grooves are soaked with the coloured substance, but then the substance is thinned until it is deposited only in the papillary grooves, creating a negative-like appearance of the papillary pattern (Drăghici et. al., 2018, pp. 169-170). Given this peculiarity of the formation of the coloured traces, it is important to point out that errors may occur in the comparison process when papillary ridges are considered to be grooves and grooves are considered to be papillary ridges. In the case of such an error, identification becomes impossible and the conclusions of the expertise will always be negative. Therefore, when a stained trace (with blood, dust, mud, paint, ink, etc.) is found and lifted, it is recommended to compare it as found, but also to make a photographic inversion of it in order to check that the trace does not reproduce the grooves. This helps prevent errors in identification and ensures a more accurate analysis of the tracks (Constantin et. al., 1975, p. 148). Invisible handprints are left by the deposition of sweat and human fat on the skin, as a result of touching (voluntarily or involuntarily) certain objects at the scene of the crime (e.g. when the offender touched the window glass through which he entered the room, the door and its handle, knick-knacks, light switches, furniture, books, glasses, glass, fruit, etc.). These traces are dormant and need to be detected using chemicals in order to be noticed (Drăghici et. al., 2009, p. 209).

2.8 Search and Discovery of Handprints on Site

Papillary marks can be reproduced on a wide variety of objects with a smooth or relatively smooth surface, capable of reflecting the general and particular characteristics of the skin relief (Ionescu, 2008, p. 111).

The term ,,handprint investigation" in forensic science means, on the one hand, all the forms of activity carried out by the criminal justice authorities with a view to discovering, fixing, lifting and interpreting handprints in order to establish the circumstances in which the crime was committed and, on the other hand, their examination by forensic experts with a view to identifying the perpetrator and establishing other circumstances of the crime committed (Doraș, 1996, p. 127).

The work of discovering the traces of a crime involves a systematic search and examination of the scene of the crime and all the objects found there, making extensive use of contemporary forensic technical means, methods and procedures. In addition, great patience and perseverance are required, as well as unlimited search time (Gheorghiță, 2017, pp. 189-190).

Before starting the search for traces at the crime scene, it is necessary to take a general overview of the crime scene and the facts (Golubenco, 2015, p. 30). Handprints are not searched at random, but according to a certain plan, drawn up in relation to the factual circumstances in which the crime occurred. At the scene of the crime, handprints – and by this we mean, in particular, fingerprints – can be found throughout the offender's journey (iter criminis) in the various parts of the interior of the room where he acted and in particular in the places where he insisted by the very nature of the crime, in the places where he ate or drank and in the places where he left, in these cases being less careful than during the commission of the crime (Suciu, 1972, p. 208).

The process of searching for handprints begins by identifying objects that are likely to receive and retain such marks. These objects are selected according to their purpose, location and position during the commission of the crime. Once these objects have been identified, a detailed examination of each object is carried out, assuming that it could bear handprints. The purpose of this examination is to discover and highlight possible handprints that may be relevant to the forensic investigation (Mircea, 1999, p. 67).

When searching for traces, particular care must be taken not to leave one's own traces and not to inadvertently wipe away those belonging to the perpetrator (Anghelescu et. al., 1976, p. 131).

The correlation between the commission of the crime and the appearance of fingerprints must be established with great care. Forensic scientists will consider the hypothesis that in some cases the fingerprints may have been carried unintentionally or intentionally to the scene of the crime. Indeed, fingerprints may be found on bottles of drinks or on the bottle of medicine brought into the crime room to help the victim. Nor can anything prevent a clever criminal from bringing in objects bearing foreign fingerprints to create false leads. Disclosing them at the crime scene can confuse the forensic expert (Cîrjan, 2005, pp. 207-208).

The search for traces can begin at the presumed place of entry by examining door latches, locks, switches and so on. If the entry was made by breaking a window, the shards of glass may preserve traces of papillary ridges in good condition. Porcelain objects, glass, metal surfaces, furniture and other scratchy surfaces, such as collars or shirt cuffs, can retain traces in satisfactory condition. These objects are carefully examined for traces relevant to the investigation (Stancu, 2015, p. 123).

Also searched are the tools used by the offender, items the offender has lost or abandoned, items belonging to the victim, clothing and even the victim's body. When it appears from the facts of the case that the offender has used motor vehicles, which he has abandoned, handprints are searched on the steering wheel, dashboard parts, doors and door handles, windscreens and side windows, etc. (Mircea, 1999, p. 67).

In addition to using the technical means available, the search for tracks also requires knowledge of tactical methods, appropriate to the specific location searched. This is why the prosecuting authority will have to mentally (Suciu, 1972, p. 203) reconstruct the route taken by the offender and each phase of the crime. Even if it is concluded that the offender has used gloves, the search must continue, as there are times when the offender has to remove the gloves and they sometimes no longer cover the entire surface, or they break off and leave a fragment of a papillary trace (Ciopraga et. al., 2001, p. 44). At other times, the surface of the object is touched by a portion of the skin of the palm, unprotected by the glove (Stancu, 2001, p. 126; Swensson et. al., 1957, pp. 22-24; Constantin et. al., 1975, p. 144-145).

2.9 Establishing Age and Interpreting Handprints on Site

Determining the exact age of handprints can be a complex task and often cannot be done with absolute scientific accuracy. There are certain methods and techniques used in the analysis of papillary notch marks to estimate their age, such as assessing physical deterioration, observing changes caused by environmental factors and comparing with other reference samples. However, it is important to note that the estimation of the age of the marks can be subjective and there may be uncertainties associated with this assessment. Also, influenced by factors such as environmental conditions and subsequent handling of the object on which the trace is found, estimates may be approximate and may not provide absolute accuracy in determining the age of handprints (Stancu, 2015, p. 124; Țurai, 1947, pp. 204-206; Constantin t. al., 1975, pp. 152-153; Constantin et. al., 1979, pp. 107-114).

From the perspective of forensic techniques, the determination of the age of handprints does not require a separate procedure, but relies on the selective use of detection methods, applied to small portions of them, in order to obtain relevant clues.

As regards the search for papillary traces, especially latent ones, rigorous requirements must be met by the forensic specialist. These requirements include speed in conducting the search, as well as perseverance, patience and composure in the process of searching and revealing traces, given the complexity and difficulty of this task (Stancu, 2001, p. 128).

It is important for the prosecuting officer conducting the prosecution and the forensic expert participating in the crime scene search to keep the number of persons participating in the search to a minimum in order to avoid creating additional traces or destroying those left by the offender (Cîrjan, 2005, p. 209).

Interpretation of the traces found at the crime scene can provide information on the object creating the trace, the person of the perpetrator, the activities carried out by the perpetrator in the field of the offence and the sequence in which they were carried out (Cătuna, 2008, p. 31).

The interpretation of handprints in criminal investigations involves determining the location and relevant objects, analysing the grouping and arrangement of the footprints and assessing the crime scene. This information can provide details of the perpetrator's modus operandi and help to establish further details of the crime and the perpetrator. Handprint interpretation is an important process in criminal investigations and can provide valuable clues to solving the case (Drăghici et. al., 2018, p. 173).

The interpretation of the handprints found at the crime scene provides valuable data about:

- the activities carried out by the perpetrator in the area, allowing the identification of the objects with the papillary prints, the places where the perpetrator moved and the instruments used to commit the crime. In some cases, fingerprints left on fine surfaces (such as glass, porcelain, ceramics or polished furniture) can indicate whether the hand that left the print was rough or well-groomed, which may give a clue to the person who committed the crime;
- by assessing the size of the papillary marks, we can estimate the age of the person who left them: child, teenager or adult;
- depending on the height at which the handprint was created, we can determine the height of the suspect;
- by analysing the clues provided by the places where the handprints were found, their grouping and mode of operation, and the overall circumstances of the crime, we can deduce whether or not the perpetrator knew the area in which he acted, whether he acted hastily, nervously, calmly, whether he was a novice or a specialist in crime, etc.;
- if the perpetrator's hands were dirty with grease, oil or other substances specific to different areas of activity, we can determine his profession;
- identification of the finger, hand or palm region from which the papillary trace originated. The interpretation of the papillary marks also aims to determine the probable finger and hand that left the mark at the scene (Drăghici, 2003, pp. 142-143).

In very rare cases, the entire palm print remains at the scene. Traces left by certain regions of the palm are usually found. Determining the hand and the region of the handprint is therefore of particular importance in identifying the perpetrator. With knowledge of the structure of the palmar papillary pattern, determining the hand and the region is no longer a problem. In the case of right hand prints, the flexion line of the thumb, starting from the base of the papillary pattern, follows an upward curve to the left, thus delimiting the tenar region. Likewise, the metacarpal flexion groove, which starts below the little finger, curves upwards to the left towards the index finger. The flexion grooves separating the three palmar regions are skin creases, without papillary ridges, and their traces are represented by white lines. In the case of the left hand prints, the flexion groove of the thumb points to the right, as does the metacarpal flexion groove. Thus, the reverse direction in which the flexion grooves of a palm print are oriented indicates the hand that left the mark at the scene. The digito-palmar region has distinct features, where crosses are usually found at the base of each finger, and the arches that form here are concave and oriented with the opening to the right in the case of the right hand and with the opening to the left in the case of the left hand. Each of the other regions of the palm has papillary ridges with characteristic shapes and structures, which, in combination with the traces left by the flexor grooves, helps to establish the region that created the marks on the spot (Anghelescu et. al., 1976, p. 140).

2.10 Optical Trace Detection on Site

Optical detection methods represent a modern approach to papillary trace detection, using advanced, state-of-the-art techniques. These methods focus on the use of optical technology to highlight and record papillary traces in an accurate and detailed manner. This makes a significant contribution to the investigation process, allowing faster and more accurate identification of papillary traces and providing greater reliability in the collection of samples for subsequent analysis (Drăghici et. al., 2018, p. 198). Modern techniques used in handprint investigation involve the use of ultraviolet lamps, specialised light sources such as Polilight or Crimescope, or even lasers. During the use of these light sources, the specialist must wear protective goggles fitted with filter lenses, which are adapted to the apparatus used. For examining traces in the infrared spectrum, an assembly consisting of a video camera and a screen, which are compatible with the infrared spectrum, is used (Ciopraga et. al., 2001, p. 46).

Papillary traces are sensitive to the action of dry air, heat and direct solar radiation, leading to their rapid disappearance. Consequently, in the case of outdoor crime scene investigation, it is crucial to give priority to the rapid detection of traces or to shielding these traces from sunlight. This can be done by using appropriate techniques and tools to highlight and fix papillary traces before they deteriorate or disappear. Protective measures can also be taken, such as covering the marks with light-opaque materials or using umbrellas to prevent direct sun exposure. All these precautions are aimed at preserving and keeping the papillary traces as intact as possible for further investigation and analysis (Anghelescu et. al., 1976, p. 132).

The first activity for the discovery of handprints on detected objects consists of examining them under different angles of observation in ordinary ambient light. Latent marks created by sweat deposition appear slightly translucent, and marks consisting of a substance of the same colour as the surface of the object bearing the mark have a different colour shade from the object. To facilitate the search for handprints, a beam of light, inclined at an angle of 45° to the surface of the object from the opposite direction, shall be used. At such an angle, the directed light reflects off the shiny surface and a dull spot appears where the fingerprint has been left as a result of the grease soaking the fingerprint and absorbing the light rays (Mircea, 1999, p. 67). Another method, which can be applied in other cases, is to search under the action of ultraviolet radiation, the trace will appear in a specific luminescence for a short time (Moise et. al., 2020, p. 74).

In the case of transparent objects (glass, bottles), it is advisable to examine them through transparency. Also, adjustable coloured lasers or lasers with a wide range of wavelengths, lasers that produce one or more beams in one part of the spectrum or high-power lamps that stop wavelengths can be used as light sources (Drăghici et. al., 2004, p. 107).

Some authors (Drăghici et. al., 2009, p. 117) recommend the use of the Polilight PL500 UV-Vis-IR device for latent trace research. The Polilight®PL500 is a forensic instrument that offers particularly high optical power compared to other light sources currently available. This 500 W xenon lamp has a typical lifetime of 3000 hours and a minimum lifetime of at least 1000 hours. Filters are automatically selected by simply pressing a single button on the front of the instrument and the selected band is displayed on a digital screen, along with the filter range and output power setting. In addition, the Polilight®PL500 is housed in a corner-protected aluminium case to provide shock protection, and for easy transportation, it comes with a reinforced carrying case. The instrument features

12 bands in the UV/Visible range, with an IR option available. In addition, the power supply has been redesigned to accept any AC input voltage between 85 and 265V and at any frequency between 50-60Hz.

Among the technologies used in trace investigation is the use of lasers. For this purpose, a specific argon laser radiation is used which is projected laterally obliquely under a 45 degree angle. This causes a specific fluorescence of certain substances secreted by the sebaceous glands, known as riboflavin. If necessary, the fluorescence can be enhanced by treatment with ninhydrin. It is important to note that this method is non-destructive, as low power laser radiation is used, so it can be repeated several times. This method was developed by Canadian specialists and has made it possible to reveal latent traces up to 9 years old on the pages of a book. Now an American company, CRIMESCOPE, has developed a portable laser machine used to detect latent traces, not only papillary traces, but also document forgeries (Drfãghici et. al., 2009, p. 132; Pareaux et. al., 1982, pp. 16-17; Garcia, 1984, pp. 83-94).

Light scattering is a scientific method used in dactyloscopy to detect and document papillary traces. It is based on optical principles and uses light beams and electronic filters to obtain clear images of the marks. This method is non-invasive and does not damage the papillary traces, allowing them to be accurately fixed and recorded through photographs or videomagnetic recordings. The use of the light scatter method in dactyloscopy has been studied and developed in scientific research to increase the efficiency and accuracy of the papillary trace identification process. By applying scientific principles and advanced technology, this method contributes to accurate and reliable results in the analysis and interpretation of papillary marks (Drăghici et. al., 2018, p. 199).

Microparticle suspension. The microparticle suspension method is a quick and simple procedure that can provide satisfactory results, especially for fresh traces. However, the effectiveness of this method decreases for old traces. The solution is a suspension of molybdenum disulphide in a detergent solution which adheres to the grease components of latent traces, forming a grey layer. It is recommended for non-porous surfaces such as leather substitutes, plastic bags, glazed or laminated papers and expanded polystyrene. The suspension can be sprayed onto all non-porous surfaces, even wet ones, but is not recommended for paper (Pășescu et. al., 1996, p. 165).

Relief with gentian violet. The gentian violet spotting process is an effective way to highlight papillary marks on adhesive-coated protective tapes and films, which are used in industry and medical fields. The process involves dipping the adhesive tape into a pot of working solution, with the adhesive surface towards the solution, or applying the solution with a pipette to the adhesive surface. After two minutes of treatment, excess dye on the adhesive tape is removed with a water jet, then photographed with an orange light filter. It is important to note that this procedure is more effective for fresh papillary marks than for old ones (Pășescu et. al., 1996, p. 166).

D.F.O. (1.8 dialysate – 9 fluorenone). The D.F.O. (1.8 dialysate – 9 fluorenone) procedure is effective in revealing papillary traces. D.F.O. is an amino acid reagent that produces a red colour of the treated papillary traces. It has the additional advantage of being photoluminescent at room temperature, without the need for secondary treatment and in a very short time, between 10 and 15 minutes. The procedure is simple and quick, consisting of rapidly immersing the standard in a D.F.O. solution, drying and then further treatment before being heated to 100°C for about 10 minutes. The fingerprints thus revealed are visible in daylight or in photoluminescence at 530 nm excitation. The only disadvantage of D.F.O. is its weak colouring, hardly visible in daylight, which requires the use of a filter lamp and photoluminescence detection work (Drăghici et. al., 2009, p. 133).

2.11 Handprint Detection by Physical (Mechanical) Methods

Trace development by physical methods involves spraying very fine-grained powders or dusts, also known as dusting or powdering, onto objects or surfaces bearing traces (Stancu, 2015, p. 125).

Dusting (powdering) of the object bearing the latent trace consists of applying and spreading on the surface of the object on which the papillary trace has remained a small quantity of powder used for detection and which has the property of adhering to the papillary ridges existing on the surface of the object, thus colouring them and making them visible, with the aim of using a powder of a contrasting colour to that of the object on which the handprint has remained (Drăghici et. al., 2009, p. 120). The development of papillary marks on multi-coloured surfaces is a scientific method used in dactyloscopy involving the use of fluorescent substances. These substances include yellow fluorescent powder, which becomes visible under ultraviolet radiation. These substances are used to highlight and emphasise papillary traces, making them easier to identify and analyse. However, it is important to note that fluorescent developers cannot be used on surfaces such as unfinished wood or paper. This is because these surfaces absorb or scatter ultraviolet radiation, making fluorescents ineffective in highlighting papillary traces (Moise et. al., 2020, p. 75; Buta et. al., 1969, p. 50).

The author, Dorash S., also mentions some of the powders most commonly used in the detection of handprints on the spot, such as:

- aluminium powder (silver) of a shiny white colour, with a high power of attachment to sweat marks. It is successfully used to highlight latent traces on glass, furniture, plastic table;
- zinc oxide, also white in colour, with increased adhesion. It is used to highlight latent marks on coloured glass objects, dark coloured plastic tableware, rubber, leather;
- wax, a white powder used to highlight latent marks on dark coloured furniture objects, plastic tableware;
- graphite, a black powder, which is effective in highlighting latent marks on paper;
- copper oxide, a dark brown powder, which can be used to highlight latent marks on virtually any surface;
- bronze, a powder used to highlight latent marks on nickel-plated objects, porcelain surfaces, ceramics, etc. (Doraș, 2011, pp. 138-140).

Other authors (Drăghici et. al., 2018, pp. 193-194; Stancu, 2015, p. 126) also mention other powders which are used to reveal handprints, such as:

- Sudan red III, which is a coloured earth based on iron oxides, is used both as a powder and especially in a diluted alcohol solution to highlight latent traces formed on porcelain objects, glass, paper, plastic materials, etc.;
- bronze gives different colours depending on the metals with which the copper alloy was formed. It is used for highlighting latent traces on very shiny surfaces, such as nickel-plated objects, etc.;
- antimony black is used for highlighting traces on glass, porcelain and plastic objects. It gives good results when mixed with wax;
- titanium white, which retains wax-like properties;
- green chromium oxide, recommended for highlighting marks on earthenware, ceramics, paper, vellum, as well as on chromium-plated or nickel-plated objects;
- yellow mercury oxide, mini-lead, zinc oxide, cobalt oxide, etc. iodine powder mixed with starch powder (1:10) gives very clear traces on various surfaces, but the traces do not last very long and must be photographed or covered with cellophane;
- xerox dust. This is a very fine, black powder and is used to reveal marks on earthenware, plastics, paper, etc. (Drăghici et. al., 2009, pp. 124-126);

– Scarlach red, used like the previous one, but the results are less reliable. Antimony and English red (a mixture of phyllo oxide and clay) are particularly recommended (Cîrjan, 2005, p. 211).

Today, we are seeing an increase in the diversity of products used to reveal latent traces. Companies specialising in the production of forensic equipment are launching new products on the market, based on the same substances as before, but including other substances (such as cyanoacrylate or molybdenum disulphate microparticles).

Dustiing can be applied by one of the following methods:

By tweezing, a method used for large objects that are horizontal or for small objects that can be handled and brought into this position. The powder sprinkled over the trace is spread with the brush in a circular motion, which is also the direction of the papillary ridges on the drawing. Excess powder is removed from the ridges with the brush, each brush being used only for powders of the same colour and cleaned after each use, without touching the hair with the hand and without touching objects with greasy surfaces, thus avoiding smearing (Drăghici, 2003, p. 135; Drăghici et. al., 2009, pp. 120-121).

The fresh marks left on the paper can in some cases be removed by dusting, but without using a brush. Normally, the use of a brush is avoided in these situations unless magnetic powder is used. In the case of other types of powders, use tweezers to carefully grip the edge of the paper, avoiding the creation of new marks, and move in such a way that the powder, which has been sprinkled on top, is evenly distributed over the entire surface of the paper. This method requires careful handling of the paper to avoid further damage or contamination of the papillary traces. The aim is to ensure an even application of powder and to highlight papillary marks without creating new marks or disturbing existing detail (Anghelescu et. al., 1976, p. 134; Pășescu et. al., 1996, p. 157; Drăghici et. al., 2018, p. 191).

In the case of objects such as rubber, wood, leather or walls, the ordinary dactyloscopic brush cannot be used as it colours both the background and the traces, making them indistinguishable. In such cases, magnetic brushes are used. The magnetic brush consists of a cylindrical magnet attached to a handle. The magnet is coated with a fine powder of hydrogen-reduced iron. The powder accumulates around the pole of the magnet in accordance with the magnetic lines of force. When applied to the surface with papillary traces, the powder will stick only to the ridges of the traces, leaving the background clean most of the time. It is important to note that the magnetic brush cannot be used to reveal traces on greasy surfaces or ferromagnetic objects such as iron, steel or cast iron (Anghelescu et. al., 1976, p. 136; Constantin et. al., 1975, p. 166).

Also, in the case of fires where flammable substances have been used, or in the case of theft of car parts or food, where traces remain on greasy or oily surfaces, they cannot be detected with the brush as they become soaked. In such cases, lead chloride is recommended for the detection of greasy surfaces, especially on car parts, bakelite and plastic objects, oil or petrol bottles and cans, leather objects and clothes with greasy surfaces, etc. (Anghelescu et. al., 1976, p. 136; Perjoiu, 1974).

Spraying is carried out using special devices or sprays and is applied to vertically positioned objects that cannot be turned horizontally. (furniture, shop windows, glass, window frames, doors, etc.). Excess powder after spraying is removed with a finger brush (Drăghici et. al., 2018, p. 114).

Smoking consists of obtaining soot by burning quantities of camphor or polystyrene, or even by burning a candle made from petroleum products. The object is passed with the portion on which the traces of the smoke resulting from the burning are supposed to be present, and the soot thus adheres to the place reached by the papillary ridges. Removing the excess soot with the brush, the black coloured trace appears. The method is used to investigate chrome or nickel-plated surfaces (Ciopraga et. al., p. 45).

A modern process for revealing latent traces, especially on paper, is metalizing in a vacuum chamber. This process involves evaporation of a gold-cadmium mixture, whereby the vapour selectively attaches to papillary ridges and grooves, giving very good results even on rough surfaces such as bricks. However, this process is laborious and relatively expensive. A mixture of zinc, antimony and copper is used for ordinary surfaces, including paper. This mixture allows efficient detection of papillary traces (Stancu, 2015, p. 126; Theys, et. al., 1978, p. 106).

Another method for revealing hand, lip, glove and footwear marks on plastics or textiles (carpets, doormats) uses a medium frequency electric field device (Coman, 1975, p. 68; Stancu, 2004, p. 113).

One of the methods used to detect latent handprints is the use of radioactive isotopes. This technique was developed by Japanese researchers, who adopted a system of marking proteins in sweat and then performed autoradiography to reveal these traces. In the process of protein labelling, the radioactive isotope carbon-14 was used, which was introduced as a formic aldehyde or stearic acid solution in a solvent such as benzene. Objects containing traces were marked in a special facility and then washed and dried. For autoradiography, objects marked with latent traces were placed in a photographic darkroom, in close contact with the photographic emulsion of a Roentgen film, for 24 to 48 hours, depending on the age of the trace. The proteins in the sweat, which retain the carbon-14 label, emit beta radiation, which impregnates the photographic emulsion and thus reproduces the structure of the papillary pattern. The radioactive isotope method is effective in revealing latent traces on textiles and in cases where other methods cannot be applied. However, it should be noted that this method becomes expensive and difficult to use in detecting latent traces on other types of objects (Suciu, 1972, pp. 221-222).

2.12 Handprint Detection Using Chemical Methods

Many chemical survey techniques are known, used less in the field and more frequently in the laboratory due to the complexity of their use.

The simplest techniques involve steaming with iodine, hydrofluoric acid or cyanoacrylate vapour. The choice of one or other of these techniques depends on the surface being investigated and the age of the trace (Ciopraga et. al., 2001, p. 45).

Depending on their characteristics, these methods can be structured as follows:

Iodine vapour highlighting. The iodine vapour method is a commonly used method to detect papillary marks on porous surfaces such as wood, cardboard or paper. This process involves the use of an iodine vaporiser, which generates vapour by heating metal iodine wires in a glass retort in combination with a stream of air mixed with rubber paraffin. The interaction between the iodine vapour and the organic substances on the skin surface results in the appearance of a copper-coloured staining, thus highlighting the papillary marks. It is important to note that the visualisation of the traces revealed by this method is of short duration, requiring rapid fixation by means of a camera. However, it is important to consider that the use of iodine vapour may present certain health risks and therefore it is essential to use appropriate protective equipment to minimise exposure to harmful substances (Buruianova et. al., 2020, p. 69; Badia, 2017, p. 57).

Iodine vapour is usually applied by one of the following methods: one method consists of spreading iodine vapour on the tracer surface using a sprayer consisting of a glass tube. At one end, the tube is open like a funnel, and at the other end a rubber vane is attached for pumping air. Inside the tube are iodine crystals, placed between two glass wool stoppers which allow air to filter out and prevent the crystals from escaping. In the process of pumping air, the tube is held in the hand by the area where the iodine is located; under the action of the heat of the hand, the iodine evaporates and the pumped air removes the vapour thus created through the funnel. Another process consists of condensing the iodine vapour on a glass plate, which is then applied to the surface of the tracer object. For this purpose, a porcelain capsule, half filled with sand, is heated with a spirit lamp and a few iodine crystals are placed in it. When the iodine begins to evaporate, the glass plate is held 25 to 30 cm above the capsule until a suitable condensation of vapour is obtained, after which it is immediately applied to the object in question. Regardless of the method applied, immediately after highlighting, the print must be fixed by photography and adhesive film, otherwise it disappears due to evaporation of the iodine (Mircea, 1999, p. 69).

Highlighting with chemical reagents. This method is used to highlight older traces (other methods are contraindicated). This method is possible because of the colour reactions between the substances contained in the trace and the chemical substance used. The treatment of trace objects varies according to their nature (paper, metal, glass, celluloid, etc.) (Drăghici et. al., 2009, p. 127).

Highlighting with hydrofluoric acid vapour. The procedure is applied exclusively to papillary marks on glass surfaces and is based on the corrosive properties of hydrofluoric acid on this material. In areas where fingerprint ridges are present, which are mainly composed of fat, the glass is protected and does not react with hydrofluoric acid, while the spaces between the ridges are susceptible to corrosion, resulting in a matte texture on the glass surface. The steaming procedure can be performed by positioning the portion of glass with the papillary imprint over a plastic container containing concentrated hydrofluoric acid so that the vapour interacts with the glass. The time required to fix the papillary impression is a maximum of 5 minutes. After this step, the bottle is rinsed generously with water and then dried with filter paper or a cloth (Anghelescu et. al., 1976, p. 137; Drăghici et. al., 2018, pp. 195-196).

Highlighting with cyanoacrylate vapour. The detection of latent (invisible) traces using cyanoacrylate vapour has proven to be an effective tool for professional investigators and the quality of the results has made it well known (Pleșca, 2005, pp. 3-6; Drăghici et. al., 2009, p. 129).

The method of steaming with cyanoacrylate vapours is based on their property of polymerising in contact with the sweat substance. The use of cyanoacrylate vapour is extremely effective in revealing papillary marks on various surfaces such as polyethylene film, cellophane, metals and alloys, plastic, thick glossy cardboard, coloured or white paper, indigo paper and artificial leather. Cyanoacrylate is available in liquid form and packaged in bottles of various volumes. For evaporation, glass containers are usually fitted with evaporation equipment, in which a vat of cyanoacrylate solution and the objects suspected of bearing traces are placed. The heating apparatus also contains an object to reveal the test sample and a vat of hot water to moisten the air. The trace detection process using this method generally takes 10-12 hours. The vaporisation plant is opened only after the control trace has been revealed. The papillary traces revealed are white in colour. It is essential that they are photographed as quickly as possible to avoid damage. Due to the harmful nature of cyanoacrylates, the detection of papillary traces is carried out in closed installations. The cyanoacrylate spray detection method is also very successful in treating very small objects such as shards, tubes or iron fragments and bullets (Buruianova et. al., 2020, p. 70; Selezneov et. al., 2014, p. 233).

Highlighting with ninhydrin-based reagent. Ninhydrin-based reagent is usually used to reveal handprints on paper. Ninhydrin reacts with amino acids in sweat, colouring the marks purple red. For the detection, a solution of 100 ml acetone and 0.8 g ninhydrin is prepared (the solution is allowed to homogenise for 24 hours) and applied to the trace object using a cotton swab. The object may also be immersed in the solution and then left to dry at room temperature or in front of a 100 W light bulb. The time taken to reveal the marks depends on the age of the marks (1-2 hours or 3 days or more for old marks). The procedure is used in particular to reveal papillary marks on porous paper, to which it is not possible to apply physical methods of revealing (Drăghici et. al., 2018, p. 196; Ionescu, 2008, p. 117).

Highlighting with Sudan Red III solution. This method is applied to greasy marks. The reagent consists of 2% Sudan Red III in alcohol. The solution is poured over the trace object. After a few minutes, when it is almost dry, the spot is washed with water to remove the excess reagent. After another few minutes the latent stain appears brown, but does not last long. It is necessary to photograph it (Suciu, 1972, pp. 220-221).

Highlighting with silver nitrate solution. The silver nitrate method is used to reveal papillary marks on paper, cardboard and unpainted wood. A silver nitrate solution is used to reveal latent traces. This solution is prepared by mixing 10 g of silver nitrate with 500 ml of methanol in a clean glass beaker, and can then be stored in opaque 500 ml screw-neck bottles in a dark environment. The surface of the object can be treated by spraying, dipping in the solution or applying evenly with a brush or soaked cotton swab. After applying the reagent to the substrate, the object should be allowed to dry completely and then exposed to a strong source of artificial light or sunlight. Silver nitrate reacts with salts in the secretion of perspiration to form silver chloride which, under the action of light, causes the trace to turn black. The detection of papillary traces must be followed by their rapid photographing to ensure the preservation of the information (Buruianova et. al., 2020, pp. 69-70; Pășescu et. al., 1996, p. 136).

Another reagent used by specialist bodies is the solution known as DEMAC, which is sensitive to urea present in sweat. There is a particular case with regard to handprints formed by the deposition of blood, where their detection is carried out using specific methods for the detection of bloodstains. These methods may involve the use of solutions that produce a specific fluorescence or leuco green malachite solution, which is used especially for bloodstains such as luminol (Stancu, 2015, p. 127; Pășescu et. al., 1996, p. 162).

A reagent consisting of silver nitrate and Rhodamine B in solution is also used to prepare forensic traps (Cîrjan, 2005, p. 212).

Highlighting handprints on human skin. Discovering and highlighting handprints on human skin, which was considered unimaginable a few years ago, is now possible thanks to chemical reactions that have achieved the best results. Although attempts have been made with Roentgen or iodine radiation, they have not produced equally satisfactory results. The current method is successfully applied and can be used without hesitation by law enforcement agencies to discover handprints on the skin. Japanese specialists have achieved a particular success by highlighting and lifting a fingerprint from the neck of a strangled person, even nine hours after the time of death. This demonstrates the effectiveness of the method under difficult conditions and can serve as valuable evidence in forensic investigations (Stancu, 2001, pp. 131-132; Anghelescu et. al., 1978, p. 33; Colectiv, 1985, p. 36).

2.13 Fixing and Removing Handprints from the Crime Scene

Fixing and lifting handprints usually takes place after the latent marks have been revealed. The methods and means of fixation are multiple. Their choice depends on whether the marks in question are deep or shallow, then on the nature of the object being carried and its size, as well as its age (Mircea, 1996, p. 77; Mircea, 1999, p. 70).

The main way of keeping track is by means of the transcript. Recording involves a detailed, precise and exhaustive recording of the tracks and the methods used to record them, as well as a precise description of where they were found and their relationship to the main objects. Explicit mention is also made of photographs taken, transferring the traces to adhesive film or by making casts, including picking up objects bearing handprints, such as glasses, pots, ashtrays and other relevant objects. The minutes serve as the primary document to ensure a rigorous record of all relevant details relating to the footprints, including the techniques used to highlight and preserve them. By providing a detailed description of the traces and the procedures used, the minutes ensure the integrity of the information and prevent any errors or omissions that may occur. Minutes are therefore an essential means of documentation in forensic investigations (Stancu, 2015, p. 128; Lambert, 1979, pp. 47-48).

From a forensic-technical point of view, handprints are fixed by photography. The traces left at the scene are photographed firstly to highlight the general environment of the crime scene, the place and the objects where the traces were found (a place which has previously been marked by one of the known methods) and secondly to illustrate the construction features of the papillary drawing (a detail photograph is taken). By doing so, the description given in the on-the-spot investigation report will necessarily be matched by the photographs taken, thus certifying that the trace was taken from that place and not from elsewhere. In principle, a photograph is taken of the group of fingerprints or of the entire palm, after which the fingerprints or the entire palm are photographed, and then the most valuable details for identification are photographed (Drăghici et. al., 2004, p. 111; Drăghici et. al., 2009, p. 135).

In order to take detailed photographs of the handprints, the camera lens is fixed perpendicular to the trace and at a distance of 5-10 cm. In order to obtain a clear image at such a short distance, the focal length is increased by inserting intermediate rings or flexible bellows between the lens and the camera darkroom. These traces are illuminated from behind the camera or from two sides, with light sources of the same intensity, at an angle of incidence of 65-90°. If the objects bearing the marks are shiny, such as glass, earthenware, porcelain, enamelled dishes, polished furniture, steps will be taken to prevent reflection of the light rays. To this end, the objects in question will be illuminated at an acute angle from two sides by means of lamps equipped with frosted bulbs (Mircea, 1999, pp. 70-71).

Particular situations for photographing handprints arise when they are on both sides of transparent objects or on mirrors. If they are on both sides of transparent objects, it is necessary to highlight the marks on one side with white powder and those on the opposite side with black powder. Traces highlighted with white powder are photographed after a black screen has been placed behind them, and those highlighted with black powder can be photographed after a white screen has been placed behind them. Handprints on mirrors are photographed after a black screen has been placed in front of the camera so that only the rear-facing lens is not covered. This avoids reflection in the mirror and printing on the film of the objects in front of it (Mircea, 1999, p. 71; Stancu, 1981, pp. 159-160; Stancu, 1994, p. 195).

The procedures for fixing the traces also include the drawing up of sketches and drawings made on the spot, which, like the photographs, are attached to the report. They serve to establish the place where they were found, their general shape and their relationship to other objects, and cannot be used in the process of identifying persons (Gheorghiță, 2017, p. 195).

The final stage of the forensic investigation of handprints at the scene is the lifting process. The specialist will use the appropriate methods depending on the nature of the trace object and the specific conditions of the crime scene. These methods include photography, transfer to adhesive film and the use of casts in the case of deep tracks. Where trace objects are small in size, they will be lifted for further analysis and investigation (Ciopraga et. al., 2001, p. 46; Pășescu et. al., 1996, p. 178).

Photography is the main method of survey, which is applied whenever site conditions permit. When the photographic survey is not possible due to the pronounced concavity or convexity of the trace objects or due to restricted space, reflection phenomena, etc., other survey methods shall be applied (Drăghici, 2003, p.141; Drăghici, et. al., 2009, p. 136.).

Transfer to adhesive film will be carried out after photographing the print; the adhesive film may be transparent, white or black, the choice of which depends on the colour of the print. A layer of gelatinous substance is applied to the film, which is intended to detach the print with all its details by direct contact with the object bearing the print. For lifting, the protective coating of the gelatin layer is peeled off the backing of the gelatinous substance. Traces on the adhesive film are photographed after the protective film has been removed, and copying from negative to positive is done by placing the emulsion clip towards the light source of the enlarger or copier, since the traces on the adhesive film and photographed are the reverse of those photographed directly from the receiving object (Cîrjan, 2005, p. 214; Boboş, 1981, p. 153).

Films (folio) specially prepared for the detachment and transplantation of prints are based on glycerol nitrocellulose and may be black or yellowish transparent. In certain cases, in the absence of special adhesive films, photographic films with a gelatin layer which retains the print in good condition may be used. In order to obtain colour contrast with the substance used in the development, the photosensitive material is either developed unexposed to produce a transparent film or exposed to light after development of the film using a black background (Țurai, 1947, p. 188-190; Stancu, 2001, p. 134).

Fixing of depth marks by moulding. This method is used when depth marks created in materials of some plasticity (butter, soft chocolate, fresh putty, plasticine, flour, dust) are found on the spot. Plaster, paraffin, wax, latex or various polymers are used as materials for these marks. The substances and processes used differ, depending on whether the materials in which the depth marks have been formed melt easily at a higher temperature or resist well. For materials that melt easily, dental plaster is the most commonly used, while in other cases a mixture of 75% wax and 25% zincwais (zinc white) is used (Drăghici et. al., 2009, p. 136).

Before casting, the depth trace is prepared for this fixation. When it is in powdery substances, it is first treated with a solution of serac, which is sprayed from a distance of at least 25 cm, so as not to destroy its details, in order to make it more resistant to the action of the moulding paste. Then, in order to ensure that the moulding is thick enough to give it the necessary strength, a plastic substance is applied all round the moulding. After this operation, a basin is made next to the trace, in a higher position, which communicates with the trace via a channel. The moulding paste, of perceptible fluidity, in order to mould well the details of the trace, is poured into the basin, from which it drains gently into the trace (Mircea, 1999, p. 71; Swensson et. al., 1957, p. 57).

As for depth marks on soft and consistent plastic objects, such as clay, putty, plasticine or wax, they can be reproduced with better results by using a powder called alginate. The moulding paste is prepared by mixing one part alginate with three parts cold water (between 16-20° C). These are mixed in a rubber capsule for one minute and then applied immediately afterwards, with setting taking place after a few minutes (Pășescu et. al., 1996, p. 178).

The lifting of objects bearing handprints is subject to the general rules for lifting offending objects. The only condition to be taken into account is that the removal of these objects requires provisions to ensure that the traces are in good condition (Gheorghiță, 2017, p. 196).

Hard objects (glass, metal, wood, ceramics, plastics, etc.) are handled with gloved hands or a handkerchief; flexible objects (documents, cellophane and various other films) are held by tweezers, while handling, objects with traces are held by the parts on which relatively few traces remain. Hand-carried items are packed in hard materials (veneer, plank, pressed cardboard, etc.) so that the hand-carried surfaces do not come into contact with other items and the walls of the packaging (Doraș, 2011, p. 142). Similarly, the given objects can be placed in a container, polymer glass with a volume of 1.5L, 2L, 5L, which is preliminarily cut in half and after placing the object is coupled and fixed with adhesive film.

The seal is applied to the packaging in which the traceable objects were placed, and the assistant witnesses participating in the crime scene investigation are asked to sign. In this way the authenticity of the traces and the place from which they were taken is once again certified (Drăghici et. al., 2009, p. 136).

Strict requirements must be met when packing and transporting trace objects to prevent the destruction or alteration of the trace taken (Gheorghiță, 2017, p. 196).

Authors Cîrjan L. and Chiper M., also define some specific rules for the transport of objects bearing handprints:

- the transport must be carried out in a way that does not cause destruction or degradation of the traces, does not interfere with the production process and does not present a public danger;
- the destruction of existing traces or the creation of new ones during the lifting process must be avoided;
- the object is lifted only after it has been previously marked and photographed;
- the object shall be lifted by gripping the edges or using tweezers;
- no cotton wool or cloth will be used to wrap the object;
- the object will be sealed with the seal of the judicial body to ensure its integrity and authenticity;
- a numbered label will be attached to the object, bearing information such as place, date and contents (Cîrjan et. al., 2009, p. 135).

2.14 Handprint Expertise

The identification of the person based on the general and individual characteristics of the hand as a creative object, reflected in the traces found on the human body – is possible if several basic requirements are met, which refer to: the good reproduction of the morphological characteristics of the traces, the presence of elements capable of identifying the creative object of traces, the possible presence of biological products from the perpetrator.

The basis for identification in this type of expertise lies in the ability of living tissue to react to external stimuli and to retain, for a certain period of time, signs of external morphological changes triggered by defensive reactions. Reactive changes are present only in the living person and become evident if the intensity of external stimuli exceeds the body's ability to counteract them (Anghelescu et. al., 1978, p. 25).

Fingerprint forensics is the final phase of the process of investigating aspects of handprint formation at the scene of the incident, with the aim of obtaining information about the object that created the print and establishing the relationship between the print and the criminal activity. This stage marks the completion of a process that extends from the discovery of the handprints to the identification of the perpetrator (Stancu, 1981, p. 162). Fingerprint forensics has the ability to solve various problems in the field of crime investigation and personal identification such as:

– revealing latent papillary traces on various objects;
– identifying the person who left the incriminating papillary traces;
– identifying persons and corpses of unknown identity in anthropological records;
– identifying persons who have given a false identity;
– verifying finger signatures of illiterate persons (Popa et. al., 2008, p. 66).

In the processing and examination of papillary urns in the laboratory, two categories of specialists are involved, with their own specific skills and duties. Those who intervene at the time of the on-the-spot investigation to make initial findings are forensic officers, police officers specialised in the investigation of papillary traces. Their intervention is required to remove the danger of degradation or disappearance of the traces. The findings they make on the spot constitute the basis for detailed examinations, which will continue in the laboratory, where the appropriate technical means are available. Forensic experts may also be involved in the course of on-the-spot investigations, depending on the specific features and degree of difficulty of the facts. However, their work is mainly carried out in the laboratory, in order to examine trace objects taken from the crime scene, traces of papillary drawings taken by the technicians or fingerprints submitted by the prosecution, which constitute models for comparison (Ciopraga et. al., 2001, p. 47).

In order to be able to proceed with fingerprint analysis, the judicial body must be in possession of the traces taken from the scene and of comparison models (fingerprints) taken from the suspects, which it must make available to the forensic expert. Comparison patterns are obtained by fingerprinting suspects, which may be done before the suspect commits a crime or after the crime under investigation is discovered (Cătuna, 2008, p. 31).

In order to carry out the comparative examination, the expert must have the impressions of the suspects, of other persons who entered the crime scene, sometimes even of the persons who carried out the search and who inadvertently or negligently created traces at the scene (Moise et. al., 2020, p. 78).

When the expert is presented with only the trace (possibly together with the trace object) from the scene, he or she is able to determine, among other things, the following information:

- the origin of the hand: The expert can determine whether the trace came from the right or left hand based on the specific characteristics of the papillary line and the relative position of the fingers;
- the region of the hand and the finger that formed the trace: Through detailed analysis of the trace, the expert can identify the region of the hand (such as the palm, fingers or wrist) and determine the specific finger that created the trace;
- the type or variety of papillary pattern: The expert can identify the type of papillary design present in the trace, such as a bow, loop or swirl, and determine its specific variety;
- how the trace was formed: The expert can assess how the trace was formed based on the characteristics and pressure pattern, determining whether it was a direct press, slip or strike, for example;
- nature of substance on papillary ridges: By analysing the appearance and properties of the substance present on the papillary ridges, the expert can provide information about its chemical composition or nature at the time of contact with the trace-receiving object;
- age of the trace and identifying features: Using specific methods and techniques, the expert can estimate the age of the trace and determine

whether it contains sufficient identifying elements, such as distinctive papillary line details, cracks or other unique features (Stancu, 2015, p. 131; Anghelescu et. al., 1978, p. 36).

If the expert is also presented with fingerprints from the suspect or from the fingerprint library, he or she can determine by comparison whether the print and the impression originate from the same finger and therefore from the same person (Stancu, 2001, p. 137). In the literature, the term ,,print" has been used to distinguish between a print made in the course of criminal activity and a ,,print" obtained experimentally for the purpose of comparative examination, in this case called an impression. The terms trace and impression express essentially the same thing, i.e. the reflection of the papillary pattern with its most characteristic features (Moise et. al., 2020, p. 78).

The laboratory investigation of handprints presupposes the existence of comparison traces. Traces taken from the scene, or from the carrier objects brought to the laboratory for detection and examination, will be compared with patterns obtained from suspected persons or corpses (Ciopraga et. al., 2001, pp. 48-49).

In order to check whether a person is registered in a fingerprint database as the perpetrator of a crime for which he/she has been convicted, or in the case of a fingerprint examination to identify the person who left the fingerprints at the scene, as well as in any other situation where fingerprint identification is carried out, it is necessary to collect fingerprints, palm prints or footprints from persons involved in these activities. The process used to obtain these papillary prints is known as dactyloscopic fingerprinting (Constantin et. al., 1975, p. 134).

The process of fingerprinting persons or corpses must be carried out in a way that ensures that clear and accurate papillary impressions are obtained, reproducing in full the relevant papillary design or region in each specific case. In the field of dactyloscopy, these papillary impressions are witness evidence and, depending on their quality, directly influence the speed and efficiency of the identification process. Therefore, it is necessary that fingerprinting is carried out with great care and precision in order to obtain accurate and reliable results in the analysis and comparison of papillary prints (Drăghici et. al., 2009, p. 139).

The situations in which fingerprints, palm prints and comparison plantar prints are required to be taken are as follows:

– in the case of a criminal investigation, suspects will be fingerprinted to compare their impressions with the prints taken from the scene. This also applies to persons included in the circle of suspects identified during the investigation;

- for the comparison of fingerprints of victims and other persons who had access to the crime area, in order to eliminate their fingerprints from the group of papillary prints taken from the crime scene;
- when a body of unknown identity is discovered, its fingerprints will be taken for identification purposes and for comparison with the papillary traces taken from the crime scene and left by unknown perpetrators;
- when a person of unknown identity is discovered, a similar procedure will be followed, taking his/her fingerprints to facilitate identification and comparison with other papillary traces taken from crime scenes or other incidents (Pășescu et. al., 1996, p. 186).

Taking papillary fingerprints is not a complicated operation, but it does require a certain level of familiarity and appropriate technique. The process involves rolling the curved, soft surface of the finger pulp over a flat, hard surface such as a fingerprint sheet. This operation is extremely important as it is essential to obtain quality prints, both in terms of uniformity and clarity, to facilitate subsequent examination and classification.

Depending on the materials used and the purpose of the impression, three types of impressions are made:

- typographic ink impressions;
- chemical impressions;
- special impressions to reveal the pores of the papillary ridges (Drăghici, 2003, p. 144).

The following tools and materials are used to obtain prints from persons and corpses:

- flat plate for spreading the ink: A flat plate measuring 12 x 30 cm, made of zinc, glass or plastic, is used for fingerprinting;
- curved plate or cylinder: A curved (convex) plate measuring 20 x 30 cm or a special cylinder will be used for palm printing;
- fingerprint table: A fingerprint table with a height of 110 cm will be used. In its absence, an ordinary table or board may be used on which to place the sheet of paper or card on which the fingerprints are printed;
- roller: A roller made of rubber or other material with similar properties will be used to apply the ink to the fingers to obtain the prints;

- bottle of printing ink: A special typing ink bottle is used to provide the ink required for fingerprinting;
- fingerprint sheets: Fingerprint sheets printed on plain paper or on special paper for chemical fingerprinting are used. These sheets are used for recording and classifying fingerprints;
- sieve: A sieve impregnated with special chemicals for fingerprinting is used;
- chemicals for poroscopic fingerprinting: Various chemicals are used to make the necessary recipes for the poroscopic fingerprinting process;
- special spoon: A special spoon adapted for this purpose is used for the fingerprinting of corpses;
- solutions and substances for the preservation of skin fragments: Special solutions and substances shall be used for the preservation of skin fragments with papillary ridges taken from corpses;
- thick needle syringe: A thick needle syringe shall be used for injecting fluids under the skin of the fingertips of corpses to be fingerprinted;
- bottle of gasoline: A vial of gasoline is used for cleaning and preparing surfaces prior to fingerprinting;
- soap, towel, nail brush: These are used for sanitizing and preparing hands for fingerprinting (Drăghici et. al., 2018, pp. 202-203).

Fingerprinting with typographic ink is a multi-step process. In order to obtain quality prints, clean hands are essential. Proper cleaning is achieved by washing with soap and water or detergents. If the papillary grooves are soiled by specific activities, such as certain trades, cleaning with a nail brush or neophalin is recommended. The etching procedure starts by applying a small amount of printing ink to a zinc or glass plate. The putty is spread evenly over half of one side of the plate using a rubber roller. Then the remaining putty on the roller is applied to the other half of the plate, which must be clean, ensuring even coverage of the plate surface. The person responsible for taking the fingerprints shall be positioned in front of and to the side of the person being fingerprinted, ensuring that he or she is on the opposite side of the hand being fingerprinted. During the procedure, each finger is grasped at the sides of the phalanx with one hand, and the other hand is used to grasp the finger at the joint between the phalanx and the phalangin. The finger is then rotated on the zinc plate, and at the same time gentle pressure is applied to the fingertip. While rotating the finger, a full motion is ensured so that the tuft is deposited on the entire papillary drawing of the phalanx.

After each finger has been rotated on the zinc plate, the impression of each finger is applied to the space indicated on the control impression sheet. The same procedure is followed, avoiding the return by twisting the finger, as this may result in the ridges of the papillary design being impressed twice, resulting in a blurred impression. In order to ensure a high quality of the print, specific dactyloscopy techniques and rules are carefully followed (Anghelescu et. al., 1976, p. 144).

Chemical fingerprinting is a less widely used method, but is gradually gaining popularity. This method offers advantages as it allows fingerprints to be taken without dirtying the hands of the person being fingerprinted. The kit used in chemical fingerprinting is originally designed for fingerprinting, but can be adapted for palm printing. The chemical fingerprinting kit consists of a metal box similar to a stamp inkwell. Inside is a special, denser felt impregnated with a colourless chemical. This chemical is chosen so that it reacts quickly and turns black when it comes into contact with the substance on the specially impregnated chemical impression paper (Anghelescu et. al., 1976, pp. 144-145).

The chemical fingerprinting procedure involves the following steps: the person's finger is rolled on the felt of the inkwell, then placed on the specially impregnated paper. By rolling the finger on the paper, the chemical on the felt and the chemical on the paper come into contact, resulting in visible papillary impressions in a very dark, almost black indigo shade, similar to the prints made by printing ink. These papillary impressions can only be made on free surfaces, such as specially impregnated paper sheets, and cannot be used to make standard fingerprint cards which are not impregnated. Chemical fingerprinting is mainly used to take fingerprints from crime victims for the purpose of fingerprint comparison for exclusion (Drăghici et. al., 2009, pp. 140-141).

Special fingerprinting for pore examination is a technique used when a comparative pore examination is desired and fingerprint cards and printing ink cannot be used, as they may clog the pore openings. In these cases, a suitable method is used as follows: A hot mixture is prepared which can be stored indefinitely. The mixture consists of: yellow wax (4g), Greek resin (16g) and sev (5g). The resulting mass is left to cool in a shallow flat glass or metal container. The finger (which has previously been washed and degreased with ether or xylol) is rolled onto a sheet of celluloid. The fingerprint is photographed in reflection. The finger can also be rolled in the mixture prepared above and on a very fine and dense paper. The fingerprints obtained are highlighted with cobalt oxide or antimony black. The following mixture is used for fixation: gum arabic (25 g), potassium alum (10 g), formalin 40% (5 g) and water (300 g). The paper with the prints should be kept under a bottle to keep it perfectly smooth until the prints are compared.

To examine the pore openings, fingerprints can be obtained for comparison by rolling the fingers or placing the palm directly on the surface of a bottle. This will create latent traces of the papillary patterns due to grease and sweat on the ridges. The prints become visible and perfectly suitable for comparison by reflection photography, just like the footprints.

It should be noted that there may be some differences between the actual shape of the papillary pattern and the impression obtained, due to the degree of finger pressure or different direction of rotation. Therefore, impressions for comparison should be taken several times, with different degrees of pressure and by rotating the finger separately in both directions (Anghelescu et. al., 1976, p. 145; Locard, 1939).

In terms of fingerprinting techniques from cadavers, there are significant differences from the process of fingerprinting living persons. These differences are the result of cadaver-specific factors such as rigor mortis, dehydration, waterlogging, putrefaction or mummification (Pășescu et. al., 1996, p. 191).

Corpse stiffness can affect joints and prevent fingers from twisting, making it difficult to fingerprint corpses. To overcome this problem, forced flexion and extension movements at the wrist and metacarpophalangeal joints can be used. In situations where the flexion and extension method is not effective, it is recommended to immerse the cadaver's hands and forearms in a tub of warm water for 10-15 minutes in order to remove cadaveric stiffness. Once the stiffness has been removed, fingerprints can be taken using the same materials as for living persons. In this case, instead of rolling the fingers on a plate, the required layer of ink is applied with a roller to the fingers. Before applying the ink, it is necessary to wipe the corpse's fingers with a cotton swab soaked in benzine. Rectangular cards of a suitable size can then be used to apply the fingerprints of each finger. These fingerprint cards can then be stuck to the fingerprint spaces on the fingerprint card. To simplify the operation, instead of individual fingerprint cards for each finger, cardboard strips cut from the dactyloscopic fingerprint card can be used, on which the spaces for the fingerprints of the right and left fingers are marked. After obtaining the papillary prints, the strips are glued to a master ten fingerprint card, ensuring the correct order of the fingers (Anghelescu et. al., 1976, p. 146).

Dehydration and waterlogging can often damage the thick subcutaneous cell layer of the finger pulp, producing creases and depressions that prevent fingerprints from being taken. In such cases, it is possible to inject a liquid under the skin of the fingertips using a syringe with a long, thick needle. Liquids used may include warm water, liquid petroleum jelly, glycerine, alcohol, paraffin oil or even a mixture of gelatin and glycerine. This procedure aims to remove creases and prepare the skin for the impression. The impression should be made immediately after the injection of the liquid so that it can flow out of the pores or through the hole through which it was introduced. A similar phenomenon of reverse dehydration can occur in corpses that have been in water and have not yet rotted. The skin soaks up water, expands and forms creases and wrinkles. In these situations, there is a method known as the Schifferdeckom method, which can be used for imprinting without overcoming the stiffness of the corpse or introducing paraffin into the subcutaneous layer. For this method, carbon black, a brush and two sets of rectangular foils are used, each set having 5 coloured foils on one side: black for the thumb, red for the index finger, blue for the middle finger, yellow for the ring finger and green for the little finger. The foils should be thin, sticky and have the side where the fingerprints are applied white. For fingerprinting, apply carbon black to the fingers of the corpse with a fine marabou fluff brush. After applying the carbon black, take the corresponding foil from each finger and apply it firmly to the finger so that all the characteristics of the print are obtained. Then the foils are applied to the fingerprint sheet for recording and comparison. These special fingerprinting methods, such as dehydration and water-soaking or the Schifferdeckom method, are used in specific situations where fingerprinting with traditional methods is not feasible or efficient (Anghelescu et. al., 1976, pp. 146-147; Baranek, 1962).

Corpse decay can present significant difficulties in the fingerprinting process, often requiring operations that can only be performed by forensic scientists. In some cases, the skin on the inside of the corpse's fingers swells and peels off, forming blisters. These portions can be removed by incisions around the nails and sides of the phalanges. However, the resulting skin is extremely fragile and can break at the slightest pull. To strengthen and preserve it, it is advisable to place it in a container of alcohol mixed with glycerine. Sometimes the rotting process can flatten the papillary ridges or cause their protrusions on the outer surface of the fingers to disappear. In such cases, it is preferable to study skin fragments on their inner surface, where the ridges are better preserved. As these skin fragments cannot be stained with printing ink because of their fragility, the only option for highlighting them is photography. For photography, the fragments are gently stretched, outer side down, on boards made of linden, fir, cork, etc., and secured at the edges with grommet pins. By side lighting, the grooves on the inner face appear in black contrast, corresponding to the ridges on the outer face, and can thus be photographed. In the case of corpses found in the water and which have begun the process of putrefaction, the dead man's glove is used for fingerprinting. It is filled with cotton wool or wax and then the fingerprints are taken, in the same way as from corpses, after being kept for several days in a solution of ethyl alcohol mixed with glycerine. It is not recommended to place in formalin, as this will cause stiffness and make the glove difficult to handle (Anghelescu et. al., 1976, p. 147).

Mummification is a destructive process that causes the skin to become rough, dry and wrinkled. In these circumstances, it is often difficult to obtain prints by rolling the corpse-printing spoon around the fingers. Among the known procedures, the most commonly used is rewetting the skin with a solution of potassium hydroxide in water, with a concentration of 1-3%. For this, the fingers are kept in the solution until the skin returns to normal. After this, the fingers are rolled on the plate to obtain fingerprints. If only the skin peels off, after rewetting in the solution, it can be spread on a soft wooden support. Some practitioners recommend the use of latex or alginate casts. However, it should be noted that alginate casts should be used very quickly as they shrink considerably over time (Anghelescu et. al., 1976, pp. 147-148).

The process of dactyloscopic identification, as with any identification process, starts with a comparative examination to select impressions of the same type, group and subgroup as the crime scene print and continues with a detailed examination of each retained fingerprint, again by comparison, to discover coincident features, specific to a single papillary relief. The fingerprinting can be carried out manually or automatically when automated papillary fingerprint examination and identification systems are used (Mircea, 1999, p. 84; Mircea, 1996, pp. 85-86).

In order to reach a definite positive conclusion, the forensic expert examines the fingerprint of the crime scene print against the fingerprint of the test print (both made to the same scale), firstly by finding the group matches and then the detail matches that identify the papillary relief. Throughout this identification process, the expert must first ascertain that the pattern elements in the comparatively examined fingerprints are not in discordance, and then establish in the two fingerprints a number of at least 12 coincident points. If the required number of coincidences is not found, the expert resorts to examining pores, scars and white lines, if any, which he uses as a secondary, helpful means. In the literature, this quantitative criterion is regarded with reservations, and it is proposed that the qualitative criterion should also be applied, i.e. that the expert should draw conclusions about identity both on the basis of the number of points of coincidence established in the fingerprints examined and on the complexity, variety and frequency of the details found (Mircea, 1999, pp. 84-85; Constantin et. al., 1975, pp. 209-210; Stancu, 1981, pp. 165-166).

Starting from the fact that the papillary relief is unique in all its details, which are manifested in the number, shapes, dimensions that are found on its entire surface or on a limited area within it, to which we can add the position that these details have in relation to each other, it is necessary to establish the identity, in addition to the number of coincident points found, to take into account their frequency, complexity of configuration, topographic area in which they are found and the distance between them. Thus, if the fingerprints examined comparatively reveal only simple configuration details common in forensic practice, 12 or even more coincident points are needed to draw a positive conclusion, but when, in addition to a few simple details, more complex details are found (three overlapping bifurcations, a pair of buttonholes or hooks, the anastomosis/overlap pair, two interleavings, etc.), the number of points is reduced to a minimum.) over an area of a few square millimetres, identity can also be established on the basis of a smaller number of coincident points (Mircea, 1996, pp. 86-87).

The identification of the creative relief of the crime scene print and the impression taken experimentally, in the practice of dactyloscopic fingerprinting, is argued by simply mentioning the coincident points on the two fingerprints, by blending the fingerprints in question to show perfect linear continuity, and sometimes also by diagrams obtained on both fingerprints by joining identical details with straight lines (Mircea, 1999, p. 86).

In dactyloscopic comparisons, errors can occur, such as mistaking a negative trace for a positive trace. In homicides or in accidents with victims, situations arise where papillary marks may come from fingers stained with a coloured substance (blood, paint, soot, etc.) being visible or latent as a result of fingers repeatedly touching surfaces of objects until the coloured substance has disappeared. Traces may also appear as smudges or stains as a result of the grooves between the papillary ridges being filled with the stained substance, so that the traces often have no identifying value. As the fingers successively touch other surfaces, the substance between the ridges is deposited and the papillary pattern will become increasingly clear. The two ways in which the marks left by the same fingers are formed – by the reproduction of grooves or papillary ridges, can reveal differences in the process of comparison. Thus, ridge ends can become bifurcations, fragments appear as buttonholes, the papillary point as a ring and the anastomosis becomes an overshoot or break. Confusion of the negative trace with the positive trace can also occur in the case of papillary traces created by destratification of the coloured substances on the affected surfaces. This time the process of trace formation is reversed: the papillary ridges take up by contact the substance on the affected surface leaving clean spaces in their place, and the coloured substance in the grooves remains untouched creating the visible trace. Errors can be avoided by taking photographs of the negative image of the trace so that the coloured lines on the incriminated print become white and vice versa (Cîrjan, 2005, p. 222; Păşescu et. al., 1996, pp. 248-253).

The classical methods of identification, until a decade ago, consisted of updating and manually operating fingerprint maps (local and central), the usual tool being the magnifying glass. During the evolution of fingerprint maps, pragmatic reasons have required them to be divided into central and local fingerprint maps, each of which attempts to address the problems of establishing the identity of repeat offenders and proving the participation of perpetrators in crimes on the basis of fingerprints discovered, recovered and collected from the crime scene (Drăghici et. al., 2009, p. 146).

The automatic identification system has been used in practice since 1982 in Japan. In this system, the computer automatically detects the features (heads and bifurcations of the papillary ridges) in the image of a fingerprint, enters them into memory and compares them. The computer then determines the ratios that link the features together by defining the number of ridges that separate them. The position and direction of the features and their relationships to each other are translated into numerical data, which the computer enters into memory. The process is carried out for the whole fingerprint: the machine detects 100 features in the image of a finger (Ciopraga et. al., 2001, p. 59).

Worldwide, there are now several companies producing and marketing such systems, their design and architecture being roughly similar, and the differences mainly relate to performance in terms of accuracy and speed of work, number of stations and specialists needed to meet specific requirements, cost prices and number of users. The best known and most widespread are the AFIȘ systems of the Japanese company NEC (Nipon Electronic Corporation), the American company PRINTRAK and the French company MORPHO, and the DEX (Russia and Ukraine) and DERMILOG systems in Germany, which are in advanced study.

Depending on the specific legislation of the various countries and their administrative organisation, AFIS systems are used in two different ways for fingerprint identification: a) to establish the identity of repeat offenders, persons subject to state or international prosecution, refugees, asylum seekers, immigrants, etc.; b) to identify perpetrators on the basis of fingerprints taken at the scene.

In Europe, the system produced by the American company PRINTRAK is the most widespread, followed by MORPHO and NEC. Among the Central and Eastern European countries, Hungary has had such systems since 1993, the Czech Republic since 1994 and Romania since 1996, all supplied by the American company PRINTRAK INTERNATIONAL I.N.C., based in California (Drăghici et. al., 2018, p. 209).

Chapter III

Forensic Investigation of Footprints

3.1 General Information

Footprints are an important category of footprints frequently observed in crime scene investigation, accompanied by handprints and other footprints of more specific relevance. The identification of footprints is generally easier than the identification of handprints, however, they are not of the same importance in terms of individual identification (Suciu, 1972, p. 239) due to the relatively small number of characteristic elements, except for those specific to the papillary ridges on the sole of the foot (Stancu, 2015, p. 134).

Footprints indicate the direction from which the offender came and the direction in which he went after the crime. In some cases, footprints can lead directly to where the offender is hiding. In most cases, footprints provide clues that can later lead to the identification of the offender. These clues are given by footprints in which certain features of the foot are imprinted. On the basis of these impressions it is sometimes possible to create – in general terms – a picture of the physical features of the offender (Ruiu et. al., 2016, p. 15).

Footprints are formed due to the pressure of the body's weight both when the body is stationary and when moving in space. It should be noted that footprints will inevitably form on the spot in all cases where the commission of the offence involves actions leading to contact between the offender's feet and the material elements of the surroundings and, naturally, if they are capable of receiving traces (Doraș, 2011, p. 145).

The surface of the foot can be divided into two distinct regions: the plantar surface (sole of the foot) and the dorsal surface (back of the foot).

The plantar surface is composed of several regions, including the metatarsophalangeal, metatarsal, tarsal and heel regions. The metatarsophalangeal region lies between the toe and an imaginary line perpendicular to the longitudinal axis of the foot, passing through the joint between the second phalanx of the big toe and the metatarsal. This region is often depicted in footprints and, due to the diversity of the papillary pattern, is one of the main regions that can help identify a person. In the metatarsophalangeal region, various shapes of the papillary ridge can be seen, such as single lines, double lines, spiral lines, zones and many others.

The metatarsal region lies between the metatarsophalangeal region and an imaginary line perpendicular to the longitudinal axis of the foot, passing through the joint between the tarsus and the metatarsus. Like the metatarsophalangeal region, this region has a variety of shapes, such as single lines, double lines, spiral lines, arches and even zones (Anghelescu et. al., 1976, p. 149).

The tarsal region, which corresponds to the tarsal bone, lies between the metatarsal region and the heel, i.e. in the lower part of the sole cavity of the foot. Here there are relatively horizontal ridges that branch, break, merge or form small loops. Exceptionally, lines may also be found.

The heel region is the posterior part of the sole, corresponding to the calcaneus bone. The papillary field in this region, as in the tarsal region, has a uniform appearance, characterised by horizontal papillary ridges with many interruptions, bifurcations and contours. Papillary ridges in the form of arches, lines or spirals will never be found in this region.

Some individuals may have specific morphological features such as collapse of the plantar arch (platphus), pronounced arching (hollowing in the tarsal region), polydactyly, syndactyly, etc. In a plantar impression, deformities of the papillary pattern may sometimes appear as a result of calluses, scars or malformations located in various regions, which are important elements in identifying the person to whom the impression belongs (Anghelescu et. al., 1976, p. 149).

3.2 Classification, Formation and Significance of Footprints

Footprints are the subject of an apparent paradox in forensic work in general and forensic work in particular. The correct classification (Suciu, 1972, pp. 239-241; Mircea, 1999, pp. 86-88; Stancu, 2001, pp. 142-143; Gheorghiță, 2017, pp. 196-197; Pășescu Gh. Op. cit., pp. 96-102) and interpretation of footprints at the scene of a crime requires first of all knowledge of all the varieties and forms in which they can be found, as well as methods for their effective search and detection (Pășes cu et. al., 2000, p. 96).

The forensic significance of footprints is determined by the forensic information they can provide. Examples from forensic practice confirm that footprints make a considerable contribution to the detection and investigation of various crimes, being second only to handprints in terms of information. The level of information provided by footprints depends, on the one hand, on how they are formed and, on the other hand, on the factor that forms them (Doraș, 2011, p. 146).

According to the literature, this category of footprints can be classified according to several criteria:

According to the object creating the footprints, they are classified as follows:

- footprints created by the bare foot (plantar footprints);
- footprints created by footwear (shoes, boots, etc.);
- footprints created by the half-heeled foot (stocking footprints).

Depending on the way they are formed, footprints can be:

- deep footprints;
- surface footprints. Surface footprints are subdivided into: stratification footprints and destratification footprints.

By identification value, footprints can be:

- visible;
- invisible (latent) (Ciopraga et. al., 2001, p. 64).

Footprints can be created in various situations and contexts. They may be the result of pressure and movements exerted by the weight of the human body during walking, running, jumping or other activities involving the use of the feet.

In movement, footprints can be formed during walking (normal walking, running, jumping) or during the execution of foot actions (kicking, pushing, sliding, etc.).

In normal gait, the footprint starts to form when the heel comes into contact with the surface on which the foot is resting. The foot then rolls towards the toe, at which point the other regions of the foot are successively imprinted. In the process of walking, at the formation of each step there is a moment when the weight of the body remains on one foot. This is when the relief of the plantar surface, which remains in contact with the support, is imprinted (Anghelescu et. al., 1976, p. 151).

Static footprints are generally created by applying pressure during standing or in the normal process of walking. They more accurately reproduce the shape and dimensions of the foot as it is pressed evenly against the support.

Dynamic footprints are formed during walking, when the foot slides in a certain direction on the surface it comes into contact with. This type of footprint shows a deformation of the shape of the foot, but in some cases certain elements can be seen. Dynamic footprints appear as slips, and depending on the situation, they may show certain elements or regions of the sole of the foot. These may be more clearly imprinted at the initial or final point of the trace formation (Anghelescu et. al., 1976, pp. 151-152).

The barefoot trace directly reflects the morphological structure of the offender who created it, unlike the shod footprint which represents only the wearer's footwear and gives the wearer's characteristics only through some elements of shoe wear and gait pattern (Cîrjan 2005, p. 226). Although some authors specify that footprints, in the form of footwear traces, show, in the case of the footprint trail, a number of elements specific to a person's gait, regardless of whether he or she is shod or not (Stancu, 2015, p. 135).

Unlike handprints, footprints are less common, although the offender's contact with the ground is almost constant. The appearance of these footprints is more specific and may not occur on every type of terrain. For example, bare footprints are increasingly rare at crime scenes, but if they do occur, it can be attributed in part to chance circumstances. Places where people walk barefoot are also areas where footprints are more common, due to loose soil, clay or abundant mud, especially in rural areas (Suciu, 1972, p. 239).

The papillary relief on the soles has the same properties as that on the hands, but forensic practice has difficulty in identifying the person on the basis of this relief. There are fewer cases where identification by sole prints is used, and there are several reasons for this. Firstly, in the case of sole prints, the papillary relief may have been heavily abraded or, at the time the print was formed, contaminated with foreign substances. These situations lead to a reduced rendering of the details of the papillary relief, which makes it difficult to accurately identify the person. Secondly, the objects on which the sole marks are found do not always have a sufficiently smooth surface to faithfully preserve the details of the papillary relief. Irregular or porous surfaces can distort or damage the sole impressions, making accurate identification difficult (Mircea, 1999, p. 86).

Half-shod foot or sock impressions can provide information about the general shape of the sole of the foot, its regions and tissue characteristics. These marks can be useful in determining the group of people wearing similar footwear or even in identifying a person if they have distinctive features such as stitching or specific wear.

Footwear impressions can provide similar information but with a lesser degree of specificity. Under appropriate conditions, such as static footprints, depth and soft ground, distinctive elements of footwear such as sole patterns, grooves or other specific features may be visible (Stancu, 2001, p. 143).

Depth marks are formed when pressure is applied to materials that may deform. In terms of the frequency of footprints found at the crime scene, the most common are depth marks in soft soil, but these do not provide much value in identification due to lack of precise detail. Depth marks also form in wet sand, snow, soft clay and heated asphalt. But mud does not keep depth marks in a clear form. The presence of plant debris, wet clay and sand on the ground makes it difficult to produce and reveal depth marks (Cîrjan ,2005, p. 228). The snow reproduces in optimal conditions the characteristics of the outer construction of the barefoot or footwear, even in the melting phase due to the thin crust of ice that forms as a result of evaporation. Very frozen snow, in powder form, reproduces the tracks poorly, only vaguely indicating their outline. Ice reproduces both surface and deep tracks, and sometimes both together, when it goes through alternating phases of melting and freezing. Cement, wooden objects and sometimes carpets reproduce footprints as striations or indentations (Suciu, 1972, 240).

Depending on the contact surface and the shape of the foot, footprints typically record the plantar surface with its four regions, each with certain distinct characteristics. The calcaneal region is integrally imprinted and has an elongated, circular shape. To the right of the plantar arch, the tarsal region and part of the metatarsal region are thinned, and subsequently the impression widens, rendering the full size of the plantar surface. It is characteristic that the higher the plantar arch, the narrower the impression of the tarsal region becomes. In the case of a low plantar arch or platysma, the footprint may be wider than normal or very wide. In the case of the low arcuate foot, the surface trace is interrupted in the direction of the socket. The toe impressions appear isolated from the rest of the footprint and are circular in shape, being arranged in a certain line. In contrast to the other toes, the flexor groove appears in the big toe. In some cases, fewer toes may appear in the trace. This is due to overlapping of the fingers as a result of deformities caused by footwear or the specific position of the fingers (Anghelescu et. al., 1976, p. 152).

Surface traces are formed in two distinct ways: by layering and destratification.

Layering marks are formed by the deposition of papillary secretions or other substances from the sole of the foot onto the contact surface. These secretions may include natural oils, sweat or other substances found on the sole of the foot. Thus, the resulting footprint will largely reproduce the shape and relief of the foot, depending on the amount and physical properties of the deposited substances.

On the other hand, footprints by destratification are formed when easily removable substances are peeled off or removed from the contact surface on the sole of the foot. These substances may include dust, sand, dirt or other matter that has temporarily stuck to the sole of the foot. Depending on the physical qualities and the amount of material attached, the resulting impression may more or less accurately reproduce the shape and relief of the foot. Initially, the destratification marks may be a distorted representation of the outer structure of the foot, showing a confused relief. However, as more material accumulates or some of the substance is removed, the destratification marks may accurately depict the shape and size of the foot or certain areas of it (Anghelescu et. al., 1976, pp. 151-152).

Footprints, in general, are obvious and easy to identify, except in rare cases, due to the fact that they are visible to the naked eye. They can be observed either as individual footprints or as a compact group, and are important in the identification process, providing relevant information about the number of people involved, the actions taken, the access and exit points from the perimeter of the incident site. If the tracks form a trail, they provide additional data about the individual responsible for those tracks and other relevant aspects (Mircea, 1999, p. 87).

As an object of tracing research, footprints can also be single or multiple. If a multiplicity of footprints results from a single mechanism of formation in the individual's movement process, they are called a footprint trail. Examination of the footprints can give us information about some of the characteristics of the perpetrator and the peculiarities of the gait (limp, prosthesis, irregular rhythm, etc.) contained in the elements of the track as follows (Golubenco, 2015, p. 37):

– the axis of the track (direction of movement or line of direction) is the straight line drawn between the footprints created by the two feet, at an equal distance from each other and indicating the direction of movement;
– the line of gait is the total of the segments linking the rear ends of each footprint, i.e. the heel area. The shape of this line is a zigzag;
– the length of the step, measured between two consecutive tracks, taking as a reference the tangent projection at the heel of the track, is projected on the axis of the track;
– the width of the step is the distance between the parallel lines joining the inner contours of the tracks of the two feet;
– the gait angle is formed by the axis of the track and the longitudinal axis of each track in its component. The gait angle is considered positive

when its apex points towards the heel and negative when its orientation is opposite. The longitudinal axis of the soles may in some cases be parallel to the line of gait (Pășescu, 2000, pp. 98-99).

Investigation of the stride path provides information on the offender when the following are taken into account:

- excessive stride width is specific to heavy, elderly or obese people;
- the angle of the left foot sole of the left-handed individual is smaller in relation to the angle of the right foot, the length of the left stride in left-handed people is increased;
- the presence of traumas, diseases, prostheses is manifested by small stride width, dragging of the sick foot, the existence of cane prints. The step length of the diseased foot is comparably shorter than that of the healthy foot, the depth marks left by the diseased foot are shallower (Cîrjan, 2005, p. 229).

Investigating these elements individually or as a whole can lead to basic conclusions about the suspect. On the basis of the trace elements it is possible to predict the sex of the persons involved in the operation, their physical characteristics and possible anatomical defects, their mental state, their weight, etc. (Doraș, 2011, p. 147).

By studying the characteristics of the footprint, it is possible to roughly estimate the stature and size of the footwear worn by an individual. It is found that in men and women, the length of the sole of the foot represents, on average, about 15.8% and 15.5% of their total height respectively. Therefore, to determine the height of a person based on a footprint found, a simple calculation can be applied. The length of the footprint is multiplied by 100 and the result is divided by the corresponding percentage, either 15.8% or 15.5%, depending on gender. This method gives an indicative estimate of the height of the individual concerned (Golubenco, 2015, p. 38; Belkyn, 1987, p. 208).

Gender and age. Depending on the footwear impressions, the shape and size of the impressions, the brand marks of the footwear manufacturer, the micro-relief of the sole design, the shape and size of the heel and other distinguishing features will be analysed. The length of the step shall be determined, knowing that for men it is equal to 70-85 cm and for women – 50-65 cm. The gait angle for men is 18-25° and for women 12-20°. The literature indicates the use of a method based on the analysis of signs of heel wear. From the marks left by the upper of the shoe it is possible to determine the clumsiness of the gait, as well as its concrete orientation (Cîrjan, 2005, p. 229).

Anatomical defects (prosthesis, injury, etc.) are reflected in the footprints by the different length of steps of one foot in relation to the other and by the appearance of additional elements, such as the dragging of the affected foot.

Psychological conditions (fatigue, drunkenness), as well as diseases affecting the organs of balance, will be reflected by undue changes in the direction of movement, stopping, falling, etc. (Doraș, 2011, pp. 147-148).

Taking into account the above information, it can be seen that footprints occupy a particularly important place in the field of forensic investigation, due to their value in three distinct aspects:

- to establish the circumstances of the crime scene in the course of the investigation by assessing, on the basis of the footprints, the ways in which the perpetrator entered and left the scene, the actions committed and the time factor of the crime;
- to trace the perpetrator immediately, using precise data on the direction and mode of movement, the particulars of the gait, the physical and anatomical characteristics of the suspect;
- to identify the factor that left the footprints (of the suspect or of the footwear) by means of the pathological expertise (Doraș, 2011, p. 148).

3.3 Search and Discovery of Footprints at the Crime Scene

Because of their intrinsic nature and persistence in a variety of environments and circumstances, footprints are one of the first categories of evidence to be sought on the spot. Their importance in criminal investigations and in the identification process is widely recognised.

The discovery of footprints is considerably easier than the identification of handprints. For "latent" or invisible footprints formed by the soles of bare feet, the same techniques used to search for and discover handprints are applied (Ciopraga et. al., 2001, p. 65).

All areas where crimes have been committed should be considered as potential sources of footprints. The lack of discovery of footprints at the crime scene can largely be attributed to:

- lack of confidence that visible or latent footprints will be found at the crime scene, leading to insufficient search and lack of persistence in identifying them;
- incomplete search of the area, due to the difficulty for the criminalist to establish precise points of entry and exit into and out of the crime scene.

Also, lack of adequate knowledge of footwear traces may contribute to an incomplete investigation;

- presence of other persons at the crime scene, who step over existing footprints and cause the search for footprints in the area to be abandoned;
- allowing unauthorised persons (non-technical investigators) to pass through the crime scene, which may disturb and destroy existing footprints;
- combined characteristics of footwear and surfaces may not lead to footwear traces;
- intentional destruction of footprints by offenders. However, this operation is unlikely to be carried out except in cases where it is desired to remove blood stains which are usually visible;
- destruction of external footprints caused by adverse weather conditions (Pășescu, 2000, pp. 102-103; Bodziak, 1990, p. 17).

Footprints, whatever their nature, shall be discovered by visual spot search of all surfaces likely to be trodden on. For this purpose, the following shall be examined:

- floor surfaces and other construction objects in the room where the actions under investigation took place;
- ground surfaces of the open space where the perpetrator came and went;
- objects in the perpetrator's direction of movement and those used during the commission of the crime (tables, chairs, crates, etc.) (Doraș, 2011, pp. 148-149).

It is imperative not to underestimate the fact that the footprint search activity may be accompanied by the use of tracking dogs to detect and process scent traces. These scent traces have the ability to compensate for gaps in the identifying elements present in physical footprints, thus providing essential contributions to the identification process (Stancu, 2015, p. 136).

The discovery of visible depth traces around furniture does not pose particular problems, as a careful visual inspection of the terrain is usually sufficient.

Inside, search in small areas or rooms one at a time. To begin with, a methodical, visual search is made using existing light. Obvious and highly visible traces, such as blood, grease or other visible residues, may be detected first. To make it easier to locate footwear marks, which are not easy to see in natural light, dim the area to be searched. A very bright light source is then used, positioned so that the beams are almost parallel to the ground (Pășescu, 2000, p. 106).

Layering or destratification marks can be created in dusty, damp places with liquid debris, freshly painted, or where various powdery materials are stored in and around them.

In order to reveal latent traces formed by the deposition of sweat, a beam of light is projected at an incident angle, the trace appearing on the surface under investigation as a matt area (Anghelescu et. al., 1976, p. 153).

Impressions on carpet or porous or rough surfaces remain invisible even in oblique light. Contrast enhancement methods are available for such cases (Pășescu, 2000, p. 106, Bodziak, 1990, pp. 130-160).

Footprints, both depth and surface, are subject to the action of several factors that can destroy them (Doraș, 2011, p. 149). The footprints found are marked using indicator plates from the forensic kit and then circled with chalk. Various objects such as cardboard boxes, clean dishes, sheets of paper, cardboard or plywood are used to protect them and placed over the traces. In the event of bad weather conditions, such as rain, measures are taken to prevent water seeping into the traces and the edges of the traces from overflowing. Traces found in powdery materials are protected from the action of the wind by covering them to avoid scattering of details or covering them by levelling (Anghelescu et. al., 1976, p. 153). They must also be protected from the ,,wave of the curious" or from the presence of too many people on the site (Stancu, 2001, p. 144), those interested in the disappearance (destruction) of the tracks (Gheorghiță, 2017, p. 197).

Once footprints have been identified and highlighted, it is essential that accurate measurements, including two-dimensional measurements, are taken. These measurements specifically address the length of the footprints, widths in the metatarsal and tarsal region, heel width, position of the toes and other relevant characteristics of barefoot prints. As regards footwear impressions, measurements are aimed not only at the general dimensions and features of the sole and heel design, but also at specific wear characteristics which may help to identify at least the gender or group to which they belong (Stancu, 2015, p. 136).

3.4 Fixing and Lifting Footprints at the Crime Scene

To fix footprints, standard forensic techniques are applied, which are used for any category of footprints. These include description in the on-the-spot search report, photography, copying with adhesive film and the use of depth mouldings for footprints (Ciopraga et. al., 2001, p. 65).

Before proceeding to fix the tracks by appropriate procedures, if necessary, foreign bodies shall be removed from the surface of the tracks. Foreign bodies shall be carefully removed with tweezers so as not to destroy the trace details. Water from the depth marks, if it is in large quantities, is first absorbed with a rubber squeegee, then with a pipette and finally with suction paper, keeping it in a strip, slightly close to the trace, to protect its details (Mircea, 1999, p. 88).

Once discovered, the footprints are recorded by describing their general and particular features in the crime scene report. The report, being the procedural form for establishing the footprints, must contain data on the nature of the footprint (foot, footwear, depth, surface, stratification or destratification), its general shape and relief (in bare footprints, if papillary patterns are discernible), the dimensions of the footprint (Doraș, 2011, p. 149).

In the process of documenting footprints, begin by identifying the area in which they are located, describing the nature of the objects the footprints have left, the colour and appearance of these objects, their position and number in relation to other objects and the distance between them. After an overview of the footprints, a detailed description of the footprints is given. For this purpose, precise measurements are taken to assess the characteristics of the group. In the case of footprints, it is specified whether the footprint in question is deep or shallow (stratified or destratified), the general shape of the footprint is described, and the length and width in centimetres are measured. To do this, measure the trace from the tip of the sole along the longitudinal axis to the protruding part of the heel, measure the width in the sole area and in the narrower arch area. In the case of depth marks, the length and width of the heel and the height of the heel shall be measured separately (Mircea, 1999, pp. 88-89).

In the case of bare footprints, in addition to the measurements mentioned above, measurements of the angle formed by the position of the toes shall also be taken. This angle is created by an imaginary line connecting the toe prints with another imaginary line passing through the base of the thumb print. In addition to this exterior angle, the angles of an interior triangle may also be measured at the hollow footprints. This triangle is formed by the inner arch of the toe-mark, its hypotenuse being determined by the width of the upper part of the metatarsal, and the two legs forming an angle at the highest part of the toe-mark at the base of the second toe-mark. To ensure a more accurate measurement of footprints, the method of framing the image of the footprint in a rectangle and the method known as Caussé's method is used (Suciu, 1972, p. 243).

Thus, by precise measurements, the following will be established and fixed: in the footprints: the length of the footprint – the distance between the posterior end of the heel and the anterior end of the toes; the width of the footprint – the distance between the lateral ends of the metarsal region; the width of the footprint in the tarsal (arch) region and of the heel in the central region. in possible cases the angle (in degrees) formed by the intersection of the line joining the tips of the big and little toes with the tangent line to the inside of the trace is fixed; in footwear traces: length of the trace – the distance between the ends of the tip of the trace and the heel; length of the toe, the intermediate region and the heel; width of the toe, the intermediate region and the heel (Doraș, 2011, p. 149).

Photographing footprints primarily involves capturing a complete image of the group of footprints in order to represent the person's movement characteristics. At the same time, it is important to photograph in detail the footprint that shows the clearest and most distinct features for individual identification of the object that created the footprint (Stancu, 2015, p. 137).

Among the photographic methods of footwear trace detection, the literature distinguishes: photography in oblique light; in polarised light; in ultraviolet radiation; in infrared radiation (Pășescu, 2000, p. 107).

To begin with, footprints are photographed as a whole, regardless of their origin (footwear or barefoot) and regardless of whether they are surface or depth marks. In the process, the relative positions of the footprints to each other and their relationship to objects in their vicinity are established. This produces a photograph that captures the main objects. In order to take this photograph, the camera is mounted on a stand, with the lens directed perpendicular to the area in which the tracks in question are located, at a height which allows the entire surface bearing the group of tracks to be photographed to be included in the image (Mircea, 1999, p. 90). Basic mistakes in the process of photographing the tracks, such as not using the tripod, not ensuring parallelism between the film surface and the track plane, or not directing the light correctly, may result in questionable images (Pășescu, 2000, p. 108).

Natural lighting is best, and artificial lighting is best provided by frosted bulbs. Proper illumination of footprints in photography involves the use of a main source of artificial light, which is brighter and placed behind the camera, with the light beams directed perpendicular to the footprints. In addition, another, lower intensity light source is used, placed to the side of the camera, which casts light onto the footprints at an acute angle, creating soft shadows that highlight the details of the footprints in the image. Where footprints are printed on glossy surfaces, such as polished parquet or plastic carpets, to avoid unwanted reflections and smudges on the image, the illumination of the footprints is achieved by using two light sources placed on the sides of the camera, facing the footprints at sharp angles. It is advisable that the bulbs used have a matt texture (Mircea, 1999, p. 90).

The oblique light is used when photographing traces of dust or layering. In order for the dust particles in the trace composition to reflect light into the camera lens, the light source should be placed close to the plane of the trace or right on the surface of the trace. The optimum distance between the projector or flash and the trace is about 1.5 metres. To be sure of the result, it is advisable to make several exposures for each trace, changing the position of the light source around the trace (Pășescu, 2000, p. 108).

Detailed photography of each footprint taken separately is done immediately after shooting the footprints as the main objects. And for taking these detailed photographs of the footprints, the camera shall have the lens perpendicular to the footprint in question. The shooting distance shall be adjusted so that the footprint covers the entire field of view of the camera. In the case of detailed photography of the footprints, the illumination shall be by two light sources of identical intensity, fixed to the sides of the camera, each projecting light onto the footprint at acute angles of the same number of degrees. When, however, depth marks are photographed, the illumination shall consist of a main, intense light source at the back of the camera, with the rays projected perpendicularly on the track, and another light source at the side of the camera, with a weaker light, projected at an acute angle on the track, so as to create slight relief shadows (Mircea, 1999, pp. 90-91).

When fixing the footprints, it is important to take a linear or two-dimensional measurement at the same time as taking the photograph, by placing a graduated ruler or a centimetre along the length and side of the footprint. This type of photography is carried out according to the rules of photographic measurement (Stancu, 2001, p. 145).

The procedure of copying surface footprints using adhesive film is commonly used in situations where footprints show significant details of great importance in forensic investigations, such as papillary impression details or scars in footprints, as well as wear details in footwear impressions. The process of applying adhesive film to these marks is similar to that used for handprints. However, it should be borne in mind that the surface area of the film is larger, which can lead to the formation of air bubbles between the film and the footprint. Therefore, when applying the film, it is pressed firmly with the fingers of both hands from the centre to the edge to eliminate air bubbles. It is important to avoid slipping the protective film over the raised trace to avoid distorting the details. At the same time, it should be borne in mind that the position of the film is reversed from how it was found on the carrier object at the scene of the incident (Mircea, 1999, p. 93). The negative obtained by photographing the trace on the adhesive film shall be placed in the enlarger to obtain the positive image, with the emulsion towards the light source (Cîrjan et. al., 2009, p. 142).

In the absence of special adhesive film, the trace can be lifted using photographic paper, prepared in advance. For traces left by white substances (cement, alabaster, lime, flour), apply black emulsion paper, and conversely, for traces left by black substances (charcoal, soot, tar) apply white emulsion paper. At the spot where the marks are found, the paper is soaked in warm water, soaked in water and then pressed over the mark with a rubber roller or by hand. The rubber plate is also used in this way, having been previously worked on one side with paper-glass until a smooth relief is formed (Doraș, 2011, p. 151).

The moulding for the removal of traces formed in depth is a major step in the investigative process and is carried out immediately after photographing and possibly drawing the traces on a tracing sheet placed on a glass surface above the traces (Stancu, 2015, p. 137; Suciu, 1972, p, 547; Svensson et. al., 1957, p. 72).

The image of the footprint for drawing purposes is framed in a rectangle and the footprint is outlined on a sheet of tracing paper placed on a glass pane above the footprint, with a small distance being kept by a few matches. The rectangle will frame the length and width of the trace and the other values are measured inside it. Caussé's system uses a grid of squares into which the rectangle framing the image of the footprint is divided (Cîrjan, 2005, p. 230; Suciu, 1972, p. 246; Manea et al., 1981, p. 129).

According to the various circumstances encountered on the spot, special preparation of the footprint and moulding is required, especially when they are formed in sand, gravelly or soft soil, snow, etc. (Moiese et. al., 2020, p. 82).

In order to highlight the details in making a moulding, certain preparations are necessary depending on the condition of the track in question. In some situations, the trace needs to be fenced around, while others require treatment with chemicals to prepare it for the fixing process. In the case of shallow footprints, which frequently occur both on the ground and in snow, a fence is created around them using cardboard, wooden slats or earth. This fencing allows a thicker moulding to be made that can withstand lifting and transport. When deep tracks are printed in a sandy soil with large grain and voids that would deform the mulch, these voids are covered.

One of the methods used for this purpose is to spray a thin layer of paraffin, red wax or resin inside the trace, which is then melted using a heat source, such as portable electric radiators. Once the layer has cooled, the moulding can be made.

Another simple method of preparing hollowed-out tracks is to spray a thin layer of plaster on the surface of the track, followed, if the track is not wet, by lightly spraying a little water to form a crust. After the crust has hardened, the moulding paste can be poured in. In the case of tracks formed in the snow, plaster is used to harden and protect the track into a thin crust. If the track is in damp sand or loose soil without voids, it is recommended to harden the edges of the track beforehand to resist moulding. For this purpose, use a solution of sherlac or colodion which is sprayed from a height of half a metre, with the sprayer facing upwards, to allow the particles to fall like dew onto the trace without destroying the details (Suciu, 1972, pp. 246-248). Once the created pojghița is well enough hardened, proceed to make the moulding. In a similar way the trace is sprayed to strengthen its edges, when it is in powdery substances such as dust, wheat flour, ash, only the serac solution is diluted with medicinal spirit. If the crust formed is not strong enough, the process is repeated two or three times (Mircea, 1999, p. 92; Coman, 1975, p. 65).

Wax and paraffin are another material used to mould the depth marks formed by the feet. If these substances are used, the footprint must always be prepared beforehand with a protective layer of wax or paraffin, over which a layer of talc is then sprinkled, so that the layer with which the bottom of the footprint has been prepared does not adhere to the moulding removed later. A very thin layer of the melted wax or paraffin composition is poured over the mould at first and only after it has cooled is the rest of the moulding mass poured in (Suciu, 1972, p. 247).

Gypsum paste is used for the moulding of shoe impressions, sometimes also polymer paste Golubenco, 2015, p. 38). Gypsum paste is prepared from fine gypsum powder, preferably dental gypsum, and ordinary water, free of foreign bodies which could change the details of the trace. Depending on the nature of the soil, the paste will be more consistent or more fluid. For picking up traces in soils with slight structural voids, the paste should be more consistent, and if the traces are in clay soils, the paste can be more fluid to reproduce all the trace details. The paste is usually prepared in a rubber capsule of 2 to 3 litres capacity, into which the necessary quantity of gypsum is poured, after which water is gradually added, stirring all the time until the paste reaches the required degree of fluidity for the trace in question. Care must be taken to ensure that no large grains of undiluted gypsum remain in the paste. Once the paste has been made, pour it, preferably by spoon, then first pour in the first half of the contents required for moulding, and then place a few thin sticks or strands of wire over the mould already poured, to give the mould greater resistance to lifting and transport. Then pour in the rest of the moulding until the track is completely filled. The plaster mould, at an air temperature of 20 – 30 degrees C, sets for 30 – 40 minutes (Mircea, 1999, p. 93). To speed up the hardening of the plaster mould, instead of cold water, warm water can be used or a little salt can be added, and to slow down the hardening process, everything is processed cold (Cîrjan, 2005, p. 231).

It is very important to remember that the moulding that has been made should not be cleaned of the soil that has stuck to it. The moulding can only be rinsed with water, but not even with the hand. Violation of this rule leads to the destruction of the microrelief of the moulding and thus excludes the possibility of identification (Golunski, 1961, p. 109).

For the plaster moulding of deep tracks formed in the snow, first of all a layer of plaster is sifted over the track to form a protective crust. The gypsum composition should be mixed with cold water, close to snow temperature. The rubber pot in which the mixture is made is kept in the snow to maintain the optimum temperature. It is important that the gypsum mix is thick, otherwise it will not harden properly at snow temperature. The mold should not be removed from the snow until it has partially hardened, which takes about one to two hours. After the snow layer is removed, the moulding cannot be made until the sidewalls and bottom of the track have been hardened with a protective layer of sawdust and talc. Gypsum is introduced into the track in the form of powder. First, a thin layer of plaster is spread on a few sheets of paper laid on the snow to cool it as much as possible. Then sift it back several times and finally put it in with a spoon. Once a 2 cm thick layer is obtained, stiffen with chopsticks and add another layer of dry plaster. Place a folded cloth over the last layer of plaster and slowly pour very cold water over it. The mould remains in place for at least two hours. After the plaster cast is removed from the back, it should be allowed to warm gradually to room temperature to prevent the remaining snow detail from being destroyed. The moulding should be supported so that the bottom remains horizontal and to avoid damage to the details by dripping water. At least 24 hours is required for the plaster moulding removed from the snow trail to harden completely. During the time the plaster moulding is left behind in the snow, it should be covered with a metal pot, on top of which a mixture of salt and snow is placed to keep the temperature as low as possible (Suciu, 1972, pp. 248-249).

In the case of tracks formed in marshy regions, where the deep tracks are filled with water from seepage of the soil, plaster casts can be made by depositing it on the bottom of the track. The gypsum is sprayed dry into the water in the deep trace and gradually deposited on the bottom of the trace until the required thickness of the mould is obtained (Suciu, 1972, p. 249).

Latex casts are ideal for the faithful reproduction of deep hand and footprints. The process consists of successively pouring several thin layers of latex into the trace, which are left to harden for about 10-12 hours. After curing, the trace is filled with plaster according to the usual method. In the case of footwear marks on carpets, rugs or other plush textiles, latex, paraffin, plaster, etc. moulds are used. Before moulding, a thin layer of talc is applied to facilitate the process. This technique allows an exact reproduction of the shape and details of the deep traces to be obtained, thus ensuring accuracy and authenticity in the reconstruction process (Cîrjan, 2005, p. 232).

The electrostatic sampling method is usually used after photographing the traces. If this method is unsuccessful in picking up the residue, the trace is not destroyed and another method of detection can be tried. When electrostatic sampling succeeds and a significant amount of residue is picked up, the resulting trace may show even more detail than the original containing excess residue. Re-photography of the trace or repeated electrostatic sampling can lead to the discovery of new details and more complete images of the trace. There are specially designed electrostatic devices for transferring footwear impressions from the original backing onto a special vinyl film, which is black in colour and helps to increase contrast and photograph the impression. Due to the direct contact of the foil with the researched trace, the transferred trace will be the same size as the original trace on the backing. With the electrostatic sampler, it is theoretically possible to lift all footwear traces from porous or non-porous surfaces. The device works best with footwear impressions formed by dry dust or dried residue on relatively clean surfaces. If the trace was wet when it was created or has subsequently become wet before sampling, the electrostatic device will work slowly or not at all. If it is not known whether the trace was wet or dry initially, the use of the electrostatic sampler does not present a risk of destroying or losing the trace (Pășescu, 2000, p. 109; Bodziak, 1990, p. 105).

Chemical methods of contrast enhancement and detection. The luminol reaction occurs when it comes into contact with haemoglobin in the blood, oxidising in an alkaline solution, a phenomenon known as chemiluminescence. Simply put, when a luminol mixture is sprayed onto a blood stain, a visible and photographic luminescence is produced. Luminol is sensitive enough to detect even very low concentrations of blood. It is therefore used at the scene of an incident to fully identify bloodstains and footwear marks. Blood can be detected with luminol even after months or years and can be used in further investigations, even after the routine crime scene investigation is complete. However, it should be noted that luminol produces a weak luminescence in the presence of certain metals, strong oxidising agents (such as bleaches) and even vegetable matter. If serological testing is required, it should be carried out before luminol is used. Because a sufficient amount of luminol is required, which could affect the integrity of the footprint due to the short-lived reaction, and because the photograph must be taken in total darkness, luminol is only used at the last minute for footwear prints that cannot be revealed by other methods. The main advantage of this method is that the photograph is taken in total darkness, so the background colour is no longer important. Thus, in the case of bloodstains on red or multi-coloured carpets or dark surfaces, when the contrast for photography is insufficient and no other method of highlighting as described above can be used, the bloodstains can be highlighted with luminol (Pășescu, 2000, pp. 110-111).

Objects lifted with foot and shoe prints, casts and adhesive foils with foot and shoe prints will be packed according to the rules, which exclude the risk of accidental loss or damage of prints during storage or transport to the laboratory. Paper, cardboard or wooden boxes and crates, etc. shall be used for packaging. The trace-bearing surface of packaged objects shall be secured in such a way as to exclude: contact with the packaging; change of position; contact with chemical reagents; knocking on the object; influence of high temperatures. In order to achieve this result, casts packed in boxes or crates shall be wrapped or covered with paper, cotton wool, textile material, sponge or similar materials, which may be secured to the packaging by means of collars, avoiding contact of the trace-bearing surface with the packaging. Adhesive sheets with the given category of marks shall be packed according to the rules laid down for papillary marks.

3.5 Interpretation of Footprints at the Scene

The interpretation of the footprints at the scene of the crime, especially in cases with unidentified perpetrators, must provide the possibility of perceiving and interpreting data that can present the very person of the perpetrator, namely the specific mode of his action – modus operandi – whether he is male or female, whether he is a minor or an adult, whether he acted alone or is a co-perpetrator, as well as many other data (Zamfirescu, 2000, p. 52).

The interpretation of footprints in the field of crime can provide three main categories of information:

- information that can help to know and reconstruct the activities of the persons who left the footprints;
- information that helps to identify the footwear that left the footprints;
- information that helps to identify the persons who created the footprints. Information included in these categories may also be used to verify the statements of witnesses heard in the criminal case under investigation (Pășescu, 2000, p. 109).

The interpretation of the traces at the scene involves the analysis of both the individual traces and the whole trail formed by the traces. In interpreting individual tracks, information may be obtained on the number of persons involved, their sex, approximate height and age, and approximate weight. The track provides additional information about direction and speed of travel, gait characteristics or possible anatomical deficiencies (gheorghiță, 2017, p. 199).

A first piece of information that can be obtained from examining and interpreting the footprint can help us to assess, with a high degree of accuracy, whether the person who left the footprint is walking or standing still.

The arguments we can rely on are as follows:

- the footprint left by the bare foot of a person standing still is shorter in length than the footprint left by the same person while walking. The difference can be between 1 and 2 cm;
- the width of the barefootprint is, on the other hand, larger when the person is standing still and smaller when they are moving. The difference may be between 0.5 and 1 cm;
- the footprints left by the toes of the barefoot are round when standing still, but become longer when walking;
- the difference between the footprints left when walking and those created when standing still can be established with certainty by examining their arrangement on the ground;
- when there are several of them, they have different orientations and overlap, they show that the person has been standing still (Pășescu, 2000, pp. 117-119; Locard, 1948, p. 435; Ștefănescu, 1984, p. 26).

The track also contains data on the direction of movement, gait characteristics or any anatomical defects, height, psychophysical state, etc. For example, the length of the step is longer in men than in women by about 20 cm (70-90 cm compared to 50-60 cm). The step angle is smaller in women, children and the elderly, as opposed to people who are obliged by the nature of their work to maintain their balance (sailors, builders) (Stancu, 2015, p. 139).

Sometimes the footprint may also show some physical characteristics of the perpetrator. Limping is reproduced in the trail by the different length of the steps of one foot without the other. A wounded foot will step shorter and with less pressure. There may also be shuffling of the foot and the characteristic footprints of using a cane, crutch or prosthesis.

Irregular footprints, oscillations in the direction of travel, repeated stops, reversals and changes in direction of travel, footprints from a fall indicate that they have been left by an injured, sick, congenitally deformed, tired or intoxicated person, etc. In such cases, the body's balance cannot be controlled and generally the characteristic elements will no longer be constant (Anghelescu et. al., 1976, p. 156).

The direction of movement in normal gait is indicated by the position of the legs and the angle of gait.

The outer contour of the sole will be smooth and the starting point of the track will be well defined with a slight tendency to slide forward. Striations may be seen on the outline of the track up to the middle. At the fingertips, a dent caused by pushing back can be seen, and lifting the fingers will create an irregular outline of the trace, while bringing soil particles in front of the trace.

In the case of surface tracks, the actual direction of travel can be determined by the fact that the shape of the sole leaves a clear impression and the shape of the fingertips appears more pointed and elongated. On hard surfaces covered with dust, particles entrained in the direction of travel can be observed. The presence of attached particles may indicate the actual direction of travel, because in the process of trace formation, attachment occurs initially, which is reproduced by the formation of a destratified trace, and then the attached particles are released in subsequent traces, creating stratified traces. These are at first less clear, but gradually become more obvious until they disappear completely (Anghelescu et. al., 1976, p. 156).

The speed of movement can only be determined as a guide, indicating that the individual who left the tracks moved relatively normally or ran away.

Deep tracks created in flight have a characteristic convex, arcuate shape and sometimes the tips of the soles are clearly visible. Footprints in which only the shape of the heel, even a partial one, is visible indicate a rapid movement with large steps. If the stride length exceeds 90 cm, it is a sign that the person has been running.

The general shape of the footprints and the ratio between them, as well as their lateral distance from the gait axis, can also help to judge the speed of movement: adults (men) have, according to F. E. Louwage, a stride length greater than 0.85 m when walking normally, and the feet will be placed at the same distance from the gait axis. During running, very strong impressions will be seen on the tips of the feet, the lateral distances will not be so regular, but will be smaller (Pășescu, 2000, pp. 119-120; Louwage, 1939, p. 16).

Irregularities in gait may indicate not only certain psychological or pathological conditions (such as illness, alcohol consumption, restlessness), but also attempts to disrupt the investigation, such as walking backwards (reflected by reduced step length and angle) or walking behind a person or weight (inferred by greater depth of the footprints, slight slippage, small step angle, use of smaller or larger footwear, etc.). It can also be established whether the person knew the place, used a light at night, was on the lookout, etc. (Stancu, 2001, p. 148).

Establishing the stopping point and the duration of the stop. According to H. Gross, stopping while walking can be easily recognised because the trailing leg is pulled out and forms, together with the other leg, a second track. It is also possible to approximate whether the stop was short or prolonged, because in the case of a prolonged stop frequent departures and returns will be observed, as well as changes in the stationary position.

The joining of the two footprints at the time of the stop is also mentioned by F. E. Louwage, who adds two further aspects: stops of this kind usually occur in those carrying weights, because they need to rest, and the footprint of the object carried, which has been placed on the ground, should also appear around the resting place (Pășescu, 2000, p. 120; Louwage, 1939, p. 10).

The state of obesity, advanced pregnancy (in women) or carrying a weight can be inferred from the following aspects: short stride in length; wide stride in width; large or exaggerated angle of the stride; greater depth of the footprints compared to the footprints left by normal people; appearance of drag marks before the main foot pressure. These aspects may be more easily observed in snow, soft ground or sand, because due to weight, illness or drunkenness, the feet can no longer be raised high enough above the ground, being dragged before the body's centre of gravity changes (Pășescu, 2000, p. 121).

Assessing the number of people involved at the scene is necessary information in the investigation of any criminal case. Footwear impressions found all over the crime scene can, in many cases, help to establish the number of persons involved in the area under investigation.

The main criterion for determining this number is the shape, size and design of the footwear that created the footprints. When only one type of footprint with the same protective pattern, the same shape and similar dimensions is found in the entire area searched, the conclusion is easy to draw: only one person was at the scene. However, when several types of footprints are found which differ in shape, design and size, it can be assumed that as many people have been at the scene as there are different types of footwear remaining after the removal of the footwear created by the victim (Pășescu, 2000, p. 121).

Establishing the time elapsed since the footprints were created is relative. Depending on the intervention of phenomena, circumstances, actions – rain, wind, painting, etc. – which act in a certain way on the footprints or contribute to their formation, it is possible to estimate the period when they were created (Anghelescu et. al., 1976, p. 157).

3.6 Examination and Expertise of Footprints

The possibility of scientifically identifying a person by footprints is based on the properties of papillary patterns on this part of the human body, which are unique and stable. Identification becomes possible when papillary ridges, flexion grooves, scars, warts, calluses and other features are visible on the surface of the trace. These have a similar value to the papillary drawings used in dactyloscopy for identification. The quality of the reproduction of the identifying features of the object (sole) is determined by the way the trace is formed, the plasticity and smoothness of the object receiving the trace. Over time, these traces undergo changes that can affect their value for the identification process.

In general, identification is not possible when the trace only shows information about the shape of the sole, the fingers or their dimensions, or about the pattern of the trace. In this case, it is only possible to establish gender, taking into account the following aspects:

Some quantitative changes in the foot occur from birth to the end of the growth period, which is between 0-25 years for males and 0-20 years for females;

For a relatively short period of time within the growth period, the foot support surface of the human foot does not change significantly. A real type-dimensional "stabilisation" can be registered after the end of the growth period of the human body (Anghelescu et. al., 1978, p. 53).

The main problems that forensic footprint forensics can solve, whether it is the bare footprint or the footwear footprint, depend on whether the forensic expert is presented with only the footprint taken from the scene (in the sense of a mould, photograph or drawing), or with comparison patterns (Moiese et. al., 2020, p. 83).

Various procedures are used to obtain comparison patterns from the alleged maker of the trace found at the crime scene.

In order to obtain surface plantar prints, the suspect is first asked to step on a plate on which a layer of printing ink has been deposited, then on a sheet of white paper. In order to obtain an accurate image of the construction of the sole of the foot in different positions, at least four positions are taken for the impressions created during standing, namely: standing still in the normal position, standing still with the weight of the body resting on the outside of the sole and on the inside respectively, and a walking position (Anghelescu et. al., 1976, p. 157; Suciu, 1972, pp. 249-250).

For the examination of tracks formed in the snow and comparison patterns must also be made in the snow, the same conditions being preserved not only for the plastic rendering of details by the snow, but also for the specific shape of the mouldings raised from these tracks.

For the creation of the experimental footprints of walking in socks, the same socks should be used with which the footprints were created at the scene, as it is not only the shape of the foot that is of interest, but also the fabric or wear elements of the socks.

A mixture of clay and fine sand is used for the experimental creation of the footprints, in which the person suspected of having created the footprints discovered will step several times. The fact that the experimental model is made of finer material than the investigated trace does not disturb the comparative examination, but, on the contrary, ensures that the various characteristics of the object appear more complete. In addition to these experimental traces, depth traces can be removed, if considered necessary, from the same material as the scene.

If the depth or surface trace of the bare foot found at the scene reproduces part of the papillary pattern, the reproduction of the experimental traces should be the first point of emphasis in the execution of the experimental traces, as it is considered the main element in the identification process.

Even if the trace found at the crime scene is a deep trace, the experimental patterns in this case will be created both as deep traces and as surface traces, in order to retain as accurately as possible the shape of the papillary design (Suciu, 1972, p. 250).

The forensic expert will rely on establishing, by comparison, the coincidence of the characteristic elements of the footprint with those of the foot shown in the comparison models or of the footwear in the case of the footprint in question. The general characteristics of the sole of the foot are: shape and dimensions of the sole, size and position of the toes, shape of the flexor lines. Individual character of papillary ridges and patterns, scars, calluses, skin cracks, accidental and anatomical defects. When examining footwear, the model of the shoe, the shape and size of the sole, the shape of the toe, the configuration of the topline and the heel, the way the sole is fastened, and other general elements should be compared. The decisive role in the identification process will be played by the coincidence of individual characteristics in the form of relief elements, various defects resulting from the manufacture, operation and repair of the footwear (Doraș, 2011, pp. 151-152).

The basic rule of these comparative analyses is that objects of the same nature are always compared, i.e. traces with traces, mouldings with mouldings, photographs with photographs. If this rule is not observed, there is a risk that the various characteristic details, which are not reflected in these different forms of presentation, cannot be identified (Suciu, 1972, p. 251).

Guiding questions to ask the expert when presenting the trace and model for comparison:

- whether the footprint presented for examination is a footprint;
- whether footprints are found on the object presented and how many;
- whether the plantar footprint has sufficient individual elements for identification;
- what is the sex, approximate weight and age of the person who created the plantar footprint;
- from which footprint the footprint under examination originates;
- what is the mechanism of formation of the footprint;
- with what substance was the footprint created;
- what is the approximate age of the footprint;

- what is the direction of travel of the person who created the footprint;
- what are the anatomical and pathological peculiarities of the person who created the footprint;
- whether the footprint and the model for comparison were created by the same person (Anghelescu et. al., 1978, pp. 157-158).

Chapter IV

Forensic Investigation of Other Homeoscopic Traces

4.1 General Information

Homeoscopic traces are an important component of forensic investigation and evidence analysis. These traces refer to the marks left at the crime scene by objects or surfaces in direct contact with the human body during the commission of the crime.

Although the most common homeoscopic marks are associated with feet and hands, there are other types of marks that can be used for identification and analysis. These may include, for example, dental marks, skin marks or even traces of blood, saliva or other biological substances.

Examination of the traces formed by the components of the physiognomy can provide important information on the age group, the particular characteristics of the offender, etc. For example, the age of the subject is determined by the degree to which the age characteristics of the skin are imprinted. In teenagers (up to 29 years old) there are still fuzzy hairs on the face, rounded shapes of the facial features, "puffy" lips, and lack of wrinkles. For middle-aged people (up to 55 years) the presence of creases on the forehead is specific, the number of which corresponds approximately to the number of decades of the individual, i.e. two creases – from 20 to 30 years, 3 – from 30 to 40 years, etc. In older people (over 55 years) the degree of general wrinkling of the skin increases, creases and wrinkles on the face become more pronounced and therefore more visible in the traces. Lip marks take on the character of narrow stripes. The particular markings imprinted in the trace can be considered as peculiarities resulting from trauma or skin diseases: scars, burns, cuts, warts, pimples, pigmentation spots, hairy spots, moles, eczema, etc., which register specificities when imprinted in traces.

The tracing research of such traces sometimes allows to solve also identifying tasks, therefore, being extremely fine, the process of fixing and lifting them requires the involvement of specialists, often under laboratory conditions (Golubenco, 2015, pp. 40-41).

4.2 Forensic Investigation of Teeth Marks

In forensic research, there are two aspects to the issue of teeth marks: the forensic aspect, which is mainly concerned with establishing the identity of unknown corpses (forensic odontology), and the forensic aspect, which is concerned with studying teeth and teeth marks in order to establish the truth in the judicial process (Cîrjan, 2005, p. 236).

The field of intersection between forensic medicine and forensic science, known as forensic odontology, focuses on the study of teeth and the interpretation of dental traces in the context of the judicial process. Through the use of dental expertise, forensic odontology aims to contribute to the truth in the judicial system, as expressed in the literature (Stancu, 1992, p. 150; Harvey, 1976, p. 2).

Dental records are a category of records that provide a solid basis for identification, both from a forensic and a forensic perspective, due to the characteristics of the shape, arrangement and peculiarities of each tooth. These characteristics become more relevant after the age of 25, when the development of the dentition is complete. Thus, the width of the teeth, their position and spacing, wear, absence of some teeth, presence of diseases (such as caries), dental treatments and dental work, provide sufficient elements to identify individuals (Stancu, 2015, p. 140; Minovici, 1930, p. 1055; Anghelescu et. al., 1976, p. 165; Suciu, 1972, pp. 258-259; Simonin, 1974, p. 748; Derobert, 1976, p. 1082; Svensson, 1957, pp. 82-84; Gayet, 1973, pp. 46-47; Le Moyne Snydere, 1959, pp. 54-57).

The tooth is an organ that creates impressions and is fixed in the tooth socket. In total, there are 32 teeth, equally divided into the two hemiarches, with their shape and volume adapted to their function in the chewing process. The tooth structure comprises a visible portion called the crown and a portion covered by gum called the root. Between these two areas there is a narrowing called the colectum. The crown of the tooth is made up of two layers – enamel on the outside and dentin on the inside – and has six sides. The root of the tooth is encased in cement and surrounded by an organic tissue called the paradontium, and all of these structures lie within the tooth socket. The dental alveolus has a cavity shape and is made up of spongy bone lamellae covered by gingiva, which can undergo sclerocicatarrhotic changes following tooth extraction (Anghelescu et. al., 1976, pp. 165-166).

The scientific basis for identifying a person by the teeth marks created on the human body is based on several characteristics of the dento-alveolar apparatus. These characteristics include uniqueness, relative stability, individuality and reflectivity, which combine with the ability of the tissues to react defensively to mechanical and biological aggression. Uniqueness is evidenced by the fact that no two individuals have a perfect correspondence of all morphological and morpho-pathological characteristics of the dento-alveolar apparatus at the same reference time. Relative stability refers to the fact that teeth retain the same characteristics for a certain period of time. Individuality is the permanent dynamics of the dento-alveolar apparatus, imposed by vital processes, defence factors and adaptation to new operating conditions, etc. Reflectivity refers to the ability of tissues and substrates with minimal plasticity to receive and retain morphological and morpho-pathological characteristics of teeth (Anghelescu et. al., 1978, p. 68).

Tooth marks are formed as a result of biting actions undertaken with the aim of detaching a piece from a whole. More frequently this category of marks is found on the surface or in the depths of objects of a food nature (chocolate, cheese, butter, fruit), less frequently on smoking remains, hard objects, corpses and the body of the offender (Doraș, 2011, p. 153).

Tooth marks, created on various surfaces, can be observed at the incident site in static form, where the outline, location, spacing and width of the teeth are highlighted, or in dynamic form, where striations are formed on the receiver surface, resulting from irregularities in the occlusal surfaces of the teeth.

Dynamic marks are mainly created by the teeth in the upper jaw, as they exert resistance when the object in contact is pushed upwards by the teeth of the mandible (Anghelescu et. al., 1976, pp. 166-167).

Through biting, the teeth typically create depth marks on the human body. However, because of the elasticity of the skin, these marks become surface marks. In the case of lesions produced only on the epidermis on the living body, after a few hours, excoriations may appear on the contact areas. If the bite has also affected the dermis, the marks may bleed and form scabs, and due to the body's reactivity, they may increase in volume, going beyond the skin. In the case of marks created on the human body, it should be taken into account that after the bite, the skin relaxes, causing changes in the width of the teeth and the distance between them behind. The degree to which the marks undergo changes depends on the area injured and on each individual body. However, tooth marks imprinted on the human body can provide important information in identifying suspect individuals, especially when wear features are present or when a tooth is missing from both jaws (Mircea, 1999, p. 96). Tooth marks reflect, and this has been confirmed in practice, structural elements of the dental apparatus, including features of the external construction of the teeth which, taken together, ensure identification of the perpetrator of the marks (Doraș, 2011, p. 153).

Since tooth marks, regardless of the nature of the receiving object, are always visible, searching for and finding them does not create difficulties. In view of the crime committed and the whole of the place under investigation, by careful examination, under natural or artificial light, these marks are discovered by the naked eye (Gheorghiță, 2017, p. 200).

By meticulously examining the teeth marks, highly relevant information can be obtained, which makes a significant contribution to the operational profiling of the individual who generated the marks and to their identification by means of the trace forensics. Tooth marks, most of which are visible, are discovered by detailed investigation of all objects present at the crime scene on which these marks may have been deposited (Doraș, 2011, p. 153).

From the study of the teeth marks, made at the scene, it is possible to obtain data about the person who created them, in terms of the mode of operation, the placement of the teeth, the distance between them, their absence and other relatively unchanging characteristics.

The teeth impression is able to give some information about the constitutional type of the person who created it, as well as his or her age, at the scene. Anatomical elements are taken into account which are deduced from the interpretation of the appearance of the teeth impression, such as: their size and arrangement; the width of the alveolar arch; the presence of dental malformations and their appearance corresponding to the person's state of health.

The condition of the receiving object, manifested by the degree of oxidation, melting, freezing, dehydration, etc., makes it possible to make interpretations of the time that has elapsed from the time of the creation of the trace to the time of discovery. When formulating the various hypotheses, the temperature, humidity and ventilation conditions in which the trace object was kept until its discovery must be taken into account (Anghelescu et. al., 1976, p. 168).

In order to be used during the investigation, the traces must be fixed by various methods, such as description in the on-the-spot investigation report, photography and the use of moulds.

The description of the traces in the on-the-spot investigation report must follow the general rules for the preparation of this important document. Particular attention shall be paid to the description of the substrates on which the tracks were found, including information on their nature and consistency, number and shape. If the item is the body of a living person or a corpse, the area where the footprints were found shall be mentioned, specifying the nearby organ such as eyes, ear, nose, etc. If there is more than one footprint, the distance between them shall be recorded. Each trace is described separately, mentioning shape, size and appearance, as well as colour, and other relevant details (Ciopraga et. al., 2001, p. 73).

Photographing this category of traces is reasonable, because with the author of the photograph it is possible to adequately demonstrate the object, the nature of the traces and their characteristic details (Gheorghiță, 2017, p. 200).

The photographing of teeth marks is carried out both on the object bearing the mark and on the moulding that is subsequently raised. Photographs of mouldings give more accurate details of the trace, due to the light colour of the background, but moulding of traces does not always succeed and sometimes completely destroys the traces, so that photography remains, if not the best means of mirroring the trace, in any case the most reliable (Suciu, 1972, p. 259).

Toothprint photography is carried out in a systematic way, respecting certain technical parameters. Groups of marks are photographed from a distance of about 30-50 cm, with the camera positioned perpendicular to the surface of the trace-bearing object. Illumination can be provided by natural sunlight or by an artificial light source such as matt bulbs. In the case of surface tracks, illumination shall be provided by a single light source positioned behind the camera, with the light beams directed perpendicular to the track. In the case of depth marks, in addition to the main light source, a secondary light source of lesser intensity is used, placed laterally, with the light beams obliquely directed on the marks, to create subtle shadows to highlight details. After the group shooting, to obtain the details of the tracks, photographs are taken from an even shorter distance, around 5-10 cm. For this purpose, the focal length of the camera is increased, similar to photographing handprint details. To ensure stability and accuracy, the camera is fixed on a stand and the lens is oriented perpendicular to the track (Mircea, 1999, p. 97).

To obtain the actual dimensions of the footprints, it is recommended to use a graduated line placed next to the track (Ciopraga et. al., 2001, p. 73).

For moulding depth marks, it is important to follow certain steps and to observe the necessary preparations. Before moulding, the trace should be described and photographed, as the moulding process will destroy the trace. In order to prepare the trace for moulding, it must be cleaned of any foreign bodies or impurities. Then, around the trace, a plasticine fence can be created, if necessary, to obtain a thicker moulding with greater resistance to handling. This plasticine fence helps keep the moulding paste inside the trace area and prevents it from leaking out of the moulding. After preparing the trace, the moulding paste can be poured into the trace according to the specific instructions of the moulding product used. It is important to work carefully and accurately to obtain a faithful moulding of the deep trace (Mircea, 1999, p. 98).

The choice of material for moulding the trace is made in relation to the resistance of the trace material to pressure, heat and water. The moulding of depth marks formed on the human body is made with: latex, or various polymers. Good quality plaster can also be used, with a little salt added to speed up the hardening process (Suciu, 1972, p. 260).

In order to prevent the trace object, i.e. the trace, from being altered by the composition of the mould, either because of its dissolution in water or because of the pressure exerted by the weight of the composition through which the mould is lifted, the trace should be hardened with a layer of serac or with colodion in ether before casting (Gheorghiță, 2017, p. 201).

Once the trace is prepared for fixing by this process, the moulding paste of dental plaster and water is prepared, in the manner we have seen in the depth traces left by the feet. The moulding paste, in order to render the smallest details, should be quite fluid, about the consistency of cream. After 20 – 30 minutes the moulding is hardened enough to pick up and transport (Mircea, 1999, p. 98).

Tooth mark moulds on various types of toothbrushes are removed with: high quality plaster mixed with salt, Momax paste or Kerr paste, but more diluted than used for dental moulds. Latex and polymers can also be used.

Tooth marks formed on food, such as liver pâté, salami and various sandwiches, can only be removed after a good curing of the mark with collodion or serac.

Traces formed on apples, orange peels, and pears are removed with salt plaster after spraying a protective layer of serac with collodion.

Traces on chocolate and glazes are removed with dental plaster with a little salt, but only after the trace has been well hardened by spraying with collodion.

The mouldings lifted from teeth impressions found at the scene and from experimentally created impressions should be photographed only with side light, as the uniformity of colour of the materials used as mouldings would lose the outline of the details (Suciu, 1972, pp. 259-260).

Special care should be taken when picking up and transporting objects bearing teeth marks. As a general rule, teeth marks should be picked up together with the tooth-bearing object, but given the inherently deformable nature of most tooth-bearing objects, special precautions and safeguards should be taken when picking up, transporting and storing them (Gheorghiță, 2017, p. 201).

If the teeth marks found at the scene are formed on food objects such as butter, cheese, chocolate, etc., they should be kept cold for as long as they are not being worked on for photographing or moulding. The fruits are kept in a 5% formalin solution, but during transport they are removed from the solution and wrapped in very thin paper soaked in formalin, because they would be crushed in the solution due to sloshing during transport.

It is a mistake to cut off the tooth-bearing skin and keep it in formalin. The skin shrinks and distorts the trace both in size and construction details. The clearest deep marks on the human body are those formed after the death of the victim, in which cases the body does not react to the bite (Suciu, 1972, p. 260).

Before obtaining models for comparison, it is necessary to make a preliminary comparison between the mould or photograph of the disputed trace and the dentition or mobile dental plate of the suspect persons, excluding on this occasion those which show obvious distinguishing features. Bearing in mind that the dentition may undergo changes due to various causes, it is necessary to take steps to ensure that as little time as possible elapses between the time when the impression is taken and the time when the models are obtained for comparison.

Depending on the material on which the impression was made, its shape – static or dynamic – and the area of the dentition that came into contact with the receiving object, models for comparison are obtained from the suspects (Anghelescu et. al., 1976, p. 168).

Comparison models are obtained with common dental materials (dental plaster, dental wax, plastics, etc.) and latex or various polymers may also be used for mouldings made on the trace-bearing objects (Stancu, 1992, p. 152). In most cases, which is justified by the laboriousness of this procedural action, tooth and lip impressions are obtained with the help of forensic medicine, dentistry or otolaryngology specialists (Doraș, 2011, p. 154).

The perpetrators are asked to perform experimental bites in dental wax, soaked paraffin, plasticine or even in the same kind of object as the one in which the disputed marks were left. As the position of the perpetrator's jaws during biting may be different (one jaw may be pushed forward or back or deviated sideways), it is recommended that the person from whom the comparison model is taken should bite at least 3-4 times, with the jaw in different positions.

For comparative examinations, especially in cases where the curvature and placement of the teeth – more common in bite marks on human skin – are shown, suspects are asked to squeeze a piece of filter paper or sucker folded in 4-6 layers between their teeth several times.

In order to correctly compare and identify the dental striation marks, it is necessary to obtain comparison patterns on objects similar to those bearing the marks discovered on the spot. These master models are created to serve as references in the comparative examination process.

It is important that the test patterns are obtained on substrates of similar hardness to the trace objects. This makes it easier to obtain an accurate impression of the dental features in the contact area. If less hard substrates are used, all tooth characteristics can be printed, including insignificant ones, which can make the comparative examination process more difficult.

Also, in obtaining master models, care should be taken to ensure as far as possible that the object on which the models are created is positioned in a similar way to the object bearing the impressions. This ensures a more accurate comparison between the streak marks and the master patterns (Anghelescu et. al., 1976, pp. 168-169).

The examination of teeth marks left on human skin (of the corpse or living person) has certain distinct features. These peculiarities are mainly determined by two aspects. Firstly, there are difficulties caused by the characteristic plasticity of human skin. This can lead to distortion of the trace and a special approach may be needed to record and analyse it properly. On the other hand, there are also pathological processes that can affect the integument and cause the trace to become deformed or even gradually disappear. This underlines the importance of measuring and photographically fixing the trace in an urgent and accurate way. In such cases, special techniques are used to compare impressions. These impressions can be obtained on filter or suction paper, or on media with a plasticity relatively similar to that of human skin, such as paraffin or dental wax (Stancu, 1994, p. 217).

In order to obtain the negative shape of the moulding, paste is applied to the appropriate area. Dental plaster is also used to make the positive. Both the moulding and its photograph can be used in the identification process (Anghelescu et. al., 1976, p. 169).

The expert examination of the tooth impressions consists of comparing the characteristic elements revealed in the impressions with those in the comparison models, using visual or microscopic observation methods. The purpose of the examination is to identify the person responsible for the teeth marks and to determine the mode of biting, the features of the bite, the biter's dental apparatus, approximate age and other relevant information (Doraș, 2011, p. 154).

The general characteristics of the teeth reflected in the marks left by them on the human body refer to the following:

The shape of the dental arch, which may be: square hyperbolic, characterised by the slightly flattened curve of the incisors and the two-step positioning of the premolars and molars; semi-elliptic, characterised by the portion of the circle formed by the set of front teeth. The line of the premolars and the first two molars on the right is diverging from the midline in relation to the similar anatomical region on the left, and the line of the last two molars is again converging on the part of the right semi-arch; U-shaped, characterised by the fact that the front teeth are placed on a circle with a smaller radius than the semi-elliptic arch. The line of the premolars and molars is straight; Omega-shaped, characterised by the narrowing of the arch at the level of the premolars and the first molar, which causes the curvature of the lateral line, with a vestibular concavity; M-shaped, characterised by the accentuated vestibularisation of the canines, the normal orientation of the lateral group and the arrangement of the frontal group on a curved line; V-shaped, characterised by the vestibularisation of the incisors, the palatalisation of the canines and premolars. The two half arches are divergent from the midline to the distal end; length, width and depth of the bite; size of the interdental space; indications of the presence or wearing of full dentures; appearance of the incisal edge of the arch.

Group dental disharmonies: prodention, retrodentation, exodention, endodentation, superdentation, etc.; the emergence of an edge of a tooth from the dental row.

Dento-alveolar disharmonies: dental crowding, dental spacing.

Dento-maxillary anomalies: sagittal disharmonies (mandibular prognathia, superior retrognathia, mandibular retrognathia, inferior prognathia); transverse disharmonies (endoalveolus with proalveolus, superior endoalveolus with dento-alveolar congruence, mandibular laterogenesis); vertical disharmonies (deep occlusion, open occlusion) and complex disharmonies (Anghelescu et. al., 1978, pp. 70-71).

The individual characteristics of the marks created by the dento-alveolar apparatus on the human body are: anomalies of site, number, shape, size, orientation, structure; presence of signs of odontostomatological intervention or inflammatory reactions of a specific character (lues, T.B.C.); signs of alterations in the conformation of the incisal edge or vestibular surface; particular location of teeth; dimensions of interdental spaces; presence of supernumerary dental tubercle; changes in the consistency of the dental organ; presence of trace-material of dental origin; malocclusion; denentulous fissures; dental fractures; irregularities of the incisal surface; degree of dental abrasion; missing teeth; root remnants; congenital malformations; mesio-distal and vestibulo-lingual dimensions of the incisal margin; tooth height; height variability of teeth belonging to the same anatomical-functional group; infra- or superposition; rotation in the axis; eruption anomalies; formal angle of the incisal edge with the horizontal; degree of wear of the incisal edge; paradental anomalies; enamel pearls, dentuoam (Anghelescu et. al., 1978, pp. 70-71).

Guiding questions to ask the expert when presenting the impression and model for comparison: whether the impression was created by human dentition; what are the approximate sex and age of the person who created the impression; what are the characteristics of the dentition of the person who created the impression; what is the anthropological type of the person who created the impression; whether the dentition that created the impression underwent dental treatment; what was the mechanism of formation of the impression; whether the tooth impression presents sufficient elements for identification. The expert may also be asked to reconstruct the person's physiognomy from the teeth marks; whether the teeth mark was created by the person from whom the model was taken for comparison (Anghelescu et. al., 1976, pp. 169-170).

The examination of the teeth marks includes the following steps:

Separate examination. At this stage the features reflecting the external macroscopic appearance of the morphology are examined and noted, and then, depending on the case, specimens are taken and analysed for histopathological examination. The expert will analyse the specific features of the victim's dento-alveolar apparatus to determine whether there is a possible self-healing (simulation). If anatomical or morpho-pathological details cannot be sufficiently highlighted, either because of the presence of a full denture or because of a long time elapsed from the occurrence of the trace to its examination, the expert can only make an assessment based on general features. The separate examination of tooth impressions created on the human body, in order to obtain comparison models, is concerned with highlighting descriptive elements such as: number, location, general appearance compared to a well-defined geometric shape, dimensions (length, width, depth), colour, presence of biological products and foreign bodies, variation of dental levels within the same group of teeth, size of areas on indicative support, repeatability characters, overlapping of traces, accessibility of the anatomical region for self-reading, general impression, local reactions, neighbourhood reactions, signs of intentional aggravation of objective symptomatology, occurrence of mutilations or serious bodily injuries, arrangement of traces in relation to anatomical landmarks, deviations from the contour line, condition of underlying tissues and age. During the separate examination of tooth impressions and those taken for comparison, various procedures and techniques are used, adapted to the specifics of each situation. These may include: Metric and angular measurements to determine the dimensions and configuration of the impressions; External macroscopic morphological examination of the impression surface to reveal features visible to the naked eye; Macroscopic morphological examination of biological products associated with the impression (e.g. saliva, blood etc.); External macroscopic morphological examination of the impression surface to reveal features visible to the naked eye.); Radiological study of the bone substrate to analyse the underlying bone structure of the trace; Internal macroscopic morphological study on the sectional surface to examine the internal structure of the trace; Odontostomatological examination of the person with a tooth trace to assess the general condition of the oral cavity and identify any features of the dental apparatus; Removal of histopathological specimens for further laboratory analysis; Collection of normal or pathological biological products associated with the impressions for further investigation, such as microbiological, parasitological or virological examinations; Taking casts or dental impressions to create three-dimensional reproductions of the impressions; Outline drawing and photography for detailed documentation and recording of impressions for analysis and comparison purposes (Anghelescu et. al., 1978, p. 71).

Comparative examination. In the comparative examination stage, the forensic scientist will analyse the following characteristics of the trace for identification and evaluation purposes: Overall conformation of the trace: examine the overall shape and contour of the trace to identify similarities or differences between the traces; Metric and angular data: measure the dimensions and angles of the trace for comparison with reference patterns and evaluation of the degree of match; Depth variability: depth variations of the traces are analysed in order to highlight distinctive features or peculiarities of each trace; Trace arrangement: examine how the traces are placed in relation to each other and to other nearby objects or structures; Numeric variability of traces: compare the number of traces for the same circle segment, identifying possible differences or coincidences; Elements representing the structure of the dento-alveolar apparatus: Examine the specific features of the impressions that may indicate the structure and configuration of the dentine apparatus of the individual who left the impression; Type of dental occlusion: examine how the teeth fit together and interact after detailed examination of the impressions; Depth aspect of the impression: study how the depth of the impressions varies and how this may influence the overall shape and appearance of the impressions; Size of the untouched support interval: assess the space unaffected by the trace, which can provide clues about the specific size and configuration of the dental appliance; Changes due to malformations, denture support or surgery: consider possible changes in the trace caused by factors such as dental malformations, the presence of dentures or previous surgery (Cîrjan, 2005, pp. 239-240).

Demonstration. In order to demonstrate the results of the examination carried out by the expert, the following procedures may be used:

- the synoptic table procedure: comparative presentation of the general and individual characteristics of the tooth marks and comparison patterns in a table;
- the comparison procedure: parallelisation of tooth marks and comparison patterns to highlight coincident characteristics;
- the linear continuity procedure: sectioning and reverse bonding of tooth impressions and comparison patterns to check that the features maintain their morphological appearance;
- the superimposition process: superimposing the transparent tooth impression image over the comparison pattern image or superimposing the tooth moulding over the tooth impressions;
- the quinogram process: use to illustrate the stages of the tooth impression creation mechanism (Anghelescu et. al., 1978, p. 72).

Drawing conclusions. The following conclusions can be drawn in tooth impression surveys: positive certainty; negative certainty; probability; impossibility (Cîrjan, 2005, p. 240).

Anthropometric and pathological expertise can be used in the evaluation of tooth marks. The answers provided by the expert may include the following aspects:

Identification of the nature of the toothprint: the expert can determine whether the toothprint is of human or animal origin, based on the morphological and structural characteristics of the toothprint;

Determination of the approximate sex and age: in some cases, the expert can provide information on the approximate sex and age of the person who created the tooth impression, taking into account the dimensions and specific characteristics of the teeth and dentition;

Identification of anthropological type: by analysing dental and anthropological characteristics, the expert can provide clues as to the anthropological type of the person who created the impression;

Specific characteristics of the dentition: the expert can highlight specific features of the tooth that created the impression, such as the presence of caries, restorations or dental malformations;

Mechanism of impression formation: by examining the impression in detail, the expert can deduce how the impression was formed, providing clues about the pressure, angle and direction applied when the impression was created;

Checking fit with comparison models: The expert can assess whether the tooth impression is consistent with the comparison patterns taken from the person suspected of leaving the impression, identifying any similarities or differences;

Identifying the tooth group: the expert can indicate the tooth group that created the impression, such as molars, incisors or canines, based on the characteristics and configuration of the impression (Anghelescu et. al., 1978, p. 73).

4.3 Forensic Investigation of Lip Marks

The importance of lip print research in the scientific process of identifying a person has recently been highlighted in forensic research. Although not all authors agree, the arrangement and shape of papillae and corial grooves, commissural angles, median dimple, upper lip tubercle, all make it possible to identify a person. This becomes more feasible when the data obtained is correlated with other forensic identification elements. Some express reservations about identifying on the basis of lip prints, arguing that lips can change during life as a result of injuries or pathological conditions. In contrast, proponents of lipprint-based identification rely on the stability of the lip patterns because identification occurs within a short time after the creation of the lipprint, when the person cannot undergo essential anatomical changes (Cîrjan, 2005, p. 242; Papilian, 1979, p. 14; Ifrim et. al., 1988, p. 374; Mircea, 1996, p. 133; Ceccaldi, 1962, p. 50; Anghelescu et. al., 1978, pp. 61-62.).

The identification of the person from the chorionic lip patterns is based on the following: the categorical uniqueness (individuality) of the chorionic patterns; the stability over time of the individual characteristics of the chorionic patterns.

For the forensic identification of lip marks, only those left by the anterior wall of the buccal vestibule, i.e. the upper and lower lip, through the chorionic papillae are of interest. Congenital malformations of the anterior wall of the lips reflected in the lip marks are also important. The fidelity of the corial papillary pattern depends on the surface smoothness of the contact object, the coefficient of adhesion, the composition and abundance of lip substance, and the degree of lip pressing (Anghelescu et. al., 1978, p. 60).

Lip marks allow identification of the person with the same certainty as in dactyloscopy, because the corial drawings are absolutely unique and individual for each person. Also, the identification value of these marks lies in the fact that their design is relatively stable and retains the same shape over a long period of time, allowing identification even months or years after their creation. Lip marks, like other traces, must be corroborated with other evidence in order to establish the link with the criminal act, since their existence only in a particular place proves that the person concerned has only passed through that place. In order to understand the mechanism of the formation of the lip marks, an anatomical description of the lip marks is made, including the edges, the surrounding regions and the distinct morphological characteristics of each lip (Anghelescu et. al., 1976, p. 159).

The lips have the following four categories of tissues in their structure: the integumentary tunica, which consists of the outer skin of the lips and has numerous sebaceous and sweat glands and hair follicles. The pilosity is more developed in men and is also a secondary sexual characteristic; the muscular tunica, which is the thicker part of the lips; the submucous tunica, which contains the salivary glands; and the mucous tunica, which is the tissue lining the inner side of the lips.

Of these, the mucous membrane, which is also called the labial mucosa, is of greatest forensic importance. It continues with the cheek mucosa and the gingival mucosa, and then, at the free edge of the lips, with the skin, through a transitional tissue called ,,pars intermedia” or lipstick.

This transitional tissue is important for identification for several reasons: it is most frequently brought into contact with some objects or foodstuffs; it is permanently moist, due to the deposition of secretions from the oral cavity via the tongue; it shows individual characteristics through vertical and horizontal wrinkles (Anghelescu et. al., 1976, p. 160).

Lip marks form when they come into contact with various objects. These marks may contain deposits of a biological nature, such as saliva, as well as food deposits, such as fats, sauces, juices and wines. Cosmetics, such as lipsticks and Vaseline, can also contribute to the formation of lip marks (Gheorghiță, 2017, p. 201). The marks can be classified into static and dynamic marks. In terms of identification, static marks are particularly useful. Traces can also be visible or latent, but in most cases they are surface traces. Depth traces are rare and are not very useful in the identification process, as the lips can be deformed by pressure. This deformation is common even in normal situations and must be taken into account in comparative examinations (Stancu, 2015, p. 143).

Lip traces have a specific shape, which follows exactly the contour of the creative lips, and therefore they can have the same pairings: thin lip traces; thick lip traces; alternately paired lip traces (top thick and bottom thin and vice versa).

According to shape, the lip marks can be: long lip marks, corresponding to a wide mouth, and short lip marks, corresponding to a small mouth.

Congenital malformations of the face, which create lip conformation peculiarities, are also reproduced in lip marks.

The materiality of the substrate on which the marks are formed is not affected, the changes occur only at the surface level, through the entrainment, together with the saliva which intermittently moistens the mucous layer, of pathological products and other foreign bodies, such as: biological substances (blood, pus, small detached tumour fragments and substances emanating from the body's viral metabolism); toxic substances with salivary elimination; medicinal products and food remains, etc.

Lip marks, depending on the nature of the support on which they are found, will undergo changes in appearance, such as: blurring of the details of the surface of the mark, with central, left or right lateral location; mosaic isation of the surface by alternating areas of layering and destratification; changes in size (exaggerated enlargement: regular, irregular, eccentrically or centrally arranged;

exaggerated shrinkage: regular, irregular, eccentrically or centrally arranged); alteration of the uniformity of the surface; deposition of fragments of foreign bodies on the trace, etc. (Anghelescu et. al., 1976, p. 161).

Lip marks, in most cases, are found in a latent form and are not visible to the naked eye. For this reason, the forensic body must look very carefully for them on the objects at the crime scene and, once found, proceed to highlight them so that they are visible and can be examined in detail (Mircea, 1999, p. 100). When lip marks are visible, they are very easily discovered by simply examining the objects with the naked eye (Gheorghiță, 2017, p. 202).

Research on latent lip marks requires great care and thoroughness. These traces can be found not only on objects with which the lips come into contact on a regular basis, such as glasses, cups, cutlery, cigarette holders, pipes, but also on other objects, including clothing. Therefore, the search for these traces should not be neglected, even on the suspect's clothing, especially in cases where the manner in which the crime was committed suggests the possibility of physical contact between victim and offender, such as in cases of murder, rape, robbery, incest, and others (Stancu, 2001, p. 154).

To discover latent lip marks, similar procedures are used as for latent hand marks. First, suspect objects are examined under different lighting angles, using natural or artificial light. Foreign substances present on the surface of the object reflect light at a different angle to the background of the object. If the results are not satisfactory, a hand-held ultraviolet lamp may be used under dark conditions. Under UV light, substances left by the lips, usually of organic origin, show a bluish fluorescence, as do other organic substances. Optical instruments such as magnifying glasses in the forensic kit or pocket microscopes can be used for more detailed examination of the trace under conditions of adequate illumination of the trace object (Mircea, 1999, p. 101; Cecaldi, 1962, p. 50). One of the procedures used for the detection of latent lip prints is the same as for the detection of invisible handprints. The choice of the appropriate process and substance depends on the nature of the object on which the marks are found, the amount of sediment and the age of the marks.

The procedures for revealing and fixing lip marks are similar in principle to those used for papillary ridge marks on the hands and feet. However, methods considered “destructive” for revealing latent lip marks using chemical or physical substances are avoided. This is done mainly to keep intact the possibility of performing a serological or chemical examination of the trace substance (such as saliva, food or cosmetics). In this way, an attempt is made to maintain the integrity of the samples in order to allow their subsequent investigation in the laboratory (Stancu, 2015, p. 143).

It is recommended to pick up the object bearing the lip print and photograph it, as the adhesive foil transfer method fails to pick up all the elements of the print completely (Cîrjan et. al., 2009, p. 145). By using the method of lifting the lip print carrier and photographing it, the possibility of determining the blood group as well as other chemical and bacterial elements, which may be useful in narrowing the circle of suspects and in gender or group identifications, is not excluded (Stancu, 2001, p. 155).

Before highlighting lip prints, it is important to assess whether they are wet or dry. Depending on this, different methods and substances can be used for highlighting. For example, for wet marks, a fine, slightly oily powdery substance in a colour contrasting with the background of the object bearing the mark can be used (Gheorghiță, 2017, p. 202). If the trace object is multicoloured, fluorescent powders, which are commonly used for highlighting handprints, may be used. These powders, when exposed to ultraviolet rays, can highlight the entire trace, including lip marks. By applying ultraviolet rays, lip prints can become visible and can be examined in detail to provide useful information in the investigation process.

Lip trace detection is carried out by the following methods:

The powdering method consists of applying a fine powder to the presumed surface of the lip mark using a brush or by spraying. The excess powder is removed and the trace becomes visible, allowing the characteristic details of the lips to be observed. Various powders are used, including those used in dactyloscopy or cosmetics. Treated surfaces must be dry and at the appropriate room temperature. Wet or cold objects should be handled with care so as not to rub off or alter existing marks. In the case of objects such as glasses, it is advisable to avoid inserting fingers inside, as this can lead to the destruction of lip marks.

The smoking method, similar to that used for handprints, is used mainly for revealing lip marks on chrome or nickel-plated metal objects. An effective process involves the use of camphor granules (about 3-4 grams) which burn and produce a thick, black smoke. The object under examination is slowly passed through the thick jet of smoke so that a dense layer of soot forms on the treated surface. The soot, due to its adhesive properties, will gently cover the papillary chorionic lines. Excess soot is removed by brushing, and the black lip mark will stand out against the background (Anghelescu et. al., 1976, p. 163).

The photographing of the lip marks can be carried out using simple and known techniques, or by using modern means, depending on the nature and characteristics of the medium and the technical equipment available to the investigating prosecution authorities. In the case of latent traces, the reflection process or transparency photography is often used if the medium on which the traces were found is transparent. Special techniques involving the use of gamma rays in the photographic process can be used to reveal lip prints on a person's body (Ciopraga et. al., 2001, p. 72).

Lip prints may be subjected to physico-chemical and biological examinations, including DNA testing, in order to determine composition, blood group and to identify possible bacterial infections. Special adhesive films are used to reveal and transfer latent impressions (Cîrjan et. al., 2009, p. 145).

Interpretation of lip prints in the field can provide relevant information about the gender, age, anthropological type and height of the person involved, as well as the activities carried out in the context of the crime.

Gender can be differentiated by the shape and contour of the lip prints. In general, in women, the relief of the lip papillae is finer than in men, and traces of cosmetics can often be seen in their marks. As regards age, the size of the lips, the appearance of the papillary pattern and the height at which they were left are taken into account. Thus, in children, compared to teenagers, the lips are thinner and smaller in size, generally being under 1.60 m in height. In older people, horizontal and vertical wrinkles are more pronounced and the lines have a wrinkled appearance. Also, depending on the thickness, shape and other characteristics of the lip marks, the anthropologist can determine the anthropological type of the person who created them.

By analysing the residues remaining in the lip prints, one can deduce the activities carried out by the person who left them. For example, if traces of food are found in the lip prints, which correspond to those found at the crime scene, it can be inferred that the perpetrator consumed these foods before, at the same time as or after the crime was committed.

From the fresh or old appearance of the trace objects (fruit, chocolate, butter, cheese, etc.) to the quality of the evidence using various methods, it is possible to make rough estimates of the age of the traces.

If the lip marks found on the spot contain blood particles, pus, traces of medication, etc., some indicative assessment can be made as to the possible diseases of the person who made them (Anghelescu et. al., 1976, pp. 163-164).

Clean and sterilized flat bottles are used to obtain lip print comparison patterns. At the same time, lip prints are taken on similar supports to those on which the print was created. If the traces are left with lipstick, patterns for comparison are obtained on white sheets of paper, both with clean lips and lips made up with lipstick products. If the pattern for comparison involves the biological product, saliva is collected on filter paper or clean sucker, inviting the person concerned to put it in their mouth and bite it. To obtain the lip prints needed for the comparison, the individuals involved are asked to press their lips several times on the contact surface at different angles of mouth opening and with varying intensity of pressure. These factors have a significant influence in creating the trace on the spot, which is why patterns taken under different conditions facilitate the comparison process (Anghelescu et. al., 1976, p. 164).

General and individual characteristics of lip marks. In the process of identifying lip prints, a first step is taken to establish gender. At this stage, an anthropological expert will collaborate with the person who, by examining the marks, can reach conclusions that will guide the prosecution particularly in forming the circle of suspects. Thus, it can be concluded that the suspect is a child or an adult, that he or she has thick or thin lips, it is possible to assess the anthropological type to which he or she belongs, the size of the mouth and even of the teeth, certain anomalies, such as macro stomia, rabbit lip, etc.

The general characteristics of lip marks relate to shape, thickness and length. The shape of the lip mark can be associated with long lips, corresponding to a wide mouth, or short lips, corresponding to a small mouth. In practice, the shape of the lips is less evident in lip prints compared to the other characteristics. As for the thickness of lip traces, they can be thin, thick or alternately paired (top lip thick and bottom lip thin or vice versa). The central part of the lower lip can vary in thickness between 5 and 14 mm. Thickness of 10 mm is more common in young people with an average age of 25. The length of lip traces can be long, medium or short. It is measured between the ends of the lips (commissures) and varies between 32 and 56 mm. The length increases with age. In 25-year-olds, the length of the lip mark is about 47 mm. Depending on the commissural distance, the lip traces can have different openings, with small, medium and large opening segments. The distribution of the corial papillae (furrows) is greater in the central area of the lip, where their number varies between 3 and 8 per centimetre. In terms of width, the papillae can be thick (1 mm or more) or thin (less than 1 mm). In smokers, the papillae are spread over the entire surface of the lips, predominantly transverse (vertical), and number up to 16-18 per cm. In non-smokers, the number of these papillae is a maximum of 12. Research has also shown that non-smokers have thick, dense and long papillae. In children and adolescents, the number of chorionic papillae is very low (Anghelescu et. al., 1978, pp. 61-62).

Individual characteristics of lip marks include the position, shape, length and thickness of the papillae. The position of the corial papilla refers to where it is located on the surface of the lip. The corial papillae can have different shapes, such as convex, punctate, fragmentary or line-headed. The length of the corial papillae can be long (when it crosses the entire lip), medium (when it crosses only part of the lip) or short (in the form of papilla beginnings or discontinuous). The thickness of the corial papillae increases towards the inside of the lip and decreases towards the outside. The shape of the corial papillae provides a guarantee of individuality and precise identification of the person, similar to the papillary designs known in dactyloscopy, but they are not stable over time. The lines of the chorionic papillae have specific names that express their shape, such as downward bifurcation, downward oblique bifurcation (to the right or left), upward oblique bifurcation (to the right or left), horizontal bifurcation (to the right or left), concave line, convex line, sinuous line, fragment, fragmentary line, line head and intersecting lines. In order to ascertain the identity of a person based on lip prints, it is necessary to establish a minimum number of coincident features in the compared lip print (Anghelescu et. al., 1978, pp. 62-62).

Guiding questions that can be asked of the expert when presenting the print and pattern for comparison:

– whether the presented trace is of human nature; whether lip prints are found on the presented object;
– whether the lip prints were left by one or more persons;
– whether the lip print presents sufficient elements for identification;
– what are the sex, approximate age of the person and his/her anthropological type;
– which lip (upper or lower) created the print;
– what pathological or congenital malformations does the person who created the lip prints present;
– what adjacent particles are found in the lip prints;
– what is the mechanism of formation, age of the print etc.;
– whether the lip print found at the scene and the comparison model were created by the same person;

- whether the cosmetic product in the print has the same chemical composition and colour shade as that printed in the comparison model;
- what is the blood group of the person who created the lip print at the scene and whether it matches that in the comparison model (Anghelescu et. al., 1976, p. 164).

The expert will have to resolve the trace issue, which is to determine whether the lip prints were left by the suspect. Diagnostic issues related to the age and sex of the person who left the traces, their anthropological type, general characteristics of the lips, the number of persons involved in the formation of the traces, the nature of the stratification of the substances and their homogeneity or inhomogeneity compared to known substances will also be addressed (Doraş, 2011, p. 154). A chromatographic and spectroscopic analysis in the R.I. allows the detection of various elements in the trace, which, in conjunction with evidence taken from the suspect's circle, can lead to the identification of the perpetrator. It is recommended to carry out blood group tests whenever possible, as well as serological analysis of the saliva that soaked the trace (Cîrjan, 2005, p. 243; Harvey, 1976, pp. 28-29).

The examination of lip prints includes the following steps:

Separate examination. In this stage, the expert proceeds to fix the general and individual features by: scale photography, macro photography, micro photography of areas containing individual features and execution of moulds, in the case of deep traces and impressions. At the same time, at the separate examination stage, the expert must determine whether the lip trace contains sufficient features to carry out the expertise, their number and shape, which he will mark both on the photomicrograph of the disputed trace and on the comparison print.

In the comparative examination process, the expert will begin by identifying a reference feature present in both the lipprint and the lip impression. This reference element must have a stable position and provide a solid basis for comparison. The expert will then continue the examination laterally, both on the right and left side, and investigate the individual symmetrical features in upward and downward directions. These individual features may include the shape and contour of the lips, any wrinkles or scars, or any other identifiable distinguishing features in the lip trace and lip impression.

Demonstration. This is accomplished by: the comparison chart, in which photographs of the incriminated and experimentally created trace are inserted, indicating with numbered arrows the coincident features; the photographic chart, showing the linear continuity of the features of the papillary chorionic lines. To make the plate, the photographs are first sectioned transversely to the vertical chorionic papillary lines and then juxtaposed. If the juxtaposed segments are left by the same lip (the disputed trace and the experimental impression), being enlarged to the same scale, all their linear features will continue perfectly from one segment of the photograph to the other; the plate with the diagram of the features, demonstrating the similar vertical placement, e.g. the sequence and distance between them. If one of the latter features is placed higher or in a different position from the same feature in the print, the diagrams of the two traces will not have the same shape; devices of the compared traces, with which coincident features can be highlighted (Anghelescu et. al., 1978, pp. 63-64).

Based on the general features, the forensic expert is able to make a judgement on the approximate anthropological type of the person, their age and sex, and also to specify which of the lips created the crime scene print. Based on the details of the lip lines rendered in the trace and in the impression taken experimentally, the expert can conclude that both traces were created by the same lip or by different lips, and when not enough details are rendered, he cannot reach a definite conclusion (Mircea, 1999, 102).

4.4 Forensic Investigation of Traces Formed by Other Parts of Human Body

Since the beginning of the 20th century, researchers have been looking for suitable methods of identifying individuals, inspired by the success achieved by Bertillon and others using anthropometric measurements. Identifying people from the traces left by their ears, nose and other parts of the body became the subject of specialised research. It has been found that any part of the human body can leave traces through contact or transfer to other objects. The possibility of using these traces to identify people for forensic and forensic purposes has been explored. This research has contributed to the development and diversification of identification techniques based on body traces (Anghelescu et. al., 1976, p. 170; Locard, 1931, p. 58).

In crime scene investigations, fingerprints and footwear prints may also be found on other parts of the human body, all of which need to be retained, corroborated and interpreted in order to obtain the fullest possible information about the offender (Cîrjan, 2005, p. 245).

In addition to anatomical features of the head, such as shape and wrinkles, there are also specific traces that can be formed by the deposition of powder, cosmetics or make-up, especially used by women. These can be layering marks, which can be static or dynamic. Static traces are more valuable in group identifications as they preserve the original shape and configuration of the substance application and can provide important clues for identification. This type of trace can reproduce certain features of the anatomical elements of the face (other than the lips), not excluding the possibility of individualisation of the person if the trace reflects a feature of identifying value (Stancu, 1999, p. 183).

Some authors also argue that, in addition to ear and nose marks, elbow, knee, buttock, chin and wrinkle marks, etc., can also be used for identification purposes, at least in order to delimit the circle of persons who could create them. This category of marks means those changes to the components of the crime scene resulting from contact with these parts of the human body in the process of committing a crime (Anghelescu et. al., 1976, p. 170).

4.5 Ear Traces

The researcher Hirschi Fr., considers the ear as one of the most enlightening signs in identifying a person. However, the expertise of earmarks was not systematically carried out and officially recognised until after the Second World War. After this period, specific techniques and methods for examining and comparing earmarks were developed, which contributed to their use in forensic identification (Anghelescu et. al., 1978, p. 89; Hirschi, 1970, pp. 184-193).

The ear is one of the human anatomical features that is immutable and diverse, which is the scientific basis for identifying people by the traces they leave (Anghelescu et. al., 1978, p. 89).

The outer ear is composed of a series of cartilages of various shapes and sizes, including triangular, rectangular, oval, round and irregular. The main components of the auricle are as follows:

- the helix: the upper and outer edge of the ear, which curves around the auricle and has ridges and indentations;
- the antehelix: a protuberance located inside the helix that bends and forms a specific pattern;
- tragus: a small prominence located in front of the ear canal, shaped like a pyramid and helping to protect the ear canal;
- antetragus: an area behind the tragus, inside the ear; lobe: the lower part of the ear that is soft and flexible. The lobe is often used to wear jewelry;

– concha: a recessed area located between the helix and antehelix (Anghelescu et. al., 1976, p. 170).

The external auricle is a distinctive anatomical feature of the human face, with two significant features. First, it is immutable in its proportions and shape from birth to death, i.e. it does not undergo significant changes over time. Secondly, it is unique in that no two ears have identical morphology. Each person has an ear flap with individual characteristics that distinguish it from others, making it valuable for identification and forensic analysis (Cîrjan et. al., 2009, p. 145). To this uniqueness of the ear „design" or shape is added another important property, namely fixity (Stancu, 2015, p. 144).

Because of its position in the head as a whole, the ear flap is protected from the direct action of external factors. The stability of the shape of the auricle is due to its cartilaginous structure. The size of the pinna can change and accidents, such as cutting or penetrating the lobe, can cause further changes. In such situations, identifying a person by the ear impression becomes more feasible (Anghelescu et. al., 1978, p. 89).

The human ear flap, as a result of the secretion of sweat glands, can leave visible or invisible traces, in static or dynamic form, through contact with flat, shiny objects. In most cases the helix and lobe are impressed, and sometimes the tragus and concha.

When the pressure exerted by the ear on the receiving object has been stronger, the antetragus and the two fossae: navicular and digital are also distinguished.

The most suitable for exploitation are latent static traces, as well as layering traces (when the ear is covered with some kind of substance, such as blood, paint, dust particles, etc.), if the pressure was merely a touch of the receiving object.

Changes in the appearance of the impression may relate to: blurring of details of the surface of the impression; mosaic isation of the surface of the impression by layering or destratification, caused by the affected surfaces of the epidermis; changes in size – enlargement, shrinkage, deformation, alterations in anatomical relief; deposits of foreign substances (medicinal substances, fragments of dressing material); disappearance of some of the anatomical elements; the existence of surgical operations, etc. (Anghelescu et. al., 1976, pp. 171-172).

In the literature, the general and individual characteristics of the ear that may be left behind, as well as the procedures for carrying out the anthropometric examination, are presented differently:

- general characteristics are represented in four shapes, namely: general shape – oval; round; rectangular, triangular. Size – very small; small; normal; large; very large. Position – normal; upper; lower; shallow; closed; deep; protruding. Main parts – edge A; edge B; edge C; edge D; lobe.
- individual characteristics – thin edge; thick edge; pointed edge; cut edge; wrinkled edge; upper ear remnant; flat ear; cauliflower ear; deformed ear; drooping ear; inner curved lobe; outer curved lobe; ear without lobe; square lobe; round lobe; sharp lobe; pierced lobe; twisted lobe; sharp tragus; crossed tragus; missing antetragus; sharp antetragus; cut frostbite; Darwinian adnexa; Darwinian tubercle; Darwinian projection; visible veins; scarred veins; hairy veins; vague veins; signs of cosmetic surgery; pinching of shedding (Anghelescu et. al., 1978, pp. 92-93).

4.6 Nose Marks

The nose is made of cartilage like the ear, and has characteristics on the basis of which gender can only be determined. This is primarily due to its great mobility and plasticity, which is why, in frontal contact with a hard surface, it leaves a circular mark of varying size, depending on the degree of pressure. The trace is also deformed due to the angles of incidence. Since the nose tip trace does not provide any other element than the circular shape and a relative size, much changed in relation to the size of the nose, there is no scientific basis for identification if there are no particular congenital or accidental signs at this level (Anghelescu et. al., 1978, pp. 90-91).

The nose has the following components: root, contour, tip, base, height, wing and nostril. It may also have some peculiarities, such as: spaced nostrils, crushed nasal bone, tip deviated right or left, wavy nose, saddle nose, ball-shaped tip, bilobed tip, flattened tip, stuck nostrils, etc. (Anghelescu et. al., 1976, p. 172).

On the spot, the nose prints do not fully reproduce the elements of the nose. They can be found more in the content of depth marks of the whole face or part of it. In the case of frontal contact, the noseprint appears circular or ovoid, larger than the nose due to the flattening of the tip (Gheorghiță, 2017, p. 203). As the nose tip trace does not provide any other element than the circular impression and a relative size, much modified in relation to the size of the nose, it cannot be considered a scientific basis for identification if there are no particular congenital or accidental signs (Cîrjan, 2005, p. 246).

If the contact with the receiving object was lateral, an incomplete trace remains, which will comprise the base and wing of the nasal pyramid and the cheek trace in the zygomatic region. Deformations of the nasal pyramid are transmitted to a greater or lesser extent in the traces at the scene of the crime (Anghelescu et. al., 1976, p. 172). The traces left by the nasal pyramid, due to lateral contact with a hard surface, make it possible to establish the shape of the contour, height and length of the nose (Anghelescu et. al., 1978, p. 90). If there are any particular marks on the nasal pyramid, these may constitute features that lead to the identification of the individual who left the mark (Cîrjan, 2005, p. 247).

The presence of a pathological condition on the nasal pyramid creates alterations in the appearance of the trace in terms of: shape, size, appearance, depth, irregularity of contour, surface adherence of material traces, such as biological products, pathological products; interposition of foreign bodies (Anghelescu et. al., 1976, p. 172).

Naturally, nose prints can only be formed in soft soil, in snow or wet sand, and on some foodstuffs such as butter, margarine, cake, etc. With all the anatomical peculiarities of the nose, as it differs from person to person, it is only possible to make generic identifications (group determination) (Gheorghiță, 2017, p. 203), i.e. it can be considered that even in these cases the characteristics for drawing certain conclusions are not met, but at most there are premises for drawing conclusions of probability (Anghelescu et. al., 1978, p. 90).

4.7 Forehead Traces

The traces left by the forehead on contact with the elastic receiving surface are important in forensics because the frontal surface of the forehead has low plasticity, which makes the traces relatively stable and provides valuable information for identifying individuals. Forehead microrelief can be evidenced by the presence of linear or elongated oval pores, funnel-shaped cavities and horizontal slices of skin. Wrinkles and creases on the forehead are generally arranged horizontally, except for those at the root of the nose, which may be arranged vertically or obliquely. Thus, these specific features of forehead marks can be used to help identify a person (Golubenco, 1999, p. 68).

In addition to the characteristics of the forehead and, in particular, the wrinkles, it should be borne in mind that they can form well on surfaces such as woodwork, cement or linoleum, because the forehead is one of the areas of the body with the most abundant sweating. Substances in sweat, especially fats and proteins, contribute to the formation of latent traces that are valuable for identification (Stancu, 2015, p. 145).

Forehead features can be well printed on various surfaces, such as woodwork, cement, linoleum, as the forehead is one of the areas of the body, after the palms, with the most sweat. Sweat is known to contain various fats and proteins, including salts, which lead to the formation of latent traces, important for the identification process. Latent forehead marks are detected and fixed using the same procedures and methods as for handprints (Cîrjan, 2005, p. 247).

4.8 Wrinkle Traces

Facial wrinkle marks have long been neglected in forensic identification work. They are formed due to contact of the human face, frontally or laterally, with rigid and shiny objects (contact with a window pane, glass, nickel-plated object, etc.). Experiments have shown that they occur on the surface of all objects on which papillary traces may remain (Anghelescu et. al., 1976, p. 172).

The individual characteristics concern differentiation aspects resulting from size, distance between them, angular value, as well as the existence of particular marks important for identification (Anghelescu et. al., 1978, p. 91).

The marks created by facial wrinkles take the form of curved, oblique, parallel or broken lines, in relation to the part of the face that left them. The variety of shape, size and angular value of some of them are valuable elements in the identification of the person, especially when the circle of suspects is formed within a relatively short time of the crime being committed. More frequently, 2-4 forehead wrinkles are found behind, and rarely 1 or more (horizontal), as well as 1-3 vertical wrinkles at the root of the nose. Traces of temporal wrinkles may also remain, along with the cheek and nasal pyramid trace (1-3 or more), constituting the so-called "goose foot".

As a result of the presence of a pathological condition influencing the development of the facial tegument wrinkling process, the trace created will show quantitative changes (exaggeration of the number of wrinkles, reduction until their disappearance or segmentation of length, width, depth); appearance (exaggerated curvatures, doubling, tripling of contours, branching of the main wrinkle trunk); surface (jaggedness, fringing, exaggerated relaxation); depth (irregularity of wrinkle depth, blurring, slightly elongated shapes, changes in edges and surface, partial suppression of continuity, etc.).

Sometimes there are also interpositions between the tegument and the substrate of substances such as biological products or foreign bodies (ten's bottom, powder, other make-up substances, medicines, impurities, dust granules, plant debris, etc.) (Anghelescu et. al., 1976, pp. 172-174).

Wrinkle marks can only be assessed if a relatively short time has elapsed since their creation, due to the changes that can occur. The traces formed by forehead wrinkles and those in the area of the outer corners of the eyes are of greater identifying value (Anghelescu et. al., 1978, p. 90; Cîrjan, 2005, p. 247).

4.9 Chin, Elbow and Knee Traces

Along with other tracks, chin, elbow and knee marks may also be found at the scene. These can only be used to determine the maker of the footprints in the group. They can be traced in the form of depth on soft soil, wet sand, snow and other features (Gheorghiță, 2017, p. 203).

The shape, size, prominence, outline and peculiarities of the chin maker's chin can be revealed in the chin trace. According to the features of the chin, one can distinguish bilobed, elongated, double, dimpled, protruding and twisted traces.

Knee and elbow marks are formed when a person hits, falls or stands on certain surfaces that are plastic (soft earth, unweathered concrete, etc.) and they show the shape, outline, dimensions and any features of the knee.

The marks left on the various types of support found at the scene of the crime may also have an abnormal appearance as a result of changes to the knee or elbow due to some kind of disease. In these circumstances, the changes will also be reproduced in the remains, in terms of: shape, appearance, dimensions, orientation of the transverse axis, depth, regularity of the outline, presence of interposed bodies (textiles) and the over-addition of material traces of a biological nature (Anghelescu et. al., 1976, pp. 174-175).

4.10 Fingernail Traces

Fingernail marks are often seen on the human body and can provide moderate information in terms of identification. However, the location and number of these marks, as well as their characteristics, may indicate certain circumstances related to the crime, such as the nature of the struggle between the victim and the offender (Golubenco, 2015, p. 40).

The fingernail, as a component part of the living organism, contains characteristics that individualise it, but it also has a number of peculiarities that can create a relationship in forensic investigation between the bearer and the social environment from which he or she comes; the socio-economic occupations he or she exercises; the link with a particular natural environment where the crime took place; the manner in which the crime took place; and so on. a. The nail is intended to help create certain indispensable human operations such as: gripping function, scratching, assisting in digging, etc. Nails are also intended to protect the upper and lower limbs from injury or other injury during everyday activities, as well as to protect and enhance sensation. Nails grow in a constant, steady manner that is affected by poor peripheral circulation as well as by the passage of time (ageing), they begin their cycle of formation and growth in the ninth month of pregnancy, in the intrauterine cycle and continue throughout life until the body ceases to function, at which point the growth cycle ends (Cioacă, 2019, 232).

Fingernail marks can be detected on both the victim's body and the perpetrator's body. Being rather difficult to value in terms of identification of the person, except for certain generic determinations, they have more of an informative value to clarify some essential circumstances of the crime. At the same time, one of the most valuable aspects of forensic investigation is that fingernail marks (their surface and striations) can even lead to the identification of the person, especially when they have formed in depth, on a surface, good plastic qualities, such as clay, putty, paint, etc. This is possible because on the nail surfaces there are a series of longitudinal striations, characteristic of each person in shape, position, size (Gheorghiță, 2017, pp. 203-204).

Fragmented or whole fingernails lost by the bearer in the case of a criminal act involving violence are primarily sought at the scene of the crime, on the victim's body and clothing, on objects around the victim or near the objects which served as the instrument of the blow, and in cases where the victim or the victim's body is present at the scene, a thorough examination of the victim's fingernails is carried out in order to identify details relating primarily to the victim (working environment, social environment, socio-professional occupation, possible intoxication with toxic substances, consumption of certain drugs, etc.). a.), secondly to discover elements that could lead to the identification of the offender (traces of blood, tissue, hair, skin, semen, fabrics, etc.), and thirdly – if the victim's body was not discovered at the scene of the crime – to identify details that would make it possible to identify the place or environment where the crime took place (traces of soil, plant traces, various materials) (Cioacă, 2019, p. 238).

Fingernail marks are important for the forensic expert in two respects: the victim's fingernails may contain the so-called ,,subungual deposit" of the perpetrator, consisting of epithelial cells, blood, hairs, which can be the subject of bio criminal expertise (determination of blood group, DNA, etc.) (Cîrjan, 2005, p. 249). So if it is suspected that the suspect may have skin particles taken from the victim or other micro-particles of substance under his fingernails, the subungual contents are cleaned and the fingernails are cut and all these are sent for forensic examination (Golubenco, 2015, p. 40).

4.11 Discovering and Interpreting Traces Formed by Other Parts of the Human Body

The discovery of latent or visible surface traces of ears, noses and other parts of the human face and body is usually searched throughout the crime scene and particularly in places where handprints remain. Depth prints are searched only on surfaces that are plastic, such as soil, mud, snow, ice or powdery material.

The means available and the methods used to search for any traces of human form resulting from contact with certain surfaces or substances will be used.

The same means and methods shall be used for surface traces as for papillary or lip traces, and the same means and methods shall be used for deep traces as for plantar traces.

Latent prints shall be made visible only if, owing to the characteristics of the object bearing the print, it is not possible to ensure that the prints found can be photographed transparently. In other cases, the detection methods used in dactyloscopy shall be used.

If the shape of the trace also contains material traces of any kind, it shall not be revealed, as this procedure excludes the possibility of subsequently establishing the nature and composition of the material traces. If the trace is of depth, it shall first be collected, as appropriate, by means of tweezers or a pipette, and only then shall a method of detection be used to reveal the trace (Anghelescu et. al., 1976, p. 175).

Human body traces can provide data (sometimes as valuable as the identification expertise itself) on what happened at the time of the crime, the relationship between victim and offender, how the perpetrator acted, the number of people, etc. (Stancu, 1999, p. 185). So the interpretation of traces found at the scene is a logical process of giving meaning to the information obtained by evaluating and selecting possible options within a specific field. This interpretation is carried out on the basis of knowledge and expertise in that field, with the aim of understanding and referring to relevant messages or meanings in the context of the investigation (Bercheșan, 2006, p. 101).

Interpretation of ear, nose and other body parts traces at the scene can provide important information for the investigation. These traces may provide clues as to the age, height, gender and number of persons involved in the criminal activities. For example, the presence of multiple ear impressions on the same part of the head may indicate the number of people who left those impressions. Also, the distance from the ground to the place where the footprint was left can provide clues about the height of the alleged perpetrator, depending on the specific conditions of the crime scene. This information helps to build a profile of the offender and can be used in the investigation to identify and reconstruct events (Gheorghiță, 2017, p. 204).

If the ear trace found at the scene shows characteristic elements of earrings or clips, it can be concluded that the ear trace was created by a woman. Also, the size of the earmark can provide approximate age data.

When traces reproducing wrinkles are found on the spot, careful examination can lead to the conclusion that they belong to an older person (Anghelescu et. al., 1976, p. 176).

Characteristic features of the face and other parts of the body of an individual may be altered either accidentally (as a result of injury beyond the individual's control) or by cosmetic operations, which allow new characteristic features to appear (Cîrjan, 2005, p. 249).

Knee, elbow or other body part marks may also indicate certain activities of the perpetrator at the scene, such as: fighting with the victim, falls, falling asleep in a certain position, etc.

When interpreting these types of marks, in addition to their characteristic shape of impression, any hairs, clothing fabric, bandages, parts of the skin, traces of blood, etc. left in them should also be taken into account. This will facilitate the identification of the perpetrator (Anghelescu et. al., 1976, p. 176).

The correlation of data obtained in the process of interpreting the indicated traces with the odds deduced from the investigation of other categories of traces is likely to provide important clarifications concerning many of the circumstances of the crime under investigation (Gheorghiță, 2017, p. 204). The forensic scientist's enemy will have to be taken into account: the time lapse between the crime and the crime scene investigation. Identification can be made much more difficult if there have been essential changes between the time the trace is created and the time the comparison pattern is taken (Cîrjan, 2005, p. 249).

4.12 Expertise of Traces Formed by Other Parts of the Human Body

For the purpose of comparing models of the ears, nose or other parts of the human face and body, several procedures can be used, depending on the specific situations in which the traces were found. For example, if an ear impression is found on the glass of a window or on a door of a house, a piece of glass, 40 x 50 cm, is fixed to the wall, the centre of which is placed at the same height above the ground as the impression. If the trace was found on an object situated parallel to or at some angle to the ground, the piece of glass shall be placed in a similar position to the object bearing the trace. In order to obtain the pattern for comparison, contacts shall be made by gently pressing the ear pinna against the glass several times (in different sectors), varying the pressure, until a trace is obtained which includes the characteristic features of the ear. During this operation, the positions of the base of the lobe and the concha should be oriented in the same positional axis as the uncovered trace. Once the models for comparison have been obtained, they are fixed and lifted using the appropriate procedures. If the trace found on the spot has been created by layering or destratification, similar conditions shall be used to obtain the models for comparison (covering the surface of the ear with a substance similar to that which created the trace or bringing the piece of glass into a situation corresponding to that which existed when the trace was created: covering with dust, etc.). The same procedure shall be followed for obtaining models for comparison in the case of the nose, facial wrinkles and buttock region. In order to obtain patterns for comparison with depth traces, mouldings are made (Anghelescu et. al., 1976, pp. 177-178).

Guiding questions that can be asked of the expert when presenting the trace and the pattern for comparison:

- whether the traces existing in the place under investigation or on the object presented were created by a human body and by which part of it (ear, nose, knees, elbows, etc.);
- whether the footprints were created by one or more persons; whether the footprints have sufficient identification elements;
- the approximate height, age and sex of the person who created the footprints; the mechanism of formation of the footprint and its age;
- whether the part of the human body that created the footprint is malformed or has a congenital disease;
- whether the footprint and the model for comparison were created by the same person (Anghelescu et. al., 1976, p. 178).

The forensic examination of the traces formed by various parts of the human body is able to provide some information about the way in which the trace was formed and how old it is, and about any characteristics capable of identifying the person or group of persons who are believed to have created the trace. At the same time, it is possible to determine the height of the person and, with a fair degree of approximation, the sex and age, the body constitution (Stancu, 2015, p. 145).

In the separate examination, general and individual characteristics are studied and delineated, both in the trace created by the ears, nose and other parts of the face, and in the patterns taken from suspected persons. The expert must bear in mind that, in relation to the nature of the receiving object, the characteristics are not always reflected in their totality (Anghelescu et. al., 1978, p. 91).

Comparative examination of the traces found and the comparison patterns, particularly in the case of ear marks and, to some extent, wrinkle marks on the forehead, may serve to identify the person, otherwise the investigation is limited to determining gender or group membership. This does not mean that other traces, even whole-body traces, cannot be used for identification, if they have formed under good conditions (Stancu, 1999, p. 185).

The existence of coincident minutiae in the trace and in the comparison pattern is demonstrated by comparison, juxtaposition or superimposition. In some cases measurements may be made of the length of features, their distance from certain reference points, the angular value of certain features, etc. Both coincident and non-coincident features are indicated with numbered arrows and described. The characteristic features are indicated on the photograph of the trace and the comparison model on the demonstration sheet (Anghelescu et. al., 1978, p. 91).

The forensic expert may draw one of the following conclusions, as appropriate: positive certainty; negative certainty; probability; impossibility.

By examining the traces left by the ears, nose, wrinkles and other parts of the human body, anthropometric and traceological expertise can be carried out. The answers that can be given by the expert relate to the following: the number of persons who created the marks; the sex, age and approximate height of the person who created the mark; the malformations presented by the ear, nose or the portion of the face bearing the wrinkles; the mechanism of formation of the mark and the approximate age; whether or not the ear, nose, wrinkle or other human body part marks were created by persons from whom comparison models were taken(Anghelescu et. al., 1978, p. 92).

Chapter V

Forensic Investigation of Biological Traces of a Human Nature

5.1 General Information

Establishing the content of the notion of a trace with a biological substrate requires an analysis of the concept of a criminal trace in its general meaning, which is accepted in forensic science and which, as is well known, is the fundamental rationale of this field (Adam, 2020, pp. 44-53). It is important to point out that among the many traces discovered at the scene of the crime, material traces of a biological nature play a special role because of the way they appear and their evidential value. These traces are formed as a result of the interaction of biological substances with the environment, representing traces of blood, saliva, sweat and grease, urine, semen, individual human odor and other similar types. They represent a distinct category of biological traces, characterised by a specific mechanism of formation. These traces can provide important information in investigations, helping to identify and reconstruct events.

Depending on their origin, biological traces can be classified into:

- secretion products (saliva, colostrum, breast milk, nasal secretion, etc.);
- excretion products (feces, semen, meconium, urine, amniotic fluid, vernix caseosa, lochia, sputum, vomitus, etc.).;
- tissues which may be soft (blood, brain mass, muscle tissue, skin, etc.) or hard (bones, cartilage, nails, etc.) (Anghelescu et. al., 1976, p. 194). In this category are also added hairs, including traces of odor, which are the object of forensic odorology (Stancu, 2015, p. 157).

Depending on the degree of perception, they can be divided into visible, faint and invisible (latent) traces.

Visible traces are detected by direct observation of the receiving surface without the need for special procedures, reagents or equipment. However, there are situations where traces may be faintly visible or even invisible due to factors such as the similar colour of the substrate to that of the trace (e.g. a blood stain on a red textile), intentional erasure of the traces or their very small size. To detect such traces, special illumination procedures or chemical reagents applied to the surface where the trace is supposed to be found (such as special indicators – ghemoFan, phosphotest, luminol, etc. in the case of blood traces, or a specialised bio detector for odor traces) are used (Adam, 2020, p. 72).

Biological traces can be classified into depth traces, surface traces and mixed traces, depending on the characteristics of the receiving object. Depth marks are not the result of deep deformation of the receiving object, but are formed by impregnation of its porous surface with the substance that generated the mark. These traces may be referred to as soak marks, whether total or partial. Surface marks, on the other hand, occur on hard surfaces that do not have the capacity to absorb substances, and are the result of surface modifications, such as deposition of substances, without affecting the shape or structure of the receiving object. They are always layering marks (they remain in cases, where the trace-generating body deposits a thin layer of some substance on the receiving object). The mixed type shows traces of layering with partial soaking of the substance in the receiving object (traces of blood with varying degrees of soaking associated with blood clots). Traces of a biological nature are only local traces, which may contribute to the formation of peripheral traces of reproduction. For example, the footwear mark – the outline of a footwear mark formed when blood is splashed around the footwear or spilled on it. In this case the outline of the shoe shows peripheral breeding marks and the blood marks are local biological marks. Their interpretation makes it possible to judge whether the blood has drained from the footwear, whether the victim had been there before the bleeding or arrived after it, etc.

Viewed through the prism of tracing, biological traces can be divided into static traces and dynamic traces. Static, traditional traces occur when the final moment of the trace formation process is characterised by a state of rest, a static position of both objects. In these traces the contact surface of the creative object leaves its copy inverted by relief (if the trace is deep) and inverted (as in a mirror) by appearance. Thus, by pressing, the breaking tool first penetrates the wood and then stops, thus forming the static trace. Dynamic traces are formed as a result of the interaction of two forces: one acts as in the case of the creation of the pressing traces, the second – by movement on the surface of the receiving body. In the traces of lunation, cutting, rubbing, crumbling the points of the relief of the creator object are not transmitted in the form of points as in static traces, but in the form of striations, lines, ridges born from the protrusions of the surface of the creator object (Adam, 2020, pp. 72-73).

Like other traces left by the human body on the scene, biological traces can provide evidentiary information both to identify the suspect who left the traces and to establish the multiple circumstances of the criminal act (Doraș, 2011, p. 157; Togvald, 1980, p. 26; Ishcenko, 1994, p. 198). Due to their specific nature, manifested in particular by their complex nature and the possibility of their rapid alteration, the discovery and examination of biological traces of a human nature is also carried out with the assistance of specialists in the fields of forensic medicine, biology, toxicology and anthropology or with similar activity profiles. For the same reasons, there is also a need to preserve these traces in an appropriate manner and to recover them quickly by arranging for expert technical-scientific reports or findings (Anghelescu et. al., 1976, pp. 194-195).

It is useful and necessary for forensic experts to be familiar with the general concepts of biological traces and the possibilities offered by their investigation from at least two points of view:

- the way in which the judicial body discovers and collects biological traces on the spot depends not only on the success of the bio-criminal expertise, but above all on the clarification of essential issues relating to the criminal offence. In particular, the persons involved in the crime (participants or victims);
- the preparation of the material for the forensic examination, the appropriate formulation of the questions to be put to the expert and the evaluation of the conclusions are the responsibility of the magistrate, who must have a minimum level of knowledge in the field. This demonstrates the professional integrity of the magistrate in dealing with the case. The magistrate must have a proper understanding of the scientific and technical issues involved in the expertise in order to be able to properly analyse and assess the results presented by the experts. This involves familiarity with the basic principles and methods used in the field so that they can formulate relevant questions and evaluate conclusions in an objective manner. The magistrate's ability to understand and evaluate expertise is crucial for fair and just judicial decision-making. A proper understanding of scientific and technical issues helps the magistrate to identify any errors or uncertainties in the expert's report and to ask further questions for clarification. In this way, the magistrate can make informed and well-founded decisions based on the expertise presented (Stancu, 1999, p. 187).

It should be noted that, on the spot, biological traces often do not appear in isolation, but in associations of two, three or even more. In such cases, selective methods of detection, fixation and removal must be applied in each individual case, so as not to destroy any traces in the process of processing the others.

In terms of frequency at the scene and the possibility of forensic recovery, biological traces could be classified as follows: traces of blood; traces of saliva; traces of semen; traces of a hairy nature (fart thread); traces of an osteological nature; traces of other soft tissues; traces of odor (Anghelescu et. al., 1976, p. 195).

The analysis of biological traces forms the object of study of the so-called science of "biocriminalistics" (Drăghici et. al., 2018, p. 101). Traces of blood, semen, rooted hair (follicle), saliva and urine (with nucleated cells), bones and tissue collected from the crime scene are suitable for DNA isolation and analysis. Other biological materials that can be collected from the scene such as sweat, tears or serum are materials without nucleated cells and are not suitable for DNA analysis. The main advantage of DNA profiling is the possibility to identify the person who created the trace without the need for any other data about him/her, similar to fingerprint identification (Cătuna, 2008, p. 53).

DNA consists of four types of nucleotides (A-adenine, C-cytosine, G-guanine, T-thymine), which by their arrangement allow the storage of all information about the construction of the organism with all its characters. These nucleotides are linked together to form two long chains, linked on the basis of complementarity between A-T and G-C (a nucleotide containing the A base is always paired with a nucleotide having the T base of the opposite chain and a nucleotide containing the C base is always associated with a nucleotide containing the G base), this structure is called the 'double helix'. A complete sequence of DNA forms the human genome, unwound measuring 1.80 m and containing around 3 billion nucleotides. The human genome is made up of 23 pairs of chromosomes (Moise et. al., 2020, p. 98).

The process of identifying a person begins when they leave a biological trace at the crime scene that necessarily contains genetic material (DNA). Next comes the sampling by the forensic scientist, followed by the laboratory analysis, the end point of which is the translation of the genetic material into a code with a unique, unrepeatable formula specific to a single carrier of that genetic information (Stancu, 2015, p. 167).

For a trace found at the crime scene to be used for DNA profiling, it is essential that it has not been contaminated, i.e. mixed with DNA from another source. Contamination of the trace may occur before its discovery, but also during the crime scene investigation process, during its collection, packaging, transport or storage (Cătuna, 2008, p. 53; Groza et. al., 2001, pp. 8-10).

The principles of human genetics underlying genotyping (i.e. testing a person's genetic profile) are:

The genetic uniqueness of each individual. Each person has a characteristic, unique appearance. Since this appearance, the phenotype, is the embodiment of the genotype, it follows that there is a great diversity of human genetic material, except for monozygotic twins. This is because parts of the human genotype are polymorphic, meaning that for those parts of the genome there are several structural variants.

Identical DNA structure in all cells of an organism. The genetic information of every living organism is concentrated within each cell, in the DNA molecule (Drăghici et. al., 2004, p. 197; Drăghici et. al., 2018, 106).

In terms of their identifying value, geneticists divide biological traces into three distinct categories (Rusu et. al., 2023, p. 408; Stancu, 2015, p. 168; Cioacă, 2019, p. 108):

Evidence with a high degree of accuracy in identifying the DNA profile: this includes blood and seminal fluid, which contains sufficient material for DNA analysis even in the absence of sperm. Saliva is also a valuable trace, irrespective of the object from which it is collected (smoked cigarette, toothbrush, cigarette wrappers, masks, tableware, chewing gum, stamps and postal envelopes, etc.).

Potential DNA profiling evidence: this includes vaginal fluid, which in rape cases may contain a mixture of cells from both parties, which can be analysed separately. Also nasal secretions, hair (only plucked hair is of value for nuclear DNA analysis, provided DNA is present only in the cells around the root), pieces of flesh, skin cells, urine, body parts and bones (bone marrow can be analysed even in cases of advanced decomposition).

Samples with potential for mitochondrial DNA analysis: this category refers to any samples that are not suitable for other types of DNA analysis and can be analysed by mitochondrial DNA analysis.

The analysis of evidence collected at the scene is an important standard in the forensic investigation of all types of crime. Evidence and objects carrying genetic material facilitate the prosecution's efforts to link the suspect to the crime scene but also to exclude the suspect from the acquired procedural quality by conducting DNA profiling. Thus they can be found on certain objects, goods or carrier documents which can be classified into types and groups.

Table of commonly encountered DNA sources found on personal effects, representative types of evidence processed and the success rate in discovering and extracting the DNA profile (Cioacă, 2019, pp. 108-109).

The middle of the porch	Possible location of DNA	DNA extraction source
Baseball bat	Surface handled	Epithelial cell debris, perspiration, tissue
Hat, mask, headband	Interior surface	Sweat, hairs, epithelial cell debris, dandruff, saliva
Eyeglasses	Skin contact area (nose, ears, lenses)	Perspiration, epithelial cell debris
Facial tissue, brushing with cotton buds	On the surface	Mucus, blood, semen, saliva
Diggers	On the surface	Saliva
Cigarettes used	Filter zone	Saliva
Seals on envelopes	Wet area	Saliva
Ribbon, knots	Their interior and exterior surface	Epithelial cell debris, perspiration, saliva
Bottles, cup, glass	Edge of containers, external surface	Saliva, epithelial cell debris, sweat
Used preservative	Interior and exterior surface	Sperm, vaginal cells, rectal cells
Bed linen	The entire surface	Sweat, hairs, semen, saliva, blood
Projectile	External surface	Blood, tissue
Bite trace	Skin surface	Saliva
Fingernail, nail fragment	Storage subungual	Blood, sweat, epithelial cell residues

In the case of trace research for genetic identification, the process follows broadly the same technical steps as for other biological traces such as blood, semen or saliva. However, additional precautions are needed to ensure the preservation and integrity of the samples. Objects or carriers bearing biological traces and traces to be analysed for DNA shall be checked for other relevant traces, such as papillary traces (fingerprints). For optimal storage and transport, a special type of container shall be used for each sample, ensuring optimal preservation and safe transport. In the case of liquid blood, tissues, organs or bones, they should be placed in special containers and refrigerated to maintain optimal preservation conditions during transport. In contrast, blood stains on objects will be dried before being packed and sent to the laboratory. Hair collection must be carried out carefully to avoid breaking the stem or touching the root, as they contain important genetic information. It is important that all these procedures are followed to ensure the integrity of the samples and to obtain valid and reliable results in DNA analysis and genetic identification (Stancu, 2015, p. 168).

The consequence of incorrect collection or preservation of both crime scene and comparison samples is that the scientific and legal criteria for DNA analysis are not met and ultimately cannot be used as evidence in court (Cătuna, 2008, p. 53).

DNA analysis is carried out for the resolution of court cases concerning: identification of persons in criminal cases; determination of natural family relationships; identification of victims of natural disasters, major accidents and terrorist acts; identification of war victims, etc. The current use of DNA profiling in the judicial process is to demonstrate that at a number of DNA loci, the DNA profile of the suspect matches the DNA obtained from the crime scene. DNA profiling, or DNA fingerprinting as it is more commonly known, aims to analyse several hypervariable loci in the human genome to obtain a unique ,,fingerprint" for each individual (Moise et. al., 2020, p. 100).

DNA profile analysis in specialised laboratories usually uses two main methods: the restriction enzyme method and the polymerase chain reaction (PCR) method. In the restriction enzyme method, an adequate amount of DNA is required, which is isolated and purified using detergents and specific enzymes, such as proteinase K. This process results in a high-quality DNA sample. This is followed by the DNA cleavage step using restriction enzymes, which cut the DNA into fragments of different sizes. These fragments are then analysed to obtain specific information about the DNA sequences. The polymerase chain reaction (PCR) method is another method used in DNA analysis and has rapidly gained a foothold in the field. The major advantage of this method is its high sensitivity, allowing amplification of a single DNA molecule to obtain sufficient quantities for analysis. PCR involves the use of special enzymes called polymerases to selectively amplify specific DNA sequences of interest. This allows a large amount of DNA to be obtained in a relatively short time, which facilitates further analysis. Both methods are used to analyse the DNA profile and obtain detailed information about a person's specific DNA sequences. These advanced techniques are essential in genetic identification and forensic investigations, providing crucial data for establishing individual identity and parentage (Stancu, 2015, p. 169; Matei, 2001, 32; Ballantyne, 1989).

If the expert is asked to determine the DNA profile, he or she will be able to answer the question whether the trace found at the scene was created by person X or Y, similar to fingerprint identification (Cătuna, 2008, p. 53).

5.2 Forensic Investigation of Blood Traces

Blood traces, with their high frequency in the crime scene and their ability to be identified, make a significant contribution to forensic investigations. They provide essential clues to clarify the circumstances of where, when, how and by what means the crime was committed, and are therefore of particular importance in the investigation process (Stancu, 2015, p. 158).

Blood traces are of significant identifying value because of their ability to determine the anatomical region or organs from which they originate, as well as their specific characteristics, such as blood type (arterial or venous), blood group, presence of alcohol or certain micro-organisms, and even to provide an approximate estimate of the time elapsed since the crime was committed. This information can indicate the origin of the blood trail and help distinguish between blood from a single person or from several people. Knowledge of the physiological properties and composition of blood is therefore essential for prosecuting authorities as it contributes to understanding the identification value of these traces. This knowledge enables specialists to correctly analyse and interpret the relevant information obtained from blood traces, thus enhancing the investigative process in criminal cases (Ciopraga et. al., 2001, p. 112).

Blood – is a complex fluid tissue, which together with lymph and interstitial fluid forms the body's internal environment. It performs multiple functions in metabolism, in the body's self-defence, in the coordination of vital functions. It is made up of a basic liquid substance – plasma – in which are suspended highly differentiated cellular elements: erythrocytes, platelets, leukocytes. Blood accounts for 6-8% or, in other words, 1/13 of body weight and contains 40-45% of the figurative elements, of which 1% are leukocytes and platelets, the rest being made up of red blood cells. Circulating leukocytes are made up of 65% granulocytes, 30% lymphocytes and 5% monocytes. Blood plasma accounts for 35-60% of the total blood volume. It is made up of 90% water and 10% dry residue of which 9% organic substances and 1% inorganic substances. Plasma is a yellowish-white fluid, the colour of which may vary depending on the rise or fall above a certain limit of certain components: bilirubin, lipids, gamma globulin. Organic substances are carbohydrates, lipids, proteins, enzymes, hormones, vitamins and intermediate or end products of their metabolism. Inorganic substances are represented by chlorides, phosphates, sulphates, sodium bicarbonates, calcium, magnesium, iron, cobalt, zinc, manganese, etc. (Anghelescu et. al., 1978, p. 235; Adam, 2020, p. 60).

The colour of blood traces can vary depending on several factors, including age, quantity, substrate and the influence of environmental factors. For example, a fresh bloodstain will have a deep reddish-stain colour and a characteristic shiny appearance. As time passes, the sheen of the trace fades and the colour gradually changes. The next stages may include a change in colour from reddish-brown to brown and even black. These changes can be attributed to the oxidation and decomposition processes that take place during blood deterioration. In the very thin layer of the trace, due to the action of the factors mentioned above, the colour may evolve towards a grey-greenish tone (Stancu, 2015, p. 158).

Human blood has distinctive characteristics that allow differentiation between traces of human blood and blood from other animals. For example, when we find traces of bird blood near a dead body or on objects suspected of having been used in the commission of a crime, it is easy to distinguish these blood traces from human blood because bird blood does not contain red blood cells. Depending on the composition and other distinguishing criteria, it is possible to determine the anatomical area or organ from which the blood originated. For example, arterial blood is lighter in colour, while venous blood is darker. In addition, blood from the brain may contain extra fibres or nerve cells, while menstrual blood is characterised by increased acidity and absence of fibrin, leading to a longer clotting time (Ciopraga et. al., 2001, p. 112).

By following different variables such as the amount of blood, the nature of the surface on which it falls and the angle of incidence, bloodstains can have varied shapes and appearances. Depending on how they are created, these marks may appear as streaks when the person was moving at the time of the blood loss, as clustered or isolated drops when the person was at relative rest, or as smears resulting from wiping hands, feet or objects covered in blood. The shape and appearance of bloodstains may also be influenced by the angle at which the blood came into contact with the underlying surface. Thus, bloodstains may be round or elongated. A round shape occurs when the blood falls at an angle of 90 degrees to the underlying surface, with smooth edges. In the case of more acute angles of incidence, blood marks may be elongated. The characteristics of the edges of blood marks vary according to the height from which the blood fell. If the blood falls from a height of up to 25 centimetres, the blood drop will have smooth edges. For heights between 25 and 150 centimetres, the edges of the blood drop will be jagged. If the drop distance exceeds 150 centimetres, the blood drop will have very jagged edges and may have rayed edge splashes. It is important to note that these shapes and appearances apply mainly to smooth surfaces. On porous surfaces, the same shapes and features of bloodstains will not be found (Mircea, 1999, pp. 124-125).

Influence of external environmental factors. The action of the cold causes a quasi-constant maintenance of the shape, size and contour of the blood mark, an almost clear demarcation from the rest of the substrate, the colour being slightly altered over time. At temperatures above 0°, plus the influence of other factors, the blood mark shows a change in shape, size, contour and separation from the rest of the substrate, and a change in colour from red to grey at a rate dependent on the value of the thermal factor and the duration of its action. In relation and with the rotting process, the trace becomes blackish. Thus, at a lower temperature and without illumination, the change in colour of the blood trail from bright-red at first to dark-red, and then to ash-red and dark-brown occurs in 2-3 weeks, while under the influence of diffuse light the same colour changes occur in only 7-8 days, and under the direct action of sunlight in 1-2 days.

Influence of internal factors. It is manifested in putrefaction processes, due to the presence of substances of an organic nature which enter into the composition of the extravasated blood mass, generally causing a change in the colour and appearance of the blood. As a result, the colour of the blood trace darkens to a greenish tinge (Anghelescu et. al., 1976, p. 198).

Actions taken by an individual to remove bloodstains, such as scraping, washing or destroying the backing or the portion of the backing containing the stain (e.g. burning a towel, cutting a piece of material, etc.), have an important influence on these stains. In many cases, these manoeuvres do not give the desired result, either because of the nature of the substrate, as in the case of their absorbent materials, or because of the way in which they are formed (spreading of the traces in the form of splashes). It is also important to take into account that a number of changes may occur as a result of contact between the blood-bearing substrate and other materials. Such aspects should not be neglected by the investigators conducting the research (Stancu, 1999, p. 188).

The qualitative examination of biological traces at the crime scene requires not only theoretical-practical knowledge and practical skills on the part of the prosecuting officer and the specialists involved in the prosecution, but also the use of appropriate technical equipment, instruments, chemical reagents and consumables.

The general forensic technical means and methods used for the detection and examination of biological traces can be classified into several groups: general illumination means – devices for creating directed, diffused, mono or polychromatic light (table lamp, photographic flashlight, pocket torch, ordinary electric lanterns, electric lighting devices with a capacity of more than 1000 wt., other illuminators with halogen lamps powered by accumulators fitted with various attachments (filters, screens, reflectors, etc.). When examining rooms, clothing, furniture and other objects, even the simplest light source such as a torch, the rays of which, being directed at a certain angle to the subject, are capable of greatly increasing the effectiveness of the search for such biological traces as sweat on the hands, hairs, blood, semen, etc.; special illumination means (ultraviolet, infrared, X-ray detectors, optical-electronic transformers, light filters, etc.). Under the action of UV radiation, the trace will be distinguished from its substrate by its colour and intensity of luminescence. When searching with this radiation for traces of a biological nature (saliva, urine, semen, sweat) the room must be darkened. Thus, traces of saliva and semen will be visible as a bluish-blue light, sweat traces – as a yellowish-blue light. Blood traces in UV rays do not create fluoriscence, but become noticeable as dark-brown spots on a luminescent background. If the hemoglobin of the blood has been converted into hematoporphyrin by external factors, then these traces in UV radiation take on a bright orange or reddish colour, depending on the pH of the environment; optical equipment which widens the sensitivity range of the human eye (various magnifying, foot, measuring, binocular, illuminating and other magnifying glasses with a magnification of up to 10X. For examining objects with smaller parameters, ordinary optical microscopes or pocket electron microscopes are used (Adam, 2020, pp. 91-92).

For the handling of human biological traces, specialised equipment with certain specificities is used. The approximate list of this equipment includes:

- collection and handling instruments: tweezers; scissors; scalpel; sterile 5 ml syringes; sterile cotton swabs;

- packaging and accessories: sterile packaging of various sizes; labels.
- storage equipment: refrigerator at 2-4ºC; freezer at -20ºC.
- it is also essential to use protective equipment, which includes: sterile clothing, such as disposable or sterilisable suits, including protective footwear; sterile disposable powder-free gloves; protective mask for the mouth; cap; protective goggles (Voinea et. al., 2011, p. 120).

5.3 Search, Discovery and Interpretation of Blood Traces at the Scene

Blood traces at the scene involve damage to bodily integrity by causing open wounds to humans or animals and the deposition of blood on various supports (Cioacă, 2019, p. 164). The shape of the bloodstains may vary depending on the severity of the injuries, the position and condition of the injured person. Arterial bleeding may result in blood trails in the form of sprays or pools, while blood drops may provide clues to the movement or transport of the injured person. The shape of the blood stains, resulting from the drops, can provide information on the direction of movement and can be useful in tracing activities. It is essential that specialists have the appropriate knowledge and equipment to examine and analyse bloodstains in a qualitative way at the scene (Doraș, 2011, p. 158).

The discovery of blood traces at the crime scene is based on general and special principles of search activity. This involves meeting at least two main conditions: the presence of a trained bio-criminal specialist with specific knowledge, and providing them with appropriate techniques and technology. The specialist must have knowledge of the general procedures, methods and rules of crime scene investigation and specific knowledge of biology (forensics) in relation to the discovery and processing of biological traces (Adam, 2014, p. 295).

The shape of blood traces found at the scene of a crime is mainly influenced by the amount of blood that has exited the human body, the speed at which it travels to the receiving surface and the angle at which it encounters this surface.

In relation to these main factors, several categories of bloodstains with different characteristics and mechanisms of formation can be distinguished, such as: bloodstains formed by free falling blood drops on horizontal and non-horizontal surfaces; bloodstains formed by splashing, spattering, throwing or projecting blood; bloodstains formed by impact at different speeds; bloodstains formed by contact (Pășescu, 2000, p. 193).

In the on-the-spot search for blood traces, so-called negative circumstances, characterised by inconsistencies between the state and position of the victim, or of objects, and the actual state of affairs, must be followed and resolved. Care must be taken to detect false traces of blood intentionally left by the offender for the purpose of misleading the investigation. Difficulties in searching the scene are stains that are small in quantity, or that are the same colour as the substrate, that have changed over time, or that have been removed in different ways by the perpetrator. A thorough search of the crime scene for hidden bloodstains must be carried out taking into account the circumstances of the crime (Cioacă, 2019, p. 172; Kirk, 1940, p. 87).

The search for traces of blood must be carried out in accordance with the specific features of the crime scene and the immediate surroundings. Several main ways of searching for blood are known from practice, namely:

- the clothing and body of the person involved in the crime (perpetrator or victim);
- the area (portion) of land, the route taken by the person bleeding and the objects found at the scene of the crime or where the body was discovered;
- the technical means (instruments, accessories, tools, etc.);
- the location of the body (the body);
- the location of the body (the body). the installations and mechanisms, vessels and other objects which could have been used in the commission of the crime or the removal of its traces (Gheorghiță, 2017, pp. 207-208).

The body of the victim or suspect is examined starting with the hairy region of the head, the natural orifices of the cranial sphere, continuing to the tips of the feet, without omitting the subungual spaces, because especially in the case of the victim she is often not able to wash her hands after the crime has been committed (Cioacă, 2019, p. 173). The clothes are subjected to a meticulous search, where each piece is examined in detail, both inside and out. Particular attention is paid to lapels, pockets, their contents, sleeves, cuffs, seams and trouser cuffs. In particular, special attention shall be paid to garments made of more hairy textured materials or thicker fabrics, such as dark coats and overcoats. Artificial light sources, such as ultraviolet lamps, and portable optical magnifying instruments are used for closer examination. This is because in such garments, blood can penetrate deep into the fabric or knitwear. The footwear is subjected to careful examination, both on the outside, in the seam areas, between the sole and the front, on the sole surface and in the details of the anti-slip pattern, and on the inside, where the lining, the socks and the feet of the person concerned are examined. In the case of house searches or of persons suspected of involvement in the offence under investigation, both the body and their clothing must be subjected to a thorough and rigorous examination (Mircea, 1999, p. 126).

The location of wounds on the victim's body and clothing may provide clues to the weapon used by the offender and the distribution of blood stains on the victim's clothing. There is a correlation between the traces of blood left on the assailant's clothing and the manner in which the crime was committed. If the injuries are caused by a tool with a small area of impact, such as a knife, fist or rock, then bloodstains will be found on the assailant's hands, face, chest or on the clothing covering these areas of the body. Conversely, if a tool with a large impact area is used, such as an axe, hammer or club, bloodstains will be more common on the back of the assailant's clothing, shoulders or chest. This is because the assailant repeatedly raises their hands above their head, which causes the blood particles to be more significantly dispersed on the back of the clothing. Correct analysis and interpretation of these blood traces can provide important information in the investigation of crime (Adam, 2014, p. 293; Svensson, 1957, p. 131).

When examining the offender's clothing, a number of forensic rules are followed, which include: the use of powerful light sources equipped with colour and wavelength adjustment options; stripping the clothing off the suspect and placing it on appropriate mannequins, which facilitate examination; marking the traces found on the clothing with circles, arrows or other visible marks; fixing the traces found by photography after they have been marked. Both overall photographs of the items of clothing and detailed metric photographs showing the area where the trace was found and the shape characteristics of the trace should be taken; the traces found should be described, measured and marked on sketches showing the shape, appearance, size and direction from which the splashes which created them are supposed to have come; checking creases and pockets for traces created by contact with dirty hands or bloody instruments used to injure the victim; carefully checking stockings and trouser cuffs, especially the inside; examination of the soles, soles and faces of footwear for blood deposits or stains; when examining clothes that have been washed, it should be borne in mind that some traces may have survived washing; the effect of water on blood-stained clothes may be haemolysis and dilution of traces of blood; traces of blood diffusion to previously unwashed areas may be observed; for the observation of very small traces of blood on dark fabrics, the use of a stereomicroscope is recommended; it should always be borne in mind that traces of blood may be confused with stains of the same colour produced by other foreign substances, such as: rust, fruit juices, paint, varnish, wines, inks, stains, etc. To distinguish blood from such substances, indicative identification tests shall be used; when traces of blood are found at the scene of the crime in the form of imprints of fabrics, experimental traces shall be obtained by printing portions of the clothes (other than those in which the traces of blood were found) on similar supports (Pășescu, 2000, pp. 213-214; Eckert, 1989, p. 197).

In the place where the crime was committed and in the area where the victim is located, search activities are carried out depending on the characteristics of the support and the existence of objects near the victim. The floors, the areas where planks are joined and areas with seams, tears, deformations or loss of material from the surface on which the victim's body is lying, etc. are carefully searched. Searches are also carried out in various containers used for waste disposal or washing, in sanitary facilities, on upholstered objects, mattresses, pillowcases and similar objects. If the floor is made of compacted earth or brick, the areas with dents or bumps and the spaces between bricks are examined in particular (Anghelescu et. al., 1976, p. 200).

Small blood stains, spatters and smears dry quickly on the spot and usually remain intact on the surface. However, there are also cases where peeling and other alterations to the bloodstains may occur after relatively short intervals of time. Such phenomena can occur when there are strong air currents at the scene such as those created by fans, open windows and doors, and when the target surfaces are heated by the various heating devices used in households. Some surfaces, such as wax-polished floors, do not retain bloodstains very well (Pășescu, 2000, p. 209).

When conducting the crime scene search in an open area, particular attention is paid to foliage, grass and other objects that can be assumed to bear traces of blood. Practice shows that in the case of crimes committed in the open and generating such traces, the crime scene generally remains untouched by the perpetrator. However, weather conditions, such as rain, wind or snow, can significantly alter the appearance of these marks, making them difficult to identify or recognize (Adam, 2014, p. 299). Interpreting blood stains left on surfaces such as stones, concrete or grass is a complex task in terms of assessing the direction and angle of impact. Bloodstains exposed to moisture may be altered in appearance and will show a diffuse and diluted distribution. Blood spatters on wet surfaces, such as ice, appear to exhibit an apparently greater volume than blood dilution. At very low temperatures (freezing), blood traces and splashes retain their characteristics very well and are very suitable for interpretation (Pășescu, 2000, p. 211). Soil, soaked with blood, shows a darker hue than surrounding areas, and blood spills on wet surfaces appear to have a larger volume appearance compared to diluted ones. Sometimes the offender may try to hide these traces by covering them with leaves, soil or other organic material. For this reason, areas recently covered with sand, foliage, wood sawdust, etc. should be carefully cleaned to allow a detailed examination of those portions of the field (Adam, 2014, p. 299). The photographing and fixing of traces left at the scene of outdoor crime should be completed as soon as possible, as an unexpected change in the weather may alter the appearance of the crime scene and destroy this material evidence. Blood-bearing objects should be secured and removed before such changes occur. During the night it is advisable to use strong light sources, ladders or crane trucks for photographing and filming the crime scene from above (Pășescu, 2000, p. 211).

Traces of blood may be found on the surface of objects used in the attack (or defence), or which were involved in causing injury or severing the victim's body. These objects may include knives, stones, weapons or other instruments used in the commission of the crime. During the crime scene investigation, particular attention is paid to searching for and collecting these traces of blood on the surface of objects, as they can provide important information for the investigation and identification of the perpetrator.

Traces of blood may also be found on instruments used to interrupt the course of tasks, on dressing materials or used to perform treatments (Anghelescu et. al., 1976, p. 201).

On the route taken by the victim, if the acts have been committed in several stages, blood traces will be looked for on the footpath or on the road supposedly taken by the victim and the assailant (Ciopraga et. al., 2001, p. 114).

Blood traces will also be searched in the vehicle alleged to have been involved in a traffic accident with unidentified perpetrators, in particular the parts of the vehicle which could have caused the injuries on the victim. The vehicle may also have been used to transport the victim, may be the place where the injury was committed, or may be a simulated suicide, in all these cases the blood traces will be searched thoroughly, as they may have crept into the most unexpected places in the vehicle (Cioacă, 2019, p. 173).

To examine the underside of vehicles, they will be raised to the appropriate height using hydraulic ramps in garages. It should be borne in mind that this part of the car is permanently covered with dust, mud and thick layers of dirt. Traces of blood no longer retain their colour, instead they can be detected with a strong beam of light in the form of denser spots that have collected more dust or in the form of droplets or bulbs. Traces of blood or fragments of soft tissue, stuck to the underside of the machine, may retain hairs or microscopic fragments of bone. The search involves examining and sectioning all deposits in the form of beads, lumps, etc., regardless of their nature. Objects found in the boot of the suspect car (crates, suitcases, bags, spare wheel, tools, strings, cables, etc.) should be examined thoroughly, using a strong light source, as they could have been touched by the killer's hands or by parts of the body being transported, or could even have been used to pack the body fragments or to transport the body (Pășescu, 2000, pp. 212-213).

The interpretation of blood traces found at the crime scene is a complex and meticulous process that can provide a diverse range of information with varying levels of probability and certainty. Careful analysis of these traces can provide relevant data relating to identifying the persons involved, determining the direction and angle of impact, assessing the violence and nature of the assault, and establishing possible circumstances relating to how the crime occurred.

In the opinion of the author Pășescu Gh., the information that can be obtained by interpreting the traces of blood at the crime scene are: calculating the height from which the blood that created the marks was spilled; determining the direction of movement of the person and the route taken by the person to the crime scene; calculating the angle of impact of the drops or splashes of blood with different surfaces; determining the point of origin of the blood marks; determining the position of the victim, the assailant and objects during bleeding; judging the nature of the object or weapon which produced the bloodstains; determining the distance from which a firearm was fired; determining the number of blows applied; demonstration of the removal of the body from the place where the assault occurred; estimates of the time periods involved in the formation and modification of the blood trail; assessment of the time elapsed between the bleeding and the action which produced the trail; estimation of the volume of bleeding, the amount of blood lost and its effect on the victim's condition; establishing the link between the victim and the perpetrator by means of blood on the perpetrator's clothing; additional criteria for estimating the time of death;

confirming or denying statements made by suspects or witnesses concerning certain circumstances of the crime (Pășescu, 2000, pp. 215-2166).

In cases where blood traces have been destroyed by washing or in situations where a long time has elapsed between the commission of the crime and the investigation of the crime scene, it is difficult to find these traces. However, by carefully investigating hidden or less accessible areas, such as in upholstery, under floorboards or parquet, in the undersides of walls or furniture, in cracks in mosaics, etc., traces of bloodstains can be discovered. It is important to bear in mind that washing removes a large part of the blood, and the remaining residues are diluted and mixed with the substances used for washing and other foreign objects. Therefore, a rigorous and meticulous examination is necessary to identify and recover such traces at the scene (Mircea, 1999, p. 127).

In addition to the technical-criminal means of searching for general purpose objects, particular techniques and methods are used to diagnose biological traces, both in the field and in forensic laboratories. These are designed in particular to carry out preliminary (indicative) tests, but also reliable laboratory examinations of traces in order to determine the very existence of biological materials on certain supports or their generic belonging. It is envisaged to use, first of all, physical methods – examination in UV radiation (currently used less frequently because many substances other than biological ones create analogue luminescence) and the application of dactyloscopic powders in the case of sweat marks (funigin, graphite, copper oxide, zinc oxide, ferromagnetic powders, etc.). The latter adhere to the fat of the sweat substance, revealing papillary patterns on different surfaces and not hindering subsequent biological expertise, as the susaminated powders do not react with the biological components of the sweat substance, making it possible to establish the blood group according to the AB0 system. The use of iodine spray and other powders is contraindicated because they produce changes in the blood substance (Adam, 2020, pp. 92-93; Shamonova et. al., 1996, p. 16).

After the discovery of suspicious stains – since a blood stain can easily be confused with other categories of stains (dyes, rust stains, wine, various food juices, ink, etc.) – it is still necessary to apply biological methods to determine whether the stain is really blood.

The first reactions to be used are of an indicative or probability nature. Such are those based on hydrogen peroxide, which produces an effervescence characteristic of the release of oxygen from the blood, now little used (Stancu, 2015, p. 159).

In the application of reagents, particular care should be taken to ensure that only a small proportion of the trace is consumed, thus leaving the possibility of examination in the laboratory. The chemicals used to identify drops as possible blood traces can be divided into two broad categories: those that react by staining and those that produce luminescence (Ciacă, 2019, p. 182; Johnoston et. al., 2008, pp. 687-689; Tobe et. al., 2007, pp. 102-109).

The first category includes a wide range of chemicals that highlight the presence of haemoglobin, a blood component protein, usually causing recolouring. The most common tests used are the phenolphthalein test (Kastle-Mayer reaction), leucocrystal violet (LCV), leucomalachite green, tetramethylbenzene (TMB) and others. The second category includes chemicals that react with haemoglobin and peroxides in the blood, but instead of producing biological trace staining, they produce luminescence, known as chemiluminescence. In this category we mention luminol, whose properties have been and are being researched by specialists worldwide. A new and much improved version of luminol is the BlueStar reagent, which is superior to the primary element (luminol) in terms of highlighting blood traces on the spot for several reasons. One reason is that the reagent highlights the trace even in foggy, lightly lit spaces, as opposed to luminol which should only be used in dark spaces (Cioacă, 2019, pp. 182-183; Dilbeck, 2006, pp. 706-720).

5.4 Fixing and Lifting Bloodstains

The fixing of blood traces, as well as other traces of the crime, must be carried out by describing them in the on-the-spot investigation report and photographing them. The report shall indicate the place or object on which the presumed blood trail was discovered, its general appearance (condition, color, size), its form and its correlation with other traces, objects of importance at the scene (Gheorghiță, 2017, p. 208). If they are on the body of the victim or suspect, the anatomical region or organ on which they were found shall be indicated, and the clothing shall also indicate the part on which they are located: collar, sleeve, lapel, etc. (Ciopraga et. al., 2001, p. 115). If necessary, during the investigation of the crime scene, particular attention shall be paid to indicating and accurately recording the location of the bloodstains on the sketches and sketches made during the investigation.

In the case of the description of bloodstains found on objects such as handkerchiefs, scarves, pocket-knives and the like, conventional indications shall be used to establish their orientation: one side of the object shall be considered the front, while the other side shall be considered the back, and pieces of paper with appropriate inscriptions shall be attached. Differences in the length or shape of the edges of the object can also be used for these purposes. In other cases, in order to locate the marks on the object, the edges of the object may be numbered with figures and pieces of paper with corresponding numerical indications may be fixed to them (by means of scallops or sewing). Accurate recording of the location of traces is necessary to monitor whether or not all the traces described in the report have been subject to forensic examination and which of them have actually been examined, providing useful information for the conduct of further forensic examination, if necessary (Adam, 2014, p. 299).

The establishment of biological traces therefore requires a documentary activity expressed in a procedural manner and carried out with a clearly defined purpose on the spot, concerning the physical imprinting of those traces, the subsequent expert examination of which may help to establish certain circumstances important for the fair resolution of the case (Adam, 2020, pp 96-97; Tomilin, 1997, p. 354; Selivanov, 1971, p. 102). Particular attention should be paid to the investigation of these traces on the spot, especially with a view to preventing their contamination and hence the possibility of genetic investigation (Stancu, 2015, p. 160).

The photographing of blood traces is carried out in two distinct stages. In the first stage, general photographs are taken to establish the general appearance of the bloodstains in relation to objects or other traces in their immediate vicinity. These photographs are intended to provide an overview of the traces present. The second stage consists of taking detailed photographs of the bloodstains. The aim of this stage is to highlight the shape, edges and dimensions of the marks in the image, using a graduated ruler to obtain scale photographs. When we have several bloodstains grouped together in the form of small drops, the detailed photographs may include several such drops. The important thing is to capture their shape and size (Mircea, 1999, p. 128).

It should be noted that, in the context of the on-site investigation of a body with signs of violent death accompanied by multiple biological traces, video-recording is usually used in practice. It has certain advantages over photography: firstly, it makes it possible to combine sketch, node and detail recordings in a single process, which facilitates the perception, demonstration and subsequent analysis of the film in other procedural actions (hearing of the suspect or accused, expert examination, court proceedings), creates the effect of being present at the event that took place, makes it possible to analyse and assess the emotional state of the persons recorded. The sound is also of added value when analysing the video-recording, as the operator can comment on his actions during the recording. Secondly, during the recording, the operator can directly view the result of the recording and its quality by changing some of the filming conditions (lighting, distance, angle, etc.) on the fly. Thirdly, contemporary technologies make it possible to take pictures not only with the help of the camera but also from the material recorded with the video camera. In addition, the modern digital camcorder can operate in both video and still mode (Adam, 2020, pp. 99-100).

In order to use the traces in this category as forensic evidence, it is necessary not only to detect and fix them, but also to pick them up, preserving as much as possible their qualities in the state in which they were discovered at the scene of the crime.

Their integrity largely depends on the way and quality of the packaging of the tracks. They are processed only with the hand wrapped in sterile surgical gloves. Before packing, if there is a risk of shaking, biological traces in the form of stains on clothing tissues are covered either with a piece of clean white cloth or with white paper larger than the stain so that when the garment is packed, the stain remains inside the garment and does not hit the fold line of the garment. Such packing makes it possible to preserve the original distribution of marks on the garment (Adam, 2020, p. 101). Objects made of wood, metal or plastics, which normally cannot be folded, are packed in boxes of a suitable size. This is done so that the walls of the boxes do not come into direct contact with the surfaces bearing the marks. This protects the objects and minimises the risk of contamination or damage to the traces on them (Mircea, 1999, p. 129; Coman et. al., 1970, p. 43).

The following principles shall be followed for objects carrying biological samples that are transportable: if the samples are not dried, they shall be left to dry in drying rooms without the use of heat sources; packaging shall be carried out in such a way as to preserve the original distribution of bloodstains; objects otherwise collected shall be carefully recorded in order to avoid confusion; blood traces to be used as references, collected from persons diagnosed with HIV or hepatitis, must be stored in special containers marked contains HIV-infected blood or contains hepatitis-infected blood'; biological samples must never be packaged in plastic containers or bags; storage of traces carrying biological samples must be done only in dark rooms protected from sunlight or heat (Cioacă, 2019, p. 194).

Traces found on items of clothing and accessories, bed linen, armchair covers or car covers shall be removed together with the backing after they have been dried. Clothing and linen with wet blood stains should never be placed in plastic bags or airtight containers, as this would cause contamination and the multiplication of bacteria destroying the sample. Packaging of these items will be done in paper bags after the stains have been dried (Drăghici et. al., 2018, p. 99; Groza et. al., 2001, p. 9).

Old traces that are dried and have been kept at room temperature until dispatch to the laboratory will continue to be kept in the same conditions (not frozen before use) (Cioacă, 2019, p. 194).

The collection of blood traces has certain particularities, particularly those found on objects that cannot be transported. For example, if the stains are dry, they can be scrapped or scratched together with a portion of the backing. If they are in the form of puddles, they can be absorbed with a pipette or filter paper. Traces on surfaces that cannot be scraped or chipped will solubilise and lift off on filter paper, but should be examined as a matter of urgency (Stancu, 2015, p. 160).

Traces formed on vegetation are removed by cutting the branches or plants concerned and placing them in cardboard boxes on a layer of damp moss so that the stains do not dry out.

Traces formed on the ground are removed by digging up the earth beneath them, and those formed on plastered walls by covering the trace with cellophane paper and peeling off a layer of plaster.

Traces formed in snow are raised by inserting filter paper or gauze under the snow layer and then introduced into the house, after melting the blood stain to keep its shape (Adam, 2014, p. 300). It is advisable not to place snow with bloodstains in a jar, as the blood will dilute once the snow melts, which reduces the possibility of determining its origin accurately. Similarly, when collecting liquid blood, a sterile swab can be used to allow the blood to dry to a crust or a test tube containing a preservative solution such as EDTA. It is not recommended to collect blood in airtight containers as anaerobic degradation will severely damage the sample. Wet material samples with traces of blood should be dried at room temperature, avoiding the use of heating devices and direct exposure to sunlight (Adam, 2014, p. 300); Averyanova et. al., p. 195).

Blood traces in most cases are composed of other biological traces, predominantly muscle tissue, skin, brain mass debris which will also be picked up and examined simultaneously. This requires the use of lifting procedures capable of ensuring the completeness of the traces (Doraş, 2011, p. 159).

The procedure for packaging material samples shall be carried out in such a way as to prevent contact of the blood-stained surface with the packaging material. Blood stains on garments are protected by covering them with paper or gauze, which are then sewn onto the garment. Fragile or glass items are individually packed in cardboard boxes and wrapped separately in filter paper. All material samples collected, preserved and packaged are appropriately labelled to prevent alteration or replacement without affecting the packaging. Information on the type of evidence contained in the package, the date of collection, the person responsible and the specific reason for collection is indicated on each package and confirmed by the signature of the prosecuting authority (Adam, 2014, p. 301).

We draw attention to the recommendations strongly made by forensic scientists or biologists not to pack blood-bearing objects in a wet state and especially not in plastic. Failure to comply with this requirement can lead to difficulties in biological examination, making it impossible to determine the blood group or even the nature of the stain. This is why objects that are still wet are allowed to dry and then packed separately, with storage time kept as short as possible (Stancu, 2015, p. 160).

5.5 Blood Trace Forensics

The presence of bloodstains at the crime scene or on the crime scene is a particularly significant aspect of the judicial process as they can provide essential information about the nature and origin of the crime. Given the complex and biological nature of blood, even in small quantities, bloodstains retain many characteristics for a considerable period of time after formation, especially in the form of stains. This opens up the possibility of forensic identification. At the same time, the biological specificity of blood traces requires multiple aspects to be examined, including the amount of blood, its age and how it is preserved. The examination of blood traces covers morphological appearance, physical and chemical characteristics, as well as the identification of common biological factors, such as the determination of antigens and other blood group elements, in order to identify the blood group of the person from whom the traces originate (Anghelescu et. al., 1978, p. 232).

Blood trace forensics – part of the broader category of bio-forensic forensics, or forensic biological forensics, as it is known in forensic science, is a specialised approach designed to provide clarification in the face of numerous questions and requests from the judiciary (Stancu, 1999, p. 192; Suciu, 1972, p. 314; Adrei et. al., 1966, pp. 219-225; Scripcaru et. al., 1979, p. 127).

Biological forensic blood evidence, either as a stand-alone or as part of a forensic examination, is intended to establish: whether or not the traces collected at the scene are human blood; the body region from which the blood traces originate and the mechanism of their formation; whether they contain alcohol, toxic and other specific elements; what the blood group is; whether the blood traces originate from the victim, the suspect or other persons whose blood comparison samples are presented (Doraș, 2011, p. 159; Baciu, 1993, p. 69); what is the approximate age of the trace; under what conditions is the trace likely to have been formed; whether the blood belongs to a man or a woman; can the DNA profile be established; what other data could be deduced from the biological investigation (Stancu, 2015, p. 161; Drăghici, 2003, p. 249; Drăghici et. al., 2018, pp. 100-101; Anghelescu et. al., 1976, pp. 202-203).

Bioforensic expertise can determine the region of the body from which the blood trace originated, as follows: blood from the oral cavity contains epithelial cells without nuclei, leukocytes, various food debris and specific microbial flora; blood from the nasal region contains nude cell elements; menstrual blood contains specific iodine and basophyte elements; vaginal blood also contains semen in the case of rape (Drăghici et. al., 2018, p. 101); blood from the liver and spleen is characterised by a predominance of white blood cells (Mircea, 1999, p. 130).

In some cases of trace blood research, it is necessary to take blood samples from suspects, corpses. The extraction of blood samples is carried out according to the procedural rules for the collection of comparison patterns with the participation of medical staff. In the minutes of this action, data on the person from whom blood samples were taken, the date, place and name of the author of the blood sample extraction operation, the way of packaging the samples shall be indicated (Doraș, 2011, p. 159).

5.6 Forensic Investigation of Saliva Traces

A „saliva trail" is the fluid secreted by the salivary glands that is deposited on various media in connection with the commission of a crime. Interest in the presence of saliva focuses in particular on the qualitative aspect, as it can provide information on the blood group of the person from whom it originates, if the person in question has the necessary secretory characteristics (is secretory for the blood group) (Anghelescu et. al., 1976, p. 203; Terbancea et. al., 1975, p. 170).

Examination of saliva stains in forensic science was introduced as a research method based on the discovery of the secretory property by Putkonen in 1930, and of factor H by Morgan V. in 1948. Phytoagglutinins have also been found to have the ability to reveal the H antigen, thus adding to the understanding and application of saliva stain examination techniques in forensic investigations (Anghelescu et. al., 1978, p. 257; Prokop, 1966, p. 643).

Saliva stains are considered to be of lower identification value in forensic investigations. These traces may be found on various objects associated with the victim, assailants or other persons involved. The value of these traces lies in the possibility of determining the secretory group of the person from which they originate.

Saliva is mainly composed of water (about 99%), organic substances (0.3%), degenerated cells (0.7%) from glands, oral mucosa, lymph nodes, as well as micro-organisms and inorganic substances. Research carried out by the Japanese scientist Yamakami K. revealed that the secretory group of the individual corresponds to the blood group. Therefore, by analysing saliva traces in the laboratory, it is possible to determine the person's blood group (Ciopraga et. al., 2001, p. 116; Anghelescu et. al., 1976, p. 203; Mircea, 1999, pp. 133-134).

Saliva is produced by three pairs of glands: parotid, sublingual and submaxillary. The secretion of the parotid glands is rich in amialase and contains few mucoproteins. The secretion of the sublingual and submaxillary glands is rich in mucoproteins, which gives it its viscous character. Quantitatively the secretion of saliva represents about 1.5L in 24 hours, with variations under the influence of different factors. Thus, depending on the type of food or other substances introduced into the mouth, there will be significant variations in salivary gland secretion. Dry food particularly excites the parotids, while acids increase the secretion of all salivary glands (Cîrjan, 2005, p. 274).

Traces of saliva are formed on the spot by direct contact between the carrier and substances secreted by the oral cavity and/or the oral cavity itself. This contact may be voluntary, created by habitual activities (such as smoking, eating, playing wind instruments), or it may be imposed, violent contact (e.g. force-feeding, gagging, etc.). Common cases are those in which a saliva trail is formed by contact between the backing and the mucous surfaces of the lips, such as wetting the adhesive side of an envelope or stamp or a seal applied to plasticine. Voluntary expectoration, hypersalivation of a physical-reflexive nature, touching surfaces with the tongue, and not least the deposition of saliva on one surface and subsequent transfer to another surface (sneezing), are other ways of forming a salivary trace on a surface (Cioacă, 2019, p. 207; Anghelescu et. al., 1976, pp. 203-204).

The forms in which saliva traces appear depend on many factor, such as (Mircea, 1999, p. 134; Drăghici et. al., 2009, 265) the nature and shape of the substrate – there are absorbent substrates (textile, synthetic, animal, soil, etc.) and non-absorbent substrates (cement, linoleum, concrete, etc.). These substrates may have a surface with or without irregularities; the distance from the mouth cavity to the substrate – the greater the distance from the substrate, the greater the degree of dispersion of the quantity of saliva, thereby influencing the homogeneity of the trace surface, its shape, contour and its delimitation from the rest of the substrate on which it is deposited. At a short distance or in the case of intimate contact with the support, the trace is present with all its characteristics, being well marked; the age of the trace – is determined by the time elapsed from its creation to its discovery. If a longer period of time passes, the trace dries out, degrades and after a few days disappears; the amount of saliva – this makes the shape of the trace better expressed and of appreciable size when it is large, or, on the contrary, hardly visible and small when it is small; the influence of external environmental factors – high temperature, humidity, air currents, sources of substrate contamination, the action of acidic or basic substances, dilution or washing of the trace, the presence of nicotine and occupational dust, etc. lead to alterations in the shape and appearance of saliva traces; influence of internal environmental factors – enzymes, proteins, blood, etc. are likely to accentuate or accelerate certain changes in saliva traces (change in colour, reduction in volume, wrinkling of the surface with a tendency to disappear, etc.).); the presence of diseases – diseases may cause changes in the shape and appearance of saliva due to quantitative changes (excess saliva in the case of dento-alveolar irritative foci, inflammation or tumours of the soft parts of the oral cavity, etc.) and qualitative changes (presence of blood streaks, traces of pus, tumour fragments, variations in the viscosity of salivary fluid, etc.). Also, the need to administer a medicinal substance with side-effects on saliva causes the volume and quality of this biological product to decrease, i.e. its viscosity increases and its density increases; age – particularly in old age, there are quantitative and qualitative changes in salivary secretion; gender, certain physiological moments in which the person creating the trace is present (pregnancy, menstruation, starvation, etc.); and the age of the person creating the trace (pregnancy, menstruation, starvation, etc.).), dental treatments, the reflex act of salivating to certain gustatory stimulants (e.g. chewing gum) or to sensations of taste rejection, the abundance of saliva accompanying certain diseases (e.g. liver failure) (Anghelescu et. al., 1976, pp. 204-205).

The search for traces of saliva is carried out on objects likely to have come into direct contact with the human mouth (Mircea, 1999, p. 134). The appearance and colour of saliva traces vary according to the time elapsed since their deposition. Fresh traces are almost colourless, while older ones may be light yellow. To examine and highlight these traces, methods such as flashlight illumination at different angles of incidence, the use of a magnifying glass and a UV lamp are used (Ciopraga et. al., 2001, p. 116).

At the crime scene, all objects relevant to the criminal activity are searched for traces of saliva. These objects and places include the following:

- objects used for personal hygiene purposes, such as handkerchiefs, towels, toothbrushes, toothpicks or similar objects;
- objects used for smoking, such as cigarettes, cigarette butts, pipes, cigars, cigarettes, etc.;
- cutlery, plates, glasses, bottles, cups, feeding bottles and other similar objects likely to bear traces of saliva;
- musical blowing instruments and dental instruments;
- articles of clothing and footwear; articles of religious worship such as icons, crosses, relics, etc.;
- cotton wool, gauze, compresses, gags and other objects forcibly inserted into the victim's oral cavity;
- underwear and bed linen, paying particular attention to collars, combs, edge stitching, inside of bra cups, pillowcases, sheets, etc.;
- the victim's body, in particular the lips, face, neck, mammary region and pubic area, as well as the surroundings of the place where the victim was found; other objects or tools found at the scene and associated with the perpetrator, on which traces of saliva are suspected (Anghelescu et. al., 1976, p. 205).

From the scope of the research we should not exclude objects or media that are apparently not considered capable of retaining traces of saliva in research. These may include stamps, envelopes or lipstick holders. In the literature, cases have been reported where blood grouping has been achieved by examining only 1/16th of a stamp and DNA profiling (Stancu, 2015, p. 163; Svensson et. al., 1957, p. 208).

Saliva traces are established by describing them in the relevant report, indicating the object on which they were found and the specific location, their shape and condition (wet, solid), their appearance and colour. If these marks were found on the victim's body together with the bite marks, they must also be described (Gheorghiță, 2017, p. 209). Photographing is done by the usual procedures (by sketching, detail to scale, colour separation photography, if necessary), as well as by sketching, video-recording (Adam, 2020, p. 118).

The collection and transport of suspected saliva traces requires the same recommendations as for blood traces, that the object should be dry-packed and sent urgently to the specialist laboratory so as not to destroy the antigens (Stancu, 1999, p. 196).

All traces shall be removed together with the item or part of it and packed in clean containers. From objects which cannot be removed, the trace shall be collected by rubbing with sterile swabs and distilled water. The same applies to kiss marks on parts of the human body, which are gently swabbed with moistened sterile cotton wool. Cigarette butts are picked up with sterile tweezers, preserved separately, the remains of ashes being removed not by blowing with the mouth but with a clean object. The traces in question must be protected from heat, moisture and direct sunlight, and the wet ones dried at room temperature and sent to the laboratory as soon as possible, as the main component – amylase, by which the presence of saliva is established – is constantly decomposing, making further analysis difficult. In order not to allow their contamination with foreign cellular material, it is advisable not to talk during their collection and preservation, to change gloves when handling different biological traces, to use sterile instruments from the biological kit. Packaging of dried traces should be done separately for each trace, in clean paper containers, with the packaging kept at room temperature (Adam, 2020, pp. 118-119).

Interpretation of saliva traces can be used to obtain data on how the trace was formed, the person's professional background, their state of health, certain habits or vices, in particular smoking, the number of people who created the traces, the time spent at the research site, etc. (Stancu, 2015, p. 164; Anghelescu et. al., 1976, p. 206).

In order to obtain patterns for comparison with saliva traces, samples will be taken from the suspected person: at least 5 ml of liquid blood (in a test tube or vial); 3-5 drops of blood, on a glass microscope slide; 2-3 ml of saliva, which will be placed in a vial or test tube and then inactivated by boiling in a pot of water for

30 minutes; 2-3 cigarette butts smoked by the suspect (if a smoker) in the presence of the prosecuting authority (Anghelescu et. al., 1976, p. 206); the suspect will also be asked to moisten a filter paper (sucker) in the mouth (Cîrjan, 2005, p. 275).

Saliva trace testing is based on scientific methods and techniques to elucidate various aspects of saliva traces. By using specific tests and analyses, the expert can determine whether the trace in question is saliva and whether it comes from a human source. However, it is important to note that the results obtained are not always absolutely certain. In the expert opinion, it is possible to identify and determine whether the person in question is a blood group secretor or non-secretor based on the antigen content of the saliva analysed. This information can be used to determine the person's blood group (Anghelescu et. al., 1978, p. 257-264; Ciopraga et. al., 2001, p. 117; Boia et. al., 1979, pp. 126-128).

Genetic examination of DNA-specific nuclei leads to the actual identification of the person who has left such traces. Saliva can reveal a number of individual characteristics, which are reflected in the cellular composition and microbial flora specific to the oral area. The environment in which the person produces saliva can also influence certain characteristics, such as in the case of people working in chemical plants, smelters, mines, etc. (Stancu, 1999, p. 196).

5.7 Forensic Investigation of Traces of Sperm

Semen trace is defined as the secretory fluid from the male sex glands that may be deposited on various media during or in connection with the commission of a crime. This secretion may be the result of physiological or pathological processes specific to the male reproductive system (Anghelescu et. al., 1976, p. 207). The discharge of seminal fluid from the seminal vesicles may occur voluntarily, particularly during sexual intercourse, but may also be observed accidentally or as a result of disease. In cases of suicide, especially hanging, a release of seminal fluid similar to that during sexual intercourse may occur (Ciopraga et. al., 2001, p. 117).

These traces may not only be evidence of a crime, but may also provide information about the motive and nature of the crime (Drăghici et. al., 2018, p. 115; Cecaldi, 1962, p. 32). The importance of semen traces for forensic investigations lies not only in the fact that they serve to clarify questions relating to the circumstances of the crime, but above all in the possibility of obtaining useful data for identifying the person or delimiting the circle of suspects (Stancu, 2015, p. 164). However, it should be borne in mind that the possibilities of searching for traces of semen are limited by the time factor and, of course, by the conditions in which the spermatozoa exist. Specialists state that in intravaginal conditions spermatozoa survive up to 48 hours, and in absorbent tissues, under normal climatic conditions, they can be preserved for a long time, sometimes for more than 20-30 days. This makes it necessary to discover, remove and examine these traces in good time and to take appropriate measures to preserve them (Doraș, 2011, p. 160).

The shape and appearance of semen traces are influenced by a number of factors, including the nature and shape of the substrate on which they are found, the manner in which the seminal fluid came into contact with the substrate, the length of time elapsed from deposition to discovery and the state of health of the person concerned, etc. (Mircea, 1999, p. 130). The shape and appearance of semen traces on the spot are influenced by the following factors:

- nature and shape of the substrate – semen traces may remain on absorbent and non-absorbent substrates (Suciu, 1972, p. 319). On absorbent carriers, they appear as whitish-grey spots with an irregular outline, but clearly defined from the rest of the carrier, with a rough feeling when touched, and on non-absorbent carriers as shiny streaks or crusts;
- height of fall – this depends on the position of the person at the time of discharge (lying or standing). In the case of the lying position, the semen trace has an irregular shape, being imprinted in the underwear or on the bedding. When the person is standing, the appearance of the semen trace is in the form of a zigzag stripe;
- age – the age of the semen trace influences its appearance in terms of both shape and colour. Thus, depending on the nature of the substrate, it shrinks as a result of drying and the colour changes over time from greyish-white to greyish-yellow or light grey;
- influence of external environmental factors – the shape and appearance of the semen mark is influenced by some external environmental factors such as: high temperatures, humidity, lighting, environmental impurities, residues of contraceptive substances, etc.; number of people who have removed the semen mark – this factor influences the quantity, shape and appearance of the mark. When more than one man has removed semen, more traces or unusually large stains will be found, and differences in

colour, consistency, composition and degree of spread or extension on the surface of a same-gender carrier may be observed in appearance; presence of disease – diseases of the genital organs can lead to changes in the appearance of the semen trace. In such cases, blood, pus, urine, urethral secretions, vulvovaginal secretions, hairs, etc., may appear in semen traces (Anghelescu et. al., 1976, p. 208).

The search for semen traces on the spot is carried out by examination with the naked eye, and in the case of suspicious objects on which the trace is not clearly outlined, examination with the Wood lamp is used, which causes the semen stains to fluoresce greenish-yellow in the dark (Cioacă, 2019, p. 199). Under the action of UV radiation, semen traces fluoresce blue, which distinguishes them from other biological traces, but it should be borne in mind that fresh semen produces a very weak luminescence, which makes it difficult to detect them (Adam, 2020, p. 116). At the same time, it should not be forgotten that such fluorescence is also found in other organic stains, such as urine and mucus, so it is not an individual characteristic of semen traces (Mircea, 1999, p. 131; Scripcaru et. al., 1978, p. 253).

Traces of semen on textile backings can also be revealed using the scanning microscope. Often, by attempting to wash the textile backing, a real fixation of sperm on the fibres occurs. Alizarin sulphate, which gives the sperm a green colour, is also used to reveal sperm traces on the spot (Cioacă, 2019, p. 199).

The order of investigation of suspected semen-bearing objects is determined by the specific characteristics of the crime scene. If the victim's body is found at that location, it is subject to initial examination under the supervision of a forensic pathologist. Thus, semen traces are searched in areas such as the thighs, buttocks, abdomen, under the breasts, armpits, hands, natural orifices and pubic hairs. The victim's underwear and outer clothing are then examined. The investigation then continues with the investigation of objects suspected of bearing such marks. In a particular order, bed linen, nearby carpets, floors, towels, sinks, bathrooms and other objects capable of retaining and preserving traces of semen are examined. In cases where the crime scene is an open area, traces of semen are also searched on the ground, grass, leaves, flowers and other objects that could be involved in the commission of the crime under investigation (Mircea, 1999, p. 131). In cases of zoophilia, traces of semen will also be sought on objects that were used to restrain and trap the animal, soiled by performing sexual perversion manoeuvres (Cioacă, 2019, p. 19; Asanache, 2007, p. 36).

The collection of semen traces will be carried out with caution, requiring greater care than in the case of other traces, in order to preserve as intact as possible, the trace and therefore the spermatozoa, the main element examined (Cîrjan, 2005, p. 277). Traces of semen identified at the scene will be described in the report and photographed. The report shall contain precise information on the exact location of the traces, the characteristics of the objects on which they are deposited and descriptions of the shape, appearance and colour of the traces. It will also mention objects in the vicinity of the tracks, if relevant to the investigation of the crime, or highlight anatomical regions associated with the discovery of these traces (Ciopraga et. al., 2001, p. 118). Photography in these cases is rarely used because the traces may be found in certain intimate areas of the human body (Gheorghiță, 2017, p. 210). However, it is possible to photograph the objects on which the semen traces were discovered, the areas of the objects on which the traces are found (Mircea, 1999, p. 132).

After the procedural and technical fixation, they are scraped off with a clean scalpel and transferred to a clean sheet of paper to be folded or directly into a pharmacy-type envelope. Alternatively, a sterile cotton swab (ear swabs) moistened with a drop of sterile water or saline may be used to swab the impression until a sufficient quantity of sample has been transferred (several such swabs may be used). The sample is first dried and then wrapped in clean paper. Each of the pharmacy-type envelopes, or the paper used for direct packaging of the collected samples, shall be packed separately in another paper envelope which shall be appropriately marked and sealed. In the fluid state traces of semen or vaginal secretion shall be collected by syringe or by swabbing with sterile absorbent material. Depending on the case, store in a suitable tube or dry at room temperature. If traces of semen or vaginal secretions are found on small objects, the carrier object shall be lifted as such and the traces collected under laboratory conditions. If an item is wet, it must first be dried, wrapped separately in paper, labelled appropriately and stored at room temperature until sent to the laboratory. Traces of semen (or suspected semen) on non-absorbent surfaces are scraped off using a scalpel (or other sterile object) and the resulting microcrusts are collected on a clean piece of paper, which is separately wrapped and labelled. A sample containing vaginal, anal or buccal secretion, if not sterilely dried after collection or preserved at a temperature of maximum 2-3°C before arriving in the laboratory, will be almost completely destroyed by the existing bacterial microflora within a few days, making subsequent genotyping of semen traces impossible (Adam, 2020, pp. 116-117).

Traces on a hard surface (floorboard, parquet, another object) are not scraped off, but are cut away. If the stains are on hair, they are removed by cutting the hair, and those on skin are removed by moistening the stain with distilled water or glycerine and transferring them to filter paper. The soaked paper is placed in the sterilised test tube (Gheorghiță, 2017, p. 210). The specimen found at the crime scene is cleaned with a clean swab – separated inside and outside, avoiding mixing of biological material on the outside with that on the inside – and then stored at -20°C (Adam, 2020, p. 117; Voinea et. al., 2011, p. 141).

Handling of the carriers and traces should be carried out only in shaded conditions, avoiding sunlight and with gloved hands, protective mouth masks, shoe covers, protective coveralls, so as to avoid contamination of the trace with foreign biological material. Wet items are dried at room temperature, if possible, in the dark, but some authors rightly point out that in the context of criminal prosecution it is not always possible to dry these items, which is why their packaging must be temporary – only to be transported to the laboratory, where the drying procedure will be extended (Adam, 2020, p. 117; Fedosytkin, 2012, p. 185).

The same precautions should be taken when packaging objects bearing seminal traces, ensuring that they are dry and protected from heat and sunlight during transport. These measures are justified by the results of specialised research, which have led to the conclusion that the determination of secretory quality and the identification of antigens in the A.B.O. system are more reliable for semen traces than for old blood traces. The new methods allow the determination of blood type in seminal fluid stains older than one year (Stancu, 2015, p. 165; Boia et. al., 1966).

The interpretation of semen traces provides data or clues as to how they were formed, the age of the traces, the approximate number of persons from whom they originated, certain disease conditions manifested by pollution, etc. Also, the location of the semen traces can provide clues as to the neuropsychological and somatic state of the person who created the trace, as well as any possible defects.

Obtaining evidence from the suspect for comparison with the semen traces found at the scene is done by forensic laboratories. When the semen trace is also associated with other biological products (blood, saliva, pus) comparison samples will be obtained for these as well (Anghelescu et. al., 1976, p. 209).

The main purpose of bioforensic examination of semen traces is to establish whether the trace in question is in fact semen and whether it comes from a human or animal source. Among the probability reactions, there are crystallographic reactions (Florence and Barberio), chromatographic and spectrographic reactions, acid phosphatase reactions, and as a certainty reaction, the detection of the spermatozoon by a colour reaction (Stancu, 2015, p. 165).

The Florence reaction stands out as being extremely sensitive to the presence of sperm and at the same time easy to perform. By using the iodine-iodide reagent, choline periodide crystals are formed in fresh sperm immediately after ejaculation. These crystals are mahogany-brown in colour and elongated in shape. If these crystals are not observed, the result of the reaction is considered negative. It is important to note that a negative result does not absolutely exclude the presence of sperm, as the appearance of crystals may be inhibited by unsuitable storage conditions or the presence of trailing blood. However, the final diagnosis is established by identification of spermatozoa in the sample. There are other methods of analysis, such as the Barberio reaction with picric acid, which leads to the formation of yellow crystals and small prisms of spermine picrate, or the Lecha-Marzo reaction, which uses phosphomolybdenic acid. Compared to crystallographic methods, chromatographic methods have an advantage in that they allow the identification of spermine, which is particularly important in cases of azoospermia and oligospermia, where sperm cannot be clearly detected (Cioacă, 2019, pp. 200-201; Scripcaru, 1973, p. 130; Moraru, 1967, p. 723; Beliș, 1995, p. 653; Berud, 1940, p. 97).

Acid phosphatase is an essential element in the identification of semen in forensic investigations. This enzyme is made up of a group of phosphates that are maintained in a pH equilibrium. Its importance in forensic science derives from the fact that acid phosphatase is produced by the prostate and is actively found in semen. Acid phosphatase levels are not affected by vasectomy surgery. Acid phosphatase activity is maintained for about 6 months at an average body temperature of 37°C. However, the period of activity may be reduced if acid phosphatase is stored in a humid environment. Detection of acid phosphatase activity is possible even after about 1 year in dried seminal fluid spots that have been stored in a controlled environment at -20°C (Cioacă, 2019, pp. 200-201; Allard, 1977, pp. 99-108).

The colorimetric method, also known as the Welker qualitative method, is based on the fact that acid phosphatase contained in semen is soluble in water and through hydrolysis can generate a variety of phosphate ethers. To transfer a small amount of the trace found at the incident site, sterile chopsticks or filter paper can be used by pressing these objects onto the stain in dispute. To perform the test, Fast Blue B a reagent is added to the sterile swab or filter paper in contact with the test spot. If a red colour change is observed within one minute, the test is considered positive for the presence of sperm. If the time taken for the colour change to appear is greater than one minute, this indicates non-prostatic acid phosphatase activity. It is important to note that the colorimetric method of qualitative determination of acid phosphatase by colour change is considered inaccurate because this enzyme is also present in other organs such as the liver, kidneys, or in other organic substances such as milk, potatoes, etc. (Cioacă, 2019, p. 202; Beliș, 1995, p. 653).

Prostate-specific antigen, also known as p30, is the most important protein present in sperm fluid and plays a crucial role in genetic identification, being located on chromosome 19. PSA concentrations in seminal fluid range from 0.5 to 2.00 mg/ml. This protein is produced by the epithelia of the prostate and is released into the seminal fluid. ASP is present in the cytoplasm of prostatic ductal epithelial cells, ductal lamina secretions (seminal fluid, prostatic fluid), urine and serum. Prostate-specific antigen plays an important role in dissolving the gel formed during ejaculation by proteolysis of major proteins in semen, such as semenogelin I and II and fibronectin. Through proteolysis, prostate-specific antigen contributes to the liquefaction of the ejaculate and the progressive release of motile spermatozoa. This antigen has also been identified in the paraurethral gland, perianal gland, endocrine sweat gland and mammary gland. Small amounts of prostate-specific antigen can be found in urine, faeces, sweat and breast milk. The period of activity of prostate-specific antigen is about 3 years at room temperature, but this period is significantly reduced in a moist environment. Probability methods based on the immunological properties of sperm are based on the fact that sperm contain not only blood group-specific proteins but also organ-specific proteins, which allows the antigen-antibody reaction to take place. Agar or tube precipitation reactions are used to identify the presence of an aqueous macerate in a suspect spot. A positive result undoubtedly indicates whether the biological product is of human origin or not (Cioacă, 2019, pp. 202-203; Sensabaugh, 1978, pp 106-115; Li, 2015, p. 259).

At the same time, the bio criminal analysis of semen traces is used to determine whether the semen is secretory or non-secretory, the blood group (if the individual is secretory), as well as the age of the stain, the foreign substances present in the trace and any venereal diseases (Anghelescu et. al., 1978, p. 265; Stancu, 2015, p. 165).

Semen trace forensics hides a caveat recognised by experts: the ability to identify a person when their sperm are identified in traces found at the crime scene or on the victim. This identification is based on the presence of abnormal or atypical forms of sperm alongside normal sperm. The wide variation in these abnormal forms creates a unique diversity, making it virtually impossible for two men to have the same percentage of atypical cells. Although there are reservations about this method of identification, due to the instability of abnormal sperm forms, which can vary over the lifetime of the individual, conclusions about identity should be treated with caution. However, significant progress has now been made in the identification of the individual by sperm traces, with the refinement of techniques for determining the specific genetic profile of sperm, which allow the discovery and quantification of relevant genetic markers (Stancu, 2015, p. 166).

When examining semen traces, the specialist/expert will be able to answer questions such as:

- when only the semen trace as such or the object carrying the trace is present: whether or not there are traces of semen on the object submitted;
- whether the semen trace submitted is semen or another substance;
- whether the semen trace is of a human nature; what is the blood group of the person who created the semen trace;
- what is the approximate age of the semen trace;
- whether the semen traces come from a single person or from several;
- whether the person from whom the semen trace or semen smears come suffers from a venereal disease or other pathological condition;
- when the semen trace and the comparison specimens are submitted: whether the semen trace found on the spot has the same blood group as that of the person from whom the comparison specimens were collected; whether there are other indications of similarity between the semen trace and the comparison specimens (Anghelescu et. al., 1976, p. 209; Cătuna, 2008, p. 50).

5.8 Forensic Investigation of Other Biological Traces of a Human Nature

In the course of committing a crime, biological traces of a remarkable variety are formed. Apart from the most common fingerprints, such as blood, semen or saliva, other signs of human presence can also be found at the crime scene. These include traces of sweat, urine, vomit, faeces, meconium, bronchial mucus, amniotic fluid, etc. Bioforensic examination of these biological clues can provide valuable information to clarify many aspects of the nature and manner of the crime, including the identification of the person responsible.

In view of their importance in the resolution of certain cases, there is no justification for neglecting them because of a certain natural aversion to such traces, which is why they are simply overlooked. The judicial body carrying out, conducting or supervising the investigation is obliged to call on the assistance of a biocriminal specialist to discover, collect and examine all categories of biological traces which may be used to obtain data on the persons involved in a criminal offence. As a rule, their investigation, i.e. their discovery, fixation, collection, interpretation, completed by expert opinion, involves the use of procedures similar to saliva or semen (Stancu, 1999, p. 200).

Traces of perspiration, composed of organic and inorganic substances eliminated by the body, are formed naturally by wiping the hands, forehead, cheeks, neck or other areas of the body with handkerchiefs, towels, sheets or, more rarely, by dripping directly on various objects such as floors or carpets. These sweat marks, usually colourless and sometimes slightly coloured due to impurities on the body, are difficult to detect at the scene of the crime. They are collected together with objects suspected of wearing them, such as handkerchiefs, hats, scarves, shoes, pieces of clothing, etc. To identify them, suspect objects are investigated in detail using methods similar to those used for saliva and semen traces. Once discovered, sweat marks are described in the crime scene investigation report, mentioning the objects on which they were found, the shape in which they are found and in association with other marks. Trace objects may also be photographed, capturing images of them at the place where they were found in relation to the traces and other objects in the vicinity. Detailed photographs are also taken for each individual trace object. When there are distinct characteristics of sweat marks on these objects, these are highlighted in the photographs, especially when the marks are impregnated with foreign substances that have a contrasting colour to the object itself. Care should be taken when picking up sweat-stained objects to avoid creating new marks on them during handling and transport. The packaging used shall be clean and of a size appropriate to the individual item. Analysed in the laboratory, sweat stains provide information about the blood group of the person from whom they originated and, in some cases, may provide clues as to the profession or work environment of the person involved (Mircea, 1999, pp. 135-136).

Urine traces are usually formed in significant quantities at the scene and the objects on which they are found, with rare exceptions, are slightly yellowish in colour, sometimes even bright yellow. In smaller quantities, these traces can be found on underwear or bedding, and in larger quantities they can be seen on the ground or snow in the area surrounding the crime scene or even on the route taken by the offender before or after committing the crime (Mircea, 1999, 136).

Urine traces can be easily observed visually, due to their colour characteristics and specific odour. If a significant amount of fluid is found at the scene, it can be collected using a rubber pump or pipette and transferred to a sterile container, which will be labelled with the necessary identification information. Through laboratory analysis, experts can determine the blood group of the person from whom the urine originated, and nowadays, with technological advances, it is also possible to identify the person on the basis of their DNA (deoxyribonucleic acid) profile. In the case of urine from a woman, laboratory examination can provide additional information, such as the detection of possible pregnancy, recent childbirth or abortion. Objects bearing traces of urine, especially small items such as bedding or underwear, will be collected for further detailed examination and laboratory analysis (Ciopraga et. al., 2001, p. 119).

Since microscopic examination is difficult to detect certain cytological elements, two chemical detection methods are used:

- phosphotugstic acid reaction (for the detection of uric acid), which is also positive with saliva, blood serum and faeces;
- reaction with xanthydrol and acetic acid. It is characteristic of urea, but can also be positive with blood serum. It is negative with blood, semen, breast milk and faeces. Urine shows ABO blood group substances in water-soluble form, but as their titer is very low in dilution in urine spots, they are more difficult to detect. Urine spots can be collected as such or by scraping into a clean paper envelope (Drăghici et. al., 2018, p. 118).

Vomit stains are formed when stomach contents are expelled orally as a result of spastic contraction of the diaphragm and abdominal muscles. These traces are mainly composed of undigested food consumed by the person. They usually take the form of a viscous, often multi-coloured mass with an odor characteristic of fermenting food. These traces are established by description and photography. In the description, it is mentioned which objects were found, what other objects or traces are in their immediate vicinity, their age, colour and quantity. If they are found in more than one area or object, the colour and appearance of each trace is indicated. Photographing spill traces usually involves two steps. In the first stage, the main objects are photographed together with the traces, so that objects or traces in their immediate vicinity are also reproduced. It also seeks to highlight in the image the object on which the spill trace is located. For detailed photography, the vomit track shall be separated from the rest of the objects so that the shape, dimensions and certain features of the vomit track can be seen in the image. It is recommended that detailed photographs be taken using the scale photography method. The vomit traces shall be picked up by placing an appropriate amount of substance in clean jars from the mass of the trace. If there are vomit traces at the scene in more than one place and with different general appearance, laboratory samples should be taken from each trace and packed in separate jars. By examining the vomit, the expert can determine the nature of the food eaten in the last few hours and the blood group of the person from whom the traces originated, even after a longer period of time (Mircea, 1999, pp. 136-137).

Trace excrement is sometimes required for forensic examination. It has a yellow-brown appearance and remains on the substrate as a crust. It can be identified by microscopic and chemical examination. Under the microscope one can distinguish muscle fibres, connective tissue, yellow or whitish granules, vegetable debris (starch granules), remnants of plant fragments with spiral, circular or scoliform vessels; colourless plant hairs, plant cells, mucus, bilurubin crystals, cholesterol, calcium oxalate crystals, stereobilin pigments (specific to faecal material) and in some cases spores, bacteria and eggs of intestinal parasites may be found. No specific substances can be detected in the faeces that would allow the determination of individual membership (Drăghici et. al., 2018, p. 118).

Meconium is the totality of substances accumulated in the intestinal tract of the foetus during gestation. Investigation of meconium stains and their identification can provide significant evidence in cases of crimes of pre-pregnancy, termination of pregnancy or concealment of birth. The composition of meconium comprises elements from three distinct sources:

– substances of gastrointestinal origin, such as mucus, yellow-tinged fatty granules and desquamated epithelial cells from the digestive tract;
– elements of hepatic origin, including mucus, cylindrical cells detached from the bile ducts, brown corpuscles, lamellar and transparent cholesterol crystals, and bilirubin crystals;
– components from the amniotic environment, such as desquamated epidermal cells, very thin fetal peri peri and no glandular ducts. Morphologically, the meconium stains are viscous, yellowish-brown with green tinges, adherent and odourless.

Examination of meconium stains can be carried out chemically by acid phosphatase detection, but the results are not precise. Reactions with precipitating sera obtained by immunising rabbits with human meconium can also be used. However, the most valuable method of identification is the microscopic examination of the meconium stain, which investigates its various constituents. The absorption method can be used to determine ABO group antigens in meconium from secreting individuals (Drăghici et. al., 2018, p. 117; Beliș, 1995, p. 656).

Examination of traces of amniotic fluid is necessary in the case of crimes of pre-murder, concealment of birth. These stains are yellowish in colour, well outlined. They can be revealed by the macerate from them being examined under the microscope epithelial cells and fetal hair. It is difficult to determine the presence of amniotic fluid. In secreting individuals, ABO group substances can be determined, which usually correspond to fetal antigens (Drăghici et. al., 2018, p. 118; Beliș, 1995, p. 658).

The bronchial mucus trace is whitish, sometimes greenish, with a smooth outline. Microscopic examination reveals bronchial mucus cells, prismatic cells with vibratile cilia, pavement cells in the oral cavity and pharynx, polynuclear cells, microbes and some haemocytes. Of importance for determining secretory status in cadavers from which saliva or other secretions can no longer be collected. Nasal mucus stain appears stained either white, yellow or grey and contains cells with vibratile airway cilia, leukocytes, etc. (Drăghici et. al., 2018, p. 117).

5.9 Forensic Investigation of Hair Traces

Human hair is a specific type of biological sample referred to in scientific terminology as a ,,hair trace", which is a valuable source of information on its natural characteristics, ethnic origin, sex, age, anatomical region of origin, pigmentation and various morphological features specific to the individual (Moise et. al., 2020, p. 93).

A hair trace is defined as hair originating from the human body in the process of or in connection with the commission of a crime (Cătuna, 2008, p. 51).

Human hair can be analysed from an anatomical perspective, with two distinct main components: the root and the shaft. The root is surrounded by a structural complex called the hair follicle, which is composed of an inner epithelial sheath and an outer epithelial sheath, both of which are enveloped by a fibrous sheath. The inner epithelial sheath consists of three concentric layers of keratinised cells: the cuticle (also known as the epidermis), the Huxley layer and the Henle layer. The outer epithelial sheath is the extension of the skin (epidermis), which continues onto the root, providing protection and enveloping the inner epithelial sheath down to the root bulb and papilla. The outer sheath, called the fibrous sheath, is made up of connective tissue of the connective tissue type, which continues with the dermis. The papilla of the bulb consists of a connective tissue devoid of elastic fibres, containing capillaries and nerve fibres, thus providing nutrition and innervation for the hair. The hair shaft comprises specific structures such as the medulla (medullary canal), cortex (corticula) and cuticle (Anghelescu et. al., 1976, p. 210). The physiological role of hairs is to protect more sensitive areas of the human body, and the way they are distributed to regions is influenced by genetic factors and sex hormones (Cîrjam 2005, p. 280).

Human hairs differ from animal hairs in the characteristics of the medulla, cuticle, pigmentation, bulb and distal end. Added to this is the biochemical structure of the bulb and sheath, as well as some group peculiarities (Anghelescu et. al., 1978, p. 282).

From the examination of the hairs, it is possible to obtain data on the persons who participated in the crime: sex, age of the person, body region from which the hair originates, mode of detachment, general and particular characteristics (length, thickness, shape, colour, external structure, pigmentation, various morphological features of the hair). In addition, it is possible to identify the person on the basis of the DNA profile (Gheorghiță, 2017, p. 211).

A number of characteristics of the hair can be distinguished, such as: length, thickness, root, colour, waviness, degree of damage due to external factors or pathological changes. These characteristics may differ according to: the region of the body, in the sense that hairs on the human body have different characteristics depending on the area of origin (hairy region of the head, eyebrows, eyelashes, moustache, beard, armpits, pubic region or other parts of the body); the sex of the person, which influences the characteristics of the hair, especially the hair in the hairy region of the head, as a result of fashion fluctuations; the state of health of the person, which leads to partial and zonal discolouration, intensification of shades, changes in appearance (thickening, thickening or thinning, etc.); and increased brittleness, breakage, irregular shapes or the appearance of twisted, discoloured fragments, vestiges of the medullary canal, etc. At other times, the thread is much shortened, thinned at the point of implantation, progressively thickening towards the free end, or shows a succession of dilations and twists (Anghelescu et. al., 1976, p. 210).

The existence of hairs at the scene should not be attributed exclusively to violent actions. It is important to note that situations in which hairs are present can have different circumstances. For example, they may be the result of hairs simply being pulled from the head or other parts of the body, without being plucked or cut, such as when removing a hat or scarf. Also, inserting an arm uncovered by the shirt into a narrow space for the purpose of removing an object may result in the hairs falling out as a result of slight friction with the edges of the opening. It is important to note that hair loss can also be caused by pathophysiological or accidental factors (Stancu, 2015, p. 170). Hair diseases are also a guiding clue in the search for perpetrators on fresh traces and in the rapid narrowing of the circle of suspects. Thus, in the case of bifurcation of hairs they split longitudinally and individuals with this disease usually do not possess long and thick hair. Another disease – fuzzy aplasia is evidenced by alternate thickening along the hair, which in men sometimes causes false baldness. Subjects suffering from trihoptilozole the ends of the hairs are shorn of a lighter and duller shade, and in the case of trihondrosis knots appear on the hairs which, not being cared for, form tangles of hair (Golubenco, 1999, p. 79).

The shape and appearance of the hair can be influenced by factors such as: the manner of detachment of the hair from the dermoepidermal layer – this factor is likely to influence the appearance in the case of plucking, the hair shows, in addition to signs of vital activity, a number of deformations; in the case of breakage, the hair has a split, filamentous and rootless lower end; spontaneously fallen hair has a full bulb, shows signs of devitalisation, the root is broken and has a wiry appearance; degenerated hair has a dry and keratinised bulb; in the case of partial burning, the hair has a specific appearance at the injured end; time elapsed since the splitting – the influence of this factor is that in the case of recent cutting the section appears somewhat flat, depending on the degree of sharpness of the cutting object, and after 48 hours the angles begin to round off; influence of external environmental factors – under the action of high temperature there is a change in the colour of the hair. At around 180°, blond hair turns reddish-brown, brown hair turns black and white hair turns pink. At about 250° artificial curls appear, and between 300-400° charring occurs. Chemicals discolour or cause a totally different colour from the original (Anghelescu et. al., 1976, p. 211).

The discovery of hairs is not a difficult problem, as in the case of larger hairs they can be seen with the naked eye. The same cannot be said for very small hairs, such as those in eyebrows, eyelashes, moustaches, very small animal hairs or hairs that have a similar colour to the substrate on which they are deposited. This is why technical means such as magnifying glasses, torches, pocket microscopes, etc. are also used to search for hairs (Cioacă, 2019, p. 213).

Hairs can be found on a variety of objects at the crime scene, including floorboards, sofas, armchairs, blankets, carpets, bathroom or kitchen sinks, tools associated with the crime, the victim's or offender's body and others. If the crime takes place in an open space, such as gardens, yards or orchards, these traces may be found on soil, grass, flowers, leaves of shrubs. In the case of road traffic accidents, they may be found on the vehicles involved in the accident, on the bodies of the victims or on various objects belonging to people involved in the event (Mircea, 1999, p. 120). At the scene, hairs can be identified together with biological or other trace forms. It should be borne in mind that at the scene, especially in open spaces, hairs found may belong to persons or animals that have no connection with the crime (Cioacă, 2019, p. 214; Vasiliu, 1985).

Hairs can also be found on objects with which the victim or perpetrator has come into contact, using optical and focused illumination (Adam, 2020, p. 119). For this purpose, the victim's clothing, underwear and body are examined. Particular attention must be paid to the search for objects of crime (firearms, knives, axes, blunt objects, etc.) used by the offender. Biological traces, which may include hairs, should also be included in the scope of the search. When examining victims and corpses, the fingernails and, in particular, the hands should not be omitted, as they may contain hairs pulled from the offender (Gheorghiță, 2017, p. 211; Wells, 1968, p. 217).

The hairs, once discovered, shall be recorded in the crime scene investigation report by description, photographing the place where they were discovered and in detail. At the descriptive stage, the place where the hairs were identified shall be reported in detail, describing the colour and surface appearance of the object on which the hairs are located. The exact colour of the hairs shall also be reported and their number quantified, adding information on their presence in the form of strands or tufts of hair. Indicate whether any foreign bodies can be seen with the naked eye on the hair shafts, describing in detail their colour and condition. After the description, the hair will be photographed at the place where they were found, so that the image shows the objects on which they are located and any objects in the immediate vicinity. Then detailed photographs of the hairs are taken at a close distance in order to highlight their shape and appearance. The lighting can be natural or artificial. In the case of artificial illuminating, the illumination rays are directed from behind the camera so that they fall perpendicular to the object bearing the trace (Mircea, 1999, p. 122).

Hair traces are removed using tweezers with flat arms wrapped in rubber. This operation shall be carried out with particular care so as not to destroy the characteristics of the hairs; if hairs are found together with other biological traces they shall be harvested without attempting to separate them. Dressing materials to which hairs have adhered shall be cut into their respective portions without attempting to pull them out or detach them. The hairs thus removed shall be placed in sealed test tubes or cellophane bags. The hair will be placed in separate packages according to the place where they were found, which shall be clearly indicated on the envelope and on the label accompanying the sample (Cioacă, 2019, p. 214; Mircea, 1996, p. 160; Beliș, 1995, p. 170; Anghelescu et. al., 1976, p. 410).

By interpreting the hairy marks, it is possible to obtain data on: the region of the body from which they originate; whether the colour is natural or artificial; the manner and circumstances in which the detachment occurred (pulling, tearing, cutting, normal-physiological or pathological falls); the age, sex and professional background of the person; the degree of bodily hygiene; certain states of disease; the approximate time elapsed since the mark was made; the cutting instrument used, etc. Thus, for example, a long hair found at the scene can be judged to have come from a female person. A short hair that does not show any cutting or breakage marks may be considered to come from a body region other than the hairy region of the head. The colour, which may be natural or artificial, creates the possibility of forming a limited circle of suspects, which will facilitate identification work. The presence of impurities on the hairs discovered at the scene makes it possible to determine the working environment of the person from whom they originated (Cătuna, 2008, p. 52; Anghelescu et. al., 1976, pp. 212-213).

In addition to the hairs collected at the crime scene, hair will be collected from the suspects according to the nature of the hair found (head, eyebrows, etc.). Head hair is collected by combing and shaving, and body hair only by shaving. Cutting hair with scissors or trimming is the wrong procedure, both because it removes hair from the root and because of the danger of mixing the hairs (Suciu, 1972, p. 309).

The hairs that are lifted will be packed separately according to the region from which they were harvested. For head hair, it is best to harvest from several parts (crown, nape, forehead, temples), the best procedure being to divide the surface of the head into several areas (usually eight), numbered clockwise, starting from the right side of the forehead. Each hair is to be described by the region from which it comes and the method of harvesting, without omitting to give the name of the person from whom it comes. In the case of missing persons, comparison patterns are sought at their homes on combs, head brushes, towels, items of clothing and other supports (Stancu, 2015, p. 171; Saferstein, 1995, p. 205).

Each character (general and individual) is related to the 'descriptive elements' of the hairs, and these data will be studied simultaneously in the comparison: length of the hairs (whole); crimp; macroscopic appearance of colour; thickness; bulb; sheath remnants; para-radicular area; relative thickness of layers; presence (respectively absence) of pith; colour and distribution of pigments; longitudinal striation formed by cortex fibres; cuticular pattern and appearance of the free tip (distal end). In cross-section, the overall shape, the correlative position of the layers and the variability of the section in the different areas of the thread are studied. Finally, the deposition of elements (apodices), substances and after their removal, the biochemical study of serological (group) elements, spectrophotometric analysis of constituents or radiolysis after irradiation (activation) is carried out. The value of the comparative examination will increase in relation to the number of hairs available for it (Anghelescu et. al., 1978, p. 285).

Forensic hair analysis can provide valuable information in the investigation process and help to identify potential suspects. This is done by comparing the characteristics of hairs found at the crime scene or on the victim of a crime with those of reference samples taken from suspects or witnesses involved (Ciopraga et. al., 2001, p. 111). Hair forensics involves analysis of both the internal structure of the hair and its surface, including various particles and adherent traces. By examining the intimate structure of the hair, the expert can observe and identify specific features, such as the medulla (medulla), cortex and cuticle, which may vary depending on the individual. The surface of the hair may also contain various particles and adherent traces, which may provide relevant information in a forensic investigation. These may include dust particles, textile fibres, skin fragments, cosmetics or chemicals, as well as other micro-surfaces that may be associated with the crime scene or the individuals involved (Stancu, 1999, p. 203).

Biological examination methods for hairy traces provide answers to various scientific questions about hairs collected from the scene or from the victim's body, such as: whether the hairs presented are of human nature; whether the hairs are dyed and what is their natural colour; what is the area or part of the body from which the hair originated; whether the hair shows damage, pathological alterations, traces of blood or parasites; what is the mode of detachment of the hair; what is the sex of the person; what is the probable age of the person; what substances are attached to the hair; whether the hair found at the crime scene has the same general and individual characteristics as the hair collected for comparison (Cătuna, 2008, p. 52; Anghelescu et. al., pp. 213-214; Cîrjan, 2005, pp. 285-287; Mircea, 1999, pp. 122-124; Stancu, 2015, p. 172; Suciu, 1972, pp. 309-313); and whether molecular biology tools allow forensic specialists and forensic pathologists to establish the DNA profile on the basis of the analyses and expert opinions carried out and on the basis of degraded or insufficient biological material (Cioacă, 2019, p. 219).

In order to speed up the forensic investigation to find the perpetrator, it is important to determine, from the outset, the colour and external characteristics, as well as the impurities on the hair, which allows to quickly narrow down the circle of suspects and determine the environment in which the wanted person is working (Stancu, 2015, p. 172).

5.10 Forensic Investigation of Osteological Traces

Other biological traces of human nature, such as osteological ones, may also be found at the site. Like the other traces presented, the latter can, following analysis by specialists, provide useful data for forensic investigation of the crime with regard to the person of the victim, the perpetrator, the age of the trace, how it was formed, etc. (Cătuna, 2008, p. 52).

Osteological traces are specific to crimes of murder and desecration of the corpse, since fragments of this evidence are sometimes discovered. Genocide is also a crime that requires the examination of osteological and odontological traces necessary for the identification of persons (Cioacă, 2019, p. 222).

The category of osteological remains includes the skeleton as a whole, scattered bones or fragments of bone and cartilage whose discovery, examination and forensic and anthropological interpretation are carried out in order to provide data of interest to the judicial authorities (Anghelescu et. al., 1976, p. 214).

Osteology is a branch of anatomy that deals with the study of the bone system, made up of approximately 200 to 220 bones. Of these, about 33 – 34 are odd bones, such as the vertebrae, sacrum, coccyx, certain skull bones and sternum. The other bones are even. The skeleton can be divided into two main categories: axial, which includes the skull (made up of about 29 bones), the spine (made up of about 26 bones) and the rib cage (made up of about 25 bones); and complementary, which includes the bones of the upper limbs (about 64 bones) and the lower limbs (about 62 bones). The total mass of bones in a living person is around 14-20% of the total body mass. Bones provide structural support for the body, protect internal organs and allow movement through joints. They are made up of a mineralised matrix of calcium and phosphates, as well as bone tissue containing specialised cells such as osteoblasts, osteoclasts and osteocytes, which are responsible for remodelling and maintaining bones (Ștefãneț, 2007, p. 64).

Osteogenesis is the process by which bones are born and formed. Knowledge of ossification points is of interest for osteological trace expertise. For this reason, tables have been drawn up containing all this data. The first osteogenic processes appear in weeks 6-7, in the clavicle. Skeletal development continues until 23-25 years of age. The physical properties of bones are strength and elasticity. The chemical composition of bone includes 35% organic substances (ossein) which provide elasticity and 65% mineral substances (phosphates, carbonates and trace amounts of fluoride and calcium chloride) which give the bone strength. The proportion of the main materials in the structure of bone varies from bone to bone and with age. Bones that withstand higher pressures are richer in mineral salts. The proportion of mineral salts increases in old age, when bones are more brittle than in childhood (Cîrjan, 2005, p. 285). The rich content of inorganic salts gives bone tissue a particular resistance to the action of destructive environmental factors, thereby ensuring that the appearance and components of bone are maintained as a trace for a much longer period of time than in the case of other types of biological traces (Anghelescu et. al., 1976, p. 214).

Depending on their shape, structure and size, bones can be divided into five distinct categories:

Tubular bones are components of the limb skeleton and perform lever functions. They consist of a body or diaphysis, within which is the medullary canal, and two epiphyses – proximal and distal – which have articular surfaces covered with articular cartilage. Between the diaphysis and the epiphysis, until the age of about 22-25 years, there is an area called the metaphysis, which is the area where the bones grow in length. Examples of long tubular bones include the arm, forearm, thigh and calf bones, while short tubular bones include the phalanges of the fingers, metacarpal and metatarsal bones.

Spongy bones have a structure in which cancellous bone tissue predominates and is covered by a thin lamella of compact bone tissue. There are long cancellous bones, such as the ribs and sternum, and short cancellous bones, such as the vertebrae, carpal, tarsal and sesamoid bones.

Plate bones participate in the formation of body cavities and girdles. These include the bones of the cranial vault, the coccyx and the scapula.

Mixed bones have a complex structure and are made up of parts that differ in shape and structure. Examples of mixed bones include the skull base bones and vertebrae.

Aerophoretic or pneumatic bones contain air-filled cavities lined with mucosa. Examples of such bones include the frontal bone, sphenoid, ethmoid, maxilla and temporal bone, which are part of the skull structure (Ștefăneț, 2007, pp. 66-67).

Bones are encased on the outside by a membrane called the periosteum. Blood vessels, together with nerve threads, enter the bone through nutrient holes. Bones have a shape that is hereditarily inherited and changes in relation to the body's activity conditions (Cioacă, 2019, p. 223).

Bones show anatomical features characteristic of age, sex, anatomical region of the skeleton, position in relation to the midline (right-left), prenatal and especially postnatal health, medical, surgical, orthopaedic or balneotherapy treatments, as well as excessive or intense but prolonged physical effort, etc. Anatomical integrity may be affected to varying degrees as a result of pre-existing causes (illness, aggression, accidents) or subsequent causes (crushing, mummification, devouring by carnivorous animals, advanced putrefaction). Multiple remnants of bone tissue may be observed in the case of cremations, where high temperatures, with a prolonged period of exposure, lead to almost total degradation of the skeleton. In these situations, fragments of charred bone can sometimes be observed in the mass of ashes from the human body, possibly mixed with combustion debris or other foreign objects. These are greyish-white in colour, with a destroyed, contorted, broken, weakened cartilaginous structure that is totally compromised. In the case of dismemberment of the corpse (criminal disassembly), followed by the dispersal of fragments, the bone remains discovered show a great variety in terms of shape, appearance, colour, presence of adherent soft parts, etc. This variety is due to the evolution of destructive processes, which cause degradation to occur in different proportions. The influence of chemical factors with a toxic-caustic action (caustic soda, unburnt lime, sulphuric acid) leads to the melting of the organic mass (soft parts and intraosseous substances), and finally the inorganic substances in the bone tissue are also affected. In these situations, the bone loses its contour, becomes thinner and very fragile, not recognisable as a morphophysiological structure. The bones, considered as a whole, isolated or assembled into a skeleton, bear the characteristics of the species: shape, size, appearance of the areas of muscular insertion, thickness, strength, etc. Thanks to these characteristics, plus the structural features, the bone resists the destructive action of environmental factors, maintaining and restoring the mechanism for producing lesions affecting its integrity (mechanical, thermal, electrical, etc.) (Anghelescu et. al., 1976, pp. 214-215).

Osteological traces can be found in the most different places such as in water, in the ground, in marshy areas, on the ground, in the contents of latrines, in cellars, in wells, in general, these traces are found in isolated areas, in areas where excavations are carried out for the redevelopment of neighbourhoods, at the foundations of houses, in gardens, courtyards, etc. They may be found either packed and abandoned in various places, or scattered as a result of criminal despoliation, or in the form of skeletal remains, e.g. in the case of cremations, or as a result of the action of chemical agents. Often the skeleton may be found complete, subjected to the action of environmental factors over a longer or shorter period of time. If there are suspected pits containing human remains in a space, bumps may be observed, with the soil bulging or deepening depending on the date of burial (Cioacă, 2019, p. 225). Depending on the nature of the substratum, the search for skeletal remains is carried out by: digging, sifting the earth, underwater diving, emptying the latrines, under fallen foliage from trees, among the branches of shrubs, etc. (Anghelescu et. al., 1976, p. 216).

Multidisciplinary working methods are used in the search for osteological traces, involving the use of a large number of techniques from completely different disciplines. These methods are applied depending on the environmental conditions in which the osteological remains are found. The search for bone material is mainly carried out by the anthropologist, who is present at the site and has the specific knowledge of searching, recovering and examining the material, so as not to damage it and not to lose valuable information that may create false clues. Searching for, recovering and examining skeletons on the surface of the ground generally presents no difficulties, but the situation is different for bone material in the ground, which is most often encountered when special care is needed in the exposure process. When a large volume of work is expected or when bone material is exposed to the elements, measures should be taken to protect the space. In skeletal exposure work, rough action should be avoided, brushing with a soft bristle brush until the bone is completely exposed. Bone fragments should not be removed until the entire skeleton is exposed. In the case of soft, moist soils, the bone material will be lifted together with the overlying soil and deposited for drying in a shaded place, with separation to be carried out only in the laboratory. If the bones are fragile, measurements and laboratory analyses will be carried out on site (Cioacă, 2019, pp. 225-226).

By interpreting the osteological traces on the spot, it is possible to obtain data on: the person of the victim – some judgements can be made regarding species, sex, age, height, particular characteristics regarding the presence of diseases, surgical operations, foreign bodies introduced intraoperatively or accidentally penetrated. Also, if the bones are found scattered, the extent to which they belong to one or more individuals can be determined. The detailed morpho-pathological, microscopic, biological, radiological etc. examination of the victim's bones is then carried out by expert examination; the time elapsed from the creation of the trace to the investigation of the crime scene – for this, certain factors are taken into account, such as: the external environment (soil and climatic conditions, temperature, humidity, air currents, depth of the water table, the nature of the fauna and flora that have acted on the soft parts, etc.) and the internal environment (age, state of health, body integrity, presence of signs of violence, fistulas, drainage tubes, purulent collections, recent massive antibiotic treatments, etc.); the person of the perpetrator – in relation to the perpetrator, some assessments can be made regarding the instrument of violence used, the professional skill of the victim's body, the sequence of blows caused by traumatic agents, whether there were several perpetrators, their height, their position in relation to the victim and the contribution of each of them to the injuries. The neuro-psychological state of the perpetrator can be inferred from the number, location, sequence, direction and depth of the injuries, the manner in which the victim's body was concealed or any attempts made to destroy it (Anghelescu et. al., 1976, p. 216).

Osteological traces are established both by describing them in the on-the-spot investigation report and by technical means.

In the on-the-spot investigation report, the investigating body shall record: whether the traces represent a complete skeleton or are scattered bones (their anatomical name), appearance, colour, outline, integrity, friability, presence of adhering foreign bodies, shape of anatomical reliefs, traces of violence, presence of pathological conditions, calcination, etc; the environmental conditions in which they were found (in the ground, on the ground, in the water, temperature, humidity, depth of the water table or of the aquatic environment, fauna, flora); the procedures and instruments used to remove impurities and any deterioration which may have occurred during the operations of discovery, lifting and packing (Drăghici et. al., 2018, p. 124).

In order to ensure a better understanding of the text of the field report, it is necessary to supplement the description of the traces and the place where they were found with photographs, sketches and drawings, in order to highlight their individual characteristics and specificity. In forensic practice, various technical means of fixation are used, such as forensic photography, forensic film, sketches and drawings. Forensic photography is used to highlight traces of an osteological nature and can be produced using techniques such as colour separation photography, detail photography or sketch photography. These methods allow the traces to be adequately fixed and allow the features, including their colour, to be faithfully reproduced. Since other traces may be present alongside osteological traces, such as traces of blood, traces of hairs or soft tissue (such as skin, brain mass or muscle tissue), the use of colour film in fixation photography becomes essential. In fixation photography, the aim is to include both osteological traces and other objects or bodies in the environment within the image. Forensic film is used to fully capture aspects of osteological traces, showing them from different angles and documenting the entire search and discovery activity (Drăghici et. al., 2018, p. 124).

In order to preserve them adequately and efficiently for transport to the laboratory for examination of the osteological trace, proper packaging is required. Only paper bags or boxes should be used for packaging bone material. In the case of a skeleton, several bags are used: one for the skull and mandible, one bag for the long bones and another bag for the short bones. The bones of the upper and lower limbs will be bagged separately, depending on which side is left or right. Bags belonging to the same skeleton will be placed in a single box, ensuring that they do not bump into each other. The boxes will be sealed after an inventory has been taken and each bag and box will have a label indicating the contents, date and location. Once the boxes have been sealed and signed for by the investigating and investigating authorities on the scene, they will be stored in a dry place until they are transported to the forensic laboratory for forensic examination (Cioacă, 2019, p. 226).

Forensic osteological expertise is carried out by the anthropologist, who is able to determine whether the osteological remains are human or not; whether we are in the presence of a whole skeleton or whether the bones belong to more than one person. Data can also be obtained on age, sex, waist and any diseases the person may have suffered from during their lifetime (Golunski, 1961, p. 231; Drăghici et. al., 2018, p. 125).

Following the forensic examination of osteological traces, the expert will be able to provide answers to the following questions: when the osteological trace is presented – whether the bone or bone remains are human in nature; what are the approximate sex, age and height of the person; what congenital or acquired malformations are present in the bone sent for examination; what signs of violence are present in the bone, what kind of instruments were used to create them and whether the injuries were of a vital nature; whether the signs of violence were created during life or post-mortem and what is the sequence of their creation; what foreign bodies are adhered or penetrated into the bone under examination; what were the direction and position of the perpetrator in relation to the victim's body at the time of the creation of the injuries; what may have been the neuro-psychic state of the perpetrator in the process of committing the crime; what are the faunal, floral or other factors acting on the corpse; whether the various bone fragments discovered at the scene were (all) common during the victim's lifetime; when osteological trace and other bone segments are presented – whether the bone discovered at the scene was common (or is a component part) of the bone segment presented for comparison (or for making up the whole) (Anghelescu et. al., 1976, p. 217).

5.11 Forensic Investigation of Smell/Odor Traces

A very special category within the biological traces of human nature, although not specific to humans alone, are odor or olfactory traces (Cătuna, 2008, p. 54). The study of olfactory traces is the subject of research for specialists in many fields of science: biology, chemistry, physics, medicine and the cosmetics (perfume) industry (Ciopraga et. al., 2001, p. 120).

Olfactory trails, also known by the misnomer of kino-technique, are the individual odors associated with people, animals, objects and substances. They are called 'olfactory traces' because they are created during the commission of a crime or are linked in some way to it. These traces can be used in forensic investigation because of the ability of the olfactory organs to detect them. Characterised by their nature, mode of formation, duration of existence and possibility of exploitation, olfactory traces are a distinct category of evidence. Although not unique to humans and studied in forensic science, olfactory traces left by the human body are of less interest than those of other sources. The methods and techniques used to detect these traces and the procedures for their exploitation for the purposes of justice are the subject of forensic odorology (Mircea, 1999, p. 138).

Forensic odorology is a field of forensic science that develops the methodology for searching, discovering and examining odor traces left by the perpetrator (Anghelescu et. al., 1984, p. 145).

In order to understand the effectiveness of this specialised branch it is necessary to know first of all the meaning and characteristics of the term smell. The definition of the concept of odor, approached from a forensic point of view, is a material factor that provides the opportunity for trace tracing and identification. Odour is the volatile matter continuously produced and emitted by biological organisms or physical bodies possessing stable characteristics capable of affecting the olfactory receptors of specially trained animals. A person's odor is made up of natural and artificial components. Natural (biological) odor is made up of three important components: perspiration, the mucous membrane of the sebaceous glands, and the epidermal cells in the skin. The cause of the individuality of human odor (body odor) is related to these components because the composition of sebaceous acids in human smegma is different in each person. Artificial smells are those coming, for example, from clothes, shoes, perfumes or smoking, as well as from the environment (Gheorghiță, 2018, p. 323; Kisin et. al., 1983, p. 15).

Human body odor is invisible, volatile and individual, the result of the many metabolic processes that take place in the human body. Individuality is one of the most important of these properties, as it makes it possible to preserve the specificity of each individual smell, even in the presence of smells of the same nature, which helps greatly in the process of identifying a person (Drăghici et. al., 2018, p. 127; Anghelescu et. al., 1976, p. 221; Mircea, 1999, p. 138; Gheorghiță, 2017, p. 212; Cîrjan, 2005, pp. 287-288; Doraș, 2011, p. 161). These characteristics have both advantages and disadvantages in forensic research. The advantage of invisibility is that odor traces cannot be destroyed at the crime scene, but the disadvantage is that they can only be detected by the olfactory organ. Volatility is an advantage because the scent trail disperses into the air and sticks to objects for a longer period of time, but the disadvantage is that the trail evaporates quickly. The individuality of human odor is important in forensic science, as each person has a specific odor, and odor leaves a material trace in the environment of the crime and is relevant in investigations (Gheorghiță, 2017, p. 323).

The formation of olfactory traces is practically unavoidable, as every person leaves their odor molecules everywhere they go, on every object they touch, and neither shoes, clothing nor gloves can prevent the formation of this kind of olfactory "fingerprint". As stated in practice, whatever precautions are taken, it is impossible to prevent the human body from permanently emitting odor molecules which fall to the ground or settle on the objects touched (Stancu, 2015, p. 174; Szanak, 1985, pp. 58-59). As odor traces are a specific kind of trace that cannot be perceived visually, cannot be examined with certain techniques and manifest as a ,,chemical signature" of man and material substances, they are often treated as a variety of micro-objects (Golubenco, 2015, p. 53; Bercheșan, et. al., 2004, p. 289).

The olfactory traces produced by the human body can be divided into three categories of odors: individual, general and occasional or carrier odors (Cîrjan, 2005, p. 288; Mircea, 1999, pp. 138-139; Cătuna, 2008, p. 54; Anghelescu et. al., 1976, pp. 221-222).

Individual odor. In the course of normal metabolism, the human body emits through its original sources of odors (saliva, breath, dermal cells, urine, faeces and intestinal gases) a large number of chemicals that are taken up or synthesised from the environment. The chemicals in human odor belong to a wide variety of classes of compounds, such as alcohols, ketones, ethers, esters, hydrocarbons, etc., and about 135 such substances have been determined to date. The chemical composition of sweat is variable, depending on the intensity of the body's metabolic processes, the disease of certain organs, changes in food, the use of certain medicines or the ingestion of alcoholic products, etc. Physiological and pathological flaking of the surface layers of the skin are added to these emanations. The main original sources of odors fall into three categories:

- hairless skin surfaces (palmar and plantar regions);
- skin surfaces with a moderate hair cover (trunk, limbs, axillary and pubic regions); surface with a rich hair cover (hairy region of the head).

The individual odor is imprinted on the wearer's clothing or footwear, making them also objects carrying the same odor traces (Anghelescu et. al., 1976, pp. 221-222; Elin, 1974, pp. 137-152).

A person's general odor, also known as the ,,olfactory bouquet", is the result of the accumulation of different odors from the environment, such as work, home, travel and products used for hygiene and beauty. This 'bouquet' is influenced by various factors such as specific workplaces (tobacco factories, shoe factories, fur factories, sawmills, animal farms), types of tobacco, personal hygiene products and others. This olfactory imprint is not limited to the body, but permeates clothes, footwear and the surrounding air. Objects and the surrounding air also have an odor of their own, and individual body odor mixes with these at the scene. The stronger the smells of objects or air, the less distinct the individual human body odour becomes. For example, petroleum odours, fermented organic substances or odours produced during fires can attenuate the individual human body odour to such an extent that it is completely lost in the environment (Mircea, 1999, p. 139).

The smell of the holder. Individual and general human odors are deposited on a substrate which may be the ground (covered with grass, gravel, sand, etc.) or mixed with the surrounding air. In turn, the odors of the substrate (soil or air) can influence the human odour and sometimes become indistinguishable (strong odors of oil, chemicals, peppery substances, etc.). In terms of shape, the following should be taken into account in the odor trail: the width of the trail, which is approximately equal to that of the person who left it. This increases as the trail ages, and any wind will widen (disperse) it and move it to the right or left depending on the direction in which it is blowing; the height of the trail above the ground is variable. When the wind is blowing, it increases in proportion to the intensity of the wind; the length of the track is equal to the distance travelled by the person on foot or close to the ground. The longer the trail, the greater the quantity of odor due to perspiration, as the particles that make up the trail are practically inexhaustible; the direction of the trail takes the shape of the path followed by the person and can be: straight, angled, curved, looped, parallel to another, intersecting, etc. (Anghelescu et. al., 1976, pp. 222-223).

The use of olfactory traces in forensic investigations has become necessary because they are invariably formed when a person passes through a particular place and are practically imperceptible to the human senses. The existence of these traces is, however, quite limited in time (Stancu, 2015, p. 175), which varies according to the nature of the product that gives rise to them and the space in which the person concerned was present (room or open space). It is accepted that, in closed spaces, odour is retained for up to 20 hours, while in open spaces it is very short-lived, depending on atmospheric conditions: wind, high temperature, etc. (Ciopraga et. al., p. 121). To a certain extent, the cold also prevents odour molecules from evaporating; the molecules will be detectable even after a few days; warm weather, on the other hand, will speed up their disappearance: they can practically evaporate in 30-60 minutes (Gheorghiță, 2018, p. 324).

The nature of the substrate and its very odor have a negative influence on the trail. For example, dense substrates, on which odor is more difficult to imprint (glass, cement, asphalt), retain less odor. In contrast, substrates with porous surfaces, grass, vegetation in general, soil and loose snow retain odor traces better. Odor traces formed in enclosed rooms or places (no draughts, no strong volatile fumes), neither circulated nor inhabited, can be retained for a relatively longer time (Stancu, 1999, p. 208).

Odor traces (including human odors), according to their period of preservation over time, can be classified into three sub-groups: fresh traces (sometimes also referred to as ,,hot" traces), which are no more than 1 hour old; normal traces, which are more than 1 hour old but less than 3 hours old; and old traces which have been formed for more than 3 hours. Of course, this classification is quite conventional, as sometimes in open, windless places, tracks can be preserved for more than 15 hours. It is therefore valid for traces created on objects during temporary contact with various parts of the human body (matches, pens, etc.) (Golubenco, 2015, p. 54; Kirichenko, 1997, p. 15).

In order to discover scent traces, the search for them must begin at the start of the crime scene investigation from the places where the offender is presumed to have stayed or from objects that may have belonged to him (Cătuna, 2008, p. 54), abandoned or forgotten items of clothing, as well as establishing his route to/from the crime scene (Gheorghiță, 2017, p. 212).

As time goes by, especially under the influence of wind, odour molecules in the air are directed in different directions. As a result, they become more and more rarefied and their initial ,,corridor" changes. The same applies to olfactory traces attached to objects. As time passes, through the action of wind, rain or snow, these traces gradually lose their intensity, reaching a point where they can no longer be detected in a relatively short time. In addition, factors such as the movement of people, animals and vehicles have a negative impact on odour trails. Through the action of these factors, called secondary factors, the odour traces created at the crime scene during the commission of the offence, firstly, move and become more rarefied and, secondly, mix with the smells of people and animals moving in the area (Mircea, 1999, pp. 139-140).

The information acquired by humans through the olfactory organ is formless, intangible and inconstant. Testimony based solely on olfactory sensations can only provide information on the nature of the object, without the possibility of locating the stimuli in space, let alone identifying persons or objects. Thus man can only distinguish certain general characteristics of substances or objects with which he is familiar, such as: the characteristic smell of the fire itself and of the flammable substance used, the particular smell of toxic, narcotic or medicinal substances used or intended to be used to commit crimes, the nature of the smells accompanying an explosion, the nature of the smells of professional environments (especially in the chemical and pharmaceutical industries), the nature of the smells of people, animals, etc. (Ciopraga, 1979, p. 24). For these reasons, the most effective means of searching for and detecting odor traces has proved to be the tracking dogs. The dog's ability to detect odor is thousands of times greater than that of humans, due both to the special morphology of the olfactory organs and the more developed odour centre in the dog's brain (Cîrjan, 2005, p. 289).

Finding scent traces is one of the hard tasks of the prosecution officer during the on-the-spot investigation. The difficulty of this task is determined by the short duration of existence of olfactory traces, the many objective possibilities of their destruction, and the limited ability to be perceived (Gheorghiță, 2017, p. 212).

The scent trail is established by means of the report and a sketch of the route followed by the sniffer dog, mentioning the main points it passed, the traces and the criminal bodies discovered, etc. (Cătuna, 2008, p. 55).

Once on the scene, the judicial body immediately takes steps to preserve the scent traces for future use by the tracking dogs. These measures include restricting the access of strangers to the perimeter of the crime scene. If the crime scene is in a building, outside air must be prevented from entering and draughts must be prevented in the room, as air movement can cause damage to these traces, making them unusable, even by sniffer dogs (Mircea, 1999, p. 140). The object that is considered a source of odour is secured immediately, not touched, covered (in case of bad weather conditions) or picked up with tweezers and placed in a clean, dry bag (Cătuna, 2008, p. 54). Specialists strongly recommend that, in the presence of footprints or suspicious objects that may bear scent marks, researchers should not approach within 2-3 metres of them. This is done in order to avoid creating additional scent trails that could mislead the tracking dog (Stancu, 2015, p. 176).

The use of the tracking dog for processing the human scent trace is specific to the static phase of the on-site investigation, after the photographing of the facts. For the processing of the trace, the dog is directed by its handler – the dog specialist – and starts from items of clothing, material traces, other objects that may belong to the victim, the perpetrator or other persons who have had contact with the crime scene. Objects considered to be odor-bearing or footprints or other body parts will be left at the dog's disposal for sniffing, then on the command

„search” the dog will go off to search the „hot” tracks for the person in question (Adam, 2020, p. 124).

During the processing of the track, the route followed by the dog is noted, the main points where it has passed, the footwear tracks and the offending bodies discovered, etc. If various excitants appear afterwards which cause an interruption (means of transport, groups of people, herds or flocks), they are waited for to pass and an organised search is carried out on the opposite side, in both directions, until the track is found. An organised search also solves interruptions caused by railways, road junctions, watercourses, etc. (Anghelescu et. al., 1976, p. 224).

Special care should be taken to avoid tiring the dog, pausing for a few minutes where the scent is strongest. On resumption of tracking, to refresh the scent, give the dog a sniff of an object carrying the scent.

By processing the scent trail, the dog can lead directly to the location of the person of interest or where they have boarded a means of transport, to places where criminal bodies are hidden, or clues as to the direction in which they walked.

If the dog discovers evidence, it shall not be allowed to bring it to the scene, but shall be left motionless until the forensic expert arrives to photograph and protect the traces (Cîrjan, 2005, p. 290).

Tracking dogs, trained to search for drugs, can relatively easily detect where these substances are stored: luggage, storerooms, on people or buried in the ground at a shallow depth. In the practice of criminal prosecution authorities, there are known cases where, with the help of the sniffer dog, the places where large quantities of cannabis and its derivatives (in particular marijuana and hashish), as well as heroin, cocaine, etc., were stored have been discovered.

Metal detectors are ineffective for searching explosive substances, especially those enclosed in plastic walls, and the sniffer dog is irreplaceable. The method is frequently used for customs control or surveillance of military or civilian targets of particular importance (Cioprag et. al., 2001, p. 122).

In the context of the use of service dogs for trace identification and tracking of criminals, two basic conditions are respected:

- the introduction of the dog into the perimeter of the crime scene takes place in the static phase of the investigation, before strangers, including members of the search team, enter the area. This is done in order to minimise the introduction of additional scents that could disturb the dog's ability to identify and process the tracks;

– throughout the process, the dog „works” with its handler, who is familiar with the animal's capabilities and behaviour in specific situations, its reaction when it detects or loses a track, and signs of fatigue or nervousness expressed by the dog (Gheorghiță, 2017, p. 213).

The procedure for picking up and preserving scent traces is carried out according to scientific principles and is practical. On areas suspected to have been touched by the offender, sterilised cotton wool is carefully applied to an area of approximately 20x30 cm or suitable pieces of cotton cloth are used. A clean piece of glass is placed on top of the absorbent material to achieve optimal contact. After a time interval of 25 minutes, the cotton wool pad is carefully lifted with sterilised tweezers and carefully placed in a clean jar with an airtight lid. In order to identify and record the odour trace collected correctly, relevant information such as location, date and other pertinent details are recorded (Mircea, 1999, p. 141). These soft, fluffy patches of fabric can also be kept outside the jars, wrapped in 3-4 layers of tinfoil; – ordinary tinfoil in rolls; – distilled water spray; – clean, deodorised glass jars with metal lids; – tweezers, latex gloves; – wrapping paper (paper envelopes used for wrapping objects wrapped in tinfoil).

The direct collection of odor traces begins with a brief spray of the trace object with very fine distilled water vapour, directing the stream upwards over the object so that the light moisture settles freely on the surface traces without disturbing them. The object is then covered/enveloped with a piece of cotton fabric (sorbent) over which tinfoil is placed in 2 layers. To ensure close contact with the tracing carrier, a small weight is placed on top, or the sheet of tinfoil is tightly attached to the object by tying a string around it. The accumulation of the smell shall be carried out throughout the search on the spot, but not less than one hour (Adam, 2020, p. 125; Averyanova, 2011, p. 185).

Odour traces can also be absorbed using a hand-held vacuum cleaner (car type). In these cases, sterile cotton wool is placed in the 'dust bag' and the machine is then directed towards the place where the odour traces are supposed to be and are to be removed. After suctioning the place or objects in question, the apparatus is unfolded and the soaked cotton wool is removed with tweezers and placed and hermetically preserved in the sterile container with the appropriate markings (Gheorghiță, 2018, p. 214). However, practice has shown that the concentration of odour molecules "aspirated" from the spot is usually very low and is quickly consumed during odourological investigations (Adam, 2019, p. 126).

Under laboratory conditions, suspects are asked to hold a cotton swab for about 6-7 minutes. Each experimentally obtained trace is placed individually in clean jars, which are placed 2-3 metres apart. The odour trace taken from the scene is presented to a specially trained dog, after which the dog is guided in sequence to the jars containing the experimentally obtained traces. If there is a match between the crime scene trace and one of the experimentally obtained traces, the dog 'tells' its handler (Mircea, 1999, p. 141). The processing must be done within a maximum of 24 hours after obtaining the comparison patterns. The possibility of error in these cases does not exceed 1-2% (Stancu, 2015, p. 177; Cîrjan, 2005, p. 291).

The scent mark must be interpreted in conjunction with the other marks: footprints, footwear, handprints, transport, lost or abandoned objects of the perpetrator or victim, etc. From this interdependence, the elements of the scent trail are established, such as: the end, the breaks and the end of the trail. By interpreting the scent trail, it is possible to establish data on: its length and breaks; the link between the scent trail and other trails discovered at the scene; the link between the final break in the processing of the trail and the possibility that the person concerned used a means of transport, etc. (Anghelescu et. al., 1976, p. 224).

To obtain the comparison patterns, either 20 ¼ 30 cm pieces of cotton wool or a piece of special textile fabric, which does not contain any odour (known as ,,odour-fixing textile fabric”), is used, which is stored in hermetically sealed glass containers (jars) that have been previously cleaned. Samples are taken from the victims as well as from the persons connected with the crime (their bodies, shoes or belongings). Guiding questions that may be asked of the forensic expert include:

- whether the odour trail belongs to one or more persons;
- whether the odour trail has characteristics specific to a particular occupational environment;
- whether the odour trail was left by the same person from whom the patterns were taken for comparison (Cîrjan, 2005, p. 291).

Chapter VI

Forensic Investigation of Traces Formed by Objects or Various Substances

6.1 General Information

The forensic investigation of traces requires a classification of the traces based on several criteria, such as the way the traces are formed, the plasticity of the receiving object and the nature of the creating object. However, it is difficult to make a classification that includes all material objects. Therefore, particular attention is paid to traces created by objects known to be important in forensic identification of criminals, such as burglary tools or vehicle tracks. However, there are also objects that do not carry traces or leave no traces at the crime scene. Instead, these objects can be treated as traces and can be used to identify the persons who had them with them at the time of the crime. Thus, in forensic investigations, attention is also paid to these objects in order to obtain relevant information about the persons involved in an incident (Ciopraga et. al., 2001, p. 123). They can be abandoned, lost or taken away by the offender in different ways. In some cases, they are also found in the form of fragments of objects, remnants of substances, materials of the most diverse nature (organic or inorganic), etc. These may include: items of clothing (gloves, shoes, coats, hats, caps, scarves, handkerchiefs, buttons, textile fibres or threads), tools, mechanisms, hairs, etc. or remnants thereof, parts of the means of transport used by the offender or the victim, etc. (Gheorghiță, 2017, p. 214).

The presence of these traces at the scene, their nature, their appearance and the areas in which they are found make it possible to assess how the crime was committed and to determine some information about the offender. In cases where these traces are part of the offender's clothing, they can be used to identify the suspect in the crime and sometimes, by the scent imprinted on them, the tracking dog can even be used to discover the person who has them (Suciu, 1972, pp. 297-298). If such traces are in the form of remnants of objects, such as clothing, tools or means of transport, their value for forensic investigation is even greater. They can even be used to identify the objects from which they came (Mircea, 1999, pp. 141-142; Ionescu, 1968, p. 203).

The general term ,,substances” primarily includes foodstuffs, various beverages and their residues, as well as cosmetics such as lipstick, powder, perfume, cologne, sprays, etc. These substances or their residues can often be identified at the crime scene. The objects bearing these traces are usually kitchenware, crockery, cutlery, towels, used handkerchiefs, bottles, glasses, rubbish bins, clothes of the persons involved (victims, suspects), their linen, shoes, floors, carpets, etc. If the crime scene is an open space, such as a stretch of land, such traces may be found on the ground, grass, accumulated leaves, pits, gullies, asphalt, concrete, as well as in means of transport. Secondly, under ,,substances” or debris are included solid, liquid or gaseous bodies of a toxic (poisonous) nature, which can only be detected and assessed (diagnosed) by certain specialised persons with knowledge of the subject. In such cases, it is necessary to call in qualified specialists and engage in on-site investigation. These specialists can diagnose and establish at the scene the presence of toxic substances or their residues used by the offenders. Only specialists may provide qualified assistance to the prosecuting officer in the collection and packaging of substances or their remains for subsequent examination in appropriate forensic examinations, in accordance with applicable legal provisions and procedures (Gheorghiță, 2017, pp. 215-216).

Items of clothing, whether worn by the offender or the victim, may result from direct contact with various surfaces, leaving marks that reproduce the characteristics of the fabric or material from which they are made. These marks may be created by dropping, resembling, wiping, printing, etc. Depending on the nature of the object receiving the marks, they may be static or dynamic, surface or deep, layered, visible or latent. In forensic science, usually static, depth traces formed on highly plastic surfaces such as soft earth, snow, fresh grout, paint, etc. are most useful. Latent marks are formed when the clothing has previously been impregnated with a substance that remains on the mark-bearing surface (lubricants, paints, organic products). The human body can also receive and retain traces of clothing. The identification of clothing traces has a relatively low identification value and is mainly useful for determining the clothing group. However, clothing traces can be of significant importance when they are present in the form of material debris, broken fragments or catches from clothing objects (Cîrjan, 2005, p. 305).

The investigation of food and food debris is an important forensic activity. This category includes food, alcoholic beverages, food remains, as well as packaging or remnants of the packaging in which they were kept. In forensic science, food that may retain traces of teeth, saliva or traces of objects used to cut it, such as traces of cheese or fruit, is of particular interest for identification. Also, details of the blade of the knife used to cut these foods may be of value in identification. At the crime scene, food may be found left uneaten or abandoned by people who left the room or open area where the crime took place in a hurry. This includes bread, cheese, sausages, tins, etc., as well as bottles of unconsumed alcoholic beverages. Leftover food, such as bread, cheese, cold cuts, fruit, bottles of partially consumed drinks, etc., can be thrown away haphazardly, put in bags or even in the bin. On cans with paper packaging or plastic labels, on bottles of alcoholic beverages or on their labels, traces of lips, saliva or even fingerprints can be found, which may be relevant for forensic investigations (Ciopraga et. al., 2001, p. 125).

Searching for traces of burglary tools is an important part of forensic investigations. The variety of these tools is very wide and includes in fact all types of tools used in the execution of certain professions, objects found by chance at the scene of a crime, but also tools specifically designed for the commission of crimes (Pășescu, 2000, p. 371; Gayet, 1973, pp. 58-74; Ceccaldi, 1962, pp. 63-66; Locard, 1948, p. 715). The traces of burglary tools can be divided into static and dynamic traces, surface traces and depth traces, depending on the process of their formation. The most frequently encountered form of these marks is the depth mark, with static and dynamic variants. The nature and shape of the marks left by burglary tools depend on three factors, namely: the type of tool used, the nature of the material on which the tool was operated and the method used by the offender. These marks are formed by striking, rubbing, pressing or cutting, and only in very hard cases by simply placing the instrument on an object. The most common breakage marks are those resulting from pressing, rubbing or cutting, varying only according to the instrument used and the process applied as a working system (Suciu, 1972, p. 264).

The traces of pressing or forcing, for the most part, are static traces that are relevant for reconstructing construction characteristics. These marks are frequently found in the case of forcing of doors, windows, lever drawers, screwdrivers, rulers, etc. Friction marks, specific to drills, saws, bowls and the like, are mainly dynamic marks and are mainly used for group determinations, as the identification of the tool becomes difficult due to the erasure of details by the friction action of the teeth of the tool. Cut traces are also dynamic ones. If they are formed in a material that can represent the relief features of the cutting blade, such as a knife, axe or pliers, in the form of striations, they can lead to tool identification. There are many practical examples of this. Strike traces are less common, as criminals avoid them to avoid attracting attention and making noise. These marks do not always accurately reflect the characteristic details of the tool, but they can be useful for group determinations and sometimes for individualisation, if the mark also reflects features of the relief of the object hit. Burning and melting traces, although not so relevant for tool identification, may indicate the perpetrator of the breakage. For example, traces of melted metal left on the clothing of the perpetrator of a cash register robbery. In addition to these important categories of burglary tool marks, other types of marks are highlighted in the literature, such as marks specific to matching keys (Suciu, 1972, p. 264).

Interpretation of tool marks in relation to the other categories of traces found at the crime scene and information obtained from the complainant, victim, eyewitnesses or other sources can provide information on the following aspects:

- the modus operandi used in committing the crime: analysis of tool traces may reveal how the crime was committed, such as the physical effort expended, the techniques used or the methods of force and access;
- the nature of the tools used: traces may provide clues as to the type and nature of the tools used in the commission of the crime, such as knives, chisels, drills, pliers, etc.;
- the shape and size of the tools that left traces: analysis of the traces can provide information on the shape and size of the tools used and their distinguishing features;
- the direction from which the tools were operated: by examining the direction and orientation of the traces, it is possible to deduce the direction from which the tool was operated, providing clues as to the perpetrator's movements;
- the number and order in which the traces were created: studying the tracks can reveal the number and order in which they were created, which can indicate the perpetrator's mode of action and the sequence of use of the tools;
- clarifying controversial circumstances, also known as ,,negative circumstances": analysing the traces can help to elucidate uncertain or contradictory aspects of the crime, helping to form a clearer picture of events;

- developing elements necessary to form the circle of suspects: comparing the traces with possible tools and objects associated with the crime can help to narrow the circle of suspects and direct the investigation;
- assessing how long the offender was active at the crime scene: trace analysis can provide clues as to the length of time the offender was at the scene, such as the time spent forcing a door or opening a box;
- identifying the tool that left the trace: through comparison and analysis, an attempt can be made to identify the specific tool that produced the trace in order to obtain conclusive evidence. Overall, careful interpretation of tool marks in the context of other relevant evidence and information can provide a more complete and detailed picture of how the crime was committed, helping to understand the mechanisms and identify possible suspects (Pășescu, 2000, p. 376).

The investigation of tracks left by means of transport is of interest in the forensic field. These means of transport can be divided into three categories: self-propelled or mechanically driven, animal-drawn and manually operated. Examples of self-propelled vehicles include trucks, buses, trolleybuses, tractors, cars and motorcycles. Animal-drawn vehicles are mainly wagons and sledges, and manually operated vehicles include bicycles. In the event of a road accident or the use of means of transport in the commission of a crime, they can leave traces of great forensic importance. At the scene of the crime, there may be shape-marks, which reproduce the characteristics of the external construction of the contact part of the means of transport, as well as material traces in the form of remnants of objects or substances. Depending on the surface on which they move, depth and surface traces, static and dynamic traces, as well as stratification and destratification traces may be observed. Traces formed by the wheels of the means of transport are of a static nature in the case of normal running and dynamic in the case of braking action. Traces left by the soles of sledges are of a dynamic nature. Means of transport can form tracks and at the same time be track objects. In the event of an impact or collision, impact marks such as dents, tears and traces of substances such as oil, petrol, paint film, clothing fibres or blood stains may be observed on these vehicles. These traces can provide valuable information in investigations, helping to clarify the circumstances of the crime or accident, identify the tools used and assess the time the offender spent at the scene (Doraș, 2011, p. 168).

During the on-scene investigation, traces in the form of cigarette butts, whole or broken cigarettes and ashes are frequently encountered. Traces in the form of cigarette leaves or packets may also be found. Other traces specific to lighting materials include matches, candles, wax stains and other products used for burning. It is important to note that these types of traces, especially cigarette paper, can be associated with traces of saliva. Smoking residues are also relevant for the traces of lipstick or food products they may contain. There are also situations where papillary traces can be found on cigarette packets, cigarette holders, pipes or even on cigarettes themselves. Interpretation of traces formed by smoking residues is used to establish specific smoking habits of a person, such as the way they use matches and ashtrays (e.g. partial stubbing out of cigarettes followed by stacking them in the ashtray or on other surfaces), smoking to the limit of the manual grip of the cigarette, which may result in burn marks and yellowing of fingers, or biting the filter of cigarettes, among others (Stancu, 2015, p. 237).

Ropes, ropes, cords and knots are of interest in forensic trace investigations, as they can be found at the scene in various circumstances: packing stolen items, restraining the victim, strangulation using various methods, etc. They can also be used to scale walls. The knots found on these objects can be used in identification, as they are specific to certain professions, geographical areas, purposes, etc. Thus, the way the knot is made can be used as a reference between a strangulation and a simulated suicide. It should be noted that the name of this activity is not appropriate, as both the objects mentioned and the traces produced by them are investigated. Research on ropes, strings, cords and how they were used, including their knots, can help to establish gender membership, both for those who built and made them and for those who used them. They even have established names such as fisherman's knot, sailor's knot, weaver's knot, etc. Investigating the marks left by ropes, cords, etc. on the victim's body is useful in cases of strangulation, hanging or restraint (Ciopraga et. al., 2001, pp. 127-128; Anghelescu et. al., 1978, p. 193; Mircea, 1992, p. 189; Locard, 1948, pp. 84-85).

The category of traces formed by the remains of objects or various materials is very broad. In addition to the aforementioned traces, there are other traces of similar importance in clarifying the circumstances surrounding the commission of the crime and in identifying the perpetrator. For example:

Remains of wood found at the scene of the crime or on the offender's clothing in the form of wood shavings, sawdust or dust are picked up for examination in order to identify the essence of the wood or even the object of which it formed part. In order to establish whether two pieces of wood were part of the same object, the manner of cutting, the grooves formed during cutting, the visible annual rings, the direction of the fibres, and whether the wooden object was painted or had any stain, the continuity of the paint layer or stain shall be investigated (Suciu, 1972, p. 301).

Soil traces are fragments brought to or dislodged from the scene of the crime and found on footwear, clothing or other objects worn by the perpetrator or victim, as well as on means of transport used in the commission of or in connection with the crime. Soil traces of podzolic, chernozemic, sandy, clayey soil (combined or separate) may be found at the scene or on the access routes. The appearance of these traces varies according to the type of soil they come from, the degree of moisture and the impurities they contain, such as vegetable substances, minerals, slag, etc. The offender's or victim's clothing may bear traces of soil as a result of climbing steep terrain in adverse weather conditions, such as rain, mud or fog, or as a result of fighting, falling, etc. On clothing, soil marks may appear as stains, dust or dirt, depending on the weather conditions and the actions that took place previously. If the offender has brought the footprints to the scene by means of footwear, they will often have a different colour, appearance and degree of homogeneity from the soil present at the scene (Anghelescu et. al., 1976, p. 320).

Paint traces or films found in burglaries, traffic and work accidents, and other acts involving blows, require the characteristics resulting from the colour, chemical composition and number of paint layers to be determined. The films also allow the reconstruction of the portions of paint from which they have been removed (Stancu, 2015, p. 240). Paint residues are identified by: colour shade, chemical composition and the number and variety of paint layers deposited. Research is carried out by applying the following methods: chemical, microscopic, spectrographic and activation analysis. The peeled paint is embedded in a paraffin layer, which is cut with a microtome so that it can be examined in sections. The rest of the paint will be examined not only in terms of colour pigment but also in terms of solvent formed from oils or resins. Oil dissolves in ether and resins in alcohol. Paint residues are also examined by the spectrophotometric method applied in the visible and infrared spectrum (Suciu, 1972, p. 302).

Dynamic action in the form of cutting, forcing or other actions between two or more metallic bodies can create particles from the metals subjected to these actions. The result of such action, when it occurs in the process of or in connection with the commission of a crime, is called trace metal. The mechanism for the formation of these traces consists of the detachment of particles from the mass of metal bodies as a result of the processes of chipping, cutting, breaking, scratching, striking, crumbling and, in some cases, even bending or twisting. These marks can also be created by actions involving the release of heat, such as welding, melting or rubbing. The metal traces that may remain at the crime scene fall into two main types: ferrous metal traces and non-ferrous metal traces. Non-ferrous metal traces, which are more common, can be made of aluminium and copper alloys. Depending on the mechanism of production, the traces may be made up of smaller or larger particles. Thus, in the case of pitting, specific pilings will appear, and in the case of flaking, spurs, etc. Characteristic of this type of trace is the brightness of the particles that make it up. Depending on the time elapsed since the action that created the trace, the glow may be stronger or weaker. In the case of the breakage of pieces of metal objects, such as tools, machine parts or sub-assemblies, etc., the fragments that make up the traces may have more or less regular shapes, with a shiny appearance in the area where the breakage occurred (Anghelescu et. al., 1976, p. 318).

Glass fragments are examined either as larger broken pieces or as small or microscopic shards. In the case of larger pieces, the shape of the edges is emphasised so that they can eventually be assembled with other pieces, knowing that the most elongated shape of the piece of glass indicates the direction of the original breakage. The indentations indicate both the direction of breakage and the place where the first break was made. Heat breakage appears as small parallel straight lines, since the bursting does not have a central point but is evenly distributed. Glass shards are more often seen in traffic accidents when it is a question of rebuilding the glass of the headlamp in order to know which vehicle it belongs to. The question also arises when investigating fires to determine whether a window has been broken to intensify the fire with fresh air, or windows have broken due to heat or extinguishing action. Small fragments of glass are found on the ground, on the floor, on the offender's clothes, on used instruments, on projectiles, etc. Glass fragments are examined under a microscope or by the flotation method to determine their specific weight, by refractive index determination and by neutron activation (Suciu, 1972, p. 302).

The enumeration of traces formed by objects or different substances is, however, much more diverse, and in the present work we describe only the most important ones. Other categories of traces are also mentioned in the literature, such as traces of petroleum products, traces of plastic material, traces of a powdery nature, traces of toxic substances, etc.

The discovery of trace-objects on the spot does not present any difficulties. As they are relatively large, they can be seen with the naked eye. In order to detect trace-objects at the scene, the search must be organised in accordance with forensic recommendations and procedures, so that no part of the land or room where the crime was committed or the route by which the offender left the scene remains unexamined. Traces of substances or their residues used in the commission of offences may be found at the scene in various places, forms, quantities and packaging, as well as on the victim's body (Gheorghiță, 2017, p. 215).

The traces-objects of the crime are established, firstly, by describing them in the report, indicating their specific name, location and position, shape, size, condition, individual characteristics, the presence of traces or foreign bodies on the outside of the object, and secondly, they must be photographed or video-recorded according to the rules for photographing main and detail objects. The first photos should fix the object-traces with those in the immediate vicinity, clearly showing the position of each object in the crime scene, and the second photos should show the particular characteristics (clues) in detail (Gheorghiță, 2017, p. 216).

The substances or their remains shall be recorded in the report by means of a description, indicating where they were found and their characteristics. In the case of solids, information on size, volume, colour and odour shall be included. For liquid substances, the colour, odour and manner in which they are disposed of (pots, spilled on the ground, floor, objects, etc.) should be mentioned. Gaseous substances should be described by their odour in the air and their volume in special packaging, bottles, etc. Photographs of solid and liquid substances or their remains should be taken according to the same rules as for trace objects. They are collected together with the packaging or containers in which they were found, depending on their shape. If substances or their remains have been found on objects, soil or other surfaces, they shall be removed together with those objects, in accordance with the general rules for the removal of traces of offences and offenders. If this is not possible, depending on their condition, the substances or debris may be scraped or absorbed as appropriate (Mircea, 1999, p. 142).

It is important that each trace-object, substance or their remains, discovered during the crime scene investigation, be fixed with great precision, examined with great care in order to exclude cases of intoxication of the members of the investigation team, picked up and packed in such a way as not to destroy the objects themselves, not to alter possible traces of reflection on them, not to alter the characteristics (clues) of the objects and substances (Gheorghiță, 2017, p. 216).

6.2 Forensic Investigation of Micro Burglary

The microobjective approach to obtaining information for tracking and probatory purposes experienced a new development at the end of the sec. XIX – the beginning of cent. XX. (Pisarenco, 2016, p. 17). In parallel with the development of research possibilities, microwires are finding their rightful place in forensic science as well as in crime-fighting practice (Popa, 2000, p. 19).

Microwires are a subject of great importance for forensic science because of their specific characteristics. They occur in extremely small quantities, take various forms and can originate from a variety of sources. They can also be deposited on a variety of objects and created in different ways.

There are two key issues that forensic science addresses in relation to microburden. The first issue is the clarification of the concept of microbursts and their possible classification. The second aspect is the development of methods and means for searching, discovering, fixing, lifting and examining microarrays under laboratory conditions (Mircea, 1999, p. 152).

There have been a number of attempts at the definition of microworms (Romanov, 1958, pp. 612-618; Kirichenko, 1998; Ruja, 1973, p. 112; Popa, 2000, p. 20), both in the domestic literature and in the foreign literature (Gheorghiță, 2017, pp. 216-219; Pisarenco, 2016, p. 68; Golubenco, 2008, p. 87).

Unlike traces, which have found an unambiguous definition in the forensic literature, the notion of a micro-trace is still a subject of discussion (Anghelescu et. al., 1976, p. 416). Before giving this definition, it is useful to make a few general observations.

The word micro comes from the Greek word mikros and has two meanings: micro can mean small, very small or small, and in the second meaning micro means a millionth part of a basic unit (Popa, 2000, pp. 19-20).

From a forensic point of view, micro-marks are small or very small parts of traces of form and matter, which bear some relatively unchanging general and individual characteristics of themselves or of the physical actions that produced them (Cîrjan, 2005, pp. 328-329; Anghelescu et. al., 1976, p. 416; Mircea, 1996, p. 234; Stancu, 1981, p. 237; Popa, 2000, p. 20).

In the forensic literature there are opinions of some authors who adopt definitions of microworm with some measures (Hrustaleov, 2003, p. 21;

Kochubei, 2007, p. 343; Makogon, 2003, p. 98). In such an understanding, before considering a trace as belonging to the group of microbursts, some complicated measurements should be made, which are not necessary for anyone and are of no use. Constructing the definition of microwakes on such a basis is unworkable from the point of view of the practice of on-the-spot searches (Popa, 2000, p. 20).

In view of the continuous evolution of the definition of microscopic changes in materials related to the commission of a crime, identified and studied by the subjects of investigation (prosecution officers, experts, etc.), we propose the definition of the concept of micro-objects formulated by the local researcher Pisarenko C.

,,Micro-objects are micro formations, closely related to the criminal event, important for the resolution of the case and the finding of the truth, having different dimensional characteristics, the limits of which are set by the sensitive range of human sense organs, firstly, by the resolution capacity of the human eye, which has relatively stable parameters, the detection, fixation, definition and quantification of the truth does not require the use of technical means, scientific knowledge and laboratory instrumental methods. A complete picture despre microobiecte pould only be obtained if they are examined cact the obiecte of the expercising objective" (Pisarenco, 2016, p. 68).

The characteristics of micro traces can be the following:

- the possibility of observing them only under a microscope;
- a determined state of agglomeration (cohesion) of matter;
- the necessity of using specific methods in the course of investigations (Popa, 2000, p. 20).

Microwires are material objects causally related to the crime, the search, examination, lifting and investigation of which is impossible or problematic because of their small size and mass. They can be of human nature (particles of hairs, blood, various secretions and excretions), vegetable (fragments of leaves, grass, seeds, flowers, plant microorganisms), substances (soil, cement, paint, etc.), as well as micro-waste of objects (particles of glass, metal or wood dust, textile fibres, gunpowder, etc.) (Gheorghiță, 2017, p. 217).

In view of the above characteristics, it is important to note that certain types of marks are not considered microprints in the following situations:

- invisible marks which do not require special means of visual amplification to be observed, such as reproductions of papillary lines on paper or fabric, writing made with an invisible medium, etc.;

- quantities of substances or agents which present a material problem and can only be identified by microanalytical investigations, such as group, subgroup and certain agents present in human blood, chemical elements present in the molecules of materials, etc.;
- volatile bodies and odors, which cannot be observed by means of instruments which magnify the sight and which require the use of apparatus to investigate and compare them (Popa, 2000, p. 21).

One of the first attempts to classify microobjects was made by Edmond Locard. Using particularity of delimitation using the law of contradiction, he proputed a division (dihotomice) of microobiects into anorganice and organice. Subsequently, scholars from different countries have made numerous incerces to descrify the „micro-objects" by listing all the tips that fall into this category. However, when classificing microobiects, not all the timep different themes and principii were used in aceleas scopuri. Clasification itself did not always concept the cerrors of plenitude, chen all members of the clasification must be enumerated, and of accuracy, chen all members of the clasification are not concepte suprapuse (Pisarenco, 2016, p. pp. 68-69; Gayet, 1961, p. 68).

The classification of micro traces is imposed by practical needs in terms of searching, finding, fixing, lifting and further research in the laboratory.

A first criterion for classifying micro traces is the mechanism of their production, in relation to which three categories of traces are distinguished:

- secondary particles of macrourms;
- small particles of an object that was originally large;
- natural microobjects (Popa, 2000, p. 21; Anghelescu et. al., 1976, p. 417; Cîrjan, 2005, p. 329; Mircea, 1999, pp. 153-154).

Depending on the mode of transmission, there are two categories of microwaves:

- contact microtraces, which arise in all situations where two objects come into contact, regardless of whether they are stable or dynamic. This means that microbursts are transmitted from the offender to the crime scene and vice versa. The same applies to the relationship between the offender and the victim, the burglary tools used, the microbursts can also appear in the form of striations on a solid support (the damaged object) or even on the burglary tool used, which takes on the characteristics of the damaged object in relation to its mechanical properties and the contact surface made at the time of the action. The category of contact microbursts may include: dust and glass particles produced when glass or glass objects are broken; dust and metal particles produced when metal objects are cut, small particles of paint and varnish; very small streaks on a solid object; small impurities on clothing; occupational dusts; particles of earth, plaster; particles of foliage; small seeds and other particles of plant origin, etc.,

- unilaterally transmitted microtraces, which include those transmitted to objects or persons from the unclean atmosphere and as a result of activities carried out by offenders at the scene.

A further criterion for classifying microbe diseases is in relation to how they are known:

- human microtraces: hair particles, blood stains, sputum, semen; skin fragments; small amounts of organic secretion, fat particles, etc.;
- animal microtraces: these include both human microbe diseases (but of animal origin) and particles of feathers, fish and reptile scales, animal micro-organisms forming part of the microfauna, etc.
- plant microtraces: particles of algae, lichen, fungi, moss, ferns, flowers, fruits, seeds, plant micro-organisms forming part of the micro-fauna, etc.;
- object microtraces: particles of glass, paint, varnish or dyes; particles of earth, plaster, lubricant residues, particles of plastic and synthetic materials, burnt and unburnt powder from a firearm, etc. (Popa, 2000, pp. 21-23).

The author Pisarenko C. provides the following classification of the microobiects that would be welcome to the criminal prosecution officers, as well as to the other participants in the field investigation:

- after material form: microparticles, microprint, microcantities of substance;
- depending on the state of aggregation: solids (crystalline structure, amorphous), liquids (emulsions, suspensions, solutions), gaseous state;
- according to the degree of visibility: visible, poorly visible; c) invisible;
- depending on the nature of the provenience: inorganic (ghips, metal particules, etc.), organic: natural (blood, sperma, etc.) and artificial, mixed (praf, soil, and layer of vopsea and lac);
- depending on the source of origin: of natural origin (from natural obiects), artificial;
- depending on the mechanism of formation: mechanic separation, mechanic dismemberment, proven as a result of termice or chimice action;

- microobjects at the face of the plot: microobjects brought to the face of the plot, microobjects preluced from the face of the plot;
- source of provenience: provenced from the perpetrator, from the victim, from the offender's tools or means of transport, from the offender's;
- on the purder object: descoperted from the corp and clothing of the offender, descoperted from the victim, descoperted at the loc of the offender, found pfrom other items at the loc;
- depending on the probatory information: privacy of the identity of the offender, identity of the victim, identity of the tools and means of committing the offence, information on the crime, the method of committing the crime, the time and duration of the crime (Pisarenco, 2016, pp. 77-78).

Microwires are found on a wide variety of bodies and objects, so their discovery will depend directly on the orientation of prosecutors and forensic experts in detecting and picking up those bodies and objects likely to bear microtraces (Anghelescu et. al., 1976, p. 417). The search for micro-surmounds requires as an important rule their operational recovery, since with the passage of time, due to their small size, they undergo physical and chemical changes, significantly reducing their value. The analysis of the micro-surmises leads to an approximate determination of the place of the crime, especially if the body was transported from the place where the murder was committed or the time since the crime took place (Cîrjan, 2005, p. 329).

Micro-surveys are of significant importance in forensic investigation as they provide a wealth of useful information. They can help establish how the crime was committed, reconstruct the route taken by the perpetrator or victim and determine whether they belong to a particular group. They can also provide clues as to the length of time between their creation and their discovery and study. The places and objects where microburden is found, as well as the nature and quantity of the microburden, provide important data for establishing how the crime was committed and can help to delimit the circle of suspects. Through laboratory examination, the expert can determine the origin of the microurms, whether they come from plants or minerals, are of human or animal nature. The blood group of the person involved, the animal species from which the microbe originates and the possible presence of other substances with which the microbe is mixed can also be identified by analysis (Mircea, 1999, p. 154).

Practice shows that the most common carriers of micro-urms (micro-objects) are:

- the human body, clothing and footwear of the offender and the victim;
- bladed weapons and other instruments for causing bodily injury or damaging obstacles;
- objects damaged as a result of the crime;
- locality areas, earthen grounds, roads and the floor of the room where the crime took place;
- means of transport involved in the accident (Gheorghiță, 2017, p. 217).

In the human body, the micro-objects are located in the hands, under the fingernails, in the area of the cortical lesions, in the shoulder, and in case of sexual offences – in the sexual organs. Apart from this, microobjects pot be found in the ears and nose. In clothing articles, microobjects are submittead in pockets, on the lapels of jackets, cuffs of trousers. They can be amplased on the supface of the textile fabric of the coat; to seep into the braided yarns, into the fur, into the puf; from different catarms, fasteners, staples. In the garments, the clothes are localized at the waist and all over. It is possible ca they seep into the sole or heel made of elastic materials, get under the boot. The tools with which the corporal injuries were composed or aplicated remain microobiecte in the form of blood, elements of human skin, hair, fibres from clothes. The tools used for the removal of obstacles remain microobjects removed from the obstacle. The pode of the parking, the ground and the roads can be purriers for different microobjects. Everything depends on the infraction's type and the character of the objects can interact. The same applies to damaged objects and obstacles that have been dereferenced by the depension. When examining all the mentioned objects, attention should be drawn to the material from which they are made or are made of, in order to determine later the transfer factor. Automobiles, motorcycles, bicycles and other means of transport can be objects that are sources of micro-objects in the form of coat fabric fibres, hair, blood, elements of human pleather, headlight tubes, windows of the car body, fragments of lacks and vectors, particles of fuel and lubricants – all dependent to the mechanism of the road incident (Pisarenco, 2016, pp. 99-100).

The discovery and collection of microtraces is a great difficulty in forensic research, due to their very small size and sometimes the nature of the site or the objects carried, plus the difficulty of using high-powered magnification equipment in the field (Mircea, 1999, p. 154).

A first measure to be taken by the investigating authorities at the scene is not to allow any person to enter the crime scene. The purpose of this measure is also to protect micro-surveillance equipment which, by its very nature, can easily be modified, altered or destroyed (Ciopraga et. al., 2001, p. 131).

In order to carry out the raid properly, and in particular to secure the micro-surveillance, it is necessary to plan precisely the operations to be carried out by the investigation team on the spot. On the basis of the information obtained from the persons securing the scene of the crime/event, as well as on the basis of macroscopic traces of the perpetrator's action visible without entering the area where the crime/event took place or, if necessary, on the basis of traces from the entrance to the road on which other persons have previously travelled and which has been marked, the team leader must also pay attention to the following circumstances: on which road the offender arrived at the crime scene; what obstacles he had to overcome, what he had to touch and where to look for traces, i.e. what kind of traces; what tools he probably used; how the offender moved around the crime scene; whether only one or several offenders participated; how much time has passed since the crime/event and how the crime scene and therefore the traces could have been changed (Popa, 2000, pp. 25-26).

Detection of micro-surfaces at the scene can only be carried out under conditions of optimal lighting (either natural or artificial) of the objects examined and the use of optical means (devices) (Gheorghiță, 2017, p. 217). The search for microworm requires the use of appropriate technical means, such as: magnifying glasses, binoculars with 10X magnification, portable stereoscopic microscope, light sources, 30-50W portable halogen lamps, UV and infrared lamps, etc. (Cîrjan, 2005, p. 329). Ultraviolet rays cause secondary luminescence of substances, which differs from the luminescence of the tracer object, and in this way micro-worms are revealed, and with the help of infrared rays, dark micro-traces on dark surfaces can be detected. Infrared rays can also be used to detect micro-marks covered with ink, dirt or aniline dye, etc. In addition to the illuminators listed for detecting micro-worms, portable laser detectors, special vacuum cleaners, pocket microscopes, etc. can also be used (Gheorghiță, 2017, p. 218).

The micro-surfaces will first be searched on the horizontal supports, where other categories of traces have been discovered, where the perpetrator inevitably came into direct contact with various objects at the scene.

In the rooms, the spaces between floorboards or floorboards, pieces of furniture, household objects suspected of having been used in the crime, etc. are searched.

In open fields, public roads, etc., search for unevenness, recently wiped or cleaned surfaces, etc. On clothing, search in the area of seams or creases due to wear and tear, and on the human body, search on the hands and under the fingernails (Ciopraga et. al., 2001, p. 131).

Particular attention shall also be paid to the search for and discovery of micro-bumps on the body of the victim or the perpetrator or suspect/suspect. If the victim or perpetrator is admitted to hospital for urgent life-saving treatment, the prosecuting officer, together with forensic experts and doctors, must immediately take all necessary steps to find micro wounds in the wounds on their body. At the same time, the entire wardrobe of the boarding school will be secured, collected and handed over for examination to the laboratory for the discovery of microbleeds (Anghelescu et. al., 1976, p. 418).

If the death of the victim has occurred, the search of the body at the scene is totally contraindicated as this leads to the destruction of the microworms. The victim's clothes or body should be placed in plastic bags and transported to the laboratory (Cîrjan, 2005, p. 330).

For the detection of microtraces consisting of metal particles, the diffuse contact or electrographic methods can be used. These methods do not destroy traces and can be used many times, they are not time-consuming and do not exclude the use of other methods such as spectral etc. Detection of microbeads with magnetic properties can be carried out with the help of a magnet, usually using the magnetic brush from the forensic kit or any other strong magnet. In order to prevent metal particles from hitting the surface of the magnet directly, the magnet is covered in a polyethylene film. Microparticles that are picked up by handling the magnet in areas where metal microparticles are suspected to be detectable are removed by peeling off the polyethylene film from the magnet on the packaging sheet (Gheorghiță, 2017, p. 218).

Examination of the objects shall be carried out without being plashed, if it is not placable to examine the entire object, then the object shall be plashed on a white sheet of paper, providing that the unprinted specimens are not planted, precautions must be taken to precautionally prevent the specimens from being loosened by the carrier object. All sheets must be protected from soiling, and it shall not be permitted to touch the sheets, wrap the sheets in cloth or paper of poor quality. It is desirable that all handling of the objects be done with gloves (Pisarenco, 2016, p. 101).

Researcher Bibikov V.V., proposes the following sequence of actions to be carried out at the scene of the crime in order to detect the micro objects:

- obtaining non-essential information about the nature of the microobjects, their morphological characteristics, their immaturity, the type of microobjects that the offender may have carried or brought with him, etc.;
- the information can be obtained in the preliminary cercet prequirements;
- screening of the animals, establishing the amalaza, salinity, shape, size, multiplicity, the presence of luminescent properties and other features;
- defining a set of tasks to be addressed by the expert to implement the micro-objectives;
- selection of the methodology for the redirection of the product; unmediated redirection of the product and its packaging;
- the reflection in the minutes of the follow-up session of the succession of the activities of sorting the goods and their results, the process of their collection, their packaging and any other information with reference to the collection of material goods (Bibikov, 1981, pp. 12-13; Pisarenco, 2016, p. 102).

The fixing of the objects in the verbose of the setting in front of the body itself and the unfolding of the moving of the speaking object, of the organs and the articulations. The delineation of the animals themselves with the mention of their release to the speaker-object and is carried out successively, alternating with the delineation of their joints. In the case of a mass of objects, concentrated on a large surface, it is desirable to indicate the dimensions of this object and the arrangement of the moving object. The hard fixation of the bone of the female animal is due to the loosening of these joints. In the first row, the state of their aggregation is fixed, which will later influence the manner of raising them. They continue with the development of the external framework, the form, etc. (Pisarenco, 2016, p. 102; Bakanova et. al., 2004, pp. 29-30). For fixation, photos will be taken with wide film (6 ¼ 6), on the objects or traces that have been discovered, after they have previously been placed in the context of the place according to the known rules (Cîrjan, 2005, p. 330).

The method of picking up microtraces must be closely related to further research, as well as to the physico-chemical characteristics of both the microtrace and the support from which these microtraces are collected (Popa, 2000, p. 32).

To raise the cattle, sharp tweezers, like scalpels, were used. In case of emergency, they can be kissed with a drop of distilled water. The magnetic articles will be lifted with a magnetic ring. The materials raised in this way are transferred to errubettes, salted flasks, thick white paper grids, sals paper or parchment paper, the lass and dyes and other similar materials must be placed between two stilts, the edges of the stilt are loosened with tape ,,scotch", it is desirable that one of the stilt slats has a depth. When lifting large surfaces, tapes and an adhesive layer will be used, produced for the lifting of objects (,,lirofolis", tapes with a layer of sausage), summary and sheets of transparent tape. The advantage of this lifting gear is that in this band the arming of the joints and the running gear is increased. It is not recommended to lift the joints with the help of the ,,scotch" tape, because the joints lifted in this way will not be dislodged from the smooth layer of the tape during their placement in the laboratory (Pisarenco, 2016, p. 104).

For the ridication of a wide range of substances with a liquid consistency (fuels and lubricants, petroleum products, etc.) capilary tubes or pipete or caped extended are necessary. Ridication is effeccive pith the simpe touch of the tube similar to the picture, the more viscous the liquids are colected cuping the pipette. One of the ends of the tube, with the ridic in it, is held against the flame of the hibritre. Cut the moistened tissue, squeeze it from both sides with the cupping discs and place it in a hermetically sealed container. This will prevent the evaporation of volatile compounds and their interaction with oxygen and humidity.

The removable objects are best removed by means of a blade or other similar object, which is placed in a styrofoam container which is sealed with a polyethylene or cork. A staple or clip, which will pierce the capac, will secure the blade fragment to the cremos obiect at the bottom of the recipient (Pisarenco, 2016, p. 105).

Another very useful device for collecting micro traces is the dust extractor – which is fitted with a device that contains a filter to retain the aspirated micromarks. This device is equipped with various interchangeable end pieces which are used according to the shape and size of the surface from which the microparticles are to be collected. The end pieces are made of glass, which makes it possible to observe any impurities on the walls and also facilitates cleaning. The filters on which the collected particles are retained are made of a special porous synthetic material. Once the microparticles have been collected from the surface of interest, the filter is removed from this device and secured in a cellophane or polyethylene envelope, prepared in advance. The re-use of this additional device requires the insertion of a new filter and the replacement or cleaning of the end pieces (Popa, 2000, pp. 35-36).

The following rules must be followed when dealing with the microobjects:

– the non-removable ridication of the movable objects from the surface of the carrier-object is permitted only in cases where it is impossible to ridice the object itself or a part of it;
– the whole or a fragment of the object which contains traces shall be reprinted;
– the object shall be held on a white sheet of paper prinsed in preal prinsing paper, with the crumpled parts of the object. It is recommended to purrtate gloves in the timp of the procedure. It permit the use of penseta, ac for disecare, magnet or pensulei magnetice. The use of adhesive tape or adhesive tape is recommended for the removal of mucous membranes from the immediate vicinity of the patient's hands;
– blood, brain substance, saliva, greases and lubricants may be removed using sterile cotton or gauze swabs;
– scraping of the microparticles may be apliced only in exceptional cases;
– the content under the nails must be carefully scraped by cutting the nails of all the fingers with scissors and separately scraping them;
– scraping of the microobjects of a large supraction (floor, scales, etc.), from car seats, carriages, trays, unfinished surfaces, from between the edges, parchet is effected by means of mini- and special sprilling machines (Pisarenco, 2016, pp. 104-105; Gheorghiță, 2017, p. 218).

Preservation is carried out in sachets or sheets of good quality paper, on adhesive strips, stuck to another strip or to a sheet of plastic, to avoid spreading or adhering to other surfaces, especially those with porosity. For this reason, it is totally contraindicated to lift and carry them on cotton wool pads (Stancu, 2015, p. 241). Once preserved, the microworm should be sealed and kept in conditions that do not allow them to become impure (Popa, 2000, p. 37).

The packaging of microbiota should be carried out in accordance with the following rules:

– each object and each sample of the micro-organism must be packed in a sealed package;
– wet objects, blood and blood-glass swabs must be dried before packaging;

- articles of clothing, clothing and hats must be sealed in sealed packets made of polyethylene. In order to prevent contact between them, white sheets of paper shall be placed between the sheets;
- tools and other objects of small dimensions will be packed and secured in different containers (boxes, crates) to ensure the safety of the objects;
- the dactiloscpic pelicula and adhesive tape are packed in paper and plices;
- nails cut together with the subungual content are packed in pachets of paper;
- separated micicle objects, e.g. cigarette butts, wood fragments, etc. pot be plased in eprubbers and micicle vials of styrene, hermetically sealed with curate dop;
- when detecting traces of lichide in pahars, borcans and other recipients, where poisonous substances are presuped to be present, it is best to pour the lichide into a dry, cleaned borcan or a wide-necked sieve (mentioning this in the proceedings), the dope is hermetically sealed and, after it has been sealed together with the container in which the liquor was placed, it is taken as soon as possible to the experciser;
- the best recipient for narcotic substances is the styrofoam canister with the cover;
- the pachets, cans, crates and other recipients with the packaged products will be accompanied by the explictive inspriptions and identification signatures of the pention officer (Pisarenco, 2016, p. 106).

The forensic importance of microurms is that their search can yield much-needed information that can help establish the circumstances of the crime under investigation (Gheorghiță, 2017, p. 219).

The principal Cerces of the procesul cercetări microobiectelor at the loc are as follows:

- the means, methods and methodologies of the cercetria in the face of the place must be simple and acccesible;
- the probability (non-destruction) of the microobiects product parcing the cercetria ln the scopt of their possible use in subsequent expertise cercetria;
- possibility of carrying out extra-laboratory (emergency) tasks in all non-essential cases.

At the same time an essential principle for law criminalists is the fact of particularity microobjects transmit such information. One distinguishes five grups of such particularities:

- morphology, adds the internal and external spactual structure of the microparts; thus, the micropart is able to be separated mecanic by a given object and to be valid chiar and pomparation based on the separation supraction (obiect separation);
- the compotion, structure and other propeties of the substance (material) of the microobiect; acthis means of transmitting information is obvious and is used, e.g., in solving descoperation, diagnostic, identification tasks. A particular importance in which information transmission is prived pthrough this medium is given by the so-called traces of the external environment;
- the state (of the modified object in raport to the initial state) of the substance (material) of the microobject of the object-purrier;
- the ampleness pof the obiect-purveyor;
- the relative ampleness of heterogeneous substances and materiale pon the supface of the obiect-purveyor (Pisarenco, 2016, pp. 117-118; Mitrichev et. al., 2003, p. 191).

In the study of the microobiects at the face of the loc pould be included the detection of micro-objects prossing prossing-objects. At the same time it is necessary to respect the following precautionary measures:

- it is forbidden to examine the tubes in unfavourable atmospheric conditions;
- wet tubes must be dried at room temperature;
- if the preliminary cleaning is carried out in an area prepared for the purpose, it is not necessary to carry out wet cleaning in order to remove the grease and prevent the transfer of the particles;
- the subjects will be required to remove their hands, wear clean and protective gowns for their hands;
- the objects will not touch each other or the subjects' clothing;
- the area in which the test objects are to be examined will be cleaned with polythylene tissue, paper and thick, well-bonded paper;
- prior to the preliminary examination, the technical means of examination must not be applied: lupa, microscop, blades and curate blades, etc.;

- mixing of microobiecs from different objects is not allowed, they are separate; each sheet of paper on which the examination has been carried out is examined and the microobjects thus examined are separate, the packaging is recorded with the packaging (Pisarenco, 2016, p. 118; Shamonova, 2002, pp. 23-24).

Of particular importance in the subsequent investigation of various remaining crimes with unknown perpetrators, in whose files there are expert reports on the examination of micromarks, are the technical and operational issues resolved by these expert reports. As a general rule to be taken into account when interpreting the conclusions of such expert reports is that most often they help to establish gender relatedness and less often the actual identification is made. As such, a great deal of discernment is needed in interpreting the conclusions correctly, so as not to misdirect the research (Popa, 2000, p. 37).

Technical issues that can be resolved by forensics:

- what is the nature of the micro-wall;
- what are the characteristics of the micro-wall;
- whether or not it is similar to the evidence available for comparison and examination (Cîrjan, 2000, p. 330).

Problems of operational interest that can be solved on the basis of technical resolutions:

- approximate determination of the place where the crime was committed based on the identification of specific micro-organisms in the flora and fauna of the terrain;
- establishing the link between the perpetrators and the crime scene by analysing soil traces or substances found on the perpetrator's soles or clothing;
- identifying the correlation between the tools used by the perpetrator and the crime scene by highlighting paint particles found on the jaw of the pliers used to cut a metal grating;
- approximately estimating the time of the crime by analysing the evolution of micro-organisms under the corpse or other relevant temporal clues;
- analysis of the modus operandi of the crime, such as the manipulation of petrol meters with a hook, using specific techniques and tools;

- assessment of the authenticity of the crime by identifying and analysing the iron filings discovered in the cuff of the manager's trousers involved in a frame-up;
- determination of the perpetrator's profession by analysing the profession-specific dust deposited at the scene;
- identification of the type and colour of the perpetrator's clothing by analysing the textile fibres found at the scene;
- establishing the difference between murder and drowning by detecting the presence of plankton in the kidneys as an indicator of the aquatic environment in which the crime took place (Popa, 2000, p. 38).

Expertize microobiects represents an algorithm of expertize, in which the aplicate methods depend by the nature and origin of the microobiects, by the fact of which kind of information is necessary to the authorizer. An important preview of the effeccveness of expercising is the respect of the aplict of a consectivity of methods from simple to complex, from non-destructive to destructive ones. The use in practic of expertice of principles of the complex approach, the selection of suitable methods and their use by a given scheme in conformance with the importance of the data obtained, taking into account the caracter and state of the supposed objects of the practice, permitted to obtain the maximum possible information to research microobjectives. Conclusions of microobjectst expertize should be formulated taking into account the posibilities of the methods of cercetation used. If a probable evaluation of the results obtained is carried out, then the probability level of the results obtained must also be included in the expert conclutions (Pisarenco, 2016, p. 145).

Chapter VII

Forensic Investigation of Traces of Fires or Explosions

7.1 General Information

Fires and explosions are phenomena with devastating socio-economic consequences, through loss of life and significant material damage. These events have led to extensive scientific research aimed at preventing them and identifying those responsible if they are caused intentionally.

Investigating the aftermath of fires and explosions, also known as disasters (depending on the consequences), is a complex activity. Forensic investigation is really difficult, because in these situations the priority is to take action and rescue the victims, minimise the damage and remove the danger of the disaster spreading (Stancu, 2015, p. 250; Geza, 1965, p. 322).

These difficulties are even greater in the case of explosions, often followed by fires, because of the destruction or alteration of a large number of traces that can be used to establish the cause of the fire and identify the persons responsible. In the above cases, therefore, the investigation must be started without delay, together with the specialist fire brigade, as soon as it is possible to enter the scene or the area where the fire is suspected to have started (Stancu, 2015, p. 250; Gayet, 1961, p. 149).

7.2 Forensic Fire Investigation

Fire – a large fire that engulfs (and partially or totally destroys) a building, forest, etc.; a large fire that spreads causing great material loss (Dictionary, 2007, p. 896).

Fire, as a technical concept, is a complex process of physico-chemical phenomena, which is carried out by burning in the presence of at least two elements, one of which burns and the other of which sustains the burning (Anghelescu et. al., 1976, p. 360). It is usually propagated by flames, and in the process of combustion smoke of various colours is generated, influenced by the composition of the substances involved in combustion, the level of humidity and the environmental conditions (Stanciu, et. al., 1999, p. 157).

Due to their individual properties, not all substances combine as easily with oxygen in the air and therefore do not ignite as quickly. Some of them ignite at relatively low temperatures, others at relatively very high temperatures and as a result the temperature that develops during the combustion of the different substances is not the same. Depending on the combustible substance and the speed of fire propagation, burns are classified into slow burns (with a low propagation speed of up to 1m/second) and fast burns – detonations – (with a high propagation speed of up to 4 km/second) (Anghelescu, et. al., 1976, p. 360; Baș et. al., 2013, p. 10).

The burning of materials, substances and articles during a fire occurs in time and space in accordance with objective laws, which in this way manifest themselves in concrete conditions. It is due to the logical nature of the processes occurring during the occurrence and production of fires, the formation of corresponding traces on elements of the material environment and information in people's consciousness that it is subsequently possible, with a certain degree of accuracy, to reconstruct the peculiarities of the fire development (Gheorghiță, 2017, p. 224). Whatever the nature and extent of the changes, the burning produces traces which are of forensic value (Ciopraga et. al., 2001, p. 95).

The traces created by fire are understood to mean the changes produced at the scene of a criminal offence as a result of the action of incendiary substances or other causes, open flames, smoldering, temperature and other phenomena accompanying the fire. Following the occurrence of fires, traces of form, position and matter may remain on the site (Anghelescu et. al., 1976, p. 361). As a rule, fire traces are made up of a variety of objects or substances that have suffered partial damage as a result of the burning process. These traces, in their original state, are not preserved in their original form, but are subject to deterioration during the fire-fighting actions and are associated with other traces generated in this activity. Consequently, they are rarely used directly in forensic identification, but are rather useful in determining the causes of fire outbreaks, in understanding the process by which they evolved, and in identifying substances or objects involved in the burning (Mircea, 1999, p. 157).

The investigation of fire traces is carried out in a context distinct from the general investigation of crime traces, due to the extremely diverse nature of the causes that can generate the outbreak of fire, and due to the specific action of fire, which as it leaves traces also destroys them to a certain extent by burning their substrate. Another process of destruction of fire traces occurs during fire-fighting interventions, which is why the investigation of the traces must begin as soon as possible and in close cooperation with the fire services. The fire may extinguish itself or be extinguished before the fire scene is seriously damaged, or it may destroy the entire area, regardless of the fire-fighting interventions. In either case, work to clean up or remove debris and burned items cannot begin until the investigation is complete. Only surviving victims of the fire will be evacuated for medical care (Suciu, 1972, p. 322).

Fires can be classified according to several criteria: the nature of the substances or objects being burned, the consequences and the extent of the fire in terms of the damage caused or the causes leading to it. According to this last criterion, fires are divided into natural, accidental and deliberate fires (Ciopraga et. al., 2001, p. 95; Suciu, 1972, p. 322; Mircea, 1999, p. 157; Cîrjan, 2005, p. 325).

Fires caused by natural causes result from discharges of atmospheric electricity (lightning, lightning), solar radiation and self-ignition (Gheorghiță, 2017, p. 224).

Atmospheric electricity is the result of complex electrical phenomena of which forensic science studies mainly lightning, which sometimes causes human casualties and significant material damage. It is often confused with lightning (Stanciu et. al., 2005, p. 12).

Flashing is an atmospheric phenomenon consisting of a luminous electrical discharge occurring between two clouds or within a single cloud (Dictionary, 2007, p. 772).

Lightning, on the other hand, is an electrical discharge in the atmosphere, accompanied by a bright light and a loud noise that occurs between the cloud and the ground (Dictionary, 2007, p. 2050). The propagation speed of lightning is extremely high, ranging from fifty to one thousand kilometres per second. The length of the lightning discharge channel generally ranges from a few hundred metres to 2-3 kilometres, and the temperature in this area reaches extremely high values of up to 10,000 degrees Celsius. It has been found that the voltage generated by lightning can reach impressive levels of up to one billion volts, while the electric current can be between 30,000 and 150,000 amps. Typically, lightning strikes preferentially affect tall buildings, electrical grids, metal structures, and the water of streams and lakes. Tall, isolated trees such as aspens, oaks, willows, pines and resinous trees are also more susceptible to lightning strikes. At a lower frequency, lightning can also affect trees such as linden, apple and walnut. It should be noted that factors such as humidity, height and shape of objects (e.g. flat or round objects) and the presence of movement and crowding of people or animals can influence the likelihood of being struck by lightning (Mircea, 1999, p. 158; Ander, 1966, pp. 49-52).

Lightning strikes are distinct due to the extremely high temperatures and mechanical forces involved. Its effects include magnetisation of iron objects, melting and volatilisation of some metals, deposition of droplets on surrounding objects, ignition of flammable substances, melting of sandy soil, shining and cracking of rocks, fragmentation or burning of trees, cracking and crumbling of building walls, and the formation of a shiny film on bricks and roof tiles. Lightning also leaves distinctive marks on the body and clothing of human victims, which are easily distinguishable from burns produced in other circumstances. On clothing, lightning can cause holes, tears or burns, plastics can melt or magnetise, and gold can be vaporised. Small holes with charred edges or erythema-like lesions form on the skin, often accompanied by excoriations in the form of a fern, also known as a ,,lightning bolt figure” (Scripcaru et. al., 1978, pp. 366-368; Stanciu et. al., 2005, pp. 13-14; Cîrjan, 2005, p. 325).

Of particular relevance is the lightning's ability to start multiple fires simultaneously in different locations, which must be considered when hypothesizing about a person's intent to start arson (Stancu, 2015, p. 251). When a fire is presumed to have started as a result of a discharge of atmospheric electricity, information on the atmospheric conditions at the scene and during the fire should be obtained from eyewitnesses and meteorological institutes at the same time as evidence is collected at the scene (Suciu, 1972, p. 324).

Fires caused by sunlight are less common, being characteristic of forests, meadows, hayfields, etc. (Cîrjan, 2005, p. 325). Objects that show the ability to focus sunlight on a single point can be: a shard of glass with optical properties suitable for focusing sunlight, a spherical and reflective object made of aluminium. In interiors, suitable examples are glass tiles used to facilitate the illumination of attics, glass panes or flawed glass that are swollen and act as lens elements. Under certain favourable conditions, objects such as a pair of glasses, a glass vessel containing water or a shaving mirror can ignite flammable materials in their vicinity. However, solar-induced ignitions are exceptionally rare because when the sun passes through the zenith at a specific point, the sun's rays are only concentrated for an extremely short period of time so that they can trigger an ignition, assuming all other conditions are favourable (Suciu, 1972, p. 324).

The traces resulting from fires caused by the sun's rays are influenced to a large extent by the nature of the substances and objects that have been destroyed by burning, as well as by the circumstances surrounding the location and timing of the burning. Typically, the site of fires of this type may show traces of soot, which is deposited on nearby objects, or ash resulting from the burning, which may be in the form of powder or paste if mixed with liquids. These traces may be found on the ground, on floors or on certain objects in the area affected by the fire. Traces may also take the form of partially burnt, broken objects or fragments from various machines or equipment that were damaged during the fire. By analysing these traces, it is possible to determine the cause of the fire, the nature of the substances and objects destroyed in the burning process, and sometimes even the source of the fire itself. In combination with other relevant information, it can be assessed whether the fire was caused by sunlight or direct human activity (Mircea, 1999, 159).

Self-ignition is a phenomenon based on a chemical, physico-chemical or biological process, which as a result of specific reactions gives rise to manifestations that can produce a fire (Anghelescu et. al., 1976, p. 361). Included in this category of fires are situations where ignition is caused by spontaneously decomposing substances. Due to internal chemical reactions, these substances, when stored in poorly ventilated environments, can cause ignition following an explosion or sudden ignition.

Self-ignition based on chemical processes occurs when certain substances ignite in contact with air. Examples of such substances are white phosphorus, aluminium, magnesium and zinc cements, and unburned lime. White phosphorus ignites in contact with air, whether dry or moist. The above-mentioned metal fillers may ignite under certain atmospheric humidity conditions. Unburned lime may ignite when it comes into contact with water, even in small quantities that would not be sufficient to dilute it. For example, the temperature of unburnt lime can ignite the barrel in which it is stored, and its sparks and burning splinters can ignite flammable objects around it (Suciu, 1972, pp. 324-326).

Physical-chemical processes can be found in coal, cotton soaked in various oils, finely ground rubber waste, varnishes and oil-based paints (Anghelescu et. al., 1976, p. 361).

Biological self-ignition is caused by the fermentation of plant substances by bacteria when they have high humidity and are inadequately ventilated, as in the case of feed or paper deposits (Ciopraga et. al., 2001, p. 97; Crăciun et. al., 1993, p. 114).

Accidental fires are caused by a wide variety of causes. Among the most common in forensic practice are fires caused by: burning cigarette butts or matches lit and carelessly discarded in areas with flammable substances or dry vegetation; faulty or careless handling of electrical installations (lighting, heating, ventilation); operation of defective or overloaded networks, stoves, electrical appliances; keeping easily flammable substances or objects near heat sources, etc. (Gheorghiță, 2017, p. 224).

The traces resulting from fires are soot, ash, partially charred or broken objects, including wood and plastic materials, cracked or even collapsed walls, fragments of broken glass and, in some cases, even melted glass. Soot, in more significant quantities, settles on surfaces such as ceilings, walls and hanging objects. Ashes and partially charred or broken fragments are mainly found on the ground, under the ruins resulting from the fire, mixed with fallen plaster from walls and other traces associated with the phenomenon. As far as the human body is concerned, the traces of the fires manifest themselves in the form of burns of varying degrees, especially on areas not covered by clothing. In severe burn situations, charred segments can be seen on corpses when limbs are contracted in a posture known as the ,,pugilistic position" (Stanciu et. al., 2005, p. 17; Scripcaru et. al., 1979, p. 332; Mircea, 1999, p. 160).

Arson is one of the serious crimes, which can cause great damage to material goods, national or private economy (Suciu, 1972, p. 330). Specialists and experts from the fire brigade are required to take part in the investigation, and if personal injury or loss of life has occurred, the presence of the coroner is essential (Ciopraga et. al., 2001, p. 98).

The motive for such actions may be associated with feelings of revenge, hatred, concealment or aiding and abetting other crimes. It is important to note that fires can also be started by people suffering from mental disorders such as pyromania (Stancu, 2015, p. 252; Gayet, 1973, pp. 185-187; O Hara, 1970, p. 237).

In arson, the offender uses various objects, applies various methods in order to cause the fire so that it is not discovered (Mircea, 1999, p. 161). In terms of technique, these fires fall into two categories: fires with immediate ignition; fires with delayed ignition, which are usually set with special technical means (Suciu, 1972, p. 330).

Because they do not allow too great a distance from the scene to hide, arson fires with immediate effect do not allow the creation of alibis (Mircea, 1999,

p. 161). They are therefore usually carried out in isolated, unguarded places where the fire can ignite without careful preparation, or in places which, by their nature and the substances involved, could give rise to the suspicion that the fire was caused by self-ignition or negligence. In such cases, fewer traces of the crime and the offender remain (Gheorghiță, 2017, p. 225).

In delayed ignition fires, various means are used to increase the time needed for the perpetrator to get away from the scene. These means differ according to the environment in which the suspected arsonists live, their level of professional training, material possibilities and the level of technical development at the time (Ciopraga et. al., 2001, p. 98; Basarab, 1969, p. 150). The manoeuvres and means used by the perpetrator reveal – without difficulty for the specialist – the nature and premeditated nature of the fire, given the increased number of traces in these cases. For example, depending on the method of ignition, traces of petrol, kerosene gas, textile remnants, nickel, calcium phosphide, sodium and potassium metal can be found. Some of the traces may also be found in the form of trails, which are intended to spread the fire to several fires (Stancu, 2015, p. 252).

Delayed ignition means include the following:

- craft: placing a candle on a plank set to float in a vessel of flammable liquid, when the flame reaches the liquid it catches fire, thus causing the fire; incandescent coals wrapped in cloths (Mircea, 1999, p. 161; Basarab, 1969, p. 150); cotton wicks impregnated with lubricants or other substances to maintain and propagate the flame to the main flashpoint within a specific time, giving the arsonist the opportunity to move away from the scene. Another method would be to cover a live light bulb with a cloth and several layers of paper. The bulb, reaching a specific temperature, can explode, dispersing the burning paper around it. In addition, nickel wire can be removed from a reel and stretched under tension between several easily flammable objects. Plastic balloons filled with neofaline, secured by a tensioned nickel wire, can also be used (Suciu, 1972, 330).
- special devices: lens mechanisms, which focus the sun's rays at a specific time on a slightly flammable substance; providing delayed contact between the unburned match and sulphuric acid, usually using a pendulum clock (Mircea, 1999, p. 162; Bădulescu, 1971, pp. 125-127); timed devices used to time an explosion or direct ignition at a specific time, can be achieved by means of electric or mechanical spring clocks.

These devices are designed to trigger an event at a specific predetermined time. There are also timed devices that are designed to strike certain substances, similar to those used in cartridge caps, in order to generate a specific reaction (Suciu, 1972, p. 330); devices for striking mixtures of incendiary substances such as: white phosphorus dissolved in carbon sulphide, sulphuric acid, potassium chlorate and sugar, glycerine and potassium permanganate, calcium phosphide, sodium metal, potassium metal, etc. (Cîrjan, 2005, p. 327).

The traces resulting from these fires are generally similar to those of accidental fires, and are largely influenced by the nature of the substances destroyed in the burning process and the conditions under which the fire occurred. Often, in addition to the traces specific to several categories of fires, delayed effect fires also create traces resulting from the burning or destruction of the material means by which the fire in question was delayed, such as: remains of burnt fuses, destroyed timing devices or their remains, etc. (Mircea, 1999, p. 162). Whatever the timing system used, their traces will be found in the course of the fire, either in the form in which they were deposited or with significant traces of degradation or decomposition. Parts of these will be sufficient to establish how the fires started (Ciopraga et. al., 2001, p. 99). Once the fire has been extinguished, it is important to immediately start investigating the scene of the fire and identifying the outbreak(s), as this will lead to preliminary data on the cause of the fire (Gheorghiță, 2017, p. 225).

Investigating the crime scene in the event of a fire is very difficult, particularly because the traces of the crime are destroyed during the fire (or during the liquidation of its consequences). Serious difficulties arise in establishing the cause of the fire and the circumstances in which it occurred, the mechanism of the fire, without which it is usually not possible to establish the signs of the crime, discover the traces and the persons involved. This circumstance increases the importance of the application of special knowledge in the field of natural and technical sciences, which allows, under complicated conditions, to establish cause-effect relationships between the elements of the mechanism of the criminal event, which includes both human actions and the manifestation of objective laws of nature (Gheorghiță, 2017, pp. 225-226).

In investigating the traces left by the fire, the prosecuting authority must go to the scene of the fire as soon as possible and start the investigation before the fire has been extinguished (Suciu, 1972, p. 331). The presence of technicians and experts in the field, as well as the forensic pathologist, is indispensable in the team that will go to the scene when personal injury or loss of life has resulted (Ciopraga et. al., 2001, p. 100).

On arrival at the scene of the fire, until it is extinguished, it is advisable to carry out photography and/or video-recording of the phenomenon and fire location activity. During the investigation of the scene, the following objects, conditions, etc. may be recorded (photographed, video-recorded):

- the most serious damage caused by the fire;
- the fire source (or several sources);
- matches, easily flammable substances, materials soaked in oil, spatulas, etc. the condition of the floor and walls after the fire;
- signs that a crime was committed before the fire (damaged barriers/gaskets, no trace of stored goods);
- remains of substances which are prohibited from being kept in the same place;
- burnt wooden structures in the immediate vicinity of stoves and flues, cracks and gaps formed;
- signs that the source of lighting could not have caused the fire: the presence of the protective cover; the location of the lamp at a certain distance from the source of the fire; the burning of the lamp during the fire; deformation of electrical heating installations (traces of burning, melting; ignition of cables and sockets, traces of short-circuiting on the cable and fork; melting of the porcelain body of the electric iron; burnt or melted support on which the installation was located); lack of heat-insulating protective devices for industrial installations; installations which catch the sun's rays and flammable materials around them, etc. (Gheorghiță, 2017, p. 226).

The search for traces is carried out taking into account the nature of the burnt object, its location (inside a building, in the open air) and the causes that are presumed to have started the fire (Anghelescu et. al., 1976, p. 363). The place where the fire started and the cause of the fire will be determined by the prosecution authorities in cooperation with the fire brigade. In determining where the fire started, the eyewitness accounts of the fire and the direction of the wind will be taken into account (Suciu, 1972, p. 331).

The trace investigation will cover both the affected site and the surrounding area. Traces shall be sought both inside the premises (such as dwellings, material stores, feed stores, etc.) and outside, in order to identify handprints, footprints, signs of forced entry of doors, windows or locking systems, the presence of greasy substances resulting from the burning of lighting used as a fire source, traces of timer devices or fuses, the condition of electrical installations and electrical conductors, etc. (Ciopraga et. al., 2001, p. 100).

Traces of forced entry are also sought on the various locking systems (doors, desks, boxes, money boxes, etc.) and their condition is checked, as it is known that after the wood has charred, the mechanisms remain in the same position – closed or open – as when the fire started. In some cases, when the fire has been extinguished in its early stages and the victim has been beaten, stabbed or shot, some biological traces are also sought. It is also established whether windows or doors were open or closed before the fire started, and the fire brigade or the persons who first entered the room are consulted (Anghelescu et. al., 1976, p. 364).

When the building in which the fire broke out has collapsed, the ceiling or upper floor falling to the floor below, no measures shall be taken to clear the place until the investigation has been completed. Collapsing the floor or ceiling during the fire has the advantage of keeping the traces intact, protected from further action of the fire as well as from the action of extinguishers or onlookers. The investigation of collapses by the prosecution authorities should be carried out layer by layer until the surface where the collapse occurred is reached, and where the traces of the fire or traces of another crime are well preserved (Suciu, 1972, p. 331).

In such cases, the report of the examination of the fire scene shall be supplemented (illustrated) with graphic material – sketch plans, diagrams, technical drawings indicating the scale at which they were made. It is important that these materials correctly represent the necessary data (dimensions, volume, etc.) and do not allow free interpretation. In cases where the causes of the fire and the spread of the flames were linked to the architectural and construction features of the building, a sketch plan of the building where the fire occurred must be attached to the report of the investigation of the crime scene (Gheorghiță, 2017, pp. 226-227).

During the process of trace taking, it is recommended to involve a forensic expert and a specialist from the fire brigade. Appropriate quantities of charred debris from wood, metal, fabric, electrical conductors and ash samples from the fire area and other relevant areas should be collected. These samples will be packaged separately in airtight glass containers, thus ensuring the prevention of evaporation of flammable substances. By maintaining the integrity of these samples, the possibilities for quality physico-chemical surveys are optimized (Stancu, 2015, p. 253). A technique based on the controlled spraying of a thin layer of polyvinylpyrrolidone is used to remove carbonised paper or textile materials. This polymer is dispersed in a solution and applied to the surface of carbonised materials using a suitable distance to avoid droplets and to obtain a uniform layer. The spraying procedure results in a gentle peeling of the top layer, which exhibits plastic properties during drying. This method is used in the laboratory to separate layers of paper or textile materials from the charred mass, ensuring optimal preservation of the samples and creating the prerequisites for subsequent physico-chemical analyses (Suciu, 1972, pp. 331-333).

The scene of the fire usually provides a multitude of traces that can provide data on the start and development of the fire, namely: the fire, its epicentre, the short-circuiting site, traces of fuels and lubricants, etc., can provide data on how the fire started; traces indicating the movement of the fire from the epicentre of the fire and those marking the consequences of the fire can be instructive as to how the fire evolved until it was contained and extinguished. These data will also provide answers to the question of whether the fire started deliberately, negligently or due to natural causes.

When human traces (fingerprints, footwear, biological traces) are found at the scene, their interpretation can also provide information about the person who set the fire (Anghelescu et. al., 1976, p. 364).

Complex technical and scientific methods and means are used to carry out forensic analysis of fire traces, among which spectral and gas chromatographic analyses play an important role. These methods are particularly useful in identifying the petroleum products involved in the fire (Stancu, 2015, p. 253).

The forensic specialist can provide answers to questions about: the nature and properties of the burnt products; the possibilities of self-ignition; what could be the causes of the fire considered; the alleged perpetrator's knowledge of the crime scene; determination of the combustibility characteristics of the materials and substances destroyed in the fire; determination, by calculation, of the energy balance of the combustible materials and substances; comparison of the duration of the fire and the resulting temperature with the conventional duration and the temperature produced; identifying in ash, slag, melts or sampled materials the presence of substances which could have caused combustion; determining changes in the structure of metals and other materials as a result of thermal stresses and physico-chemical phenomena to which they were subjected during the fire; analysing and comparing the surfaces and contours of objects; determining the chemical composition and specifying some combustible substances; depending on the time which has elapsed since their formation, they may be in the form of a viscous, dense paste or dry crust. In forensic science they have a similar value to traces of dust. The layers under which they are deposited give the expert a picture of the place frequented by the perpetrator (Cîrjan, 2005, p. 328).

If there is a suspicion that the fire was deliberate and set by the use of specially designed devices, the investigation focuses on determining the characteristics of the installation, its mode of operation and other relevant elements that may provide clues as to the profession or special training of the perpetrator. The degree of familiarity of the perpetrator with the location of the incident, the possible involvement of several persons in the act of arson and other relevant aspects are also investigated (Stancu, 2015, p. 254).

7.3 Forensic Investigation of Explosions

Explosive transformation phenomena and the study of explosive substances have always been of interest to scientists. These types of destructive phenomena with possible consequences such as injury or loss of life, damage to property, explosions have led to the development of numerous scientific research studies to support the identification of the probable source and cause of such events in the international literature. An important place in research is also occupied by determining as accurately as possible the effects of the explosion on people, materials and structures (Voin, 2014, p. 10).

The notion of explosion is defined as: ,,A very rapid, violent chemical or physical reaction, accompanied by mechanical, sound, thermal, luminous, etc. effects, caused by the decomposition of explosive substances contained in a destructive device” (Dictionary, 2007, p. 696).

Explosion is a particular case of rapid burning, characterised by the decomposition of explosive substances and their transformation into other (generally gaseous) compounds, in which a great deal of heat development and mechanical work is carried out. The burning velocity in explosions is 10-100 m/s, and in detonations the flame propagation velocity is between 1000 and 4000 m/s, and in some explosive substances it is much higher (Ciopraga et. al., 2001, p. 101; Bădulescu, 1971, pp. 125-127).

For an explosion to occur in a confined space, the explosive mixture must be in a concentration that marks a certain ratio between combustible substances and air. Below a certain concentration limit of combustible gases, vapours or dusts the explosion does not occur because the air in that place is too high. In cases where the concentration of combustible substances is too high, the explosion also does not occur because there is not enough air. The area between the minimum and maximum explosion limit is technically called the explosion range. In this range of the explosive mixture, explosions occur when ignition sources intervene. It should also be borne in mind that environmental factors and the nature of combustible substances also have an influence on these phenomena. For example, coal dust, because of the volatile substances it contains, forms more quickly the ideal combustible mixture for triggering an explosion. Sugar dust, starch dust, textile dust, wood dust, plastic dust and metal dusts also present a high explosion hazard (Mircea, 1999, pp. 162-163).

Explosions can be classified according to several criteria. Two types of explosions are distinguished according to the speed of combustion and decomposition of explosive mixtures: deflagration, which is a chemical reaction of combustion occurring at a flame velocity lower than the speed of sound in a non-arid environment; detonation, which is combustion occurring at a flame velocity higher than the speed of sound in a non-arid environment. Depending on the type of reactions taking place, explosions can be physical or chemical in nature. From a forensic point of view, explosions are classified as accidental and premeditated, and the characteristics of the traces they form differ according to the diffuse or concentrated nature of the explosion (Ciopraga et. al., 2001, p. 101; Stancu, 2015, p. 254; Gheorghiță, 2017, p. 228; Ceccaldi, 1962, pp. 87-91; Gayet, 1973, pp. 217-244; Kirk, 1974, pp. 377-382).

Diffuse explosions are caused by mixtures of gases, vapours or combustible dusts with air and create traces spread uniformly throughout the affected space in the form of dislocations of parts, walls, smoke from walls, doors, ceilings, without forming distinct crater-like outbreaks (Gheorghiță, 2017, p. 228; Stoica, 1994, pp. 22-24). The distinctive feature of the marks resulting from this type of explosion is that they are distributed uniformly, to some extent, over the entire affected area, without forming a crater or a central point of combustion. These marks are manifested by dislocation, destruction and smoking of walls, ceilings, doors and windows. In some situations, secondary explosions may occur in addition to the central explosion, depending on the concentration and extent of the explosive atmosphere. This may result in objects or victims being oriented in different directions, in contrast to a single shock wave. As a result, the whole incident area presents a picture of disorder and disorganization (Stancu, 2015, p. 254).

A somewhat special aspect is the concentrated explosions, specific to those of a physical and chemical nature, produced as a result of contact between two dangerous substances, such as dynamite – which is based on nitroglycerine, gunpowder, especially colloidal powder, which contains an appreciable amount of nitroglycerine, mercury fulminate, plastic explosives (Mircea, 1999, p. 163). Concentrated explosions can be classified into two main categories: deflagration and detonation. Within these categories, there are different types of explosives, including progressive explosives, bursters and priming explosives. In addition to the explosives themselves, there are accessory explosives such as priming devices, also called pyrotechnic or electrical devices (such as Bickford-type detonating wires or fuses, detonators, exploders and contactors) (Stancu, 2015, p. 254). Explosive substances, commonly known as explosives, are substances or mixtures of substances which, under the effect of an initiating impulse, are characterised by a sudden and violent decomposition, with the release of heat, light, noise and gas which produces a pressure development at the place of explosion. The initiation pulse may be mechanical (percussion, friction), electrical (electrical discharge), chemical (exothermic chemical reaction), caloric (flame) or even the explosion of another explosive (explosive substance in the detonating cord) (Voin, 2014, p. 11).

The traces of concentrated explosions are formed in well-defined foci (craters); due to the shock wave, objects and debris are deformed and thrown concentrically or radially from the foci towards the periphery, with the destruction of objects gradually reducing in intensity as they are moved away from the foci. Smoke marks, especially on ceilings, are more intense near the hearth and gradually reduce in intensity (Mircea, 1999, p. 163).

In the literature (Stancu, 2015, p. 254), it is pointed out that concentrated explosions are largely premeditated. However, the hypothesis of accidental occurrence should not be ruled out, especially as these cases represent the majority in our specialist practice. However, when investigating a concentrated explosion, it is important to consider first and foremost the hypothesis of their use for criminal purposes.

The formation and description of the traces is the result of complex processes that take place depending on the type of explosion and the various activities related to the occurrence of the event, such as: moving to the scene of the explosion, handling or touching certain objects, use of various tools, packaging operations, etc. Each explosion – depending on its nature – is characterised by certain specific traces that differ in form and content (Anghelescu et. al., 1976, p. 366).

The traces present, in whole or in part, at the site are:

- in the case of explosive substance explosions: the focus (crater) of the explosion, i.e. the place where the destruction is greatest. The destruction may be greater or lesser depending on the explosive used and the specific method of use (quantity, location, etc.). Objects in the crater area will be shattered more than those at different distances; shrapnel from the warhead in different directions, which is usually spread in a radial plane, which may be circular or ovoid, reproducing the direction of propagation of the shock wave; more pronounced ruptures where there are resistant obstacles near the crater; ruptures and burns due to the effect of pressure in all planes, which becomes less pronounced as the distance from the focus decreases; smoke trails at the explosion site as a product of burning; traces of the destructive effect of the phenomenon of absorption, which in the case of an explosion in a room is characterised by the dislocation of the walls, as a rule inwards; destructive traces of the blast of the explosion, which may be found at varying distances depending on its strength and the obstacles encountered; debris of objects or materials shattered by the blast and found at various distances in the debris, in the rubble, on some fixed landmarks remaining at the scene, or having produced various shaped traces on them; particles of explosive substance in their original form or transformed in the burning process, as well as remains of Bickford wicks; gases produced by the blast which may be captured; specific sound traces created by the blast. During the search, traces not specific to the phenomenon but related to the occurrence of the explosion may also be discovered, such as: footprints, handprints, traces of tools used, shards (debris) of the infernal machine, documents, packaging, etc. (Anghelescu et. al., 1976, pp. 366-367);
- in the case of explosive atmosphere explosions: the initial explosion is usually accompanied by a succession of other explosions as a

consequence of the movement by the shock wave of detonating layers present elsewhere; traces of smoking, scorching of walls or objects in the room where the explosion occurred as a consequence of the appearance and action of the flame; traces of leakage of combustible or flammable liquids from installations; traces of cracks in installations from which such liquids have leaked; destruction and, respectively, dislocation or forcing of windows, walls and ceilings of the room where the explosion occurred. This phenomenon is caused by the pressure being exerted approximately equally on all the walls, since, on the one hand, the explosive mixtures are relatively uniform throughout the room and, on the other hand, the burning occurs entirely and almost simultaneously. It can therefore be seen that in such explosions the focus does not appear to be as well defined and precisely determined as in the case of explosions of explosive substances; the destructive effects are much smaller, and sometimes non-existent, in the various machines and installations, compared with those on the walls, since because of the irregular surfaces of the former, the shock wave front is fragmented, acting with small and uneven pressures on them (Anghelescu et. al., 1976, p. 368);

– in the case of physical explosions: the formation of cracks or tears which appear on the walls of the installation, starting from cracks or other manufacturing defects, and which always have the edges pointing outwards, unlike the explosion produced by the use of an explosive substance, a situation in which the tears appear with the edges pointing inwards; on the walls where the first crack has occurred, traces of intensive corrosion, evolving over time, or sometimes signs of fumigation as a result of dusts resulting from the burns produced in the container, are observed; traces of defects in the processing of the vessel walls, e.g. casting or welding defects; traces of operations and manoeuvres carried out contrary to the instructions and rules of occupational safety engineering; traces of prolonged mechanical stress (knocks, rubbing); various traces of stress caused by overpressure in pressure gauges, safety valves, etc. splinters from the inside to the outside, i.e. from the damaged installation to other obstacles. The shrapnel which forms is usually small and causes only minor damage, except in cases where its impact force causes the rupture of other vessels under pressure; damage to neighbouring installations due to the pressure exerted by the explosion on the line of the incoming shock wave corresponding to the direction of the initial crack; damage to the vessel as a result of its movement in the direction in which it is propelled by the effect of the overpressure (Anghelescu et. al., 1976, pp. 368-369).

Explosions, regardless of the type and the triggering cause, can also leave traces on the human body, with morpho-functional consequences. The number, nature, shape, size, depth and severity of these effects vary from case to case, but in general they are as follows:

- crushing of tissues; burns; penetration of foreign bodies by the kinetic force of the gases;
- rupture of the lungs; penetration of toxic gases, other noxious substances and airborne particles entrained or released by the explosion, etc. The traces of explosions also appear on people's clothing or on the various objects placed on them (Anghelescu et. al., 1976, p. 369).

On-site investigation of the traces of explosions – an essential stage in the process of establishing the cause, nature and, if necessary, the perpetrator – involves searching for and discovering both the actual traces left by the explosion and other traces, primarily human, needed to establish the causal link between the result and the action or presence of the perpetrator at the scene (Stancu, 2015, p. 255; Le Clère, 1974, pp. 157-161; Kirk, 1974, pp. 386-389; Gayet, 1961, pp. 245-252; Wells, 1968, pp. 58-60). At the same time, it is necessary that, in such investigations, the scene of the crime should also include a safety zone, depending on the specific situation, so as to ensure the discovery of all traces and material means of evidence which may have been blown at various distances by the blast (Alecu, 2008, pp. 161-162).

The on-the-spot investigation in cases of explosion is subject to the general rules for carrying out this procedural action, but it also has certain particularities. Special organisational measures must be taken before it can begin. For example, one of these measures consists of a prior check by a weapons specialist (bomb disposal expert) to ensure that there are no unexploded devices left at the scene. In this way, the safety of the work of the participants at the site is ensured. At the same time, the investigating officer, by looking at the crime scene, must clarify whether or not there are any victims of the explosion. If they are, they shall first of all be given the necessary medical help on the spot or transported to hospital (Gheorghiță, 2017, p. 228).

In addition to examining the traces of the explosion, investigations and hearing eyewitnesses are needed to establish who was in the area at the time of the explosion. It is also important to determine whether or not the production process was ongoing, who would have had an interest in causing damage or destruction, and who was responsible for the security of the site and how it was organised. It also seeks to identify the owners of the objects and the traces found at the site, with a view to establishing liability and identifying potential offenders (Ciopraga et. al., 2001, p. 102).

Depending on the nature of the explosion, whether diffuse or concentrated, and the consequences produced, a systematic search for traces is necessary, starting, if possible, from the centre of the explosion. Installations, pipes, tanks, switchboards and electrical circuits are searched. Traces are collected in the form of debris, ashes, soot, shrapnel, etc. Attention is drawn to the importance of looking for possible traces of detonation mechanisms, especially if there are indications that an explosion was caused for criminal purposes (Stancu, 2015, p. 255). Specially trained dogs are used in the search, as they are known to be able to detect explosive charges with plastic casings or walls, which have become increasingly common in recent years. By identifying and analysing these undetonated explosive charges, information can be obtained about the type of explosive used by the persons involved in the intentional act, thus helping to narrow the circle of suspects (Ciopraga et. al., 2001, p. 102).

Examination of the blast site is usually carried out using the eccentric method – from the epicentre (crater or blast focus) to the periphery. Determination of the focus and the nature of the explosion is based on analysis of its traces. For the focus, regardless of the explosive substance used, it is always characteristic of the substantial deterioration of the environment and the formation of the crater (depth) in the ground, massive deformation of material objects, the presence of intensive traces of supply, scorching and melting of objects, etc. (Gheorghiță, 2017, p. 229).

Recording in the minutes requires, in addition to taking sketch photographs, the main objects and details, supplemented, in special cases, with video footage or video tape recordings. The latter procedure has proved to be particularly useful in recording significant aspects of the investigation of damage or serious events in the petrochemical industry (Stancu, 2015, p. 256).

Special care must be taken when packing and transporting explosive materials found on site, as some explosives can self-initiate at temperatures below freezing or with sudden movements. Suspicious objects should not be kept at the prosecution service's premises or in the vicinity of economic and social objectives or populated places (Calotă et. al., 2023, p. 479).

Forensic expertise specific to traces of explosions are:

- technical (to establish the design or construction or in their operation or handling and the causes of the explosion;
- to identify burnt or unburnt substances;
- to verify the resistance of the exploded installation and component equipment);
- forensic;
- chemical (to establish the ignition properties of certain substances) (Anghelescu et. al., 1976, p. 455).

A number of modern methods, procedures and technologies can also be used for the laboratory examination of explosive materials or traces collected during crime scene investigation, including: X-ray and gamma ray emission equipment; technologies based on spectrometry such as: IMS3, PD5, GVD6, Al model 1997 and VIPER; chemiluminescence trace detection using the EGIS system; mass spectrometry coupled with CONDOR; thermal neutron activation (TNA), used mainly in the USA (Calotă et. al., 2023, p. 479).

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