A BANK ROBBERY – A PUZZLE SOLVED BY FORENSIC CHEMISTRY EXAMINATION

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Chimia judiciară efectuează analize calitative şi cantitative cu cea mai mare diversitate dintre toate disciplinele criminalisticii, asupra diverselor substanţe chimice găsite pe persoane, pe diverse obiecte sau în soluţii. Rezultatul final al muncii unui chimist judiciar, raportul de expertiză criminalistică, influenţează întotdeauna în mod direct destinul unor anumite persoane. Aceasta este o responsabilitate foarte importantă, care determină modul de gândire şi de acţiune în chimia judiciară, precum şi în celelalte domenii ale ştiinţelor criminalistice. În această lucrare este prezentat un caz interesant şi dificil - jaful unei bănci, în care nici amprentele papilare, nici analizele profilului genetic nu au putut furniza dovezi ştiinţifice, cea care a contribuit la identificarea autorului fiind chimia judiciară. Atât urmele ridicate de la faţa locului, cât şi sculele ridicate de la locuinţa suspectului au fost trimise spre examinare către laboratoarele de chimie judiciară. Analizele chimice detaliate ale urmelor şi microurmelor şi examinarea tuturor caracteristicilor fizico-chimice, utilizând îndemânarea, abordarea creativă şi perseverenţa chimiştilor criminalişti, pe de o parte, şi noile echipamente şi metode analitice (spectrometria FT-IR, microscopia electronică cu baleiaj) pe de altă parte, au furnizat o "istorie" completă a probelor şi au contribuit semnificativ la rezolvarea acestui caz de jaf al unei bănci.

Forensic chemistry performs qualitative and quantitative analysis of chemicals found on people, various objects, or in solutions. The final result of the forensic scientist's work, the expert report, has a direct influence on the fate of given individuals. This burden implies a high responsibility that determines the way of thinking and acting in forensic chemistry, as well as in other disciplines of forensic sciences. The goal of this presentation is to provide an example of a challenging case, in which neither fingerprint nor DNA analysis could provide scientific proof in a bank robbery, while forensic chemistry examination contributed to the identification of the offender.Both traces from the crime scene and the tools collected from suspect's residence were submitted for examination to forensic chemistry laboratories. Detailed chemical analysis of trace evidences, examination

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of all physical-chemical characteristics using the skills, the creative approach and the perseverance of the forensic chemists, on one hand, and the new equipments and analytical methods (FT-IR spectrometry, Scanning Electron Microscopy), on the other hand, provided a complete „history" of the samples, therefore playing a key role in characterizing samples, and could bring significant contribution to solving this bank robbery case.

Keywords: violent crime, trace evidences, FT-IR spectrometry, Scanning Electron Microscopy, comparison-identification

1. Introduction

Forensic science is a multidisciplinary domain used in the investigation of crime scenes and in the process of gathering evidence for the prosecution of the offenders in court. Forensic chemistry emerges where science and law overlap. Even though we might expect the marriage of science and law to be an easy and natural one, we frequently find out that it is not. The widespread perception is that science and the judicial system both exist to seek the truth, but that is an incomplete description. The term *forensic* refers to law enforcement, the judicial system and the courts, and without forensic, there is no forensic chemistry. Forensic chemistry is applied analytical chemistry, but what makes forensic chemistry unique is the same consideration that defines forensic science as a distinct discipline: *the skill, art and science of comparison*. Analytical chemistry encompasses qualitative and quantitative analysis, but forensic chemistry adds comparative analysis to the task list. When a forensic scientist works with an exhibit of evidence, generally there are three tasks to be accomplished. The first one is *identification*, the next step is *classification* of the evidence (placing the evidence into a class membership) and finally *individualization* or establishing a *common source* (placing the evidence in a class with only one member) [1-3].

Forensic scientists examine objects, substances (including blood or drug samples), chemicals (paints, explosives, toxins), tissue traces (hair, skin), or impressions (fingerprints or tidemarks) left at the crime scene. Most commonly, the evidence collected at the crime scene is subsequently processed in a forensic laboratory by scientists specialized in a particular field. Scientists identify, for example, fingerprints, chemical residues, fibers, hair, or DNA left behind [4-6].

If the bioforensics-DNA examinations, dactiloscopic examinations, handwriting examinations, rely on investigation of intrinsic specific features of person (fingerprints, DNA profile), chemical examinations, in most of the cases, refer to investigations and analysis of certain elements or specific features of objects connected to the circumstances of the offence [5].

Forensic chemistry performs qualitative and quantitative analysis of chemicals found on people, various objects, or in solutions. Chemical analysis are the most varied of all forensic disciplines. Chemists analyse drugs as well as paints, glass, remnants of explosives, fire debris, gun shot residues, fibers, inks, dyes, polymers and soil samples. The samples are obtained from a variety of objects and often contain only minute amounts of chemicals [7].

The final result of the forensic scientist's work, the expert report, has a direct influence on the fate of given individuals. This burden implies a high responsibility that determines the way of thinking and acting in forensic chemistry, as well as in other disciplines of forensic sciences. Consequently, the methods applied in forensic laboratories should assure a very high level of reliability and must be subjected to extensive and accurate quality control programmes [8,9].

There is a core set of skills that the forensic scientist should cultivate as part of a forensic mind-set. The importance of comparison in forensic analysis imposes conditions on the methods selected, on how they are applied, and on the interpretation of the results. Always and especially in those challenging cases which overturn routine, forensic scientists and forensic chemists should assume nothing, should think outside the discipline, should build a big toolbox that never stops growing, should be creative, flexible and persistent. Difficult does not mean impossible; a good forensic scientist recognizes the difference [10].

Because recent years have seen the development of powerful technologies that have provided forensic scientists with new analytical capabilities, which were unimaginable few years ago, there must follow during the crime scene investigations not only all kinds of visible traces, but also of the microtraces that are invisible to the naked eye in natural light, which can bring significant contribution in solving the cases [11-14].

The new analytical methods and equipment used worldwide: Microscope coupled with FT-IR Spectrometry, UV-VIS Microspectrophotometry, X-Ray Fluorescence Spectrometry (XRF), Scanning Electron Microscopy (SEM), Gas Chromatography coupled with Mass Spectrometry (GC-MS), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Pyrolysis Gas Chromatography (PGC) and Liquid Chromatography with Mass Spectrometry (LC-MS) have become invaluable tools to enable analysis of a wide range of samples. The greater sensitivity of these methods enables trace evidences analysis that brings more confidence in forensic expertise results and offers adequate and rapid answers required by criminal investigation process. These new techniques can extend the area of forensic expertises regarding both compound analysis and the level of detection, and have been used, especially in detection and characterization of minute quantities of analytes included very often in very complex matrices, difficult or imposible to solve until now [14-20].

For this reason, the intervention of forensic chemistry to examine both trace evidence from crime scene and tools collected from the residence of the suspect became necessary [21-22].

2. Experimental

The evidences submitted for examination to forensic chemistry laboratory were analyzed with a stereomicroscope Karl Zeiss Jena (25x magnification) in a natural light and were measured with a digital beam compass. The next aspects were discovered by visual and microscopic examinations (Table 1):

- On the front side of the grinder body (*sample 1* – Fig.1.*a*) there were white trace evidences (Fig. 1.*b*); on the interior of the disk's metallic mudguard there was a layer of white substance (Fig.1.*c*). On the abrasive disk of angular grinder (flex) were noticed trace evidences with metallic appearance as well as white trace evidences, with powdery appearance (Fig.1.*d* and Fig.1.*e*). Likewise, it was noticed that the disk matter had o tough structure and was constituted from heterogeneous particles, with different compositions and structures.
- On the unused abrasive disk (*sample 2*) there weren't noticed any trace evidences.
- On the black abrasive disk (*sample 3*) were noticed trace evidences with metallic appearance as well as white and yellow trace evidences (Fig.1.*f*).
- On one part of the cutter's razor blade (*sample 4*) and on its gliding support (Fig.1.*g*), there were noticed white trace evidences, with powdery appearance, and on the cutter's razor blade support were remarked brittle yellowish trace evidences (Fig.1.*h* and Fig.1.*i*).
- On the active part of the screwdriver (*sample 5* - Fig.1.*j*) were noticed: one spherical microparticle with metallic aspect (Fig. 1.*k*), other metallic microfragments, the same as the white trace evidence with powdery appearance (Fig. 1.*l*).
- On the orange glove (*sample 6*) weren't noticed any trace evidences.
- On the active part of the pliers for cutting iron plate (*sample 7* - Fig.1.*m*) were noticed white trace evidences, as well as grey, metallic appearance trace evidences (Fig. 1.*n*).

On the iron plate fragment (*sample 8*), which had one of its surfaces covered in white dye (Fig.1.*o*), were noticed parallel traces where the dye was removed from the support (green arrows in Fig.1.*p*), probably as a result of trepidations and imprecise manipulation of the cutting tool. Very close to the cutting area, the dye had a burning specific aspect (red arrows in Fig.1.*p* and detail in Fig.1.*s*).

All the extremities of the iron plate fragment were irregular (Fig.1.*r*) and in cutting areas were noticed cutting burrs, groups of traces with parallel striations shape, trended to different directions, as well as bleedings of colour, due to the warming-up of the iron plate during the cutting process (Fig.1.*s* and Fig.1.*t*). On one of the extremities of the iron plate fragment were also noticed traces and specific tracks which could result from usage of a pair of pliers for cutting iron plate (Fig. 1.*t*).

- Rectangular iron plate shelf (*sample 9*), with both surfaces covered in white dye, in one of the long sides, at 162 mm from one of the extremity, the iron plate shelf had one cut (black arrow in Fig.1.*u*) 1.9 mm deep and 2 mm broad (Fig.1.*v*, Fig.1.*x* and Fig.1.*y*).

On one side of the cut, there was a beige microfragment with cardboard appearance (orange arrow in Fig. 1.*x*), on which there were noticed white trace evidences.

Very close by the cut extant in one of its long sides, it was noticed that the dye had a specific burning aspect. In continuation of the section line, the dye was covered with black microparticles (Fig.1.*y*), and in the section areas, the metal had traces of parallel striations shape and cutting burrs (Fig.1.*x* and Fig.1.*y*). All these aspects are specific for a section with disk bearer instrument (type flex).

- *Sample 10*, both per se (Fig.1.*z1*) and thrown down on the adhesive extremities of the yellowish paper "post it" (Fig.1.*z2* and detail in Fig.1.*z3*) were constituted from a mixture of dye microparticles, grey metallic microfragments with various dimensions and shapes (spherical, irregular etc.), same as traces of grey dark fine-grained soil.

- The piece of ghips cardboard (*sample 11*) had one yellow surface with washable dye appearance and one beige surface with cardboard appearance (Fig.1.*z4*). On the beige surface there were some irregular orifices (red and black arrow), with variable depths, without correspondent on the yellow surface (the creator object didn't perforate the ghips cardboard).

Due to the necessity of an accurate and quick identification and analysis of the submitted samples with *high-resolution* detail, trace evidences and portions of the traces noticed on all the samples were undertaken with double adhesive tape carbon on the special buttons, in order to perform X-Ray Spectrometry analysis, with a Scanning Electron Microscope (SEM) JEOL JSM 6480LV at 20 kV fit with Energy Dispersive Spectrometer (EDS) INCA x-Sight type 7574, at accelerating tension, with 100-1300 X magnification and 18 Pa pressure (low vacuum). The analysis was performed in various points on the surface of each sample.

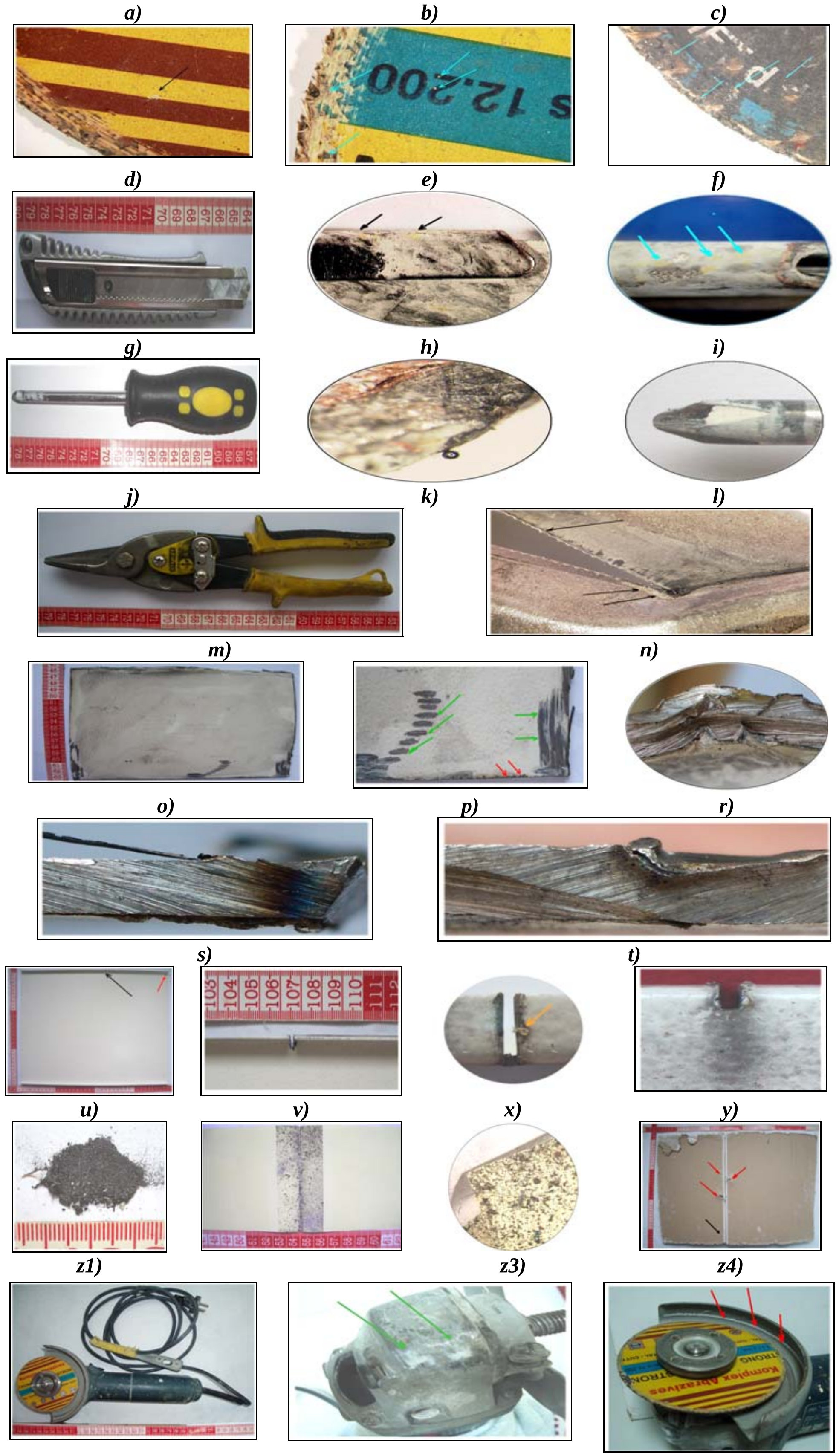


Fig. 1. Examined samples in this work

Also, for the analysis performed in this case, had been used a FTIR spectrometer, in the wave range: 4000-400 cm^{-1} with 4 cm^{-1} resolution, for identification of white and yellow trace evidences noticed in and on samples 1, 4, 5 and 11.

In order to establish the composition of the fibrous material ingredient of the cardboards existent in samples 1, 2, 3, 9 and 11, portions from them were prepared as fibrous suspensions and treated with specific colour reagents (Graff C reagent, green malachite acid solution). After that, there were analyzed with a stereomicroscope Carl Zeiss Jena with oc.10x, ob.2.5x, in both natural and artificial light (Nikon 80i with oc.10x, ob.10x, 20x, using the software Lucia Forensic).

3. Results and discussions

Forensic science and forensic chemistry are young proffessions distinguished from other branches of science by their relationship to the legal system and by the importance of comparison in laboratory analysis. Forensic chemists need an understanding of the legal foundation of their chosen field, as well as a forensic mind-set, which relies on the fundamental precept of always being open to learning more and always adding tools to the toolbox.

Legal systems are based on the belief that the legal process results in justice, a belief questioned in the last years. The forensic chemist cannot change the skepticism and the mistrust alone, but he can contribute to restoring faith in the judicial process by using science and technology in the search for facts in civil, criminal and regulatory matters.

Trace evidences abounds at most crime scenes and can be used as chemical trace evidence in a wide range of crimes with or without personal contact: in cases of homicide, assault, sexual offenses, and rape, in hit-and-run car accidents (crashes), in burglaries, robberies, fraud, counterfeiting, and so on. The forensic chemistry examination of these traces can be an important source of information, can build a path to finding the truth and, in many cases, can bring conclusive proof to the documentation of penal cases.

The importance of the transfer of material trace evidences is that it links a subject to an object, or a location to another being. Such tiny pieces of evidence can be extremely important in an investigation, because the small size of the microtraces makes the author unaware of leaving them at the crime scene and, as a result, cannot alter them on purpose. The goal of this presentation is to provide an example of a challenging case, in which neither fingerprint nor DNA analysis could provide scientific proof in a bank robbery, while forensic chemistry examination contributed to the identification of the offender.

In a case of bank robbery, in which about 236.000 RON (in lei and foreign currency) were stolen, the crime scene investigation team established that the bank was broken into by dislocating a wall it shared with a restaurant and cutting off the bank safe with a sharp tool (flex).

The wall had multiple layers: ghips cardboard, iron plate (tin) of 2 mm binded with iron screws in „U" profile to the wall skeleton, mineral wool and again ghips cardboard. Even though on the interior wall of the bank there were vibration sensors controled by a video and antiburglary watching station, they were not adjusted to great sensitivity because of the presence of vibrations owing to big tonnage vehicles which passed on the road in front of the bank.

The offenders cut with a sharp devices and separated the layer of ghips cardboard. After that, they detached the 2 mm layer of iron plate at one extremity and bent it towards the interior. They removed the mineral wool, completely cut the last layer of ghips cardboard and the first iron plate of the safe wall (17 cm x 18 cm) and partially cut into the second safe wall (9 cm x 10 cm).

Table 1

The results of X-Ray Spectrometry analyses, in fact the elemental compositions of the samples drew comparison between different anlysed evidences

Sample	Trace evidences	Composition
1	white trace evidences noticed on the frontal side of the grinder body	oxygen, Ca, Si, Fe, Al, traces of Mg, S
	microparticles from the structure of the grinder's abrasive disk	Fe, S
		oxygen, Al, traces of Si, Ti
		Fe, traces of Oxygen, Al
		oxygen, Ba, Al, Si, S, Fe
	white trace evidences noticed on the interior side of the disk metallic mudguard of the grinder	oxygen, Ca, Si, Fe, Al, traces of Mg, S
	white trace evidences noticed on the grinder's abrasive disk	oxygen, Ca, Si, Fe, Al, traces of Mg, S
2	microparticles from the structure of the unused abrasive disk	oxygen, Al, traces of Si, Ti
		oxygen, Ba, Al, Si, S, Fe
		Fe, S
3	microparticles from the structure of the black abrasive disk	oxygen, Al, traces of Ti
		Ba, Ca, Al, S, Si, Fe
	metallic trace evidences noticed on the abrasive disk	Fe, traces of Al, Si, S, Ca, Mn
	white and yellow trace evidences noticed on the abrasive disk	Ca, Al, Si, traces of Mg, K, Ti, Fe
4	white trace evidences noticed on cutter's razor blade and on it's gliding support	oxygen Ca, S, traces of Si, Al
	brittle yellowish trace evidences noticed on the cutter's razor blade support	oxygen, Ca, Ti, S, traces of Si, Al

Sample	**Trace evidences**	**Composition**
5	spherical microparticle with metallic aspect noticed on the active part of the screwdriver	Fe, Oxygen, traces of Al
	metallic microfragments noticed on the active part of the screwdriver	Fe, traces of Al, Si, S, Ca, oxygen
	white trace evidences noticed on the active part of the screwdriver	oxygen, Ca, S, traces of Mg, Al, Si
7	white trace evidences noticed on active part of pliers for cutting iron plate	oxygen, Ca, traces of Mg, Al, Si, S, Fe
	microparticles noticed on active part of pliers for cutting iron plate	oxygen, Si, Ca, Fe, traces of Al, S, Ba
	grey metallic microtraces evidence noticed on active part of pliers for cutting iron plate	Fe, Zn, traces of Oxygen, Al, S, Ca
8	dye pellicle which cover the iron plate fragment from the safe	oxygen, Ba, Ti, traces of S, Al, Ca, Fe
	iron plate fragment from the safe	Fe, traces of Oxygen, Al, Mn
	microparticles undertook from the iron plate fragment from the safe	oxygen, Ba, S, Ti, traces of Al, Ca, Fe
	metallic microtraces undertook from the irregular edges of iron plate fragment from the safe	Fe, traces of Mn, Oxygen
	metallic trace evidences undertook from the surfaces of iron plate fragment from the safe	oxygen, Al, Fe, traces of Si, S, Ca, Ti
9	microfragment with cardboard aspect undertook from the cut existent in the iron plate shelf	oxygen, Ca, traces of Mn, Al, Si, S, Ti, Fe
	white trace evidences noticed on the microfragment with cardboard aspect undertook from the cut existent in the iron plate shelf	Ca, Oxygen, traces of Al, Si, S, Fe
	metallic fragment undertook from the cut existent in the iron plate shelf	Fe, Oxygen, traces of Al, Si, Ti, Ba
	metallic fragment undertook from the cut existent in the iron plate shelf	oxygen, Ti, S, traces of Fe, Al, Si, Ca
	metallic fragment undertook from the cut existent in the iron plate shelf	oxygen, Ti, Fe, traces of S, Al, Si, Ca
	dye pellicle removed and undertook from the iron plate shelf	oxygen, Ba, Ti, traces of S, Al, Ca, Fe
	microparticles from the cut existent in the iron plate shelf	Ba, Fe, Ti, Ca, S, Oxygen
10	microparticle	oxygen, Ba, Ti, traces of Al, S, Si, Ca
	dye micropelicle	oxygen Ba, Ti, traces of Al, S, Si, Ca
	spherical microparticle	Fe, traces of Oxygen, Al
	grey microparticle	oxygen, Ca, Fe, traces of Al, S, Si, K, Ti
	white microparticles	oxygen, Ca, S, traces of Si, Al, Fe

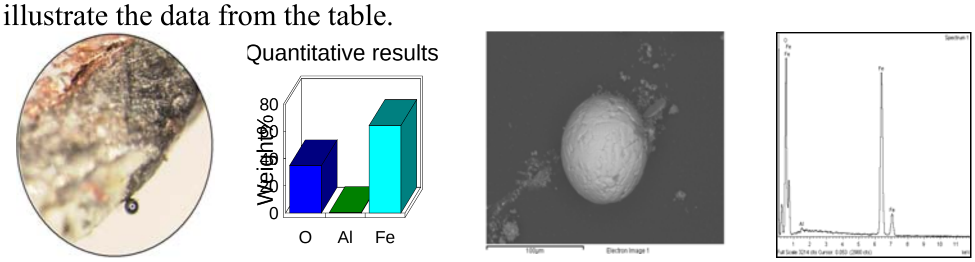
Sample	Trace evidences	Composition
	metallic trace evidences	Fe
	metallic trace evidences	oxygen, Al, traces of Fe, Ca, S, Ti, Si
11	grey-silvery metallic microfragments undertook from the area of one of the orifices existent in the piece of ghips cardboard	Fe, Zn, Oxygen, traces of Al, S, K, Ca
	grey powdery substance from the composition of ghips cardboard	oxygen, Ca, traces of Ti, Mg, Si
	yellow washable dye aspect substance undertook from one of surfaces of ghips cardboard	oxygen, Ca, Ti, traces of Mg, Si, Fe
	white powdery substance from the composition of ghips cardboard	oxygen, Ca, S, traces of Mg, Al, Si

The inner iron plate of the safe wall was found bent towards the external, separated on the upper side and uncut on the inferior side. Through this orifice the offenders embezzled the money. There were collected from the crime scene both the completely cut iron plate fragment (sample 8) and the cuted fragment of ghips cardboard (sample 11), one rectangular iron plate shelf (sample 9), as well as white and grey trace evidences per se, same as thrown down on the adhesive extremities of two yellowish paper “post it”, collected from interior of the safe (sample 10).

During the crime scene investigation, there were discovered and collected 16 fingerprints, 4 biologic traces, 15 material traces and 4 shoes traces. After the investigations and dactyloscopic comparisons of the fingerprints from crime scene in Printrak Bis System, the person which created them was identified. But this main suspect disappeared from his residence and, after the checkings, it was established that he was planning to leave Romania. In the mean time, a search was performed at his residence, during which there were not found any suspicious clothes and footwear. However, there were collected some tools used in constructions: an angular grinder (flex), mark Bosch (sample 1) equipped with an abrasive disk ingrained "COMPLEX ABRAZIVES STRONG", an unused abrasive disk (sample2), an used black abrasive disk, having undecipherable inscriptions (sample 3), a cutter with a silvery metallic handle (sample 4), a screwdriver with a star-shaped active part (sample 5), one orange glove (sample 6) and a pair of pliers for cutting tin (sample 7).

After a couple of days, the suspect surrendered, claiming his innocence and justifying the presence of his fingerprints by the fact that he had taken part, nine months before, to the construction of the wall between the bank and the next-door restaurant. In order to verify this statement, a judicial expertise was performed. It proved that the fingerprints from the crime scene were created during a dismantling process, not an assembling one. Pleading that the suspect had worked in the construction of the wall, the evidence value of the fingerprints from the crime scene was minimized and became questionable.

In Figs. 2-8 there are presented some images and X-Ray spectra in order to illustrate the data from the table.



a) ***b)*** ***c)*** ***d)***

Fig. 2 One spherical (pearl) metallic microparticle (Fe) noticed on the active part of thescrewdriver (*sample 5*)

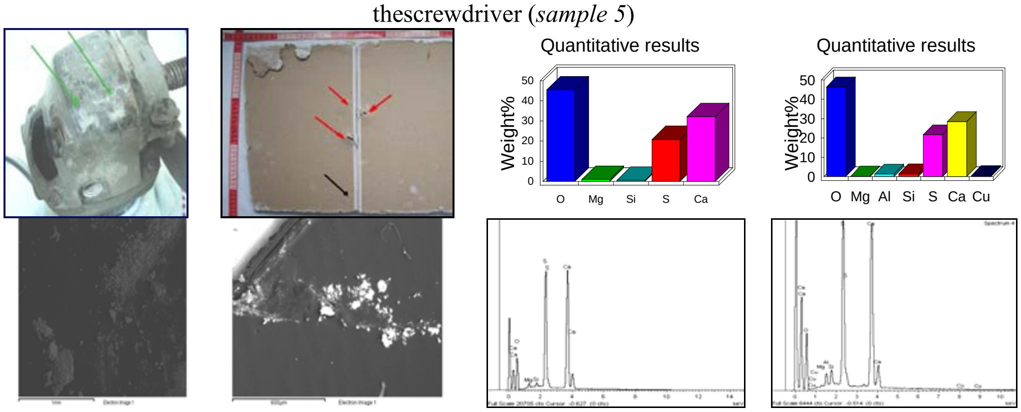


Fig. 3. *Up* - white trace evidences noticed on the frontal side of the grinder body, on the interior side of the disk metallic mudguard and on the grinder's abrazive disk (sample 1)

Down - white powdery substance (ghips) from the composition of ghips cardboard (sample 11)

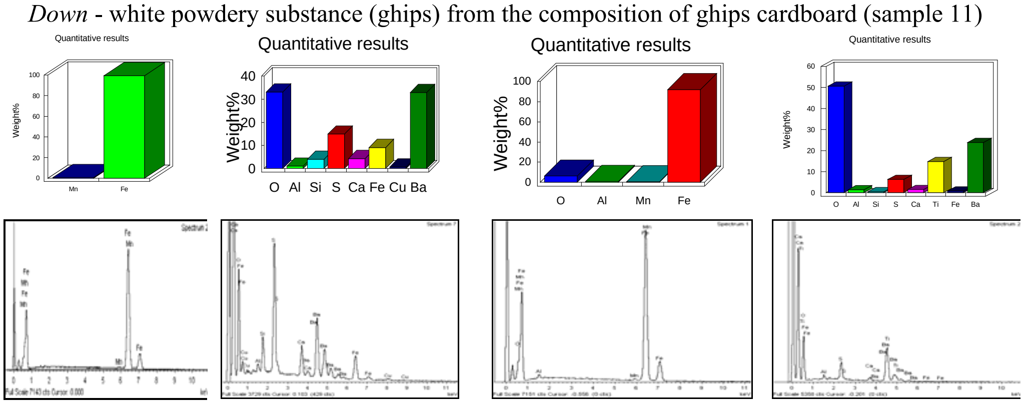


Fig. 4. *Left* - iron (Fe) microparticles - spectrum 1 and dye micropellicle - spectrum 2, noticed on the abrazive disk (*sample 1*);

Right - iron plate fragment (*sample 8*) detached from the safe - spectrum 3 and dye pellicle - spectrum 4, which cover it

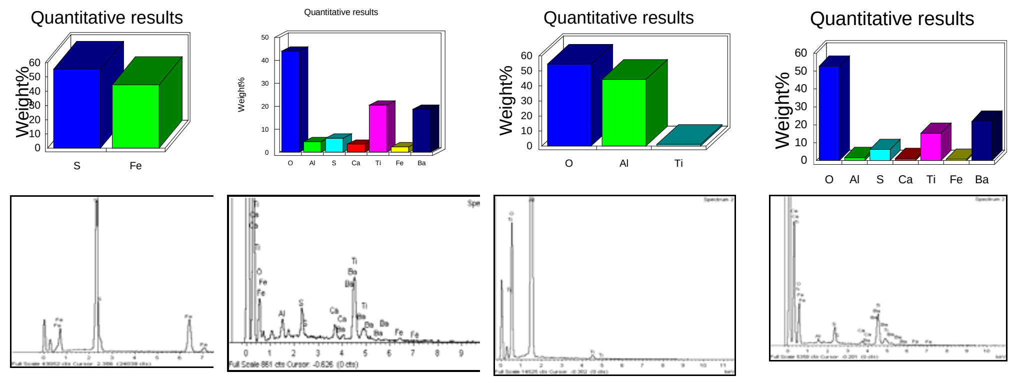


Fig. 5. *Left* - metallic trace evidences (Fe-S, Ba, Al) noticed on the surface of the iron plate fragment detached from the safe (*sample 8*)
Right - particles from the structure of the three abrazive disks (*samples 1, 2 and 3*)

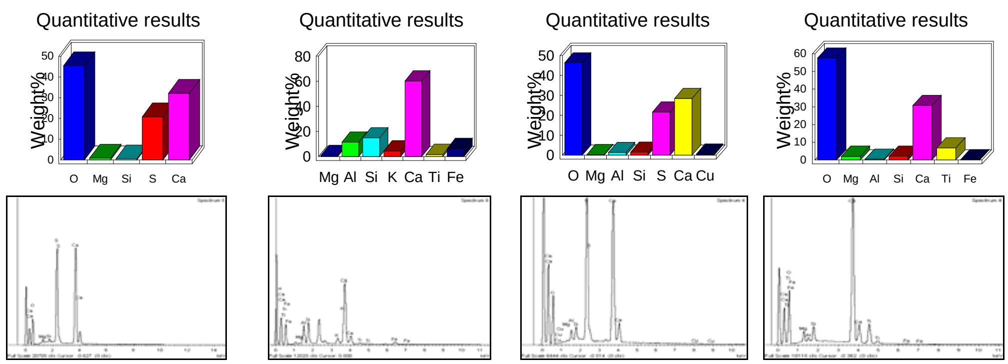


Fig. 6. *Left* - white microparticles (ghips - spectrum 1) and yellow ones (calciumcarbonate in a mixture with an organic pigment - spectrum 2) noticed on the used black abrazive disk (*sample 3*); *Right* - white - spectrum 3 and yellow - spectrum 4 powdery substances from the composition of ghips cardboard (*sample 11*)

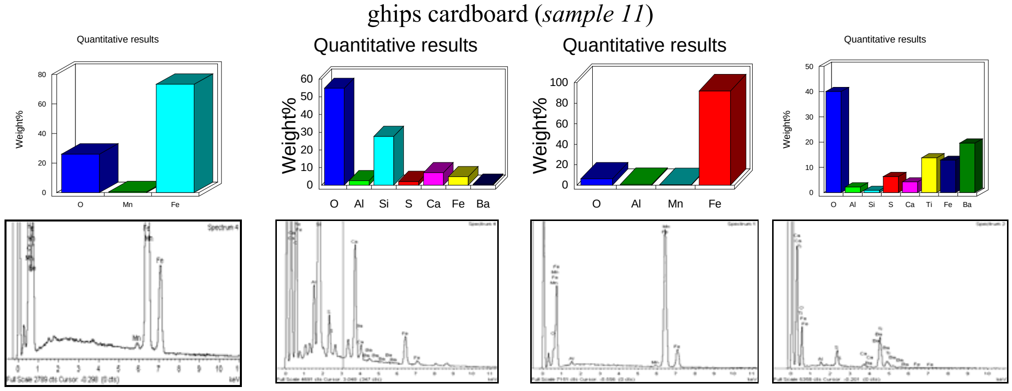


Fig. 7. *Left* - metallic trace evidences (Fe, traces of Al - spectrum 1) and white trace evidences - spectrum 2, noticed on the active part of the pliers for cutting iron plate (*sample 7*);
Right - iron plate fragment (*sample 8*) detached from the safe - spectrum 3 and with dye pellicle - spectrum 4 which cover it

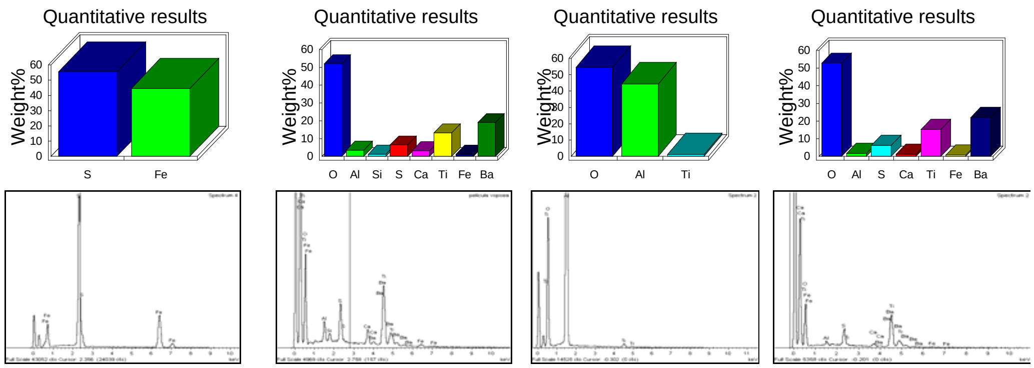
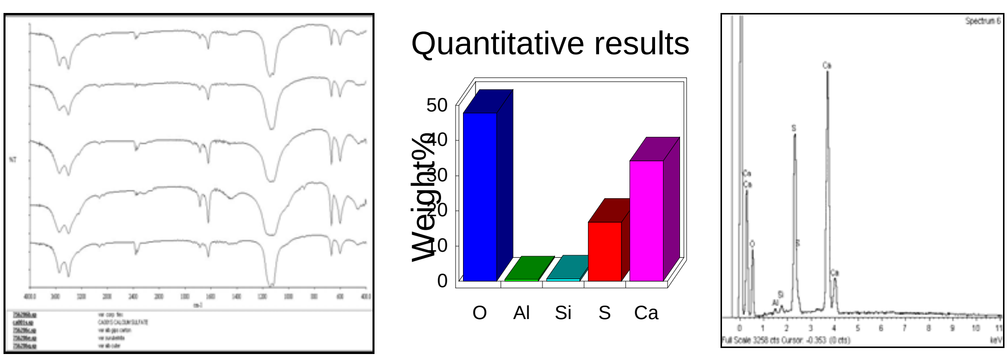


Fig. 8. *Left* - metallic microparticles (Fe, Fe-S, Al, Ba, traces of Ti) collected from the interior of safe (*sample 10*);
Right - particles from the structure of the three abrazive disks (*samples 1,2 and 3*)

The infrared spectrometry analysis of the samples showed that:

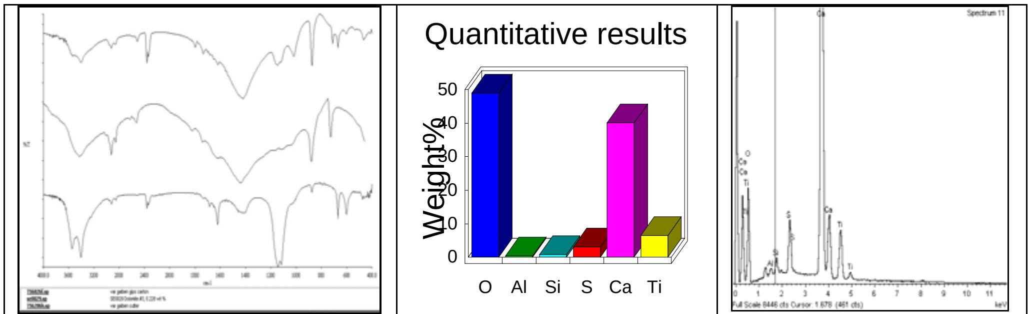
- White trace evidences noticed on the interior of the disk metallic mudguard and on the front side of the grinder body (*sample 1*), on the cutter's razor blade (*sample 4*) and on it's gliding support, on the active part of the screwdriver (*sample 5*), as well as white and grey substances from the composition of ghips cardboard (*sample 11*) represent similar shapes and absorbtion band's maximum sited on the same wavelenght with those from the ghips infrared spectrum (calcium sulphates, magnesium sulphates) (Fig. 9.*a*).



a) ***b)*** ***c)***

Fig. 9. Comparative spectrum : FTIR (*a*) and X-ray (*b* and *c*)

- Yellow substance from the one of the surfaces of ghips cardboard (*sample 11*) as well as brittle yellowish trace evidences noticed on the cutter's razor blade support (*sample 4*) represent similar shapes and absorption band's maximum sited on the same wavelenghts with those from the calcium carbonate (dolomite) infrared spectrum – (Fig. 10).



a) *b)* *c)*

Fig. 10. Comparative spectrum : FTIR (*a*) and X-ray (*b* and *c*)

The type of fibres ingredient of the carboards existent in samples 1, 2, 3, 9 and 11, determinated through colour reactions and their morphologic aspects (fig.11.*a-e*) correspond with fibrous compositions presented in the table 2.

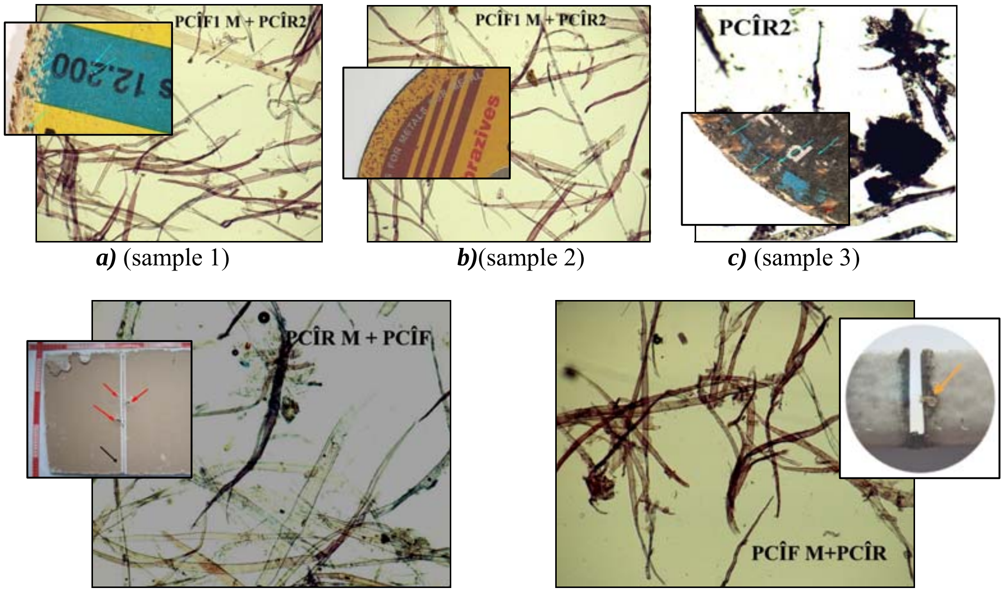
Table 2

The type of fibres ingredient of the carboards existent in samples 1, 2, 3, 9 and 11

Sample	Trace evidence	Fibrous composition
1	Cardboard fragment undertook from the grinder's abrasive disk (fig.11.*a*)	PCÎF$^{1}_{M}$+ PCÎR$^{2}_{m}$
2	Cardboard fragment undertook from the unused abrasive disk (fig.11.*b*)	PCÎF$^{1}_{M}$ + PCÎR$^{2}_{m}$
3	Cardboard fragment undertook from the black abrasive disk (fig.11.*c*)	PCÎR^{2}
11	Cardboard fragment undertook from one of the faces of the piece of ghips cardboard (fig.11.*d*)	PCÎF$^{1}_{m}$ + PCÎR$^{2}_{M}$
9	Microfragment with cardboard aspect noticed on the cut existent in the iron plate shelf (fig.11.*e*)	PCÎF$^{1}_{M}$ + PCÎR$^{2}_{m}$

where: PCÎF^{1} - bleached chemical pulp from broad-leaved trees wood;
PCÎR^{2} - bleached chemical pulp from coniferous wood; $_{M}$ - majority, $_{m}$ – minority

Even at the beginning we thought that the microfragment with cardboard aspect noticed on the cut existent in the iron plate shelf (*sample 9*) could rise from the ghips cardboard (*sample 11*), through performed analyse we demonstrated that this fragment had the same fibrous composition with the cardboard undertook from the grinder's abrazive disk (*sample 1*) as well as the cardboard undertook from the unused abrazive disk (*sample 2*).



a) (sample 1) ***b)***(sample 2) ***c)*** (sample 3)

d) (sample 11) **e)** (sample 9)

Fig.11. Morphologic aspects (*a-e*) of samples 1, 2, 3, 9 and 11

Gathering all the results of the accomplished analysis, the conclusions that we could drawn was that the tools examinated were used in the bank robbery, because:

1. On the interior side of the disk metallic mudguard and on the frontal side of the Bosch angular grinder (flex) body, same as on the grinder's abrazive disk (*sample* 1), on the used black abrazive disk (*sample 3*), on the active part of the cutter, of the screwdriver and of the pliers for cuting iron plate (*samples 4, 5 and 7*) were noticed white trace evidences (ghips) which represent similar physical-chemical characteristics with white powdery substance (ghips) from the composition of ghips cardboard (*sample 11*).

On the used black abrazive disk (*sample 3*), on the active part of the cutter and of the screwdriver (*samples 4 and 5*) were also noticed yellow trace evidences (calcium carbonate in a mixture with an organic pigment) which represent similar physical-chemical characteristics with yellow powdery substances from the composition of ghips cardboard (*sample 11*).

Because the majority of construction materials contain calcium, magnesium, aluminium etc. carbonates, sulphates, silicates, coudn't perform supplementary determination in order to establish resemblance or differentiation characteristics between compared microtraces and coudn't set out if this kind of microtraces rised precisely from the ghips cardboard.

2. On the grinder's abrazive disk (sample 1), on the used black abrazive disk (*sample 3*), on the active part of the pliers for cuting iron plate (*sample 7*) and

into interior of the safe (*sample 10*) were noticed metallic trace evidences (Fe Ba, Mn, traces of Al), as well as dye micropellicle which had the same chemical compositions with the iron plate fragment detached from the safe (sample 8) and with dye pellicle which cover it.

3. On the surface of the iron plate fragment detached from the safe (*sample 8*) and into interior of the safe (*sample 10*) were noticed metallic trace evidences (Fe, Fe-S, Ba, Al, traces of Ti) with the same compositions with the particles from the structure of the abrazive disks (samples 1, 2 and 3); because sample 2 was unused, those particles could rise from abrazive disks - *sample 1 and/or sample 3*.

4. On the active part of the screwdriver (sample 5) was noticed one spheric (pearl) metallic microparticle (Fe), which is usually shaped owing to warming-up of metals transected with cuting instruments type grinder (flex). The presence of this pearl metallic microparticle on the active part of the screwdriver could be due to its contact with such kind of the section.

The traces and specific tracks noticed on one of the extremities of the iron plate fragment detached from the safe (sample 8) could result from usage of a pair of pliers for cutting iron plate (possibly one of the submitted type – sample 7).

The cut existing in one of the long sides of the iron plate shelf from the safe (sample 9), presents characteristics specific to a section, made with an abrasive disk belonging to an instrument the type of a flex.

The cut could be made with the abrasive disk belonging to the Bosch angular grinder (flex) analyzed (sample 1) because on the one hand the microfragment undertook from the cut existent in the iron plate shelf from the safe (sample 8) had the same fibrous composition with the cardboard undertook from the grinder's abrasive disk (sample 1), and on the other hand metallic microparticles (Fe, Fe-S, Al, Ba traces of Ti) undertook from the cutting area had the same chemical composition with particles from the structure of the grinder's abrasive disks (samples 1).

4. Conclusions

Detailed chemical analysis of microtrace evidence, examination of all physical-chemical characteristics using the skills, the creative approach and the perseverence of the forensic chemists, on one hand, and the new equipments and analytical methods, provided a complete „history" of the samples, and therefore played a key role in characterizing samples and could bring significant contribution to solving this bank robbery case. The very significant contribution brought by these forensic chemistry examinations delineate the idea that truth comes from the depth and accuracy of evidence examination in these areas of forensic investigation.

The continuous improvement of equipments and analytical methods in the chemistry field have positive influence on specific forensic activities, and allow experts and specialists to overstep classical areas, permanently analyzing recent discoveries and adapting them to the forensic chemistry domain.

Our forensic science experts' pride is entitled, because the tackling of the microtraces has become a reality without which it is very difficult to conceive that the truth can be achieved in the judicial investigation and prosecution. It became part of our daily activity, which we have developed with the confidence that, whether inspected through microscope or not, in natural or artificial light, Forensic Science, assembling microfragments of truth so that they become powerful and conclusive evidence, is not only Science, but, above all, it is Art and deserves to be appreciated and loved accordingly.

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