Università degli Studi di Torino
Dipartimento di Scienze della Sanità Pubblica e Pediatriche
Laboratorio di Scienze Criminalistiche "Carlo Torre" – Sezione di Microscopia Elettronica

Microtracce

il "megaminimondo" della criminalistica ovvero note dall'infinitamente piccolo

Grazia Mattutino

Carlo Torre

(Torino 13 settembre 1946 – Lanzo Torinese 13 dicembre 2015)

La *criminalistica* attiene lo studio in laboratorio di tracce (visibili o latenti o microscopiche) rilevate sul luogo di un reato ai fini dell'identificazione dell'autore e/o della ricostruzione del fatto. Essa fa parte delle cosiddette *scienze forensi*, vale a dire delle scienze (ad es. medicina, biologia, chimica, fisica, geologia…) applicate a casi giudiziari.

In italiano **traccia** è

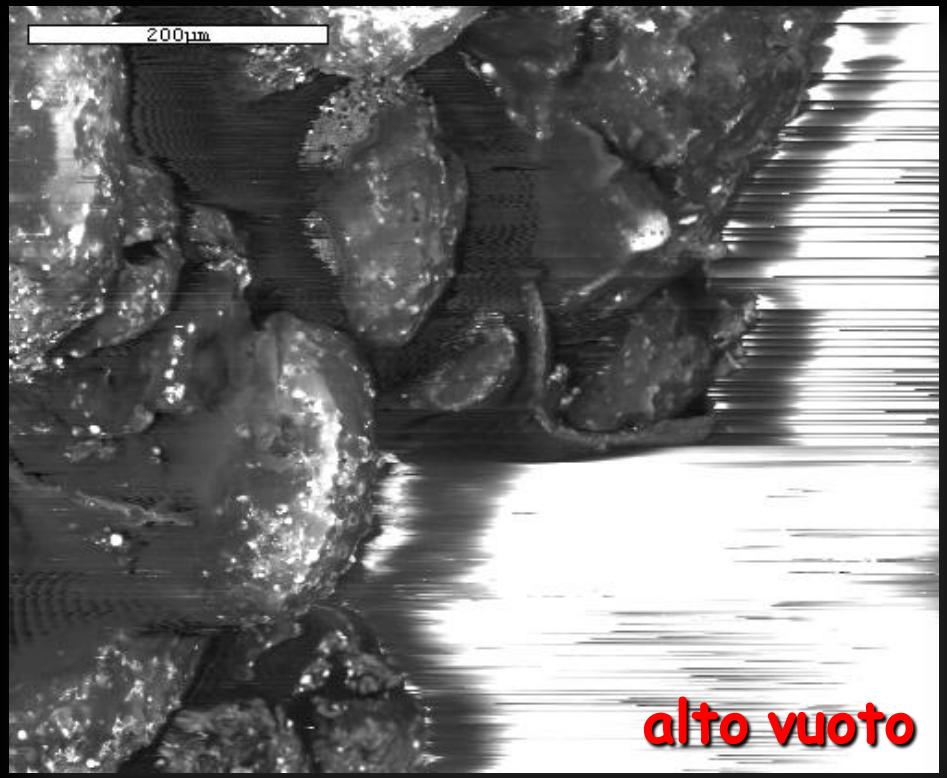
qualsiasi segno lasciato da un corpo e che costituisca indizio manifesto del suo passaggio

ogni vestigio o segno che testimoni un fatto accaduto o una condizione preesistente

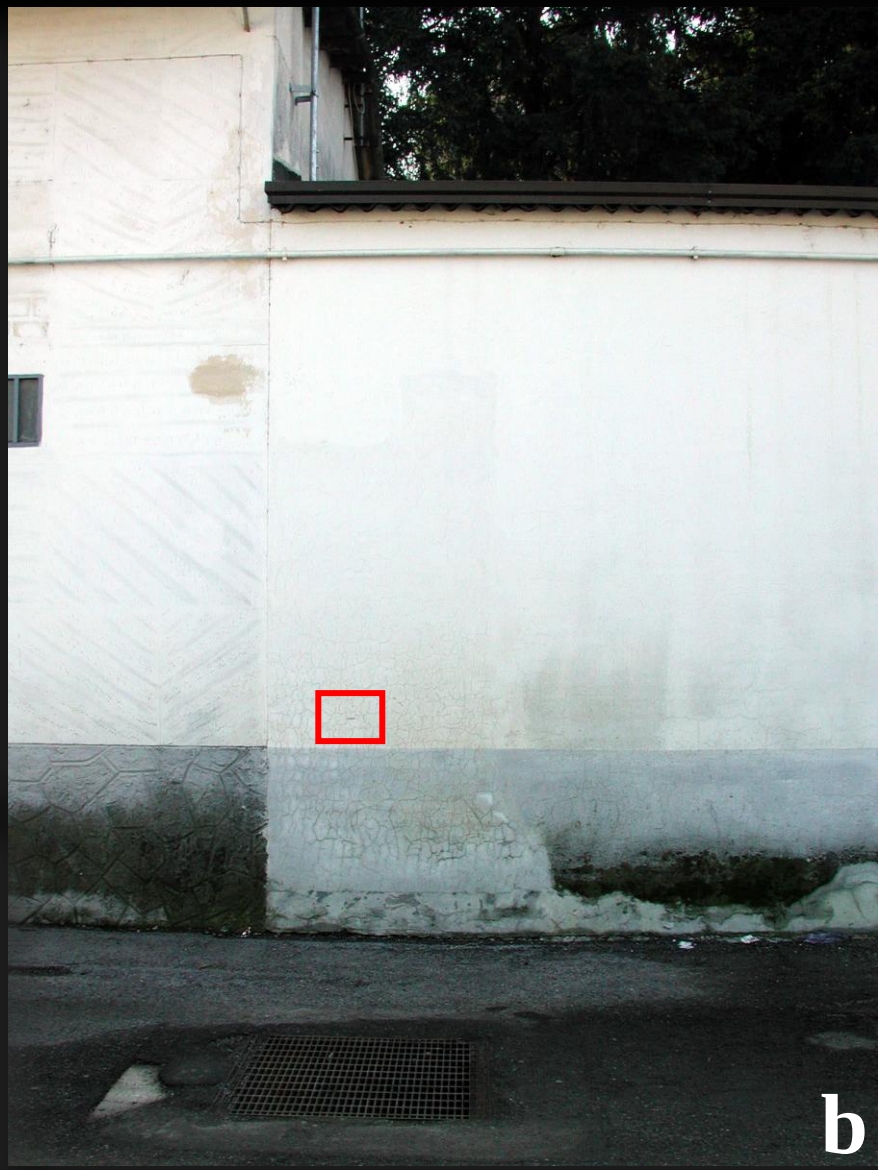

WILD
HEERBRUGG
6
12

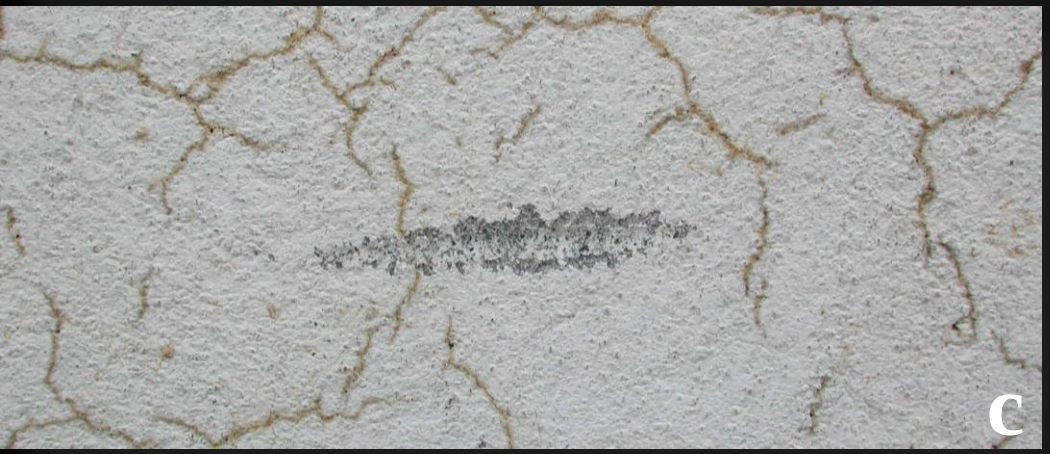

OXFORD
LEO
LEO 1430VP

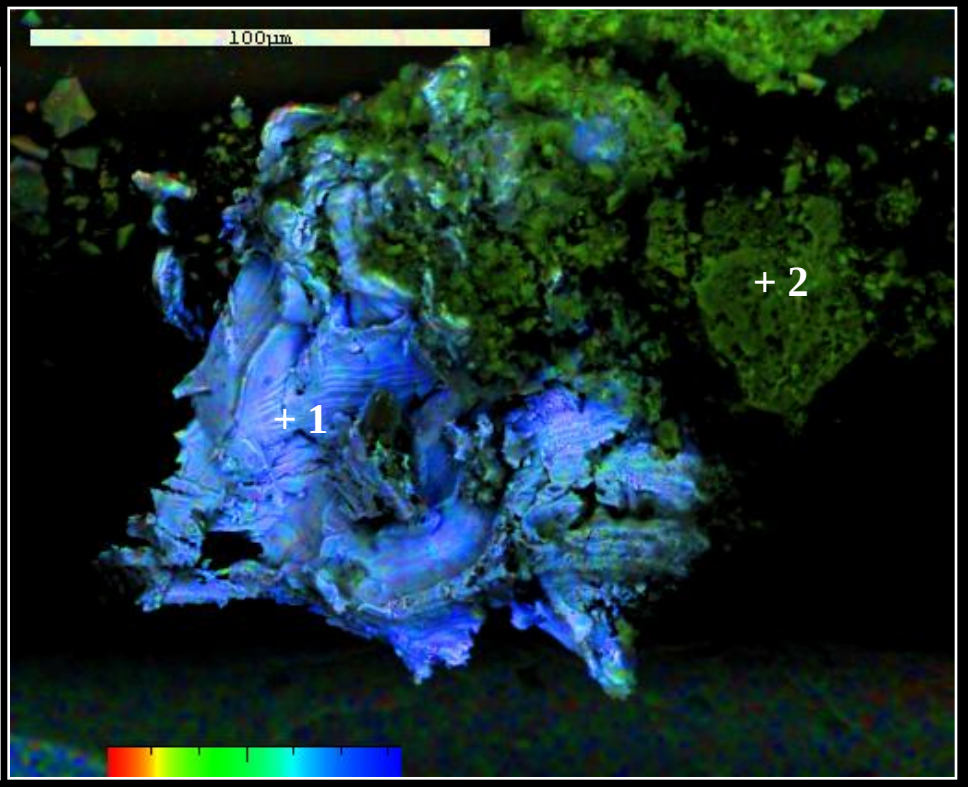
Cute non metallizzata

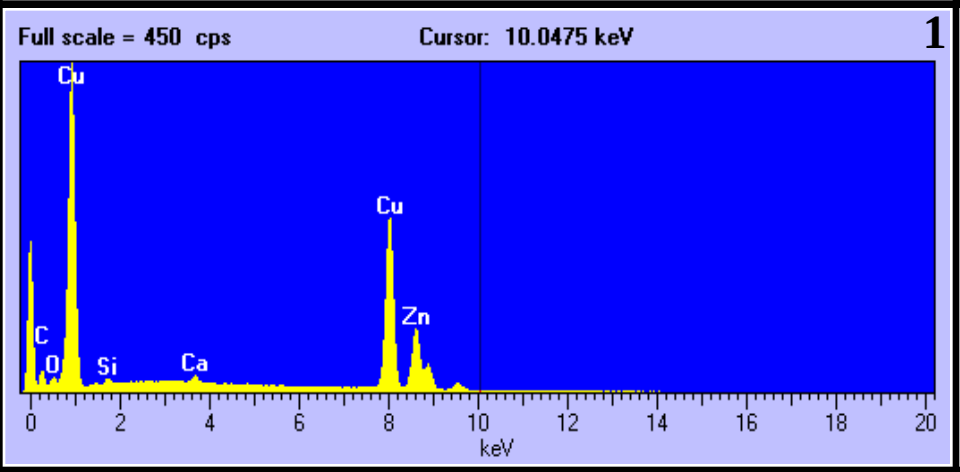


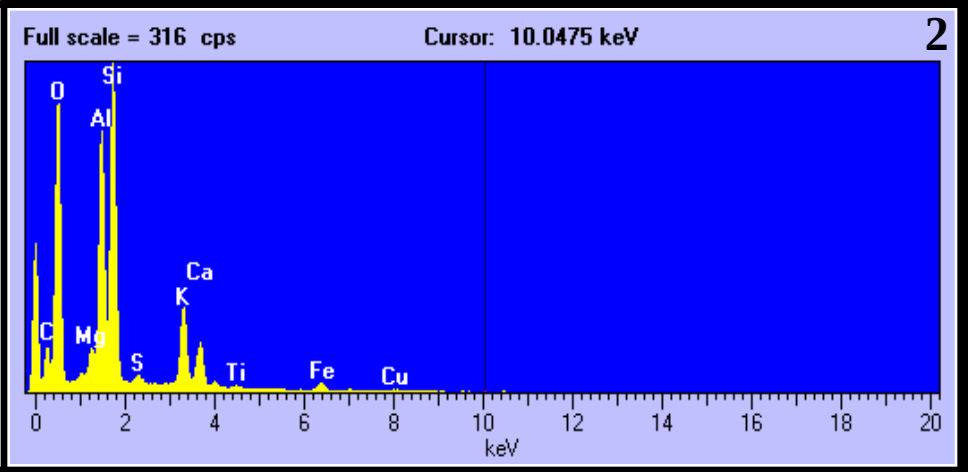

30
9
10
a

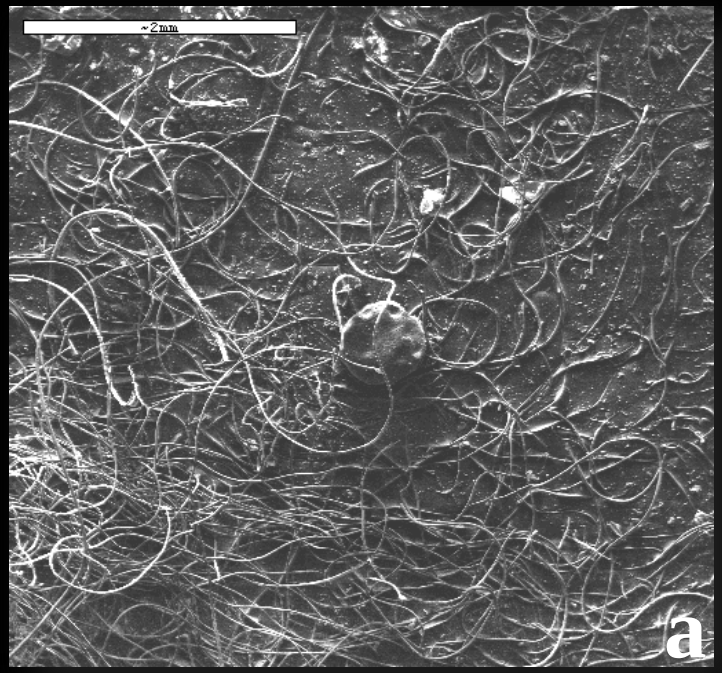

b

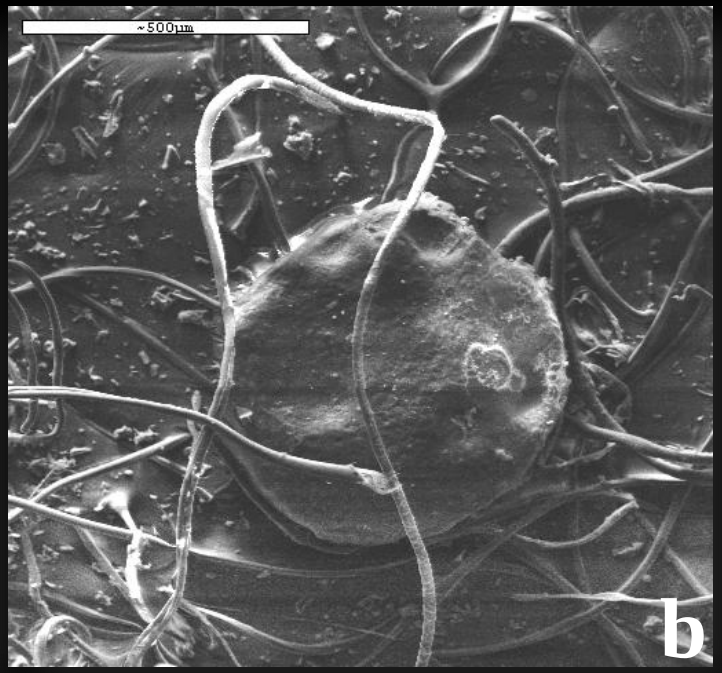

c

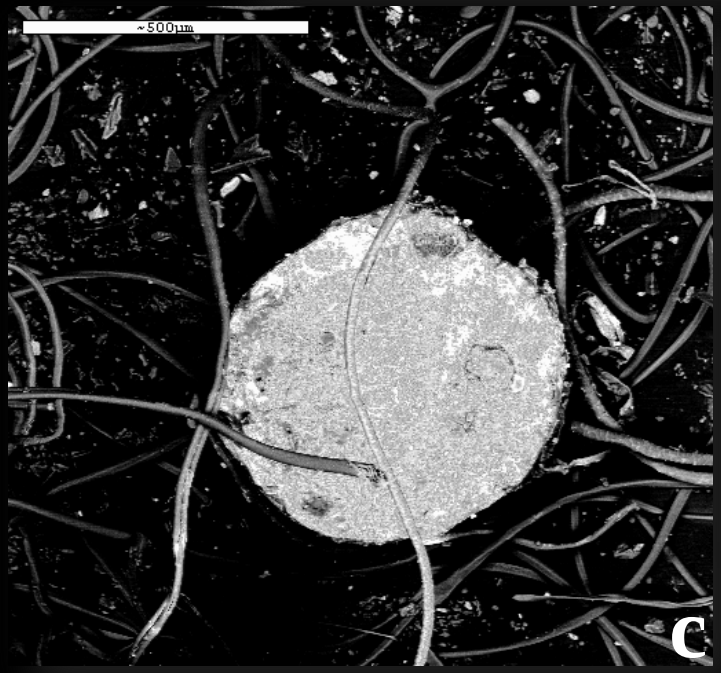

100µm
+ 1
+ 2

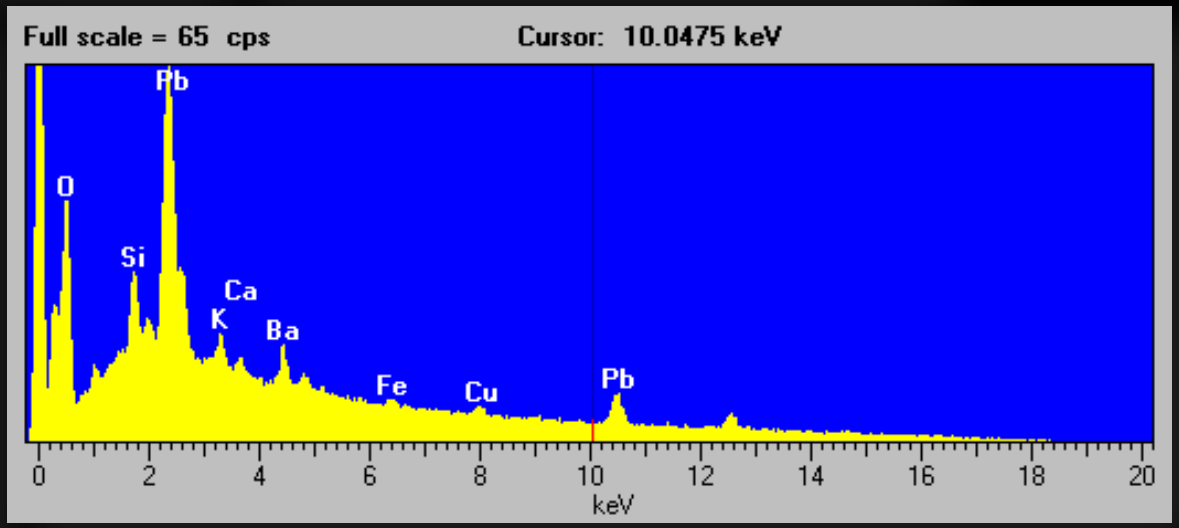

Full scale = 450 cps
Cursor: 10.0475 keV
1
Cu
Cu
Zn
C
O
Si
Ca
0
2
4
6
8
10
12
14
16
18
20
keV

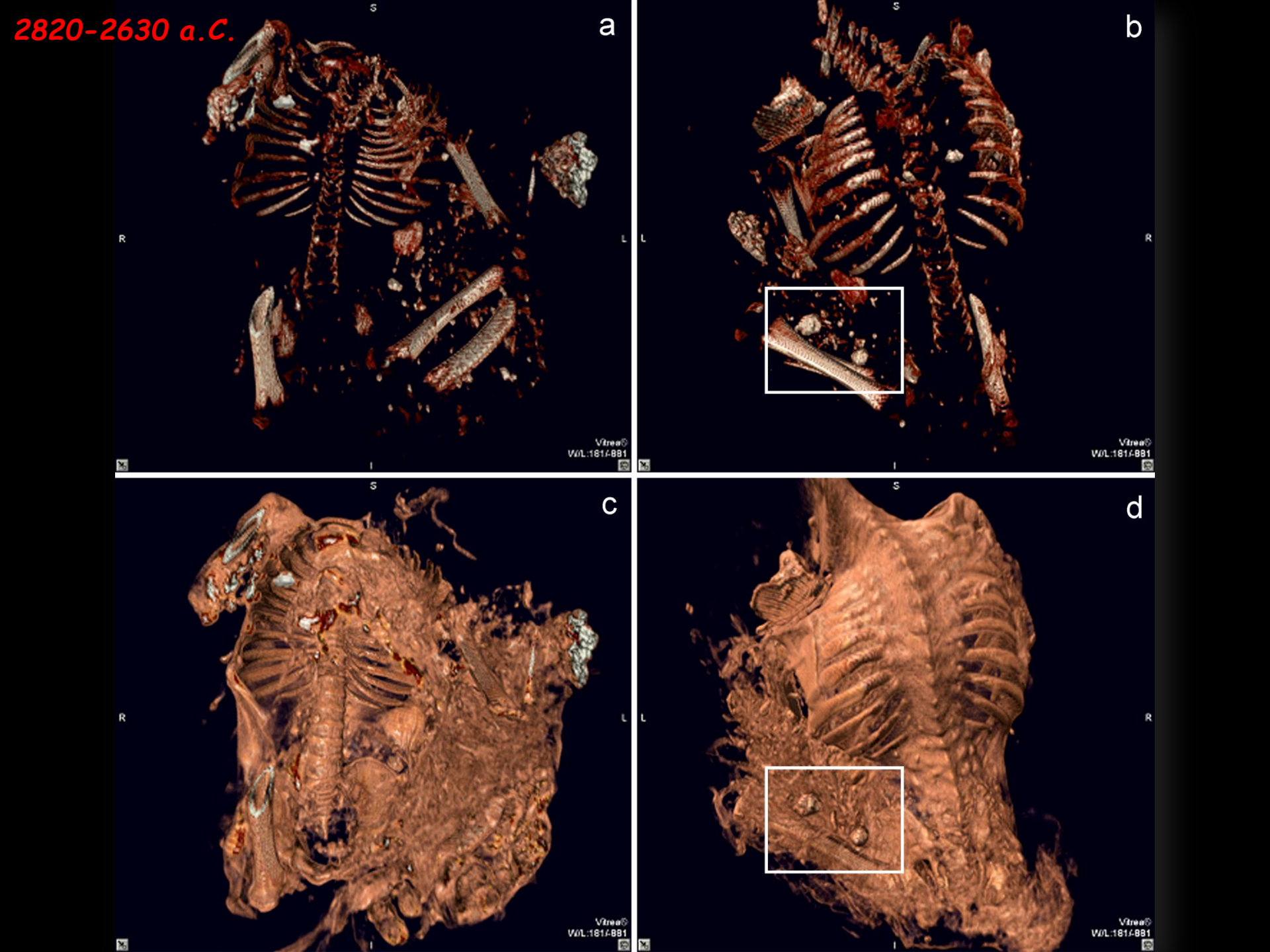

Full scale = 316 cps
Cursor: 10.0475 keV
2
O
Si
Al
Ca
K
C
Mg
S
Ti
Fe
Cu
0
2
4
6
8
10
12
14
16
18
20
keV


~2mm
a


~500µm
b


~500µm
c


Full scale = 65 cps
Cursor: 10.0475 keV
Pb
O
Si
Ca
K
Ba
Fe
Cu
Pb
0
2
4
6
8
10
12
14
16
18
20
keV

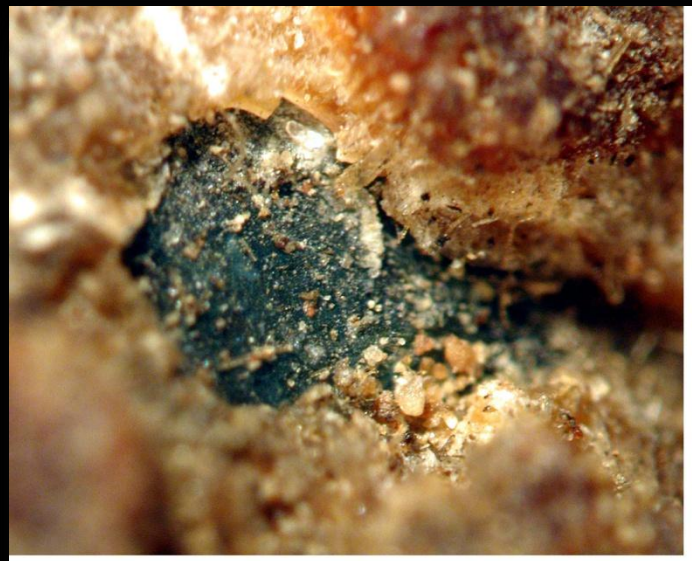

2820-2630 a.C.
a
b
c
d

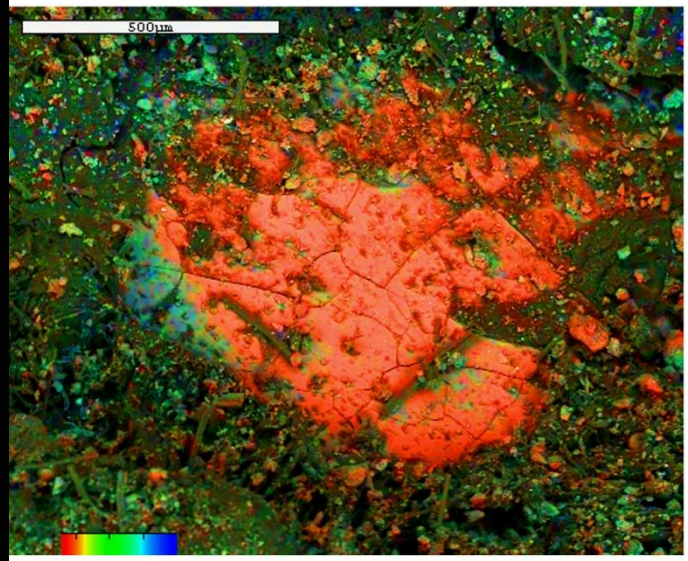

12,9 x 10,2 mm
a

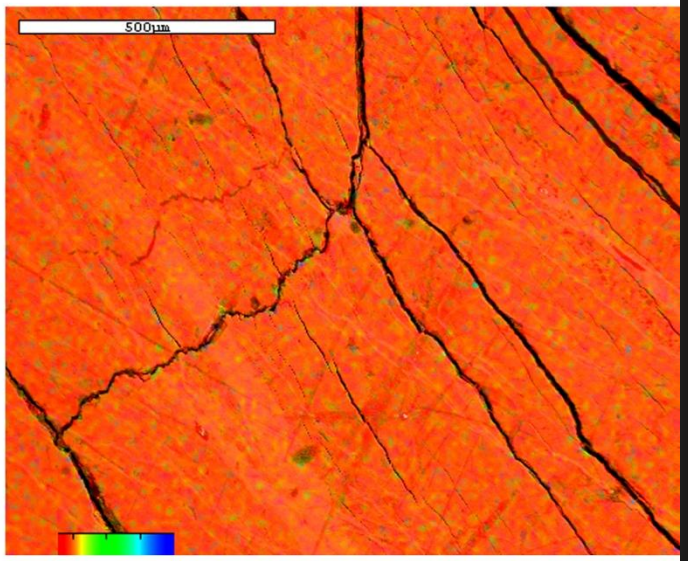

b

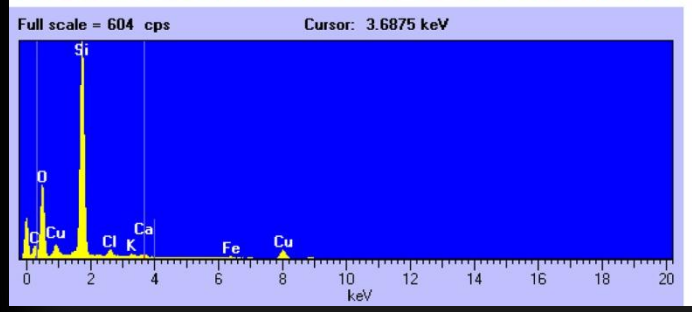

a

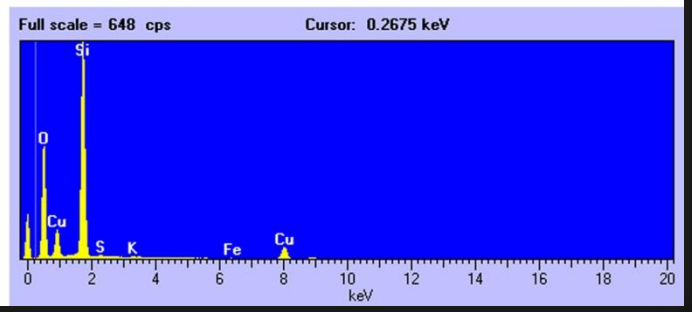

b




500µm


500µm


Full scale = 604 cps
Cursor: 3.6875 keV
Si
O
C
Cu
Cl
K
Ca
Fe
Cu
0 2 4 6 8 10 12 14 16 18 20
keV


Full scale = 648 cps
Cursor: 0.2675 keV
Si
O
Cu
S
K
Fe
Cu
0 2 4 6 8 10 12 14 16 18 20
keV

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Identification of a chrysocolla amulet in an Early Dynastic child mummy

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ABSTRACT

Two pyriform formations were identified within a bundle of linen bandages wrapping a 15–18 months old Early Dynastic mummy. The upper one was taken out of the bandages and examined to ascertain its nature.
This formation showed to be a small bag closed by a knot containing an emerald-green mineral. For identification and with the aim of identifying the compound kept inside it, several different green minerals used for adornment in Ancient Egypt (from the Pre-dynastic period up to the Ptolemaic one) were examined by scanning electron microscope (SEM-EDX) followed by microanalysis.
The pyriform formation's content is consistent, based on morphological and micro-analytical data, with the natural cryptocrystalline hydrated copper silicate identified as a bead of chrysocolla.
The use of chrysocolla was less common than that of malachite as chrysocolla ores were rarer. To present days, only one other example of chrysocolla as a funerary equipment from an Ancient Egypt child burial can be traced.
Since our archaeological finding indicates the presence of a chrysocolla bead in one other infant burial, it is possible that the use of this particular mineral was limited, in the Early Dynastic Period as a protective amulet for children.

1. Introduction

An Early Dynastic child from Gebelein (Upper Egypt) was 15–18 months old when he died some 4700 years ago (Bianucci et al., 2008).

The infant mummy 527 B* was discovered during an excavation campaign carried out by the Missione Archeologica Italiana (MAI), most likely in 1914 (Schiaparelli, 1921). The specimen belongs to the "Marro" Egyptian collection and is presently housed in the Museum of Anthropology and Ethnography of Turin University (Italy).

Atomic mass spectrometry radiocarbon dating (AMS) placed the corpse between 2820 and 2630 BC (95.4% probability range) (Bronk Ramsey et al., 2004a,b; Higham et al., 2006). This date corresponds to the end of the Early Dynastic Period (Ikram and Dodson, 1998; Aufderheide, 2003).

Early Dynastic cemeteries have been found at more than forty places in Egypt between Gebel el-Silsila in the South and El-Quitta on the west side of the Delta near its apex. The greater number of these cemeteries contains graves of minor officials or simple people (Wilkinson, 1999).

Archaeological data indicate that a necropolis dating to the Early Dynasties was discovered, in Gebelein, in the northern spurs of the second hill and was explored by Schiaparelli and co-workers in 1914 (Schiaparelli, 1921; Donadoni Roveri, 1990).

An earlier report on this infant mummy detailed the results of CT scan and of immunological investigations. The latest provided clear evidence of the presence of an acute *Plasmodium falciparum* malaria infection (Bianucci et al., 2008).

Virtual 3D reconstruction led to the identification of two pyriform formations (12.9 × 10.2 mm – upper left – and 5 × 4 mm – lower right) placed within the linen bandages, dorsally, level with the left tight. Only the upper formation was taken out of bandages and examined. Through a crevice of its surface, an emerald-green mineral of unknown composition was observed.

The purpose of our research was to ascertain the mineral's chemical composition and, hence, to interpret its meaning as a funerary equipment when associated to an infant burial.

2. Material and methods

The upper pyriform formation (12.9 × 10.2 mm) underwent dental arch X-rays and was observed with a stereomicroscope. Subsequently, it was analysed with a LEO 1430VP scanning electron microscope (LEO Electron Microscopy Ltd, Cambridge, UK) with

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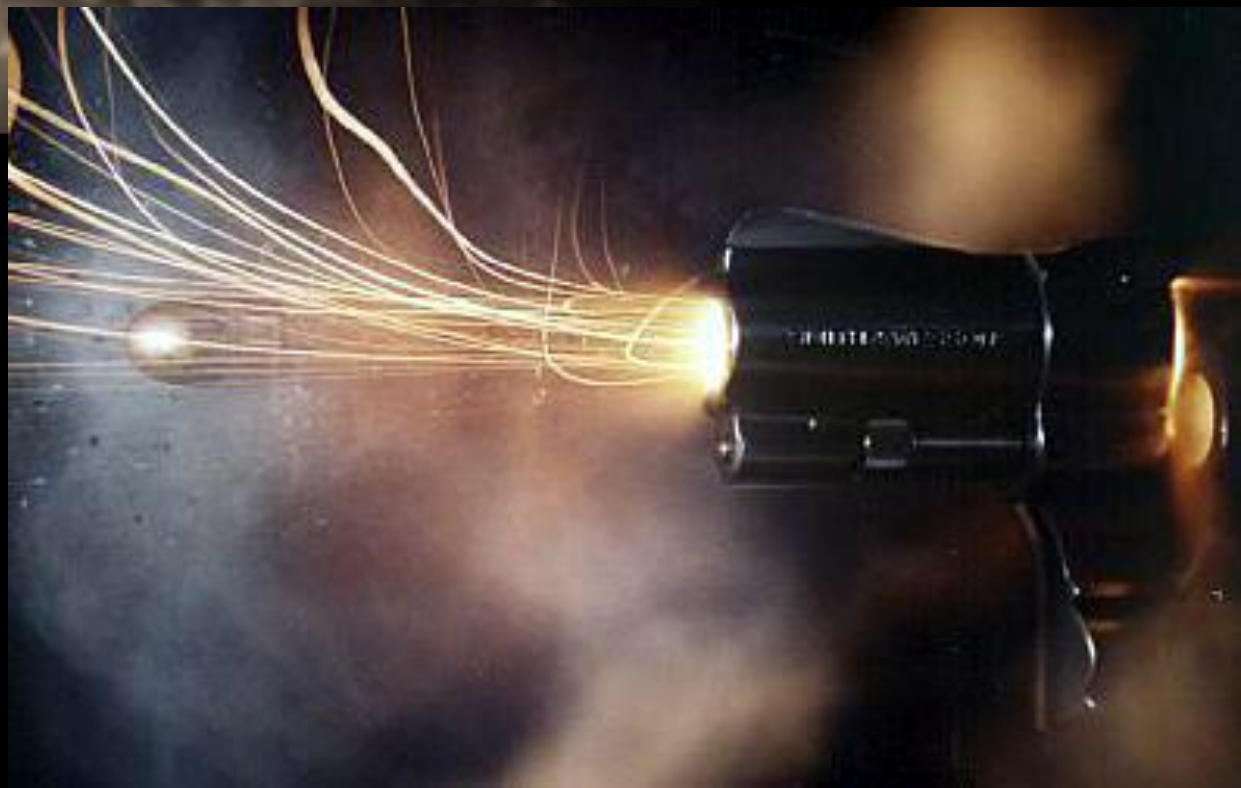
Tracce dello sparo e dintorni …




Proiettile
Bossolo
Carica di lancio
Foro di vampa
Innesco


Velocity
FIBRE WAD
English
Sporter

Ammunition in the Gun Control Debate

One strategy that has been proposed to reduce the severity of mass shootings is a ban on the ammunition for assault weapons. This would be difficult, since the modular design of the AR-15 allows the gun to be easily converted from one caliber to another. Moreover, the bullets most commonly used in assault rifles are actually less powerful than the ammunition for most hunting rifles. We emphasize regulations on certain bullet types, rather than specific calibers. See our infographic "One caliber, many bullets" for further explanation.

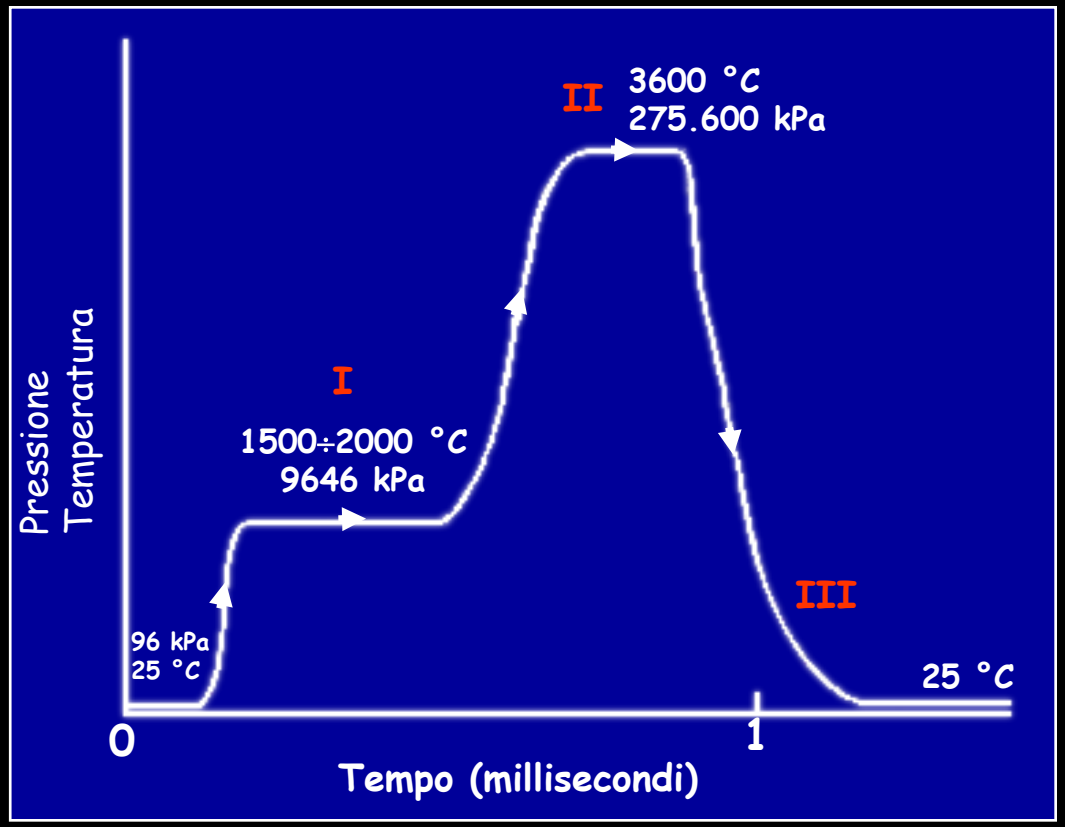
One caliber, many bullets

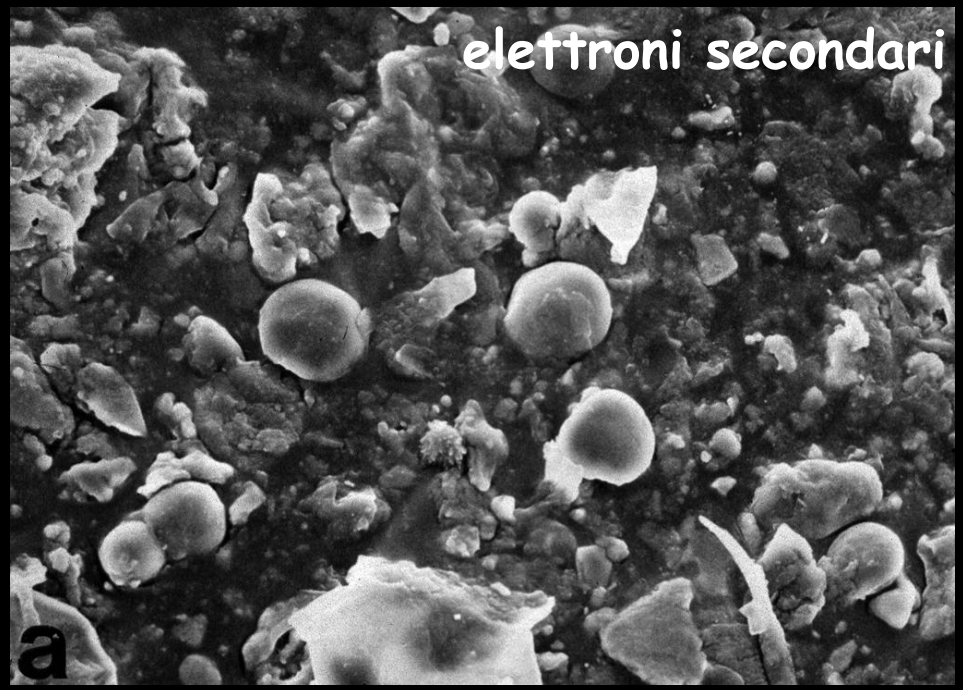
Every round of ammunition pictured below is the same caliber. (In this case .38 Special, though the same variety exists for other calibers.) These bullets can all be fired from the same gun, though each bullet has a unique purpose.

PARENTS AGAINST GUN VIOLENCE

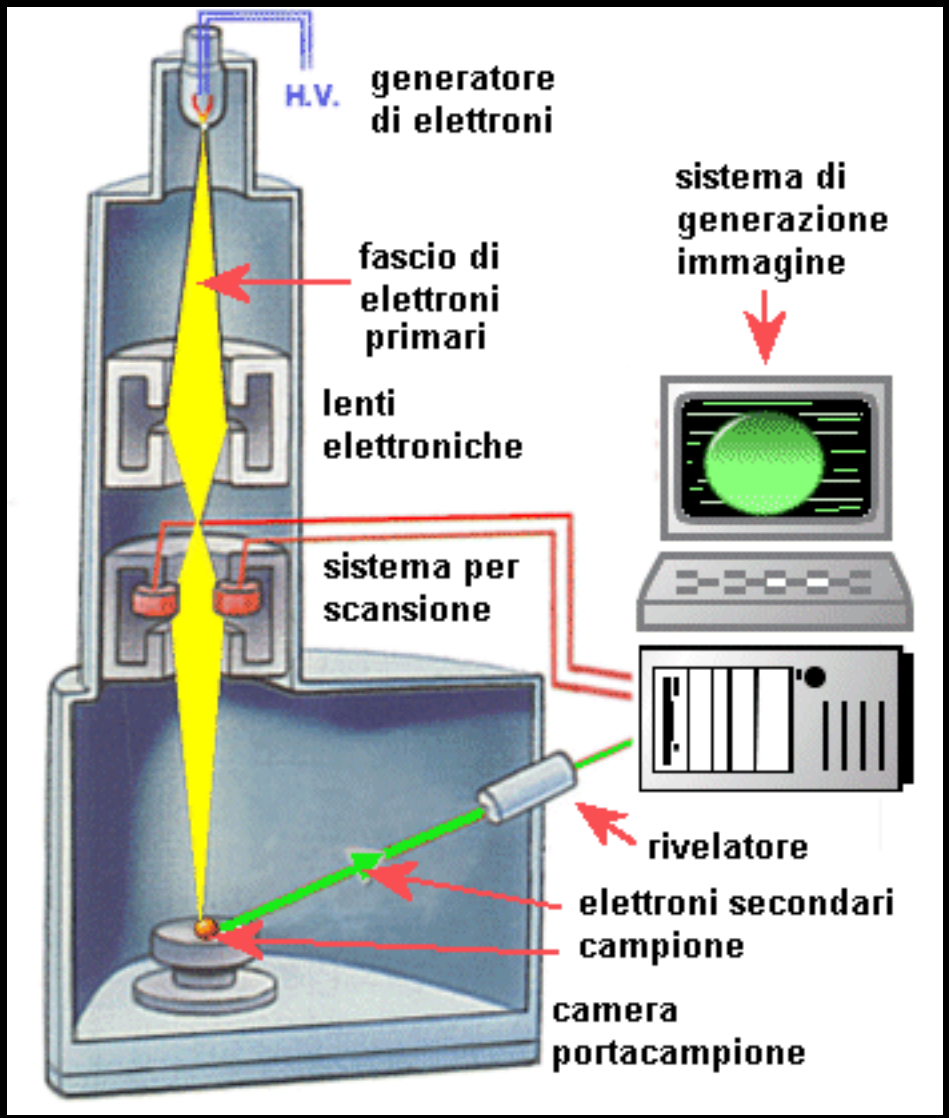
When President Obama announced the White House plan to reduce gun violence, he proposed a ban on "armor piercing" bullets. As we researched the issue, PAGV found that bullets designated "armor piercing" are virtually non-existent in the civilian market. We did learn that bullets come in an extraordinary variety. While all bullets are capable of inflicting injury and death, some carry greater risks. We propose that all handgun ammunition should be manufactured with unjacketed, soft-point, or frangible bullets, and that the manufacture of fully-jacketed and jacketed hollow point bullets should be discontinued, except for military use.

Da BASU S., "Formation of Gunshot Residues",
Journal of Forensic Sciences, 27(1): 72-91, 1982 (modificato)



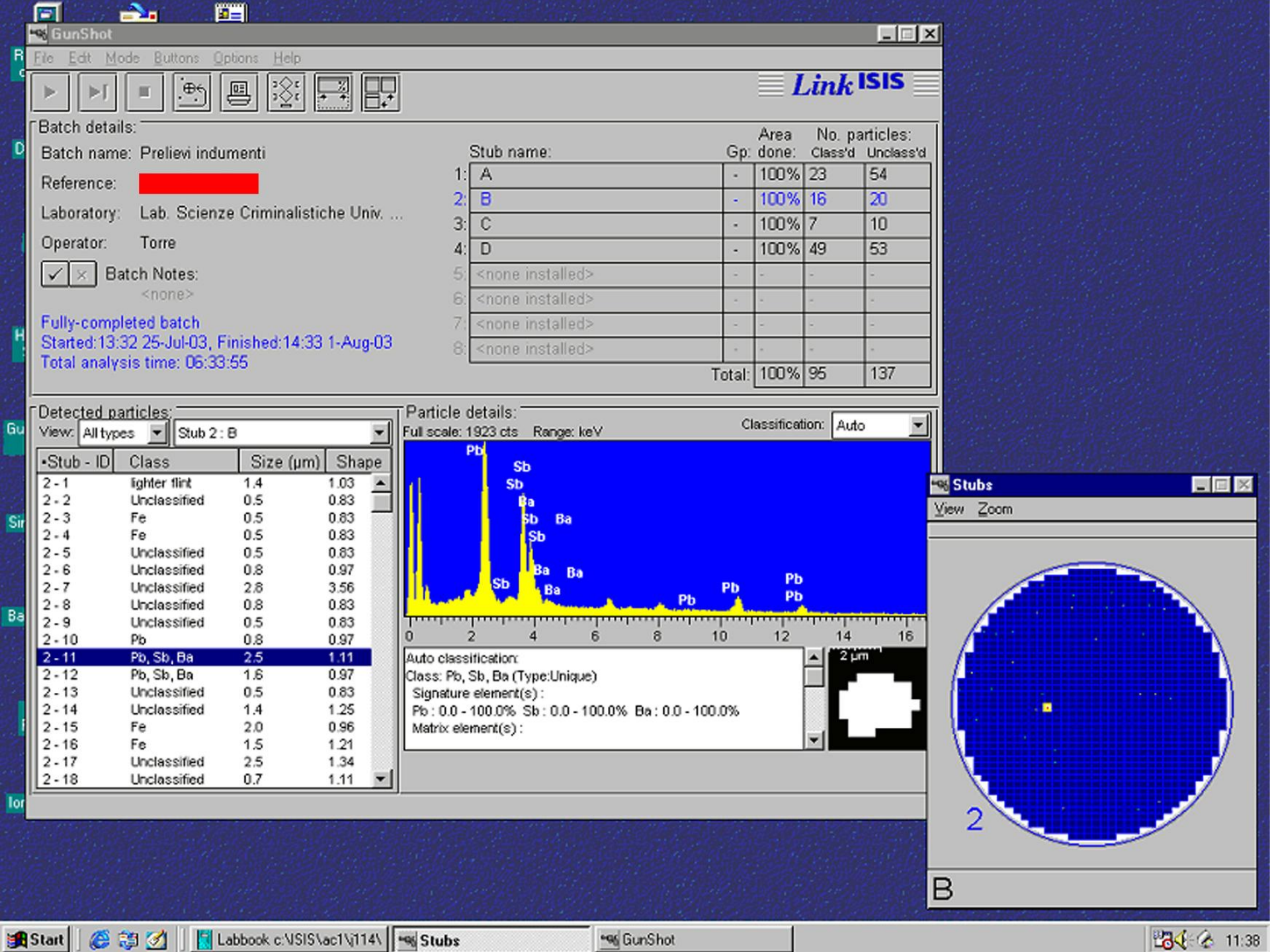

elettroni secondari
a


elettroni retrodiffusi
40 µ
b


H.V.
generatore
di elettroni
sistema di
generazione
immagine
fascio di
elettroni
primari
lenti
elettroniche
sistema per
scansione
rivelatore
elettroni secondari
campione
camera
portacampione

Ricerca sulle mani
di un sospetto sparatore


S
D
DIREZIONE CENTRALE POLIZIA CRIMINALE
SERVIZIO POLIZIA SCIENTIFICA


GunShot
File Edit Mode Buttons Options Help
Link ISIS
Batch details:
Batch name: Prelievi indumenti
Reference:
Laboratory: Lab. Scienze Criminalistiche Univ. ...
Operator: Torre
Batch Notes:
<none>
Fully-completed batch
Started:13:32 25-Jul-03, Finished:14:33 1-Aug-03
Total analysis time: 06:33:55
Stub name: Gp: Area done: No. particles: Class'd Unclass'd
1: A - 100% 23 54
2: B - 100% 16 20
3: C - 100% 7 10
4: D - 100% 49 53
5: <none installed>
6: <none installed>
7: <none installed>
8: <none installed>
Total: 100% 95 137
Detected particles:
View: All types
Stub 2 : B
Stub - ID Class Size (µm) Shape
2 - 1 lighter flint 1.4 1.03
2 - 2 Unclassified 0.5 0.83
2 - 3 Fe 0.5 0.83
2 - 4 Fe 0.5 0.83
2 - 5 Unclassified 0.5 0.83
2 - 6 Unclassified 0.8 0.97
2 - 7 Unclassified 2.8 3.56
2 - 8 Unclassified 0.8 0.83
2 - 9 Unclassified 0.5 0.83
2 - 10 Pb 0.8 0.97
2 - 11 Pb, Sb, Ba 2.5 1.11
2 - 12 Pb, Sb, Ba 1.6 0.97
2 - 13 Unclassified 0.5 0.83
2 - 14 Unclassified 1.4 1.25
2 - 15 Fe 2.0 0.96
2 - 16 Fe 1.5 1.21
2 - 17 Unclassified 2.5 1.34
2 - 18 Unclassified 0.7 1.11
Particle details:
Full scale: 1923 cts Range: keV
Classification: Auto
Pb Sb Sb Ba Sb Ba Sb Ba Sb Ba Ba Pb Pb Pb Pb
0 2 4 6 8 10 12 14 16
Auto classification:
Class: Pb, Sb, Ba (Type:Unique)
Signature element(s) :
Pb : 0.0 - 100.0% Sb : 0.0 - 100.0% Ba : 0.0 - 100.0%
Matrix element(s) :
2 µm
Stubs
View Zoom
2
B
Start
Labbook c:\ISIS\ac1\j114\
Stubs
GunShot
11:38

GunShot

File Edit Mode Buttons Options Help

Link ISIS

Detected particles

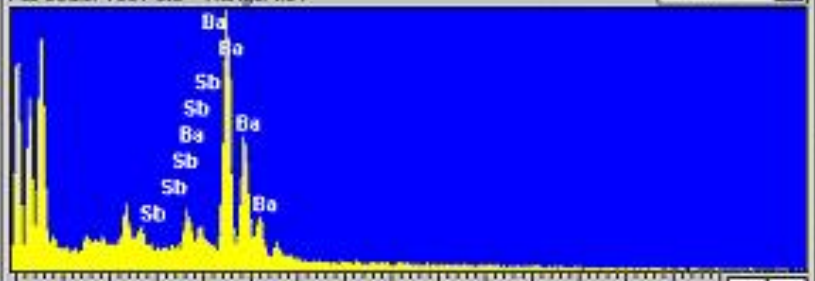
View: All types | Stub 1 : A - mano destra

Stub - ID	Class	Size (µm)	Shape
1 - 26	Unclassified	0.5	0.83
1 - 27	Unclassified	0.5	0.83
1 - 28	Unclassified	0.4	0.57
1 - 29	Unclassified	0.7	0.93
1 - 30	Unclassified	1.0	1.59
1 - 31	Unclassified	0.4	0.57
1 - 32	Unclassified	0.4	0.57
1 - 33	lighter tint	0.5	0.83
1 - 34	Unclassified	1.6	1.27
1 - 35	Pb enviro	0.8	0.97
1 - 36	Pb, Sb	2.4	1.17
1 - 37	Unclassified	1.4	1.06
1 - 38	S, Ba	0.7	1.11
1 - 39	Fe	1.1	1.48
1 - 40	S, Ba	1.3	1.51
1 - 41	Unclassified	0.4	0.57
1 - 42	Pb	3.8	4.62
1 - 43	Pb	0.7	0.93
1 - 44	Pb	2.1	4.60
1 - 45	Unclassified	1.4	1.79
1 - 46	Pb enviro	1.6	1.02
1 - 47	Unclassified	0.8	1.68
1 - 48	Unclassified	0.8	0.83
1 - 49	Pb enviro	2.2	1.86
1 - 50	Unclassified	43.0	5.13
1 - 51	Unclassified	2.7	1.05
1 - 52	Pb enviro	0.8	1.50
1 - 53	Unclassified	2.0	1.05
1 - 54	Sb	1.2	1.75
1 - 55	Sb	1.1	1.34
1 - 56	Pb, Sb, Ba	1.1	1.67
1 - 57	Sb, Ba	0.8	1.18
1 - 58	Unclassified	0.7	0.93
1 - 59	Unclassified	8.0	5.07

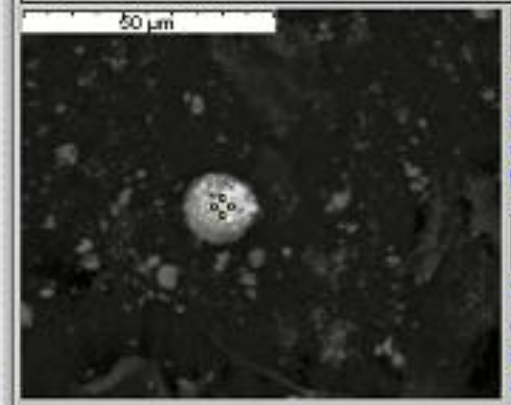
Particle details:

Full scale: 1531 cts Range: keV

Classification: Manual



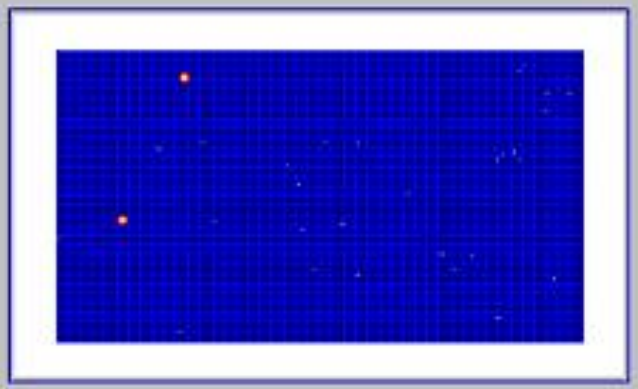
Manual classification:
Class: Sb, Ba (Type:Indicative)



This window allows you to view the current stub layout in use, in particular showing the stub areas scan

Stubs

View Zoom



1

A - mano destra

Start | Labbook c:\ISIS\sc1\j114\ | Stubs | GunShot | 10:31

Ciò che vedo
è o no
una particella di sparo?

GunShot

File Edit Mode Buttons Options Help

Link ISIS

Detected particles

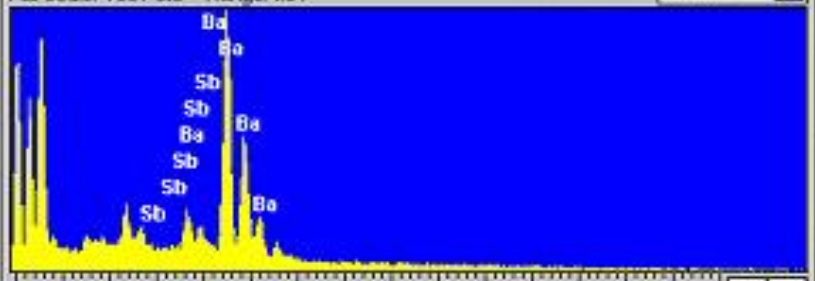
View: All types | Stub 1 : A - mano destra

Stub - ID	Class	Size (µm)	Shape
1 - 26	Unclassified	0.5	0.83
1 - 27	Unclassified	0.5	0.83
1 - 28	Unclassified	0.4	0.57
1 - 29	Unclassified	0.7	0.93
1 - 30	Unclassified	1.0	1.59
1 - 31	Unclassified	0.4	0.57
1 - 32	Unclassified	0.4	0.57
1 - 33	lighter tint	0.5	0.83
1 - 34	Unclassified	1.6	1.27
1 - 35	Pb enviro	0.8	0.97
1 - 36	Pb, Sb	2.4	1.17
1 - 37	Unclassified	1.4	1.06
1 - 38	S, Ba	0.7	1.11
1 - 39	Fe	1.1	1.48
1 - 40	S, Ba	1.3	1.51
1 - 41	Unclassified	0.4	0.57
1 - 42	Pb	3.8	4.62
1 - 43	Pb	0.7	0.93
1 - 44	Pb	2.1	4.60
1 - 45	Unclassified	1.4	1.79
1 - 46	Pb enviro	1.6	1.02
1 - 47	Unclassified	0.8	1.68
1 - 48	Unclassified	0.8	0.83
1 - 49	Pb enviro	2.2	1.86
1 - 50	Unclassified	43.0	5.13
1 - 51	Unclassified	2.7	1.05
1 - 52	Pb enviro	0.8	1.50
1 - 53	Unclassified	2.0	1.05
1 - 54	Sb	1.2	1.75
1 - 55	Sb	1.1	1.34
1 - 56	Pb, Sb, Ba	1.1	1.67
1 - 57	Sb, Ba	0.8	1.18
1 - 58	Unclassified	0.7	0.93
1 - 59	Unclassified	8.0	5.07

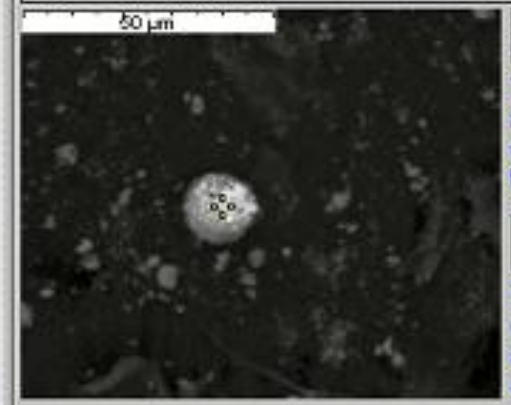
Particle details:

Full scale: 1531 cts Range: keV

Classification: Manual



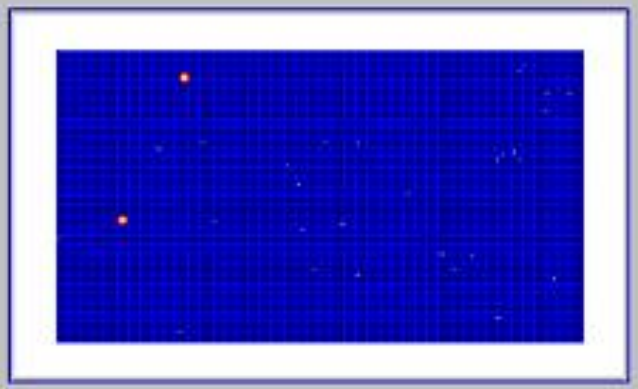
Manual classification:
Class: Sb, Ba (Type:Indicative)



This window allows you to view the current stub layout in use, in particular showing the stub areas scan

Stubs

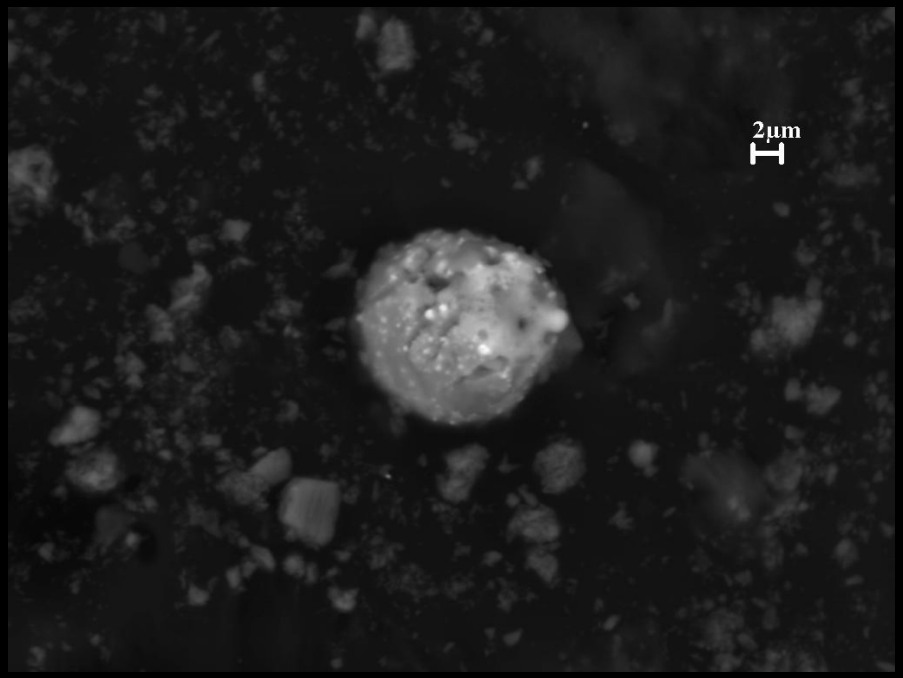
View Zoom

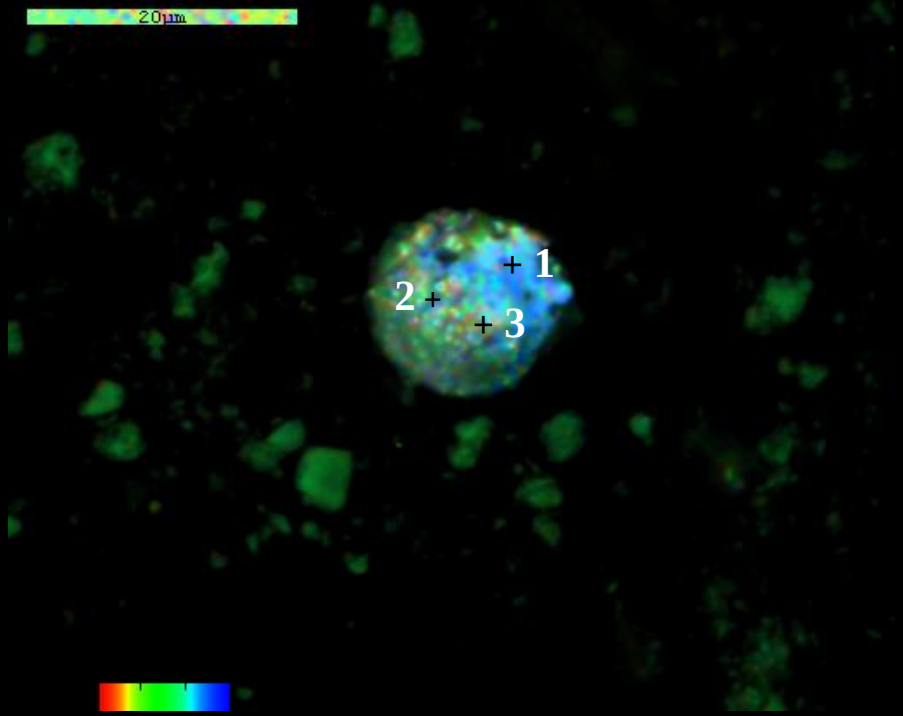


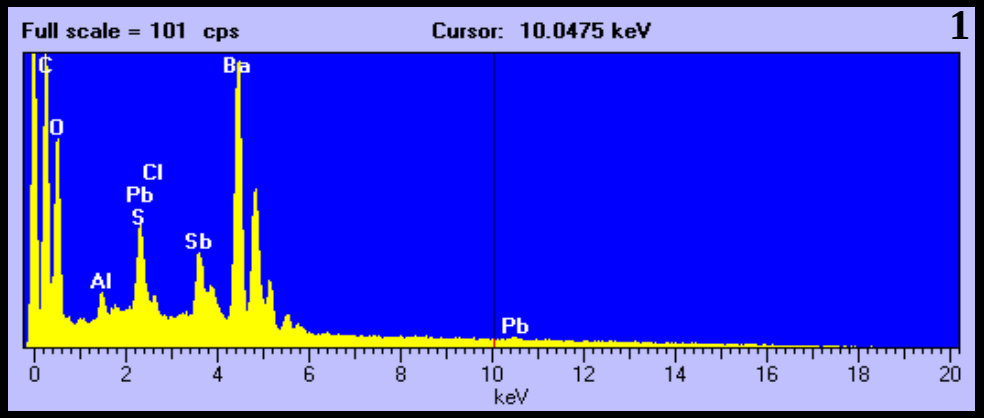
1

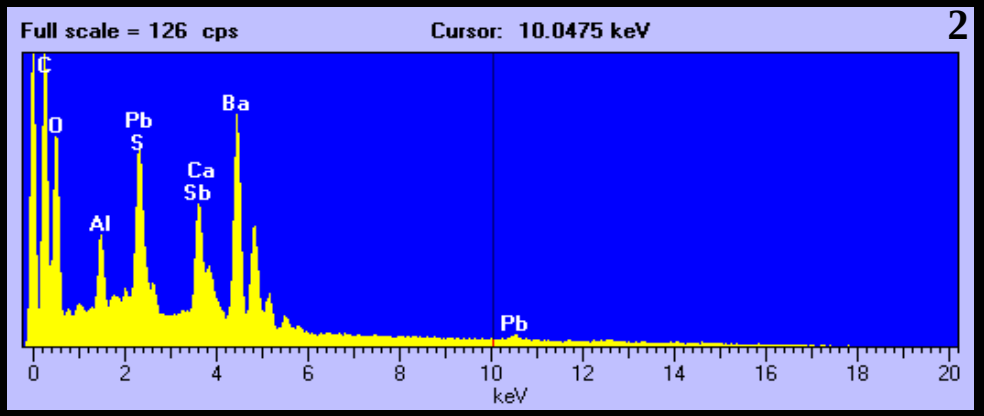
A - mano destra

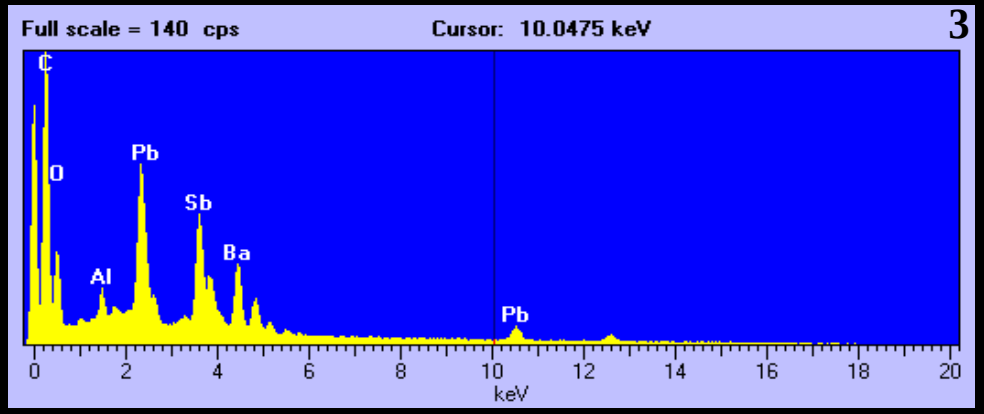
Start | Labbook c:\ISIS\sc1\j114\ | Stubs | GunShot | 10:31

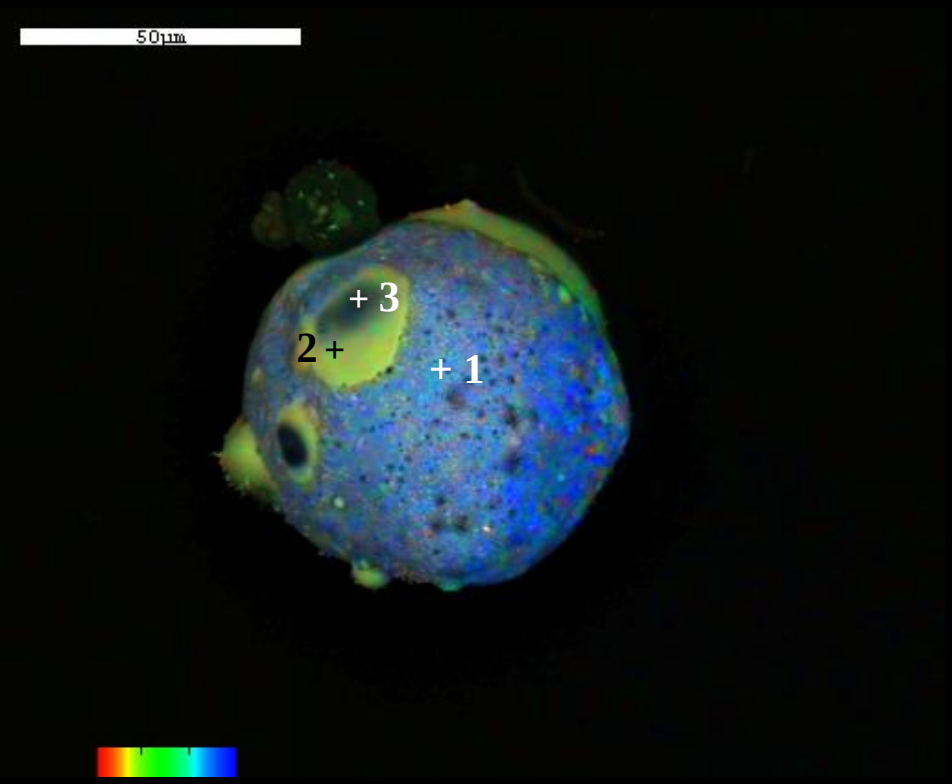

2µm

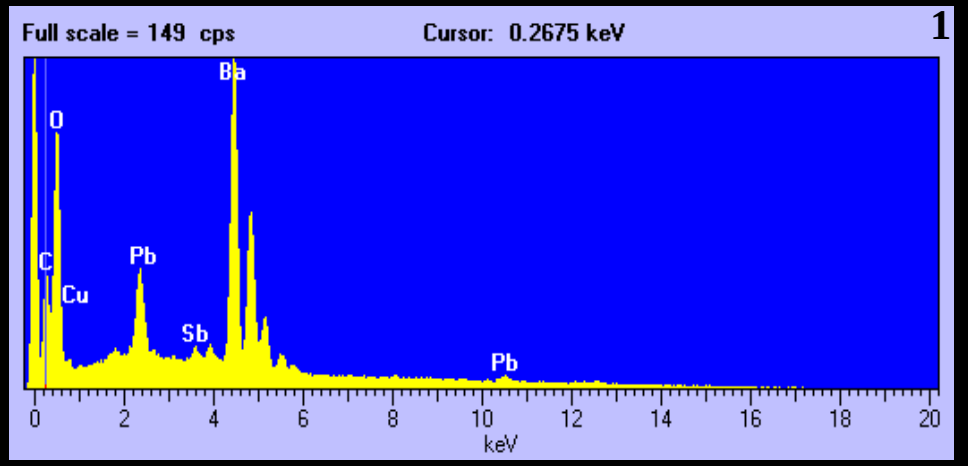

20µm
1
2
3

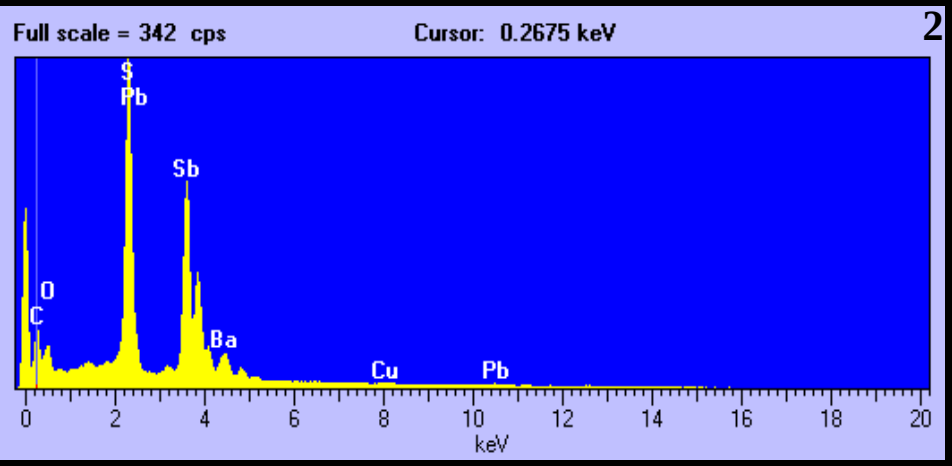

Full scale = 101 cps
Cursor: 10.0475 keV
1
C
O
Al
Cl
Pb
S
Sb
Ba
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

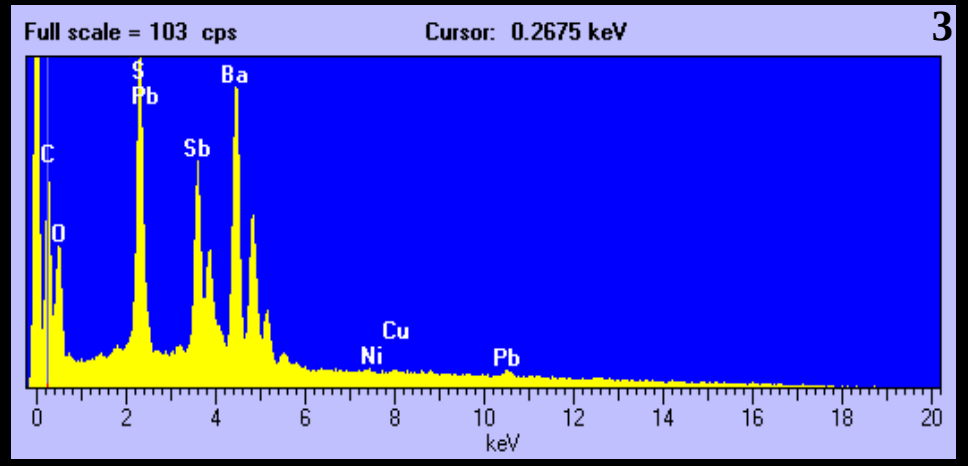

Full scale = 126 cps
Cursor: 10.0475 keV
2
C
O
Al
Pb
S
Ca
Sb
Ba
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

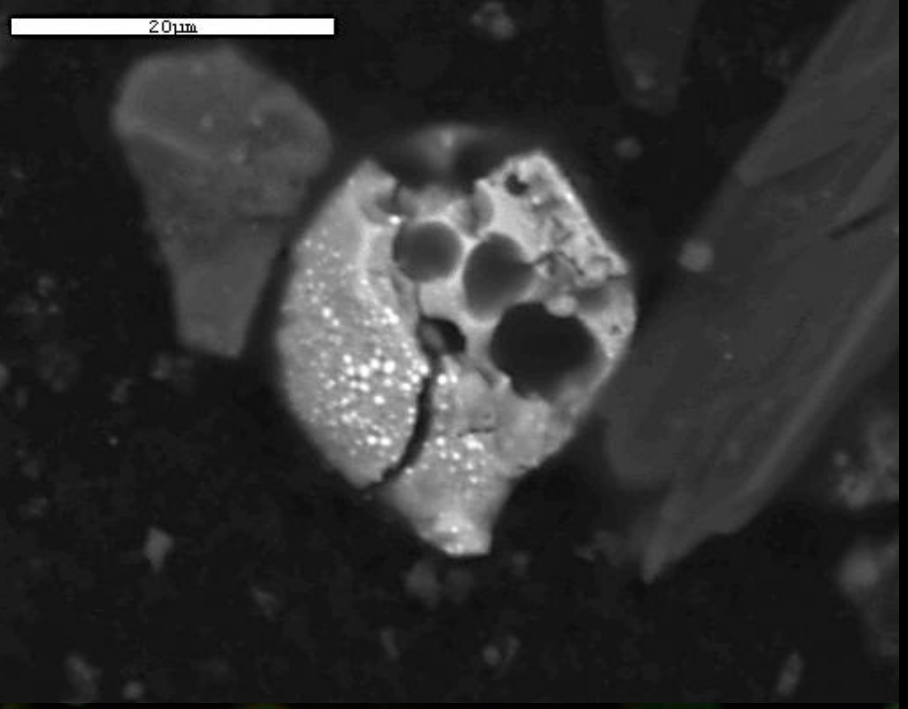

Full scale = 140 cps
Cursor: 10.0475 keV
3
C
O
Al
Pb
Sb
Ba
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

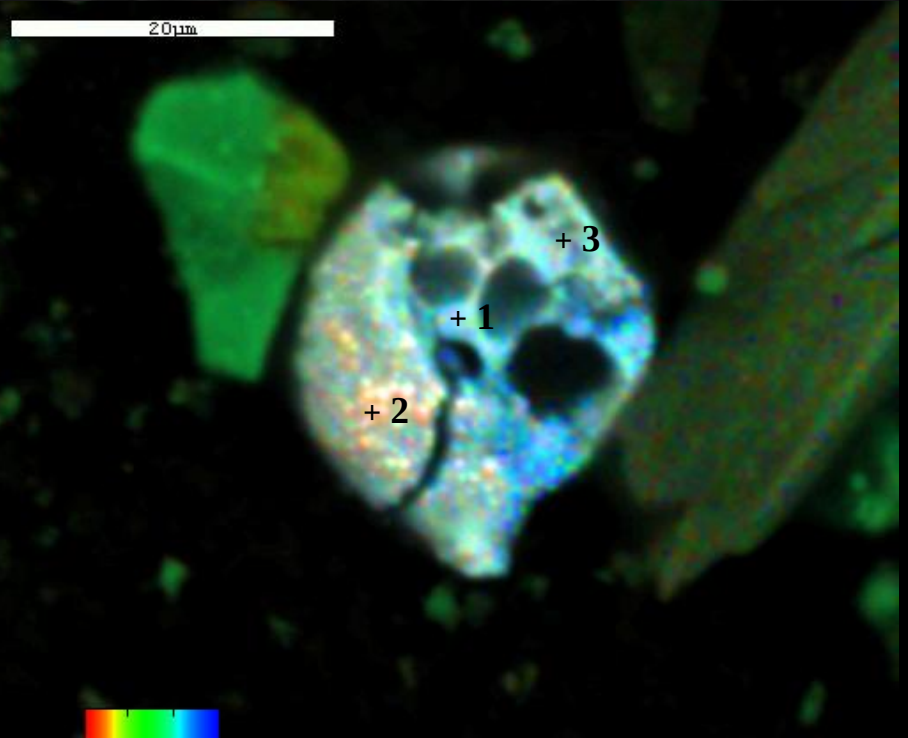

50µm
+ 3
2 +
+ 1

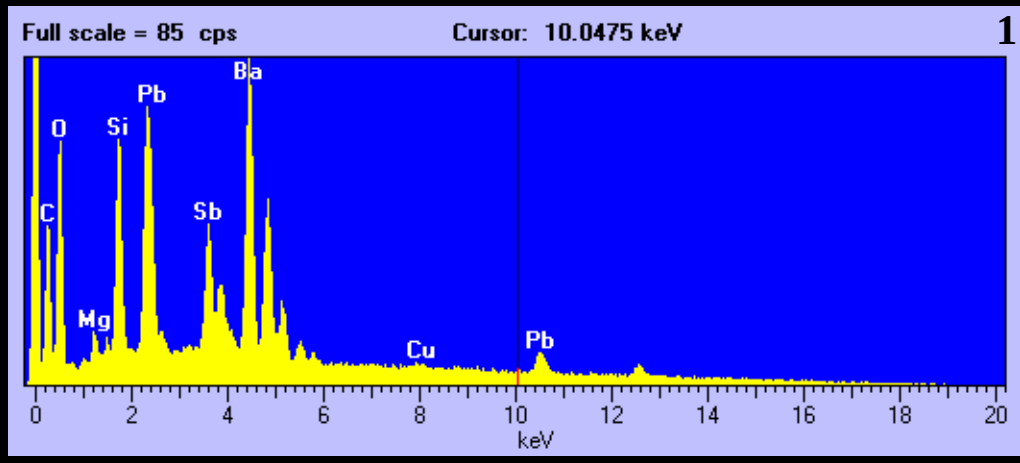

Full scale = 149 cps
Cursor: 0.2675 keV
1
Ba
O
C
Cu
Pb
Sb
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

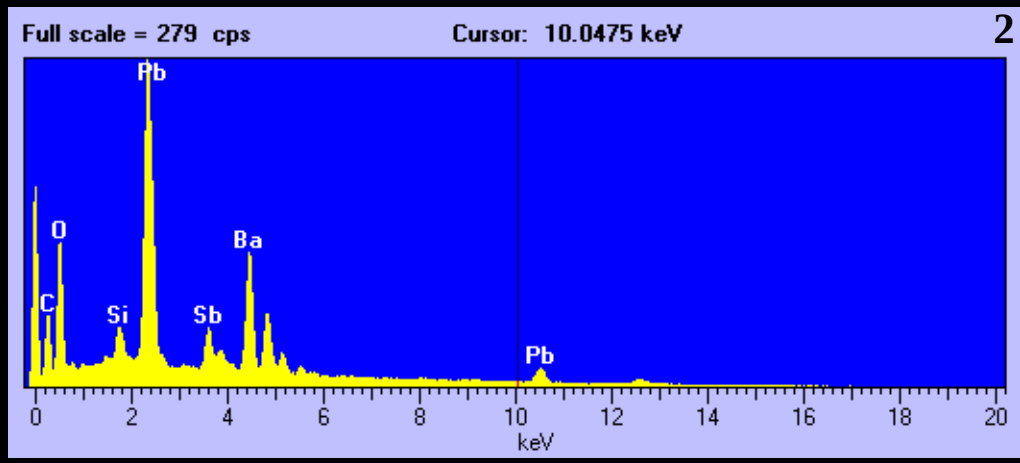

Full scale = 342 cps
Cursor: 0.2675 keV
2
S
Pb
Sb
O
C
Ba
Cu
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

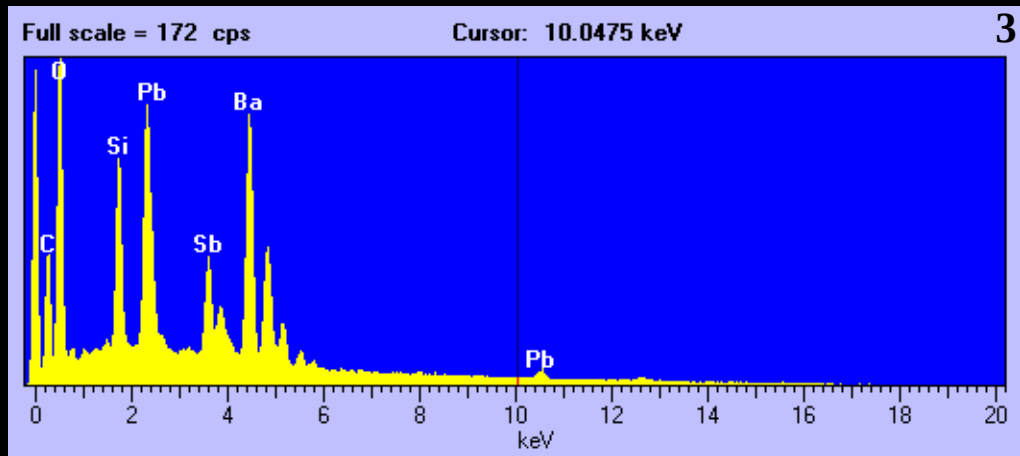

Full scale = 103 cps
Cursor: 0.2675 keV
3
S
Pb
Ba
Sb
C
O
Cu
Ni
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

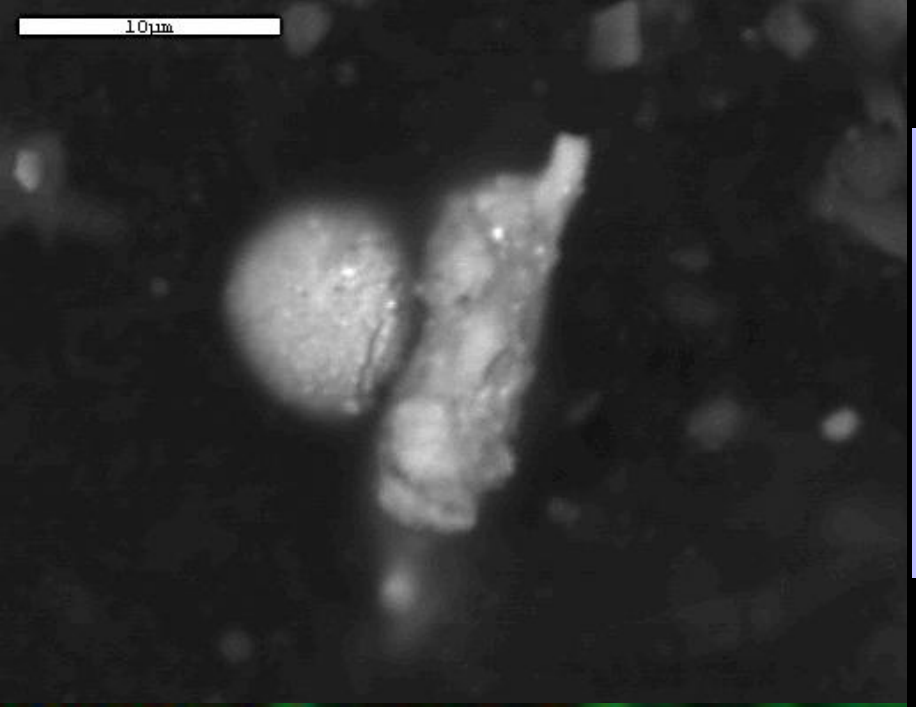

20µm

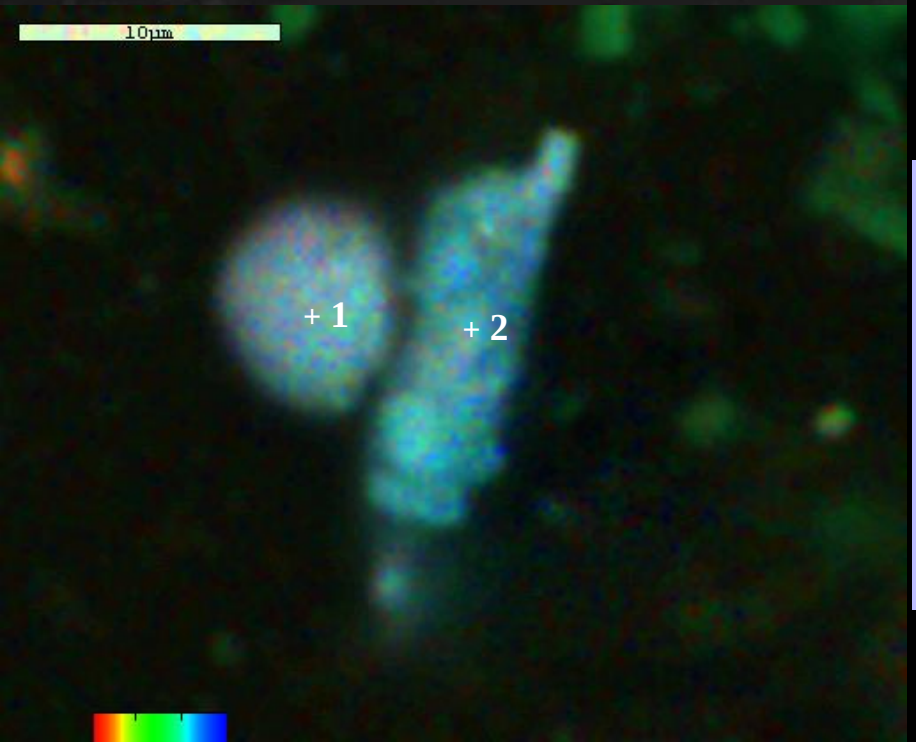

20µm
+ 3
+ 1
+ 2

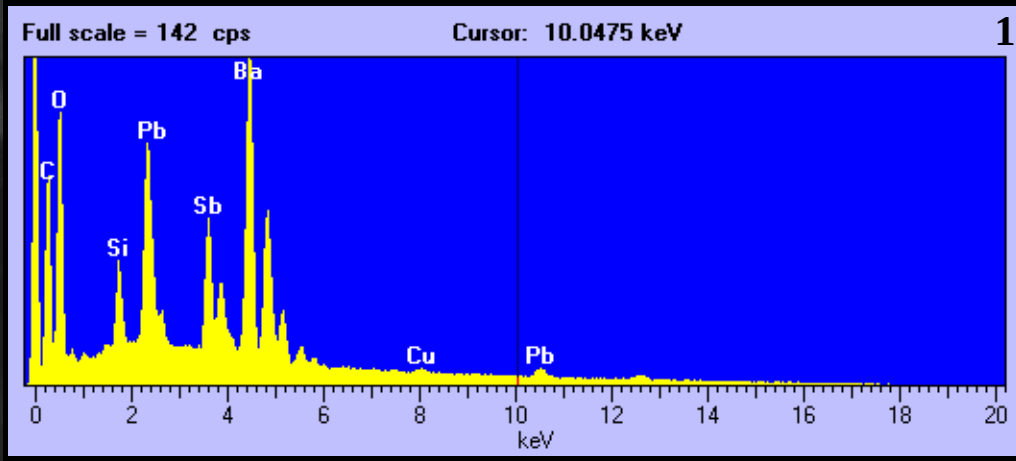

Full scale = 85 cps
Cursor: 10.0475 keV
1
C
O
Mg
Si
Pb
Ba
Sb
Cu
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

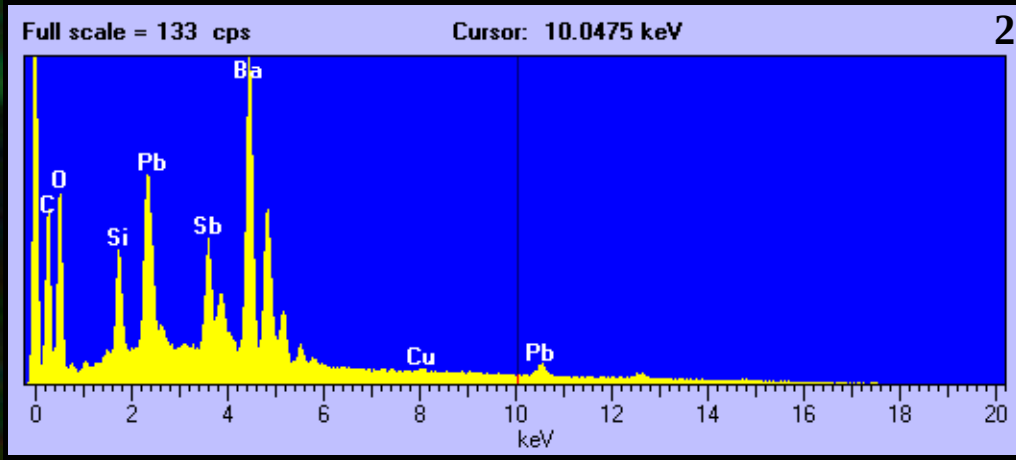

Full scale = 279 cps
Cursor: 10.0475 keV
2
C
O
Si
Pb
Ba
Sb
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

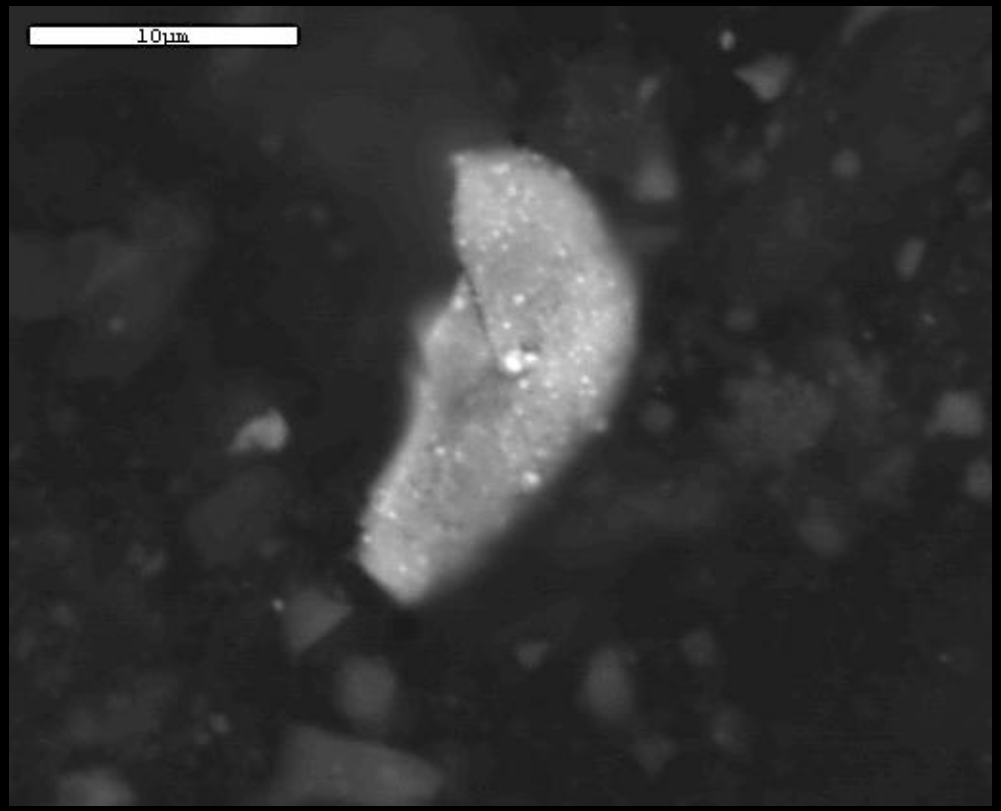

Full scale = 172 cps
Cursor: 10.0475 keV
3
C
O
Si
Pb
Ba
Sb
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

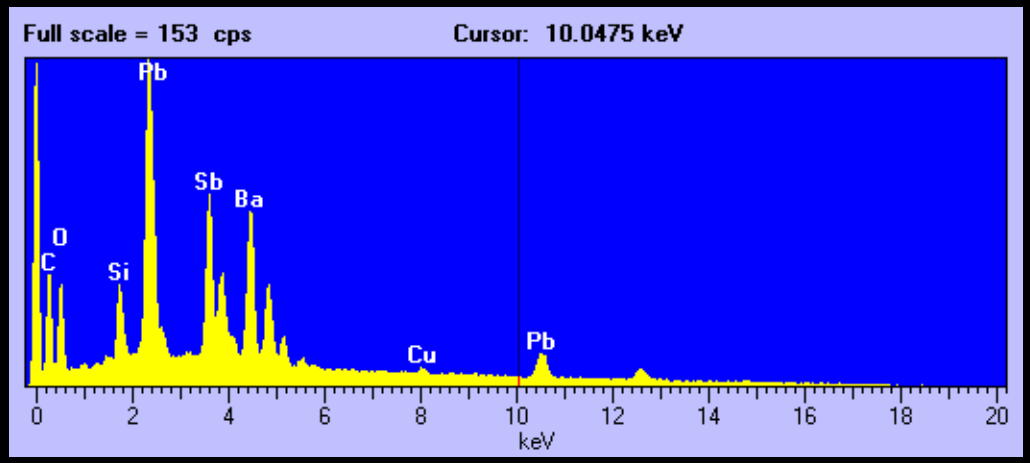

10µm

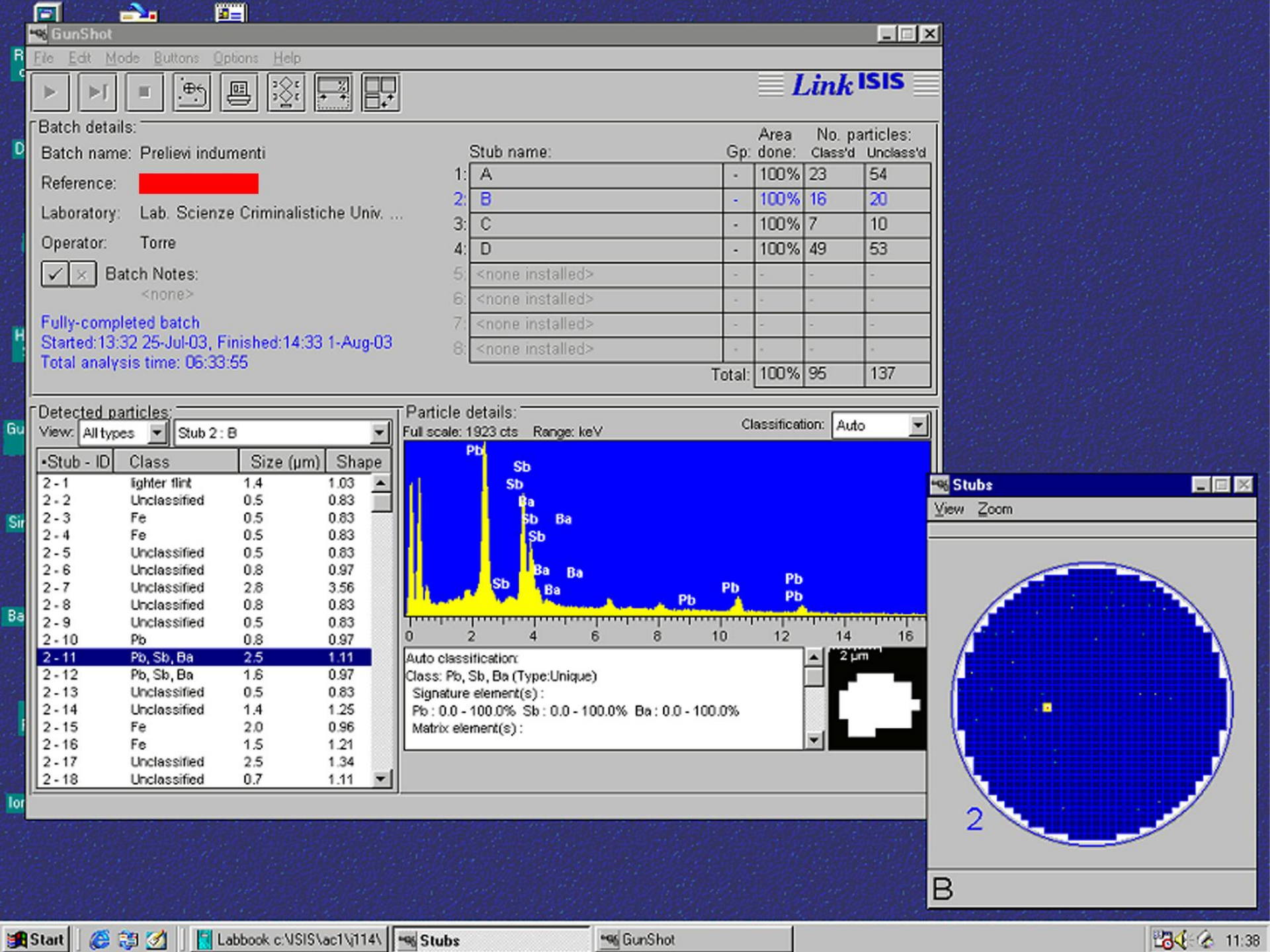

10µm
+ 1
+ 2

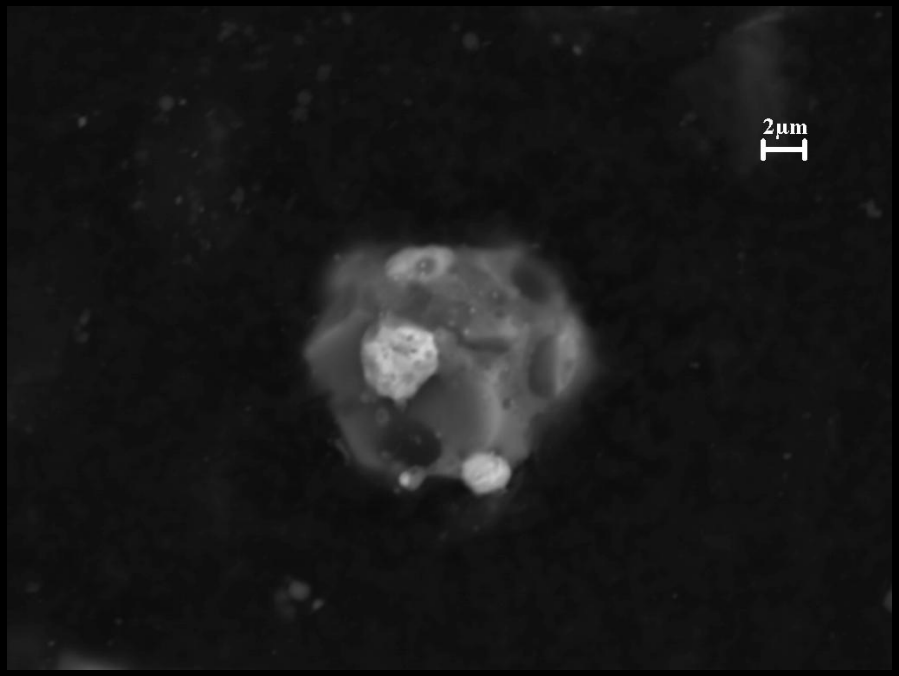

Full scale = 142 cps
Cursor: 10.0475 keV
1
O
C
Si
Pb
Sb
Ba
Cu
Pb
0
2
4
6
8
10
12
14
16
18
20
keV

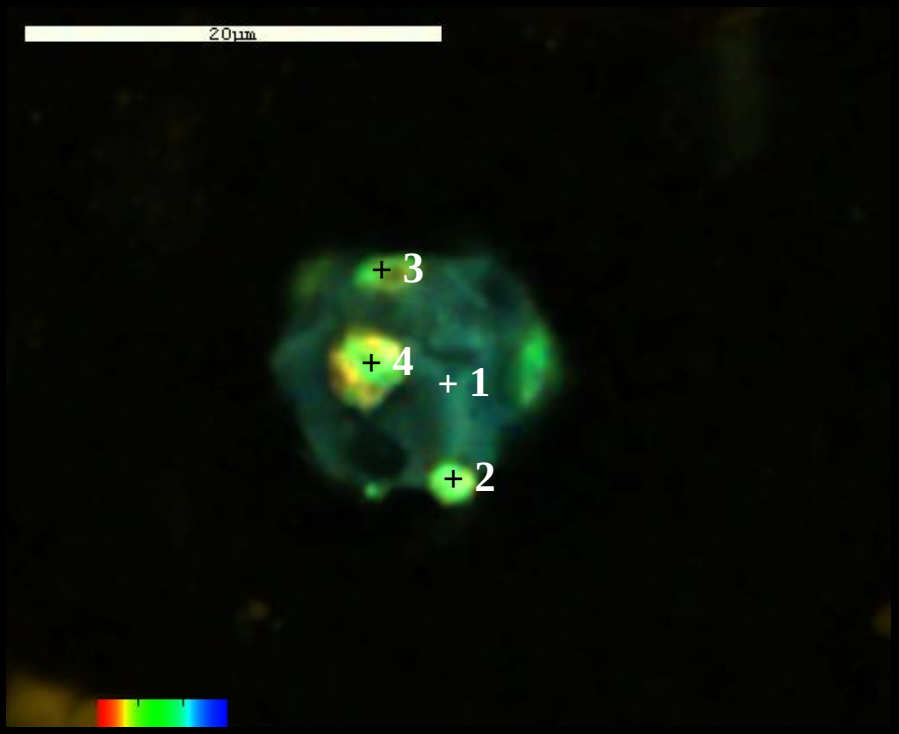

Full scale = 133 cps
Cursor: 10.0475 keV
2
O
C
Si
Pb
Sb
Ba
Cu
Pb
0
2
4
6
8
10
12
14
16
18
20
keV

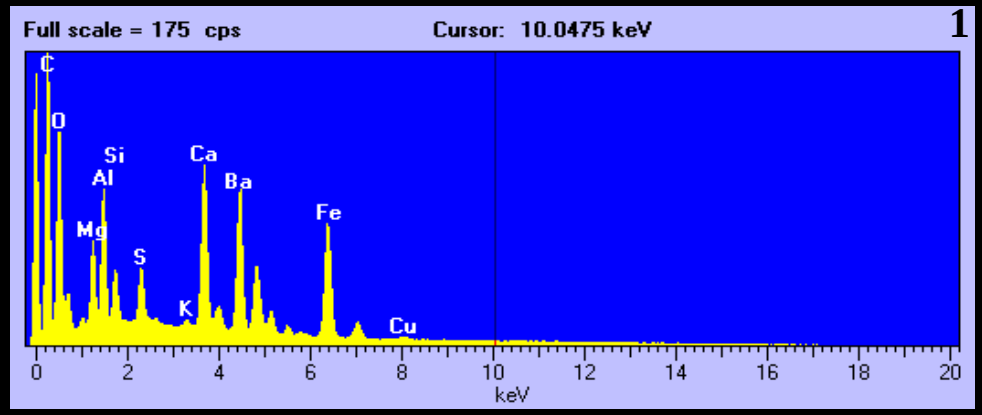

10µm

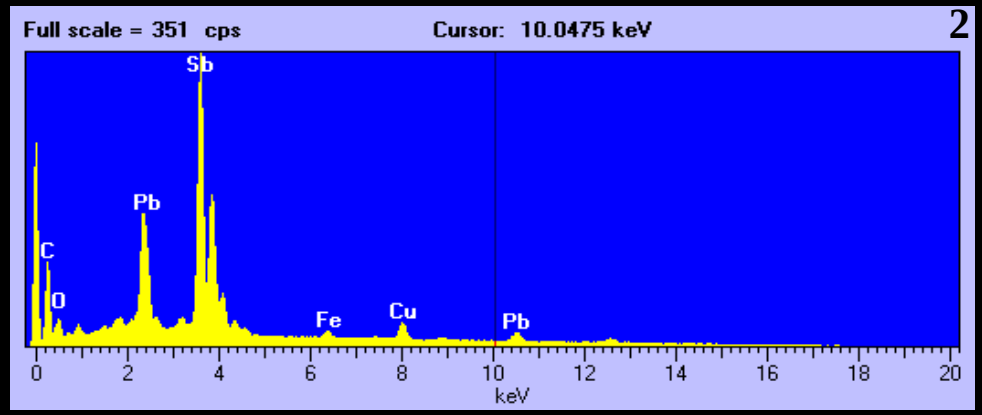

Full scale = 153 cps
Cursor: 10.0475 keV
Pb
Sb
Ba
O
C
Si
Cu
Pb
0
2
4
6
8
10
12
14
16
18
20
keV

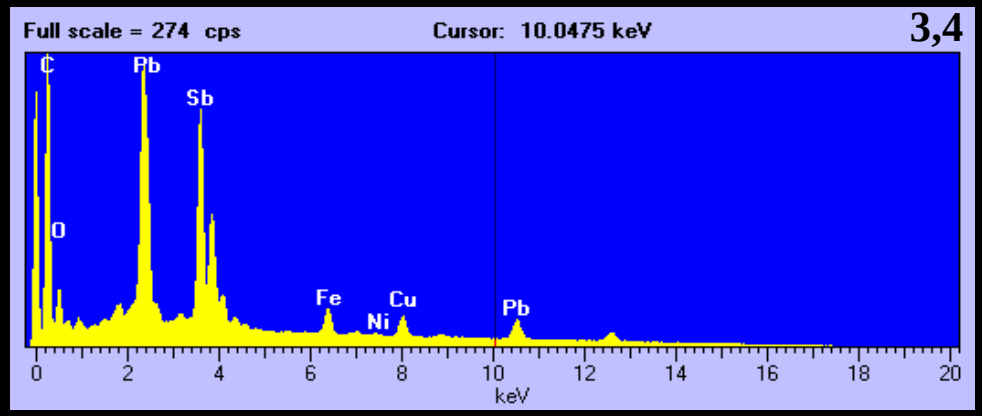

GunShot
File Edit Mode Buttons Options Help
Link ISIS
Batch details:
Batch name: Prelievi indumenti
Reference:
Laboratory: Lab. Scienze Criminalistiche Univ. ...
Operator: Torre
Batch Notes:
<none>
Fully-completed batch
Started:13:32 25-Jul-03, Finished:14:33 1-Aug-03
Total analysis time: 06:33:55
Stub name: Gp: Area done: No. particles: Class'd Unclass'd
1: A - 100% 23 54
2: B - 100% 16 20
3: C - 100% 7 10
4: D - 100% 49 53
5: <none installed>
6: <none installed>
7: <none installed>
8: <none installed>
Total: 100% 95 137
Detected particles:
View: All types
Stub 2 : B
Stub - ID Class Size (µm) Shape
2 - 1 lighter flint 1.4 1.03
2 - 2 Unclassified 0.5 0.83
2 - 3 Fe 0.5 0.83
2 - 4 Fe 0.5 0.83
2 - 5 Unclassified 0.5 0.83
2 - 6 Unclassified 0.8 0.97
2 - 7 Unclassified 2.8 3.56
2 - 8 Unclassified 0.8 0.83
2 - 9 Unclassified 0.5 0.83
2 - 10 Pb 0.8 0.97
2 - 11 Pb, Sb, Ba 2.5 1.11
2 - 12 Pb, Sb, Ba 1.6 0.97
2 - 13 Unclassified 0.5 0.83
2 - 14 Unclassified 1.4 1.25
2 - 15 Fe 2.0 0.96
2 - 16 Fe 1.5 1.21
2 - 17 Unclassified 2.5 1.34
2 - 18 Unclassified 0.7 1.11
Particle details:
Full scale: 1923 cts Range: keV
Classification: Auto
Pb Sb Sb Ba Sb Ba Sb Ba Sb Ba Ba Pb Pb Pb Pb
0 2 4 6 8 10 12 14 16
Auto classification:
Class: Pb, Sb, Ba (Type:Unique)
Signature element(s) :
Pb : 0.0 - 100.0% Sb : 0.0 - 100.0% Ba : 0.0 - 100.0%
Matrix element(s) :
2 µm
Stubs
View Zoom
2
B
Start
Labbook c:\ISIS\ac1\j114\
Stubs
GunShot
11:38

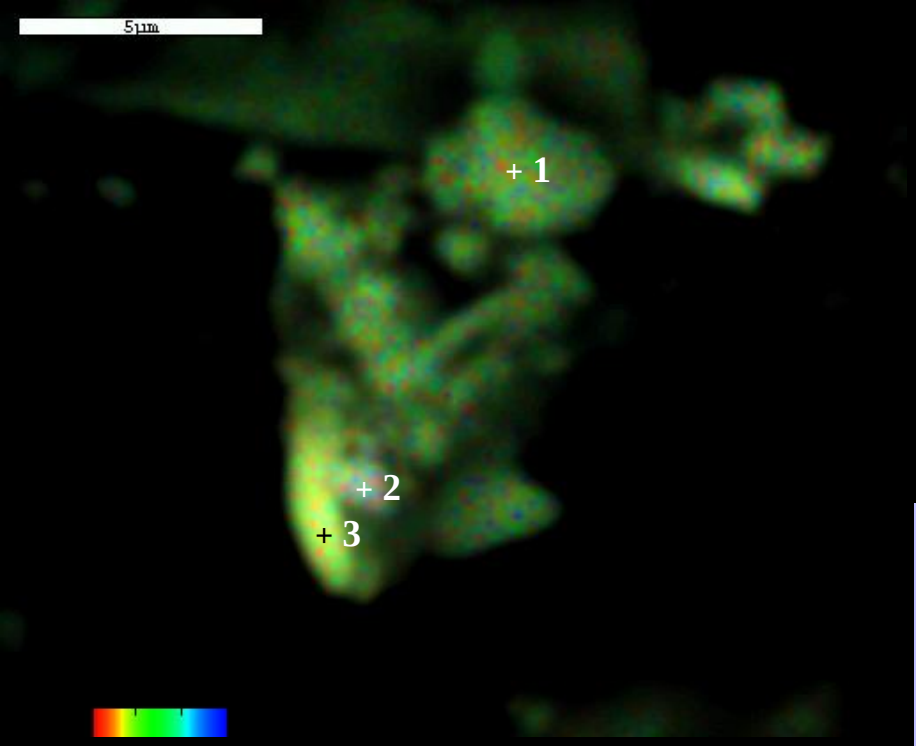

2µm


20µm
+ 3
+ 4
+ 1
+ 2

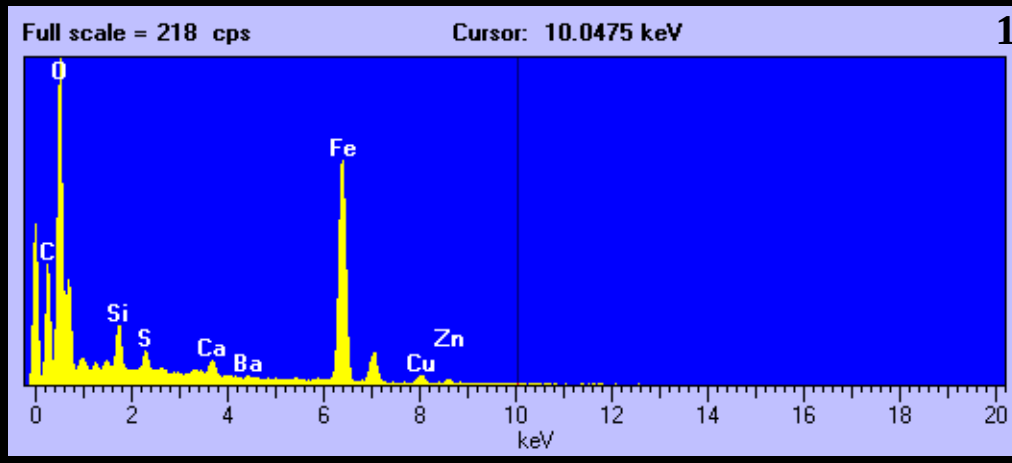

Full scale = 175 cps
Cursor: 10.0475 keV
1
C
O
Si
Al
Mg
S
K
Ca
Ba
Fe
Cu
0 2 4 6 8 10 12 14 16 18 20
keV

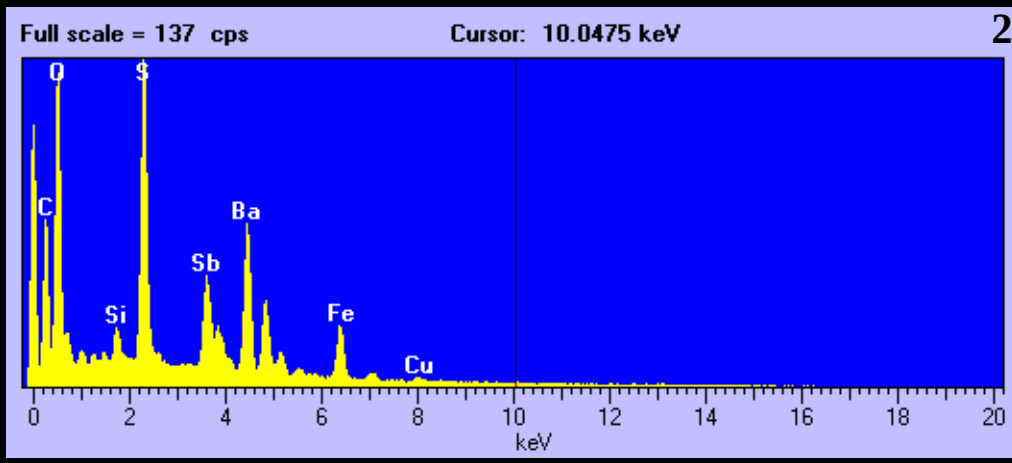

Full scale = 351 cps
Cursor: 10.0475 keV
2
Sb
Pb
C
O
Fe
Cu
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

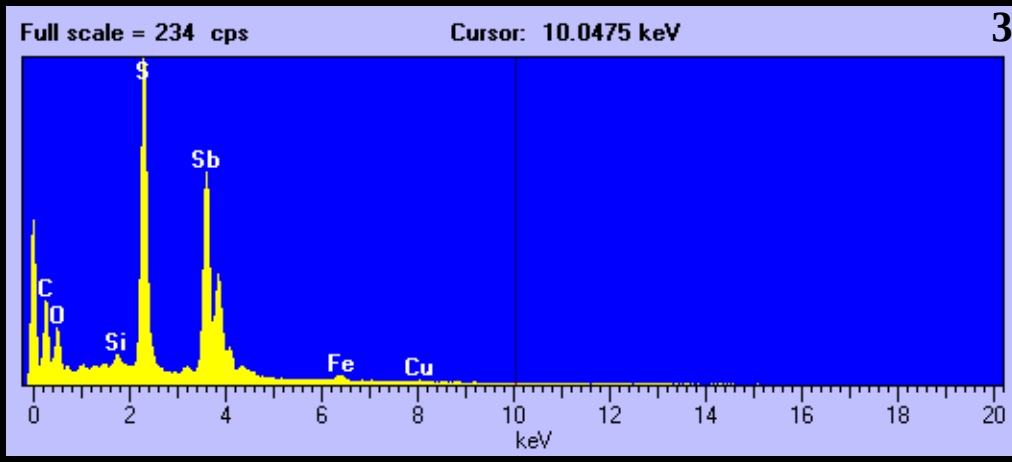

Full scale = 274 cps
Cursor: 10.0475 keV
3,4
C
Pb
Sb
O
Fe
Ni
Cu
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

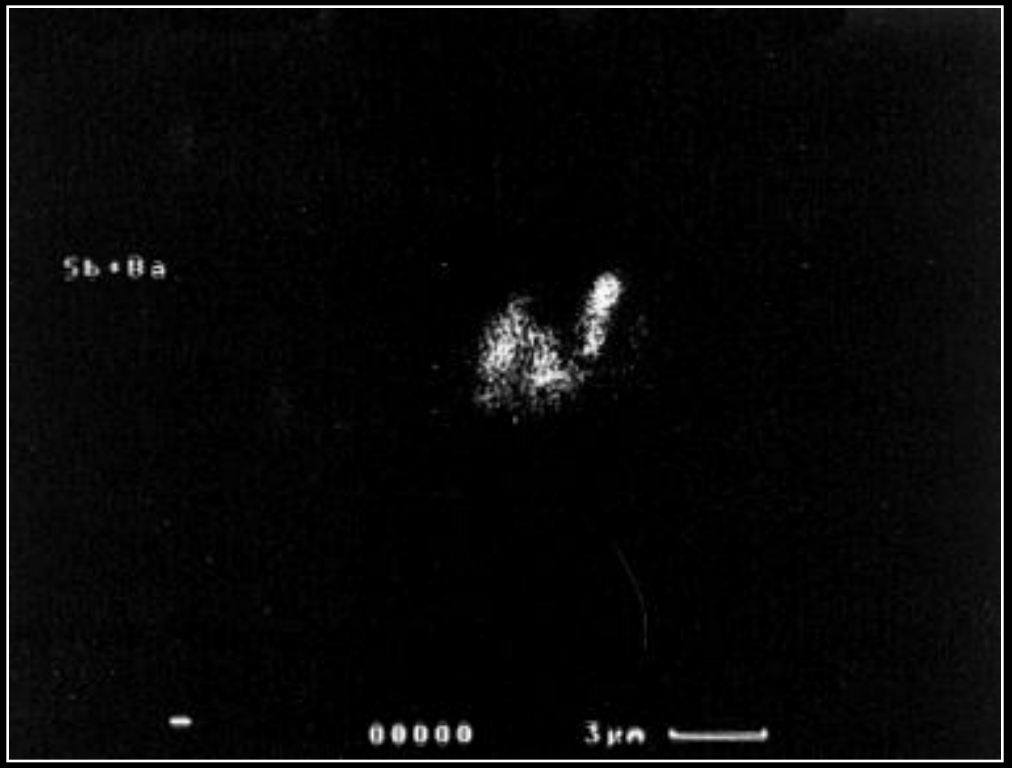

5µm
+ 1
+ 2
+ 3

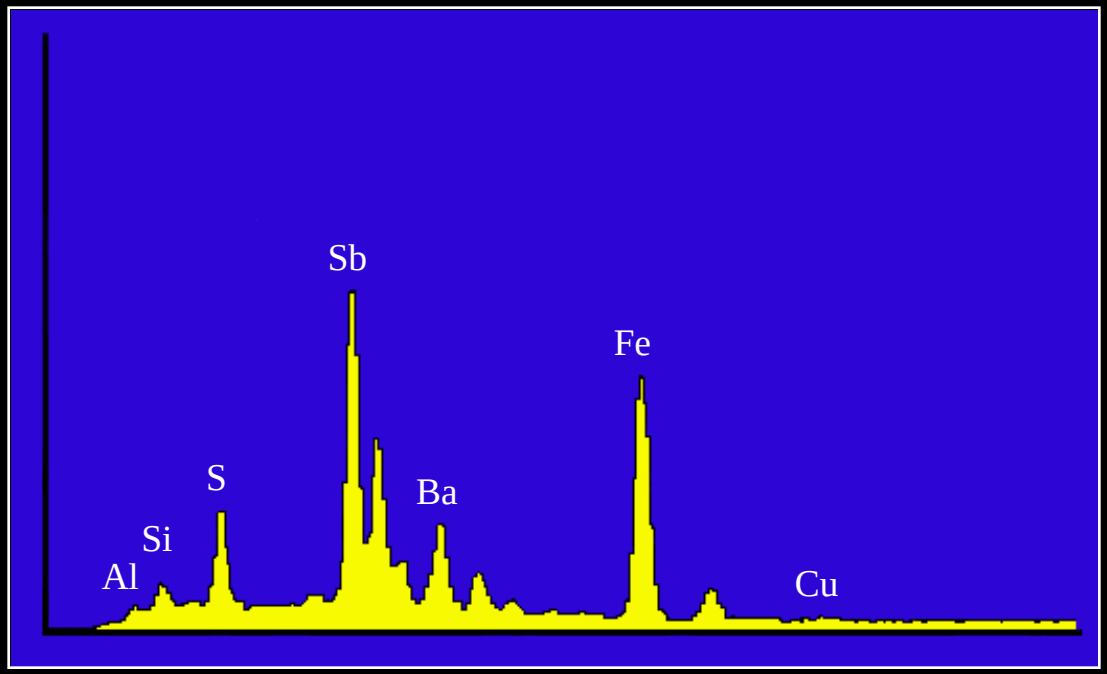

5µm

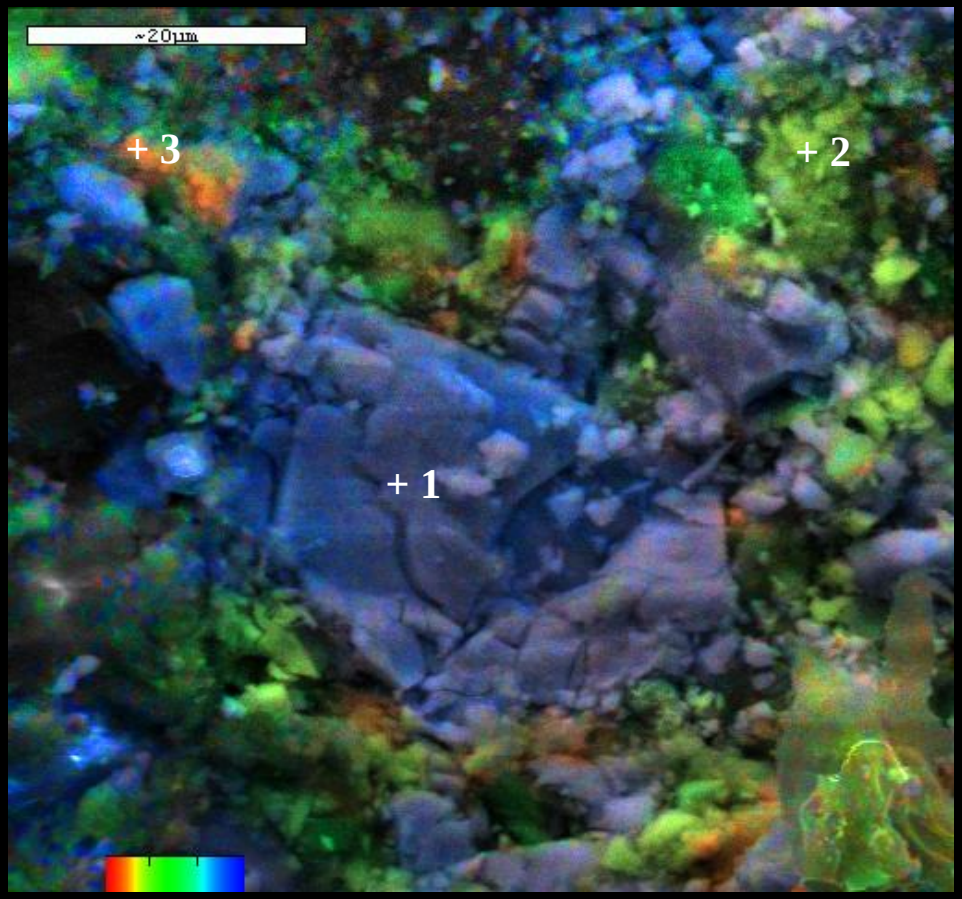

Full scale = 218 cps
Cursor: 10.0475 keV
1
O
Fe
C
Si
S
Ca
Ba
Cu
Zn
0 2 4 6 8 10 12 14 16 18 20
keV

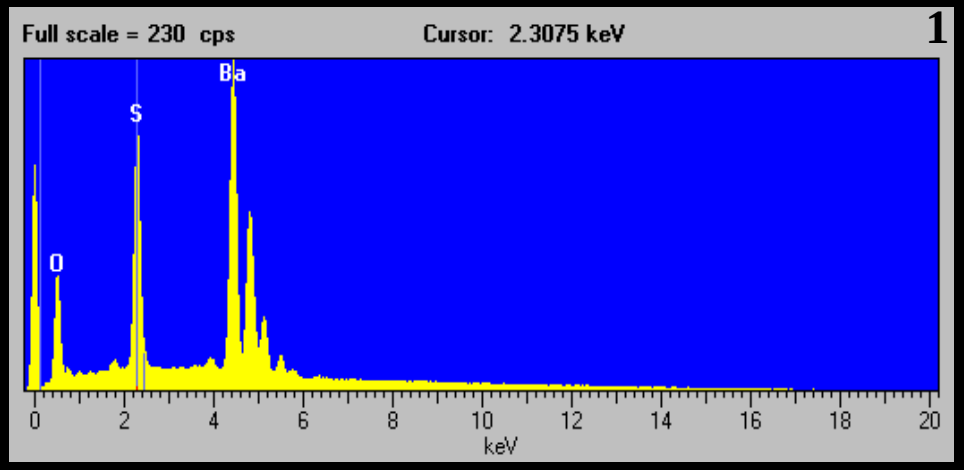

Full scale = 137 cps
Cursor: 10.0475 keV
2
O
S
C
Ba
Sb
Si
Fe
Cu
0 2 4 6 8 10 12 14 16 18 20
keV

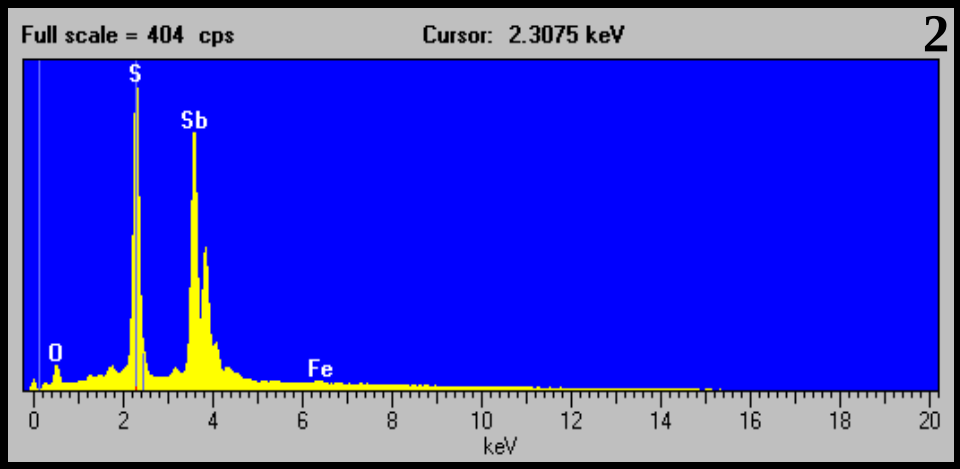

Full scale = 234 cps
Cursor: 10.0475 keV
3
S
Sb
C
O
Si
Fe
Cu
0 2 4 6 8 10 12 14 16 18 20
keV

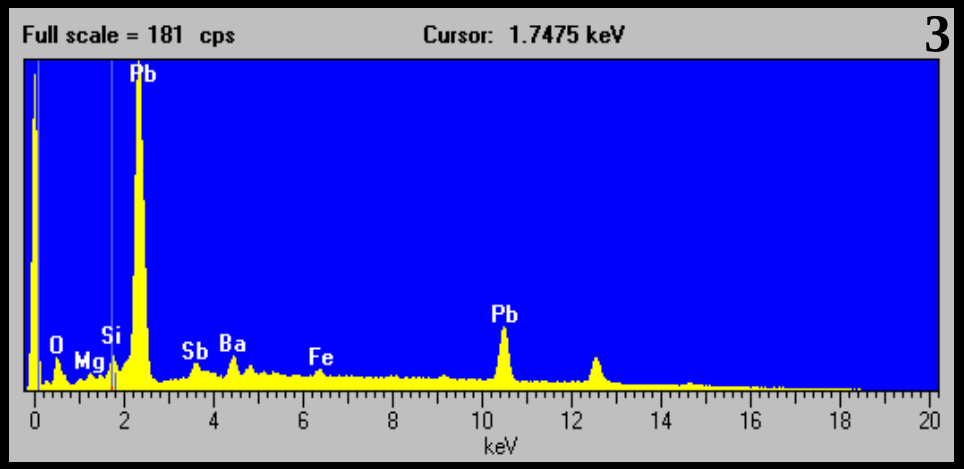

Sb+Ba
00000
3μm

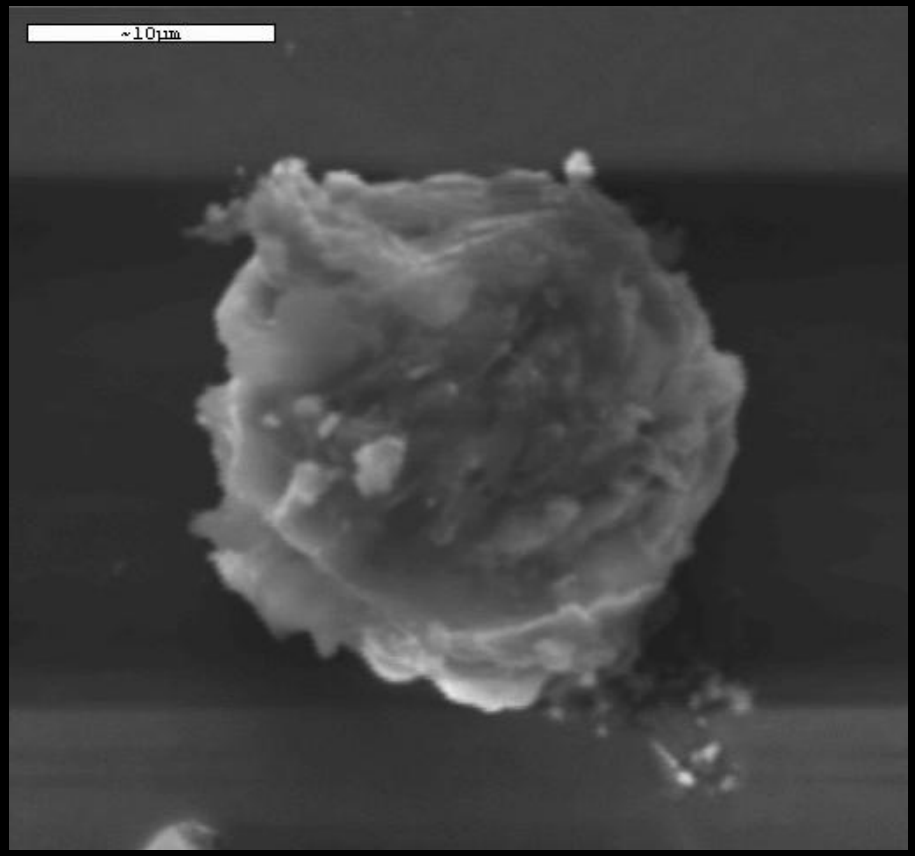

Sb
Fe
S
Ba
Si
Al
Cu

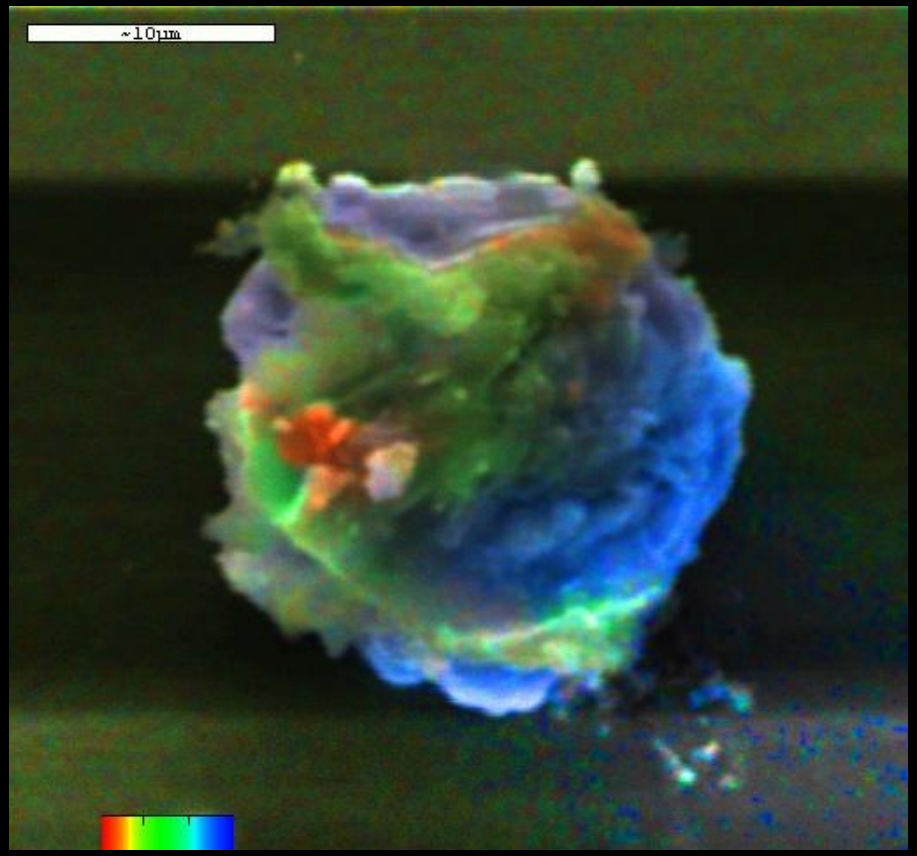

~20µm
+ 3
+ 2
+ 1

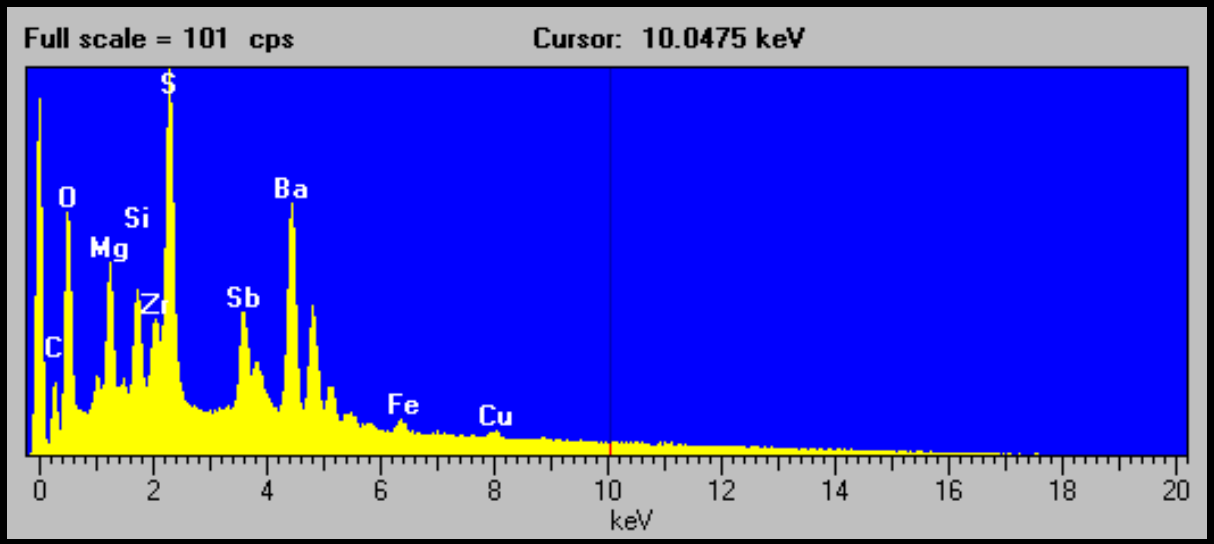

Full scale = 230 cps
Cursor: 2.3075 keV
1
Ba
S
O
0 2 4 6 8 10 12 14 16 18 20
keV


Full scale = 404 cps
Cursor: 2.3075 keV
2
S
Sb
O
Fe
0 2 4 6 8 10 12 14 16 18 20
keV

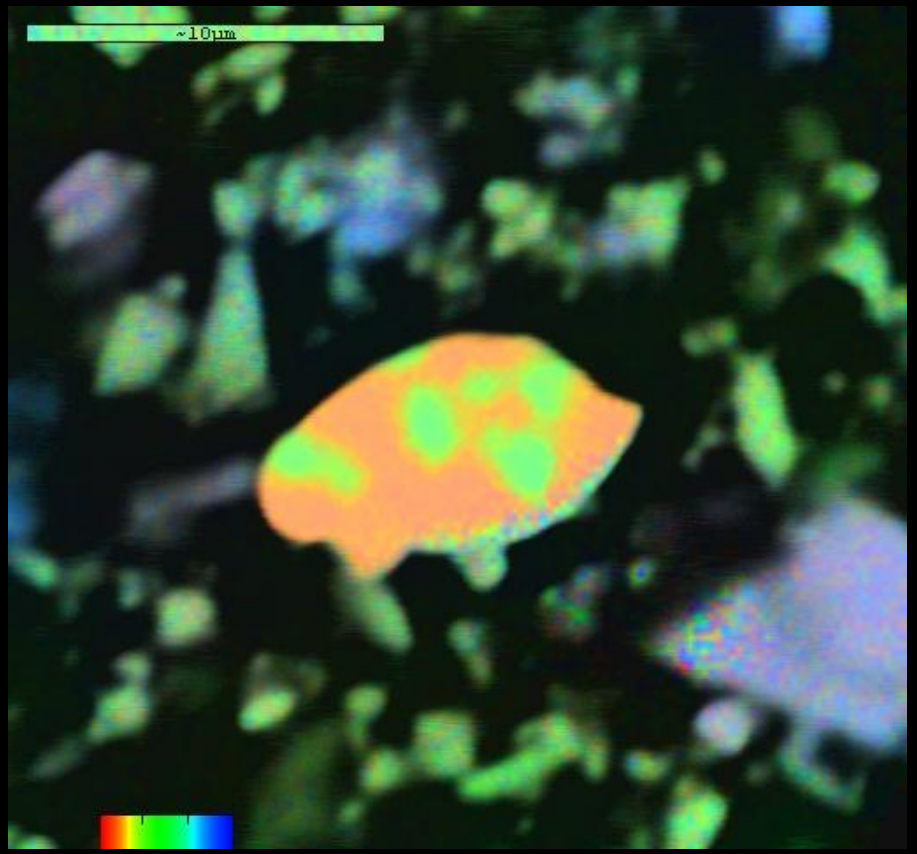

Full scale = 181 cps
Cursor: 1.7475 keV
3
Pb
O
Mg
Si
Sb
Ba
Fe
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

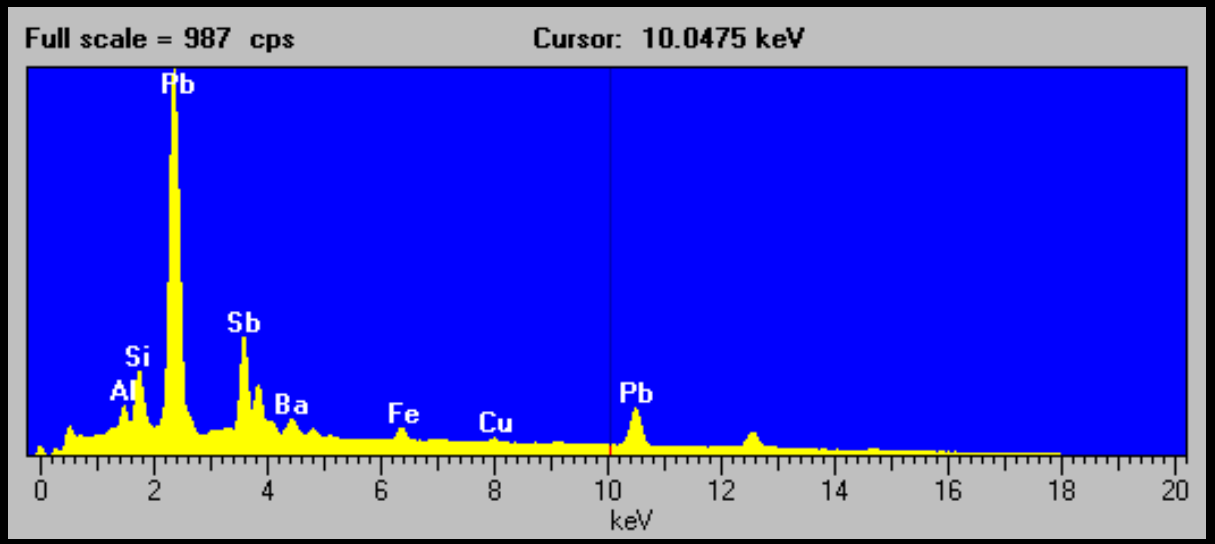

~10µm

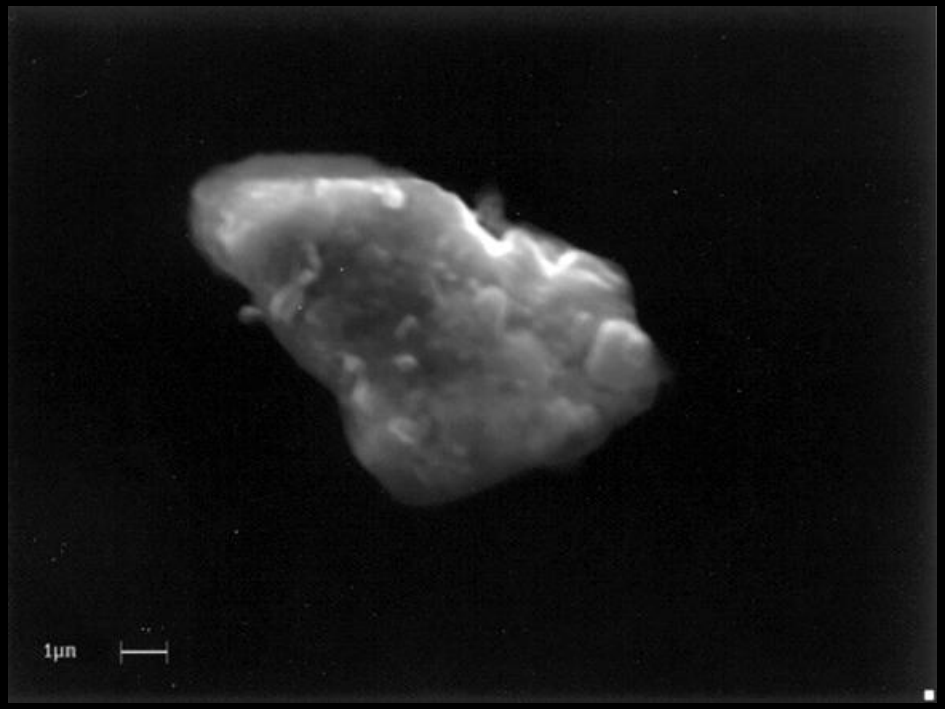

~10µm

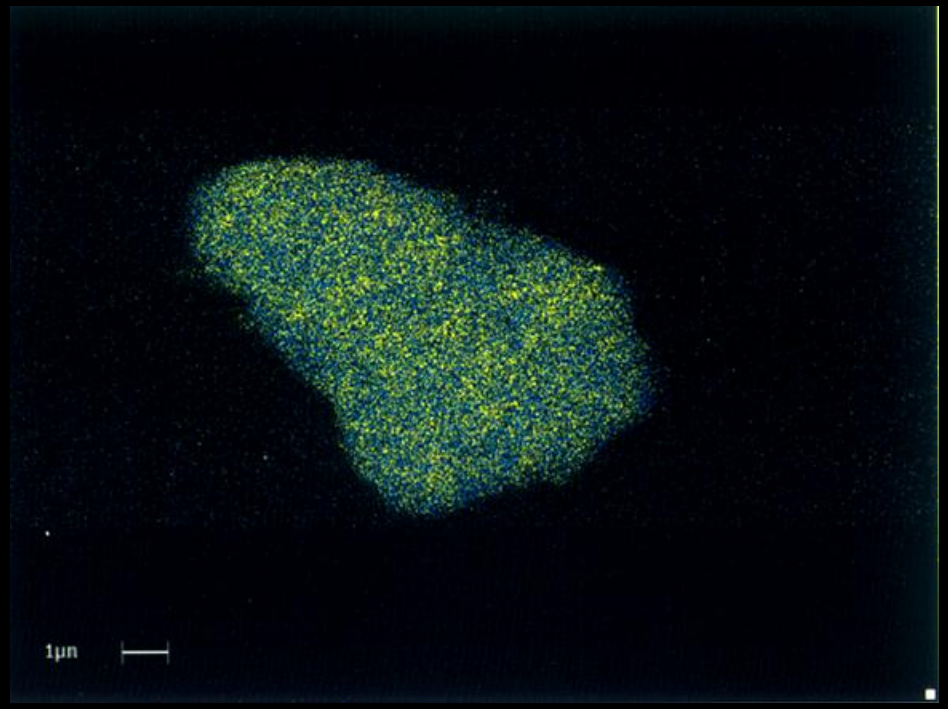

Full scale = 101 cps
Cursor: 10.0475 keV
S
O
Si
Mg
Zr
Sb
Ba
Fe
Cu
C
0
2
4
6
8
10
12
14
16
18
20
keV

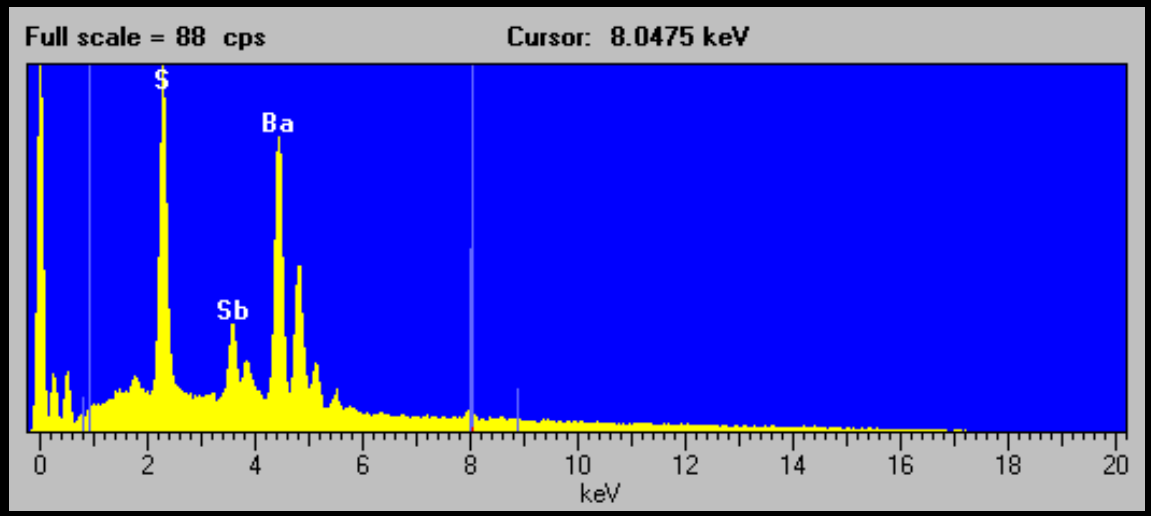

~10µm


~10µm


Full scale = 987 cps
Cursor: 10.0475 keV
Pb
Si
Al
Sb
Ba
Fe
Cu
Pb
0
2
4
6
8
10
12
14
16
18
20
keV


1µn


1µn


Full scale = 88 cps
Cursor: 8.0475 keV
S
Ba
Sb
0
2
4
6
8
10
12
14
16
18
20
keV

Zacchia, 73(vol. XVIII, serie 4a, fasc. 1-2): 137-151, 2000

Dipartimento di Anatomia, Farmacologia e Medicina Legale
della Università di Torino
Laboratorio di Scienze Criminalistiche

Piombo, bario ed antimonio in particelle non correlate a sparo

Prime osservazioni

Carlo Torre **Grazia Mattutino** **Valentina Vasino**

Gli studi che hanno posto le basi delle attuali tecniche di ricerca ed identificazione dei residui dello sparo (gunshot residue, G.S.R., degli Autori anglosassoni) con microscopio elettronico a scansione accoppiato a sistema di microanalisi (SEM – EDX) risalgono alla seconda metà degli anni '70 (8, 13, 14, 15). Fin dall'origine del metodo è apparso chiaro che il presupposto essenziale per una sua efficace applicazione nella pratica forense stava nello stabilire in primo luogo quale fosse la popolazione di particelle prodotta in uno sparo; in secondo luogo se esistessero particelle di origine diversa che avessero caratteristiche morfologiche e chimiche simili alle prime e che potessero perciò indurre ad errori interpretativi.

Si giunse in quegli anni ad una prima classificazione delle composizioni elementari modificata successivamente, nel 1984, da Wallace e McQuillan (11).

Quest'ultima classificazione può essere sintetizzata come segue:

particelle esclusive dello sparo	*particelle indicative*
piombo, antimonio, bario	silicio, calcio, bario
antimonio, bario	piombo, antimonio
	piombo, bario
	antimonio, zolfo
	antimonio senza zolfo
	bario senza zolfo
	piombo

Gli Autori ringraziano la dott.ssa Donatella Venezia e il dott. Kostantin Vikoulov della ITT Automotive Italy S.p.A. di Barge (CN) per l'indispensabile aiuto nella ricerca bibliografica sui materiali d'attrito.

Carlo Torre,[1] *M.D.; Grazia Mattutino,*[1]*; Valentina Vasino,*[1] *M.D.; Carlo Robino,*[1] *M.D.*

Brake Linings: A Source of Non-GSR Particles Containing Lead, Barium, and Antimony

REFERENCE: Torre C, Mattutino G, Vasino V, Robino C. Brake linings: a source of non-GSR particles containing lead, barium, and antimony. J Forensic Sci 2002;47(3):494–504.

ABSTRACT: The observation of environmental particles similar in composition to gunshot residue (GSR) are not new to forensic experts and have been described in the scientific literature. In order to better define the origin of these particles, brake linings and their wear products were examined by SEM-EDX. The results obtained demonstrate that some types of brake linings contain lead, barium, and antimony and that they can represent a source of particles showing GSR-like elemental profiles. Most of these particles can be easily discriminated from primer discharge residue because of the high levels of iron or the presence of "prohibited" elements in the spectrum. However, particles with iron at minor or trace levels and lacking "prohibited" elements were also found. It is thus advisable to use caution when describing the composition of similar particles as "unique" to primer discharge residue. The strict application of a rigorous morphological criterion is also recommended.

KEYWORDS: forensic science, criminalistics, gunshot residue, environmental particles, scanning electron microscopy/energy-dispersive spectroscopy

The scientific basis for the techniques currently employed in the research and identification of gunshot residue (GSR) were laid down in studies dating back to the second half of the 1970s (1–4). Since these early years, awarness of the presence of occupational-environmental particles similar in composition to GSR, which may lead to misinterpretation, prompted the creation of a first classification system specifying the compositions to be considered *characteristic* (observed only in gunshot residue) and those *consistent* with, but not unique to, firearm discharge residue (2,3). This classification was modified in 1984 by Wallace and McQuillan (5). In their opinion, only particles of lead, barium, and antimony, or barium and antimony, may still be considered *unique*, bearing in mind that the use of the term *unique* is not limited to firearm discharge residue, but must be generally extended to discharge residue of any primer based on a mixture of lead, barium, and antimony compounds. Wallace and McQuillan also suggested a list of *indicative* (but not unique) compositions. Both unique and indicative particles must show at least one of the primary elements (lead, barium, and antimony) at a major level. Particles may also include aluminium, calcium, sulphur, and silicon at major, minor, or trace levels; chlorine, copper, iron, potassium, and zinc (solely in presence of copper and with zinc/copper ratio below 1) at minor or trace levels; or magnesium, sodium and phosphorus at trace level only. The presence of any other element usually indicates an origin other than primer discharge. In this classification, the terms "major," "minor," and "trace" refer to the relative height of the main peak of the element concerned, compared to the strongest peak in the spectrum: the element is "major" when its main peak height is above 1/3 the height of the strongest peak; "minor" when its main peak height is between 1/3 and 1/10 the height of the strongest peak; "trace" when its main peak height is below 1/10 the height of the strongest peak. The strongest peak in the spectrum must be "on scale." A simplified form of the classification proposed by Wallace and McQuillan was also adopted in the ASTM standard guide for gunshot residue analysis by scanning electron microscopy/energy-dispersive spectroscopy (6).

However, the most recent systematic study comparing GSR and occupational-environmental particles (7) suggested that particles composed of barium and antimony should be removed from the "unique" category and assigned to the "indicative" category. It is also confirmed that cartridge-operated industrial tools and fireworks can produce particles with a composition that is similar to GSR.

Since 1982 the Laboratory of Criminalistic Sciences of the University of Turin has specialized in the study of GSR. As a consequence, its staff is often asked for scientific advice in the advanced stages of criminal trials, when in-depth evaluation of the results of GSR analyses performed during preliminary investigations is needed by the court. This privileged position, entitling the Laboratory's scientists to review other experts' work, has resulted in the creation of a large case record including not only personal data, but also those from several Italian laboratories carrying out GSR investigation.

Figure 1*a–d* shows a selection of particles from this case record, which were identified as GSR by experts. Some laboratories (even recently) have been classifying "unique" particles as composed of: barium and antimony with iron at a major level (Fig. 1*a*); lead, barium and antimony with iron at a major level and with exogenous elements, like chromium and manganese, in traces (manganese in traces is present in the spectrum shown in Fig. 1*b*); lead, barium, and antimony with magnesium at a minor level (Fig. 1*c*). According to the classification of Wallace and McQuillan, and to personal experience, these particles should not be considered as "unique." Strictly speaking, because of their ubiquitous environmental distribution, they cannot even be described as "indicative": only when particles with the same features are found in the discharge residue from the firearm and/or ammunition used in the crime, may they be carefully taken into consideration. Italian laboratories, as a rule, consider "unique" particles as composed of barium and antimony, with iron at minor or trace levels (Fig. 1*d*). Although the signifi-

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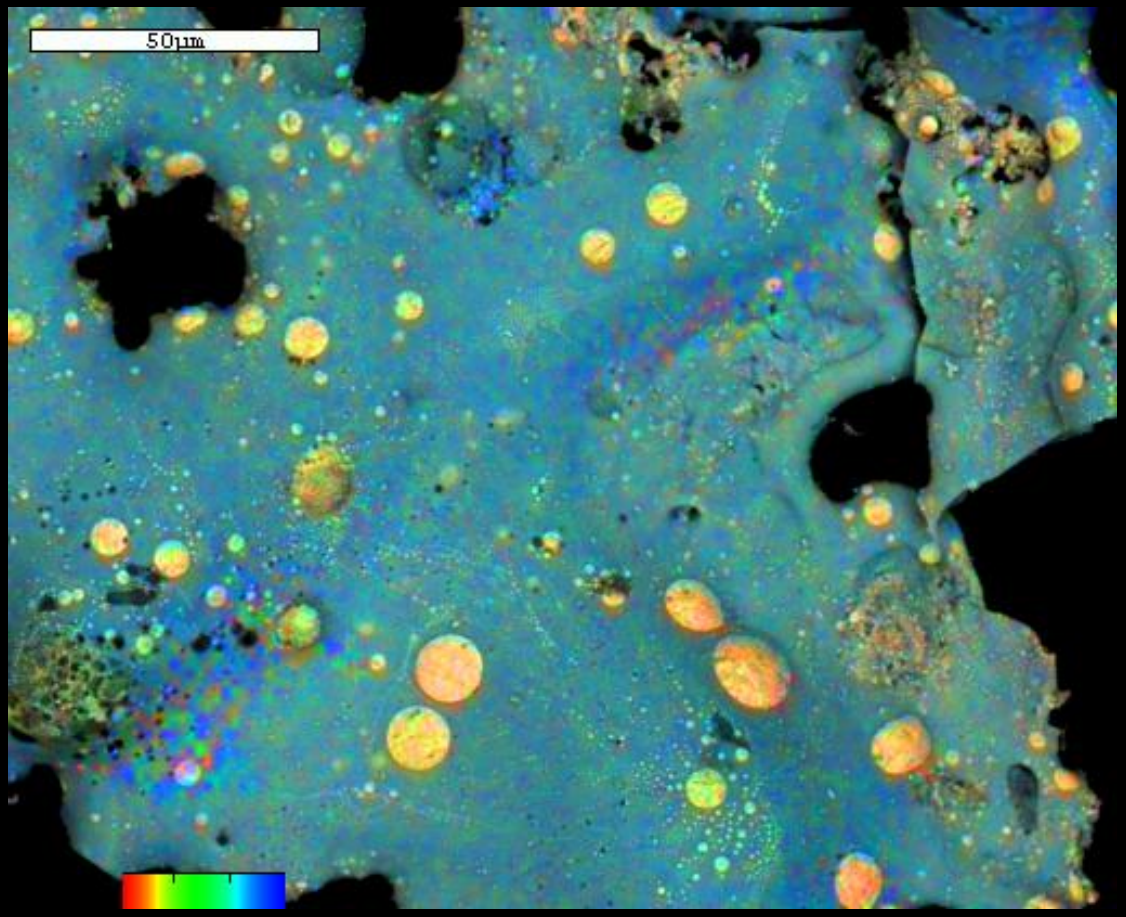
Per una corretta interpretazione
è necessario
conoscere la
composizione dell'innesco
delle munizioni
implicate nel caso che si studia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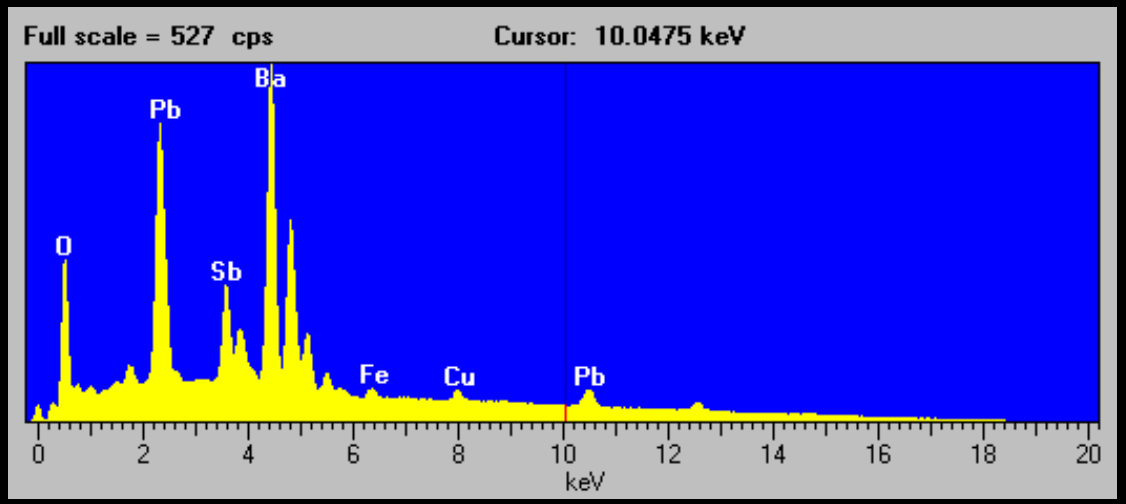
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Ba
Fe
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8
10
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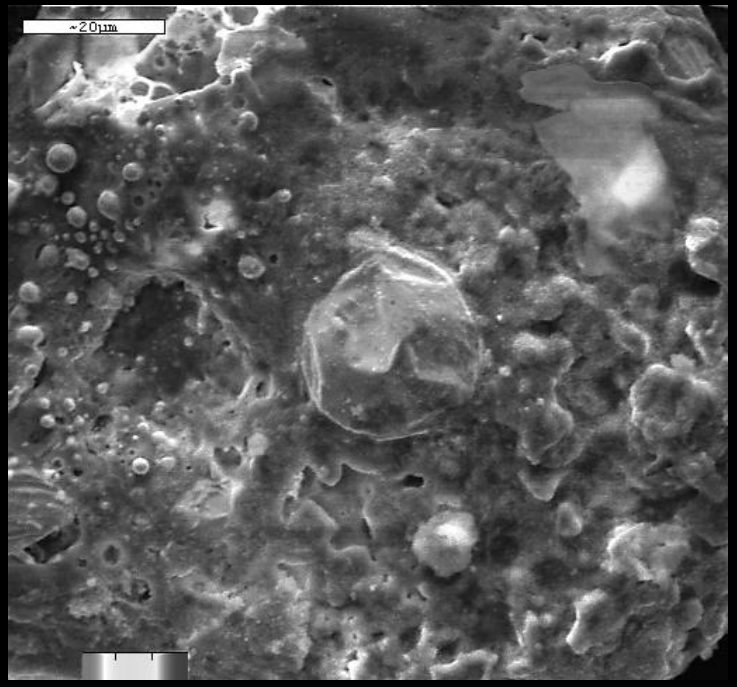
14
16
18
20
keV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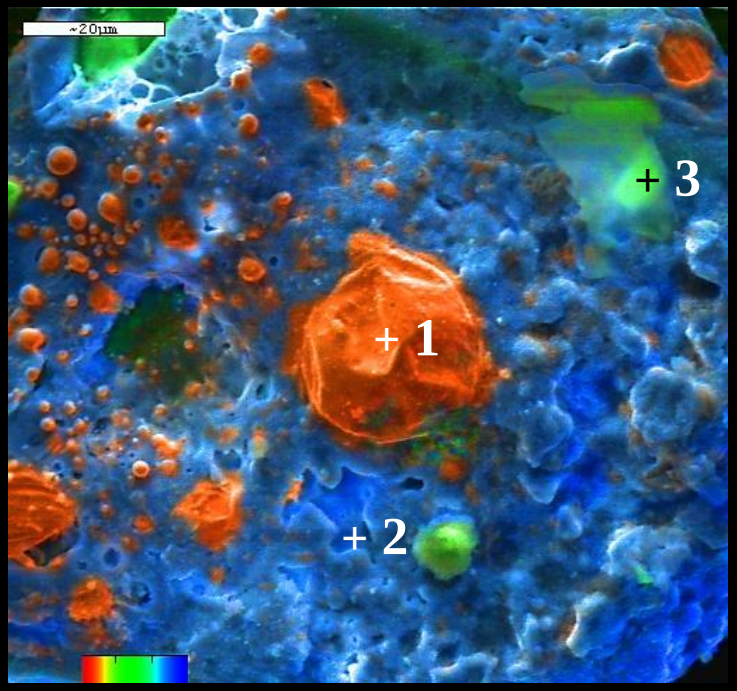
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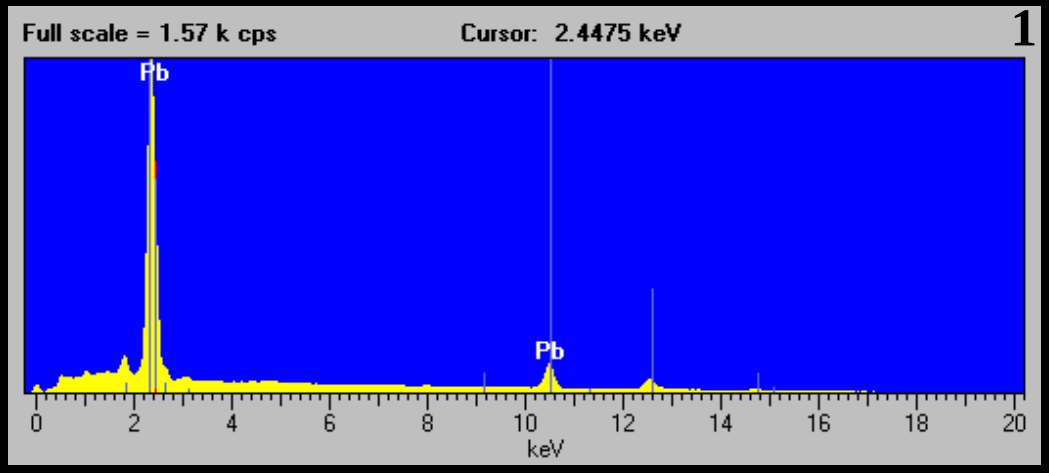
+ 3
+ 1
+ 2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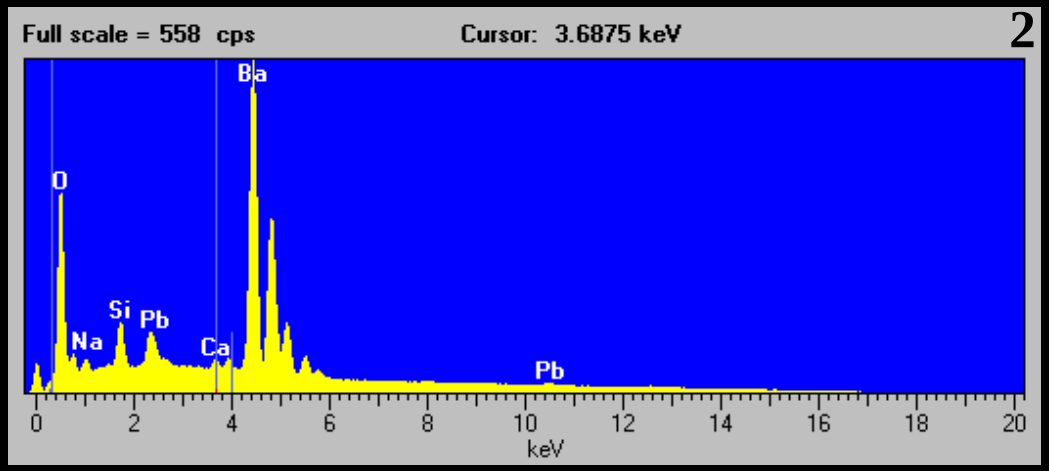
1
Pb
Pb
0 2 4 6 8 10 12 14 16 18 20
keV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O
Si
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Ca
Pb
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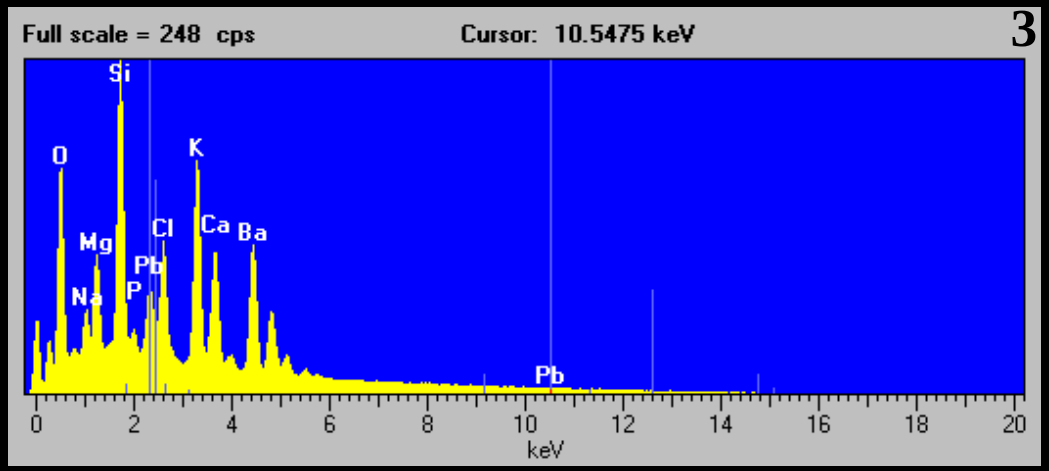
keV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K
Mg
Cl
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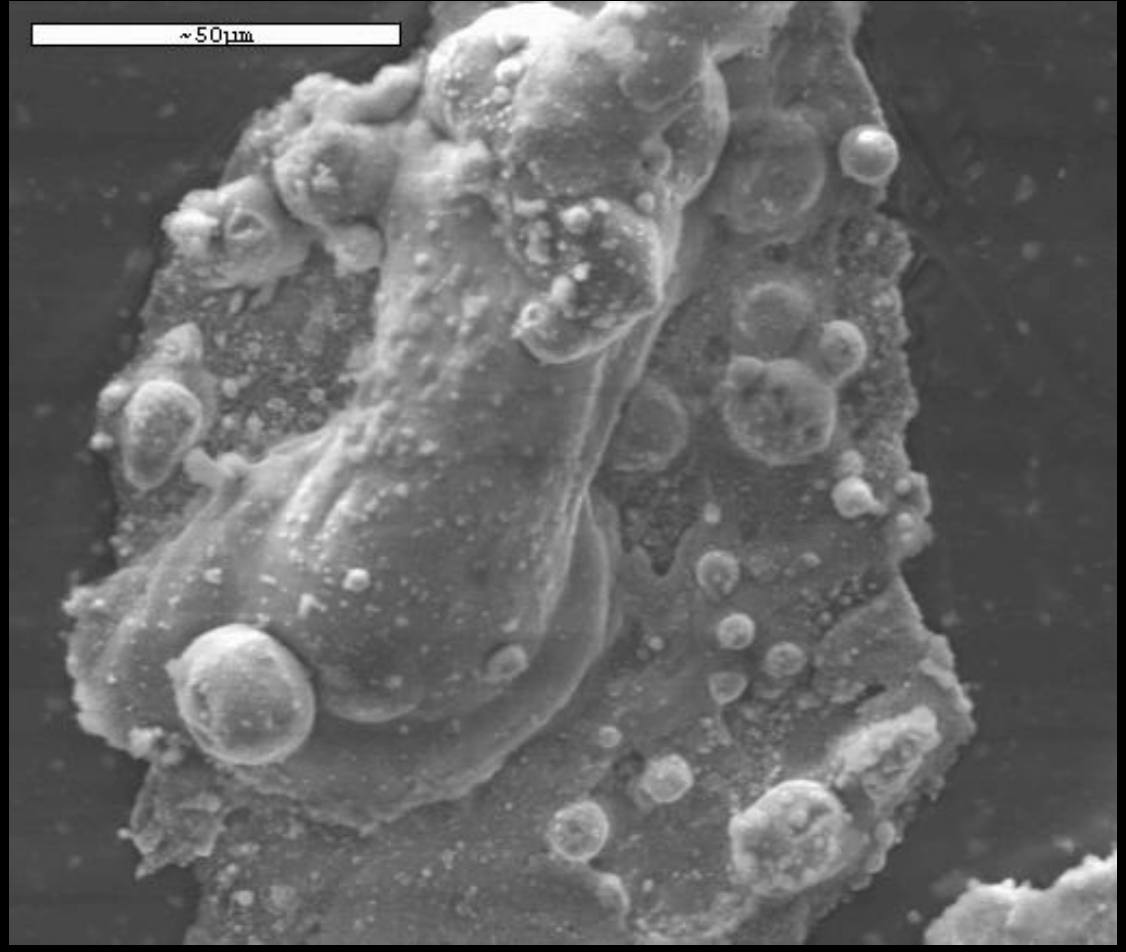
Ba
Pb
Na
P
Pb
0 2 4 6 8 10 12 14 16 18 20
keV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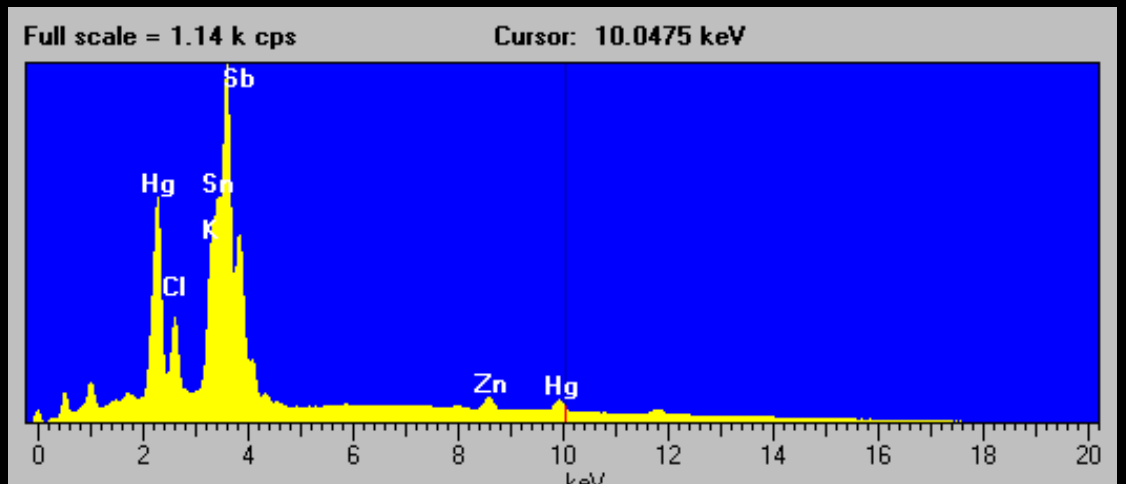
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Cursor: 10.0475 keV
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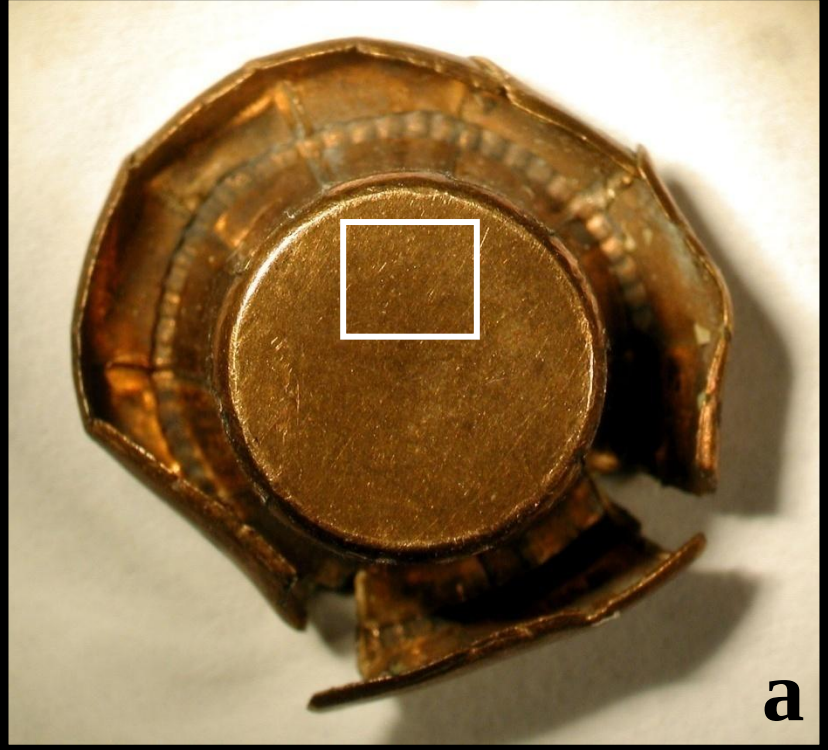
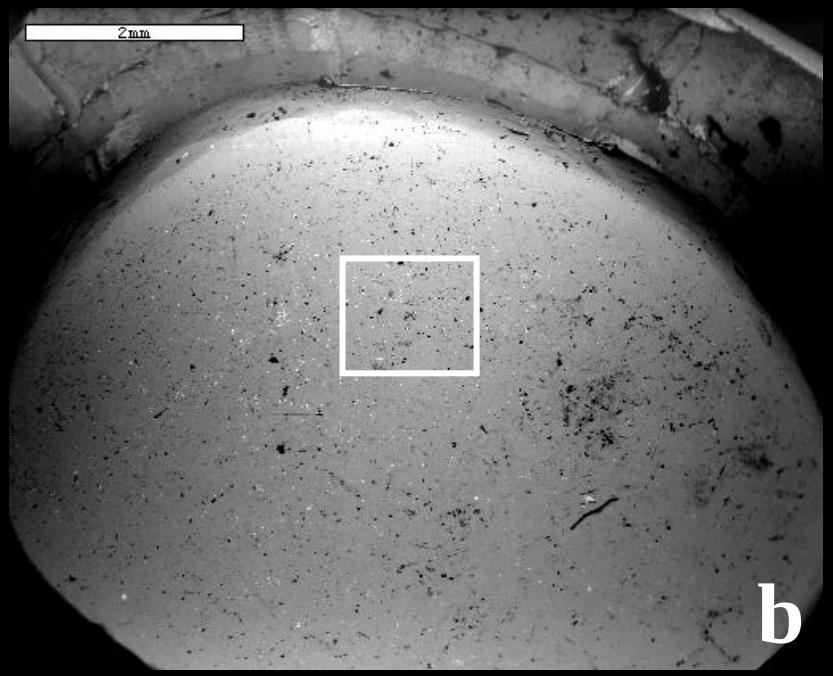
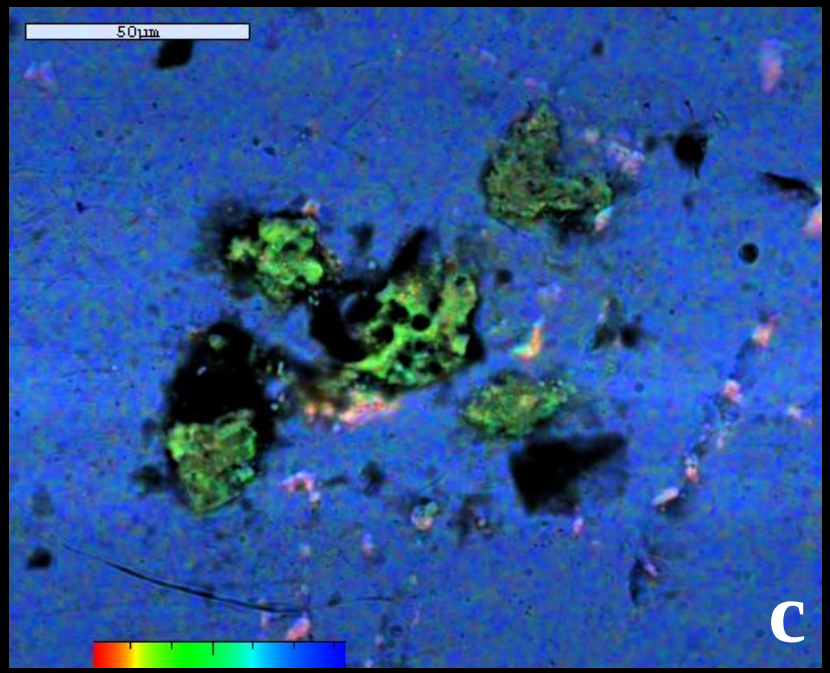
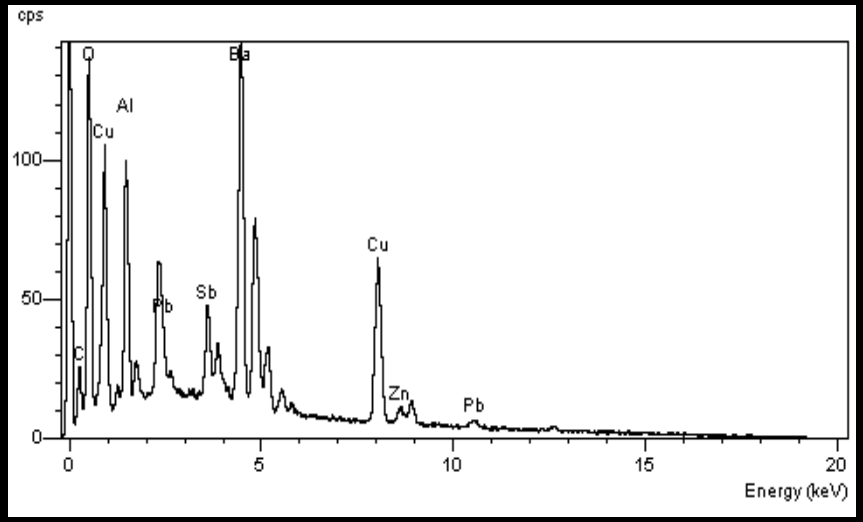
Hg
Sn
K
Cl
Zn
Hg
0
2
4
6
8
10
12
14
16
18
20
keV

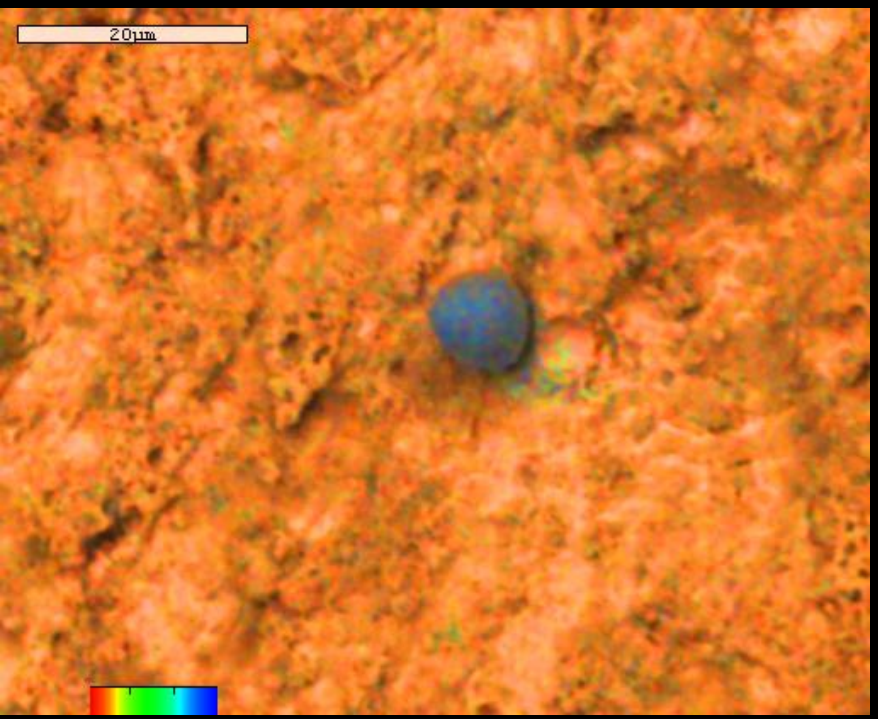

a


2mm
b


50µm
c


cps
O
Al
Cu
Ba
Cu
Sb
Pb
C
Zn
Pb
100
50
0
0
5
10
15
20
Energy (keV)


20µm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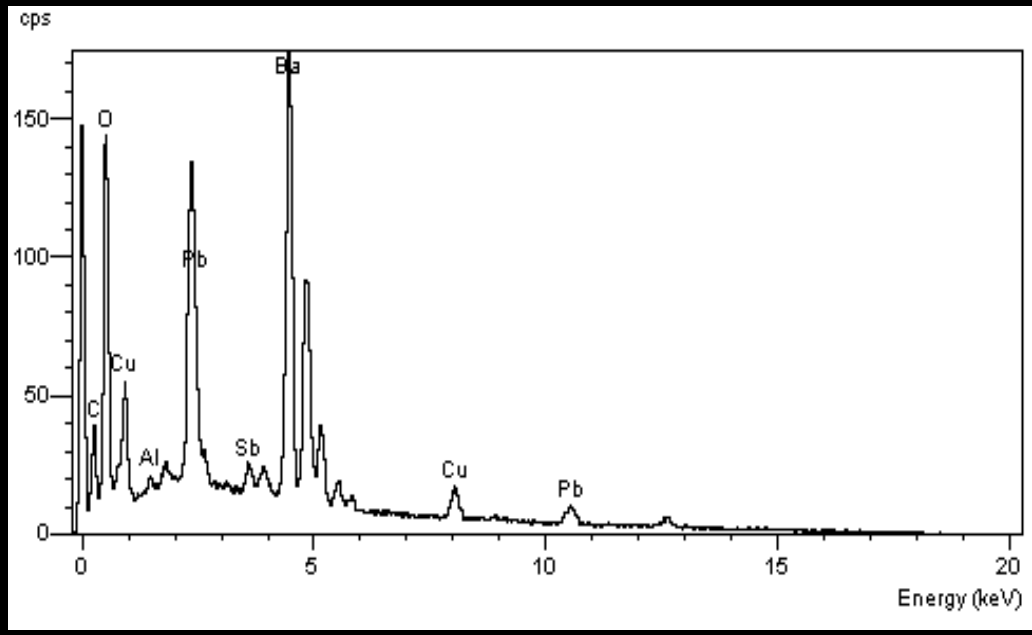
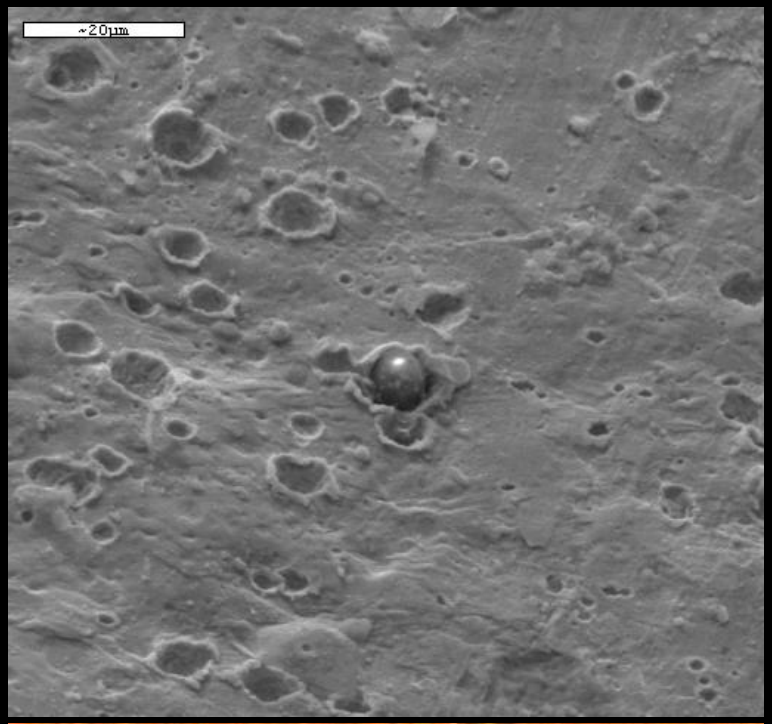

cps
150
100
50
0
O
Ba
Pb
Cu
C
Al
Sb
Cu
Pb
0
5
10
15
20
Energy (keV)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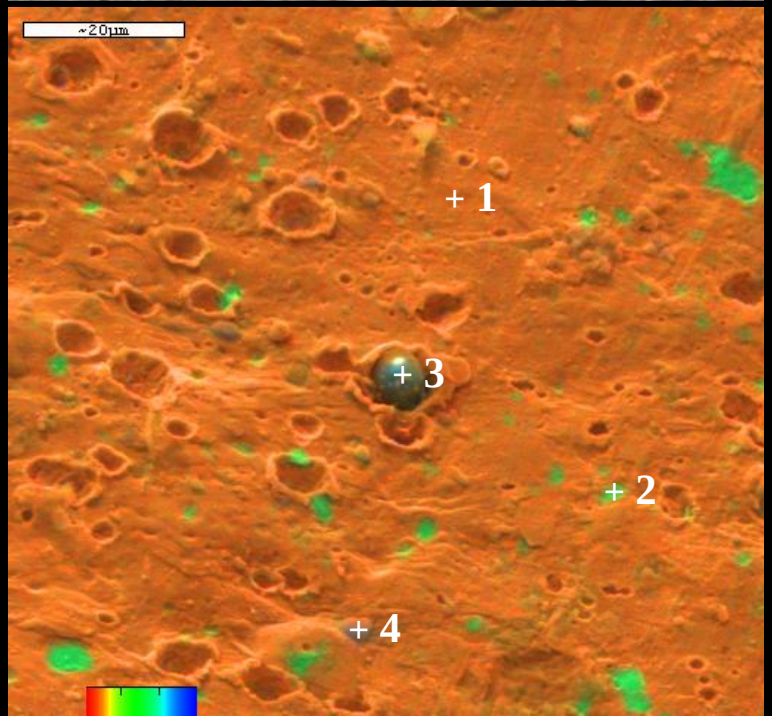
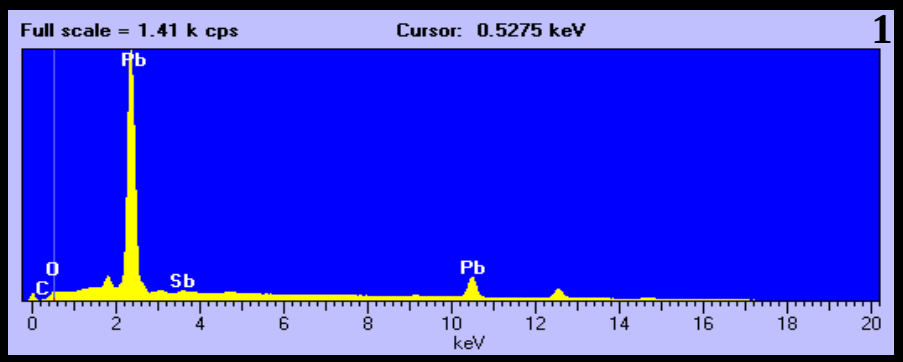

~20µm
+ 1
+ 3
+ 2
+ 4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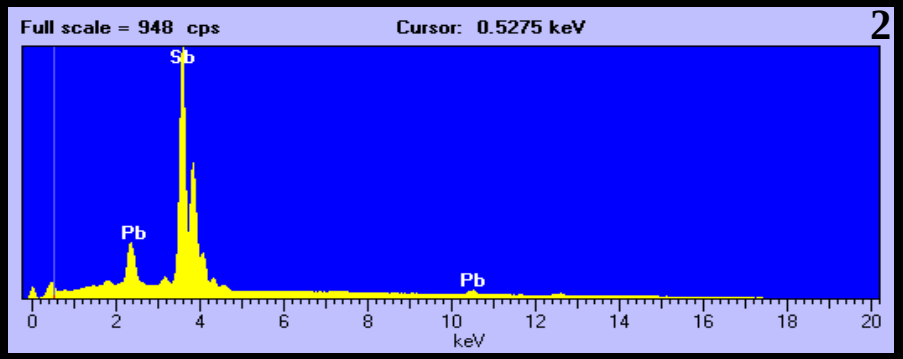
1
Pb
O
C
Sb
Pb
0 2 4 6 8 10 12 14 16 18 20
keV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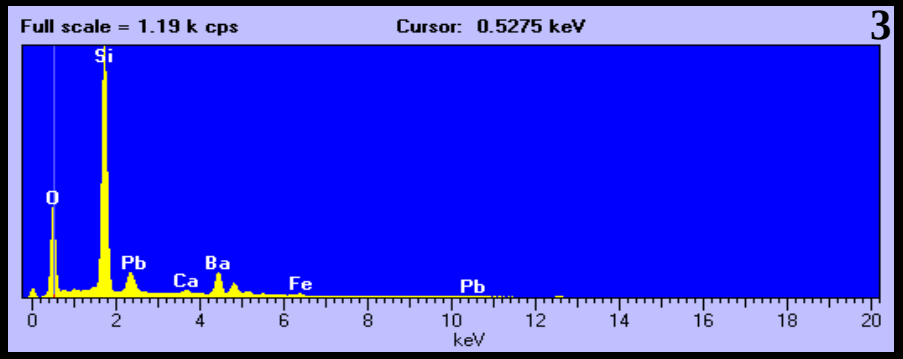
2
Sb
Pb
Pb
0 2 4 6 8 10 12 14 16 18 20
keV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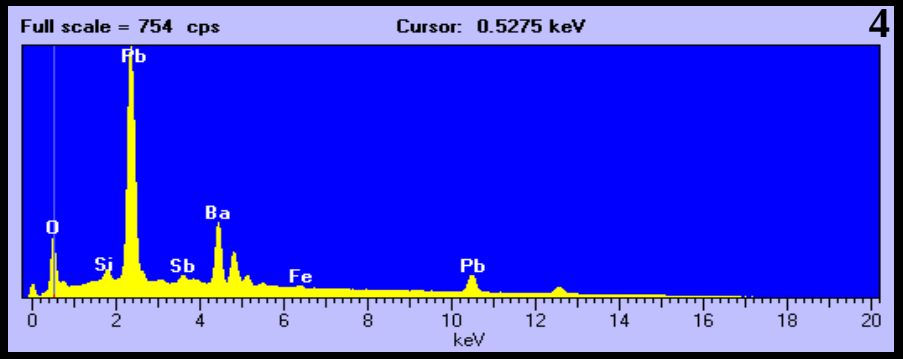
3
Si
O
Pb
Ca
Ba
Fe
Pb
0 2 4 6 8 10 12 14 16 18 20
keV


Full scale = 754 cps
Cursor: 0.5275 keV
4
Pb
O
Si
Sb
Ba
Fe
Pb
0 2 4 6 8 10 12 14 16 18 20
keV

TECHNICAL NOTE

Carlo Torre,[1] *M.D. and Grazia Mattutino*[1]

Application of True Color X-Ray Vision for Electron Microscopy in Fired Bullets and Gunshot Residue Investigation

REFERENCE: Torre C, Mattutino G. Application of true color X-ray vision for electron microscopy in fired bullets and gunshot residue investigation. J Forensic Sci 2000;(45)4:865–871.

ABSTRACT: An X-ray color imaging system was used to study primer particles and fired bullets from different .22 rimfire ammunition. The technique proved to be very useful, allowing a ready, concomitant analysis of the morphology of primer particles and their elemental composition. The investigation of the bottom of fired bullets showed that antimony present in the bullet alloy is not evenly distributed, but organized in plates made up of almost pure antimony. Moreover, particles and other traces adherent to lead bottomed bullets containing elements different from lead, therefore, useful to the understanding of primer composition are readily and easily detected.

KEYWORDS: forensic science, criminalistics, fired bullets, gunshot residue, SEM, X-ray, color imaging

Scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX) is a well-established technique for detection and classification of gunshot residue (GSR) particles (1–4). This method is especially valuable for detection of GSR on anatomical surfaces and clothes of suspect shooters. In cases of shooting from short distances, it allows the detection of GSR on the target area. Traces characteristic of ammunition can also be detected around the bullet entrance hole in cases of long range firing distances (5).

In these circumstances, knowledge of the primer composition is useful for the identification of the type of ammunition fired and to verify its compatibility with particles found on the suspect or at the crime scene. This kind of investigation is particularly helpful in cases of unusually primed ammunitions with mercury fulminate or lead free primers, or in .22 rimfire cartridges whose primers usually lack antimony. Obviously, attention must be paid to the possibility of carry-over of primer materials from previous firings (6–10).

Detection of GSR on the bottom of fired bullets (11) can be used for understanding primer composition, especially when cartridge cases are not found. This analysis is easily performed on brass, copper or steel bottomed bullets. In the backscattered image, GSR are readily recognized because of their brightness. On the other hand, detection of GSR and other primer smears in lead bottomed bullets is often challenging, since in backscattered imaging, there is no way to distinguish lead belonging to the bullet from heavy metals contained in the primers only by brightness.

In this work, the Cameo™ program for X-ray color imaging was tested for the study of GSR on fired bullets. Theoretical bases and general applications of color X-ray vision for electron microscopy and microanalysis are described by Statham (12). Briefly, the specific X-ray energy spectrum emitted in the SEM by excited atoms from different elements is detected by EDX and used to reconstruct a true color image which, still retaining the topographical and morphological features of the sample under study, also portrays its underlying elemental composition. This can be achieved by means of an energy dispersive X-ray detector and analysis system. Just as the visual pigments in the cones of the retina, the system assigns color to photons based on their effective wavelengths using a rainbow color scale. The result is similar to offsetting the human visual response to the electromagnetic spectrum into an X-ray wavelength region of choice. Unlike the other SEM color enhancement techniques, the color obtained is "natural"; that is to say, changes in topography and shadowing affect the color in the same way as visible objects.

Methods

Shooting experiments were carried out with several .22LR rimfire ammunitions (Eley, RWS, Federal, Winchester, Fiocchi, Orbea, Remington). Samples were collected from cartridge cases using wooden toothpicks and transferred to double-sided adhesive tape coated stubs. Stubs were then carbon-coated. In order to obtain the removal of any "loose" GSR particles and prevent possible contamination of the SEM sample chamber, bullets were washed in distilled water, then dried and attached on stubs that were not carbon-coated. Each sample was examined and analyzed using a Cambridge 110 scanning electron microscope with a Link ISIS 300 microanalysis system equipped with the Cameo program for X-ray color. After an initial survey conducted at approximately 350X, traces of interest were further examined at a higher magnification.

Results

The analysis of residues found in cartridge cases with an X-ray color imaging system provides the operator with a preliminary visual cue for the definition of the elemental composition of primers (Figs. 1 and 2) to be further investigated by microanalysis.

By examining lead bullets, it was observed that antimony is not evenly distributed, but concentrated in small plates with sharp contours, clearly standing out against the lead background. Figure 3

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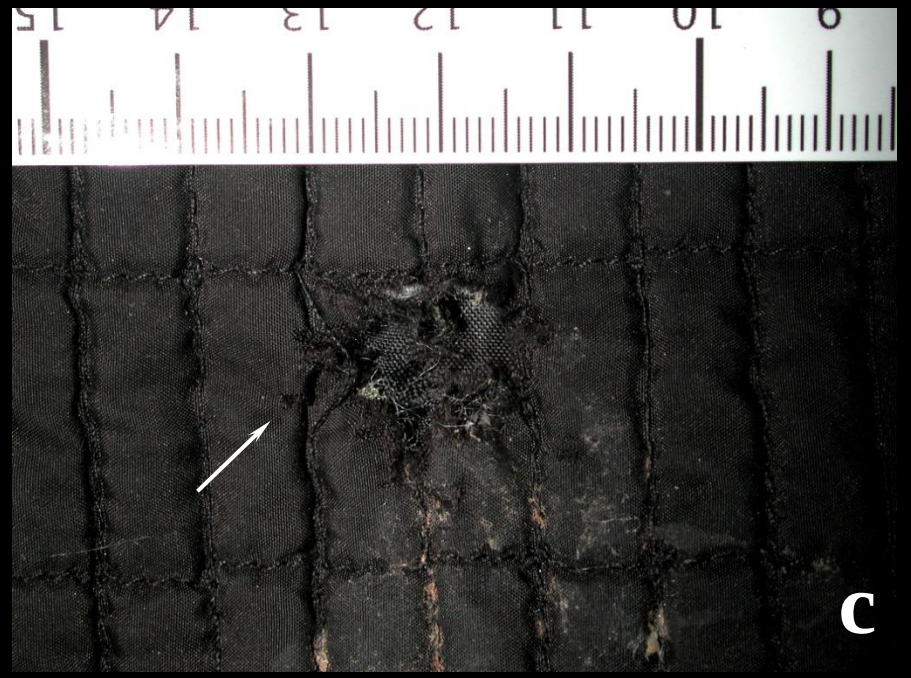
Non solo mani …


a


b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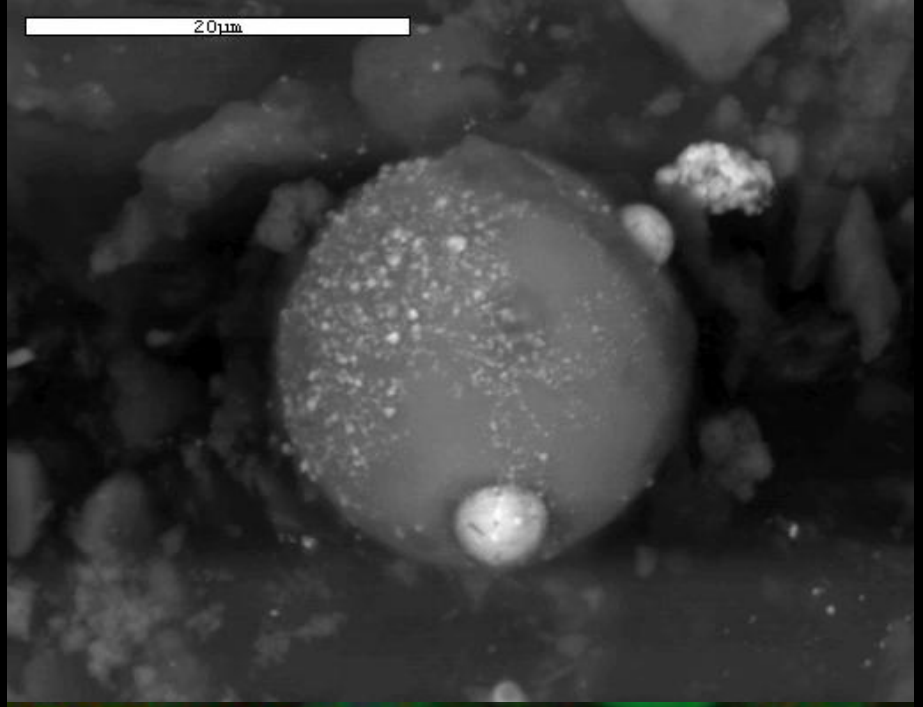
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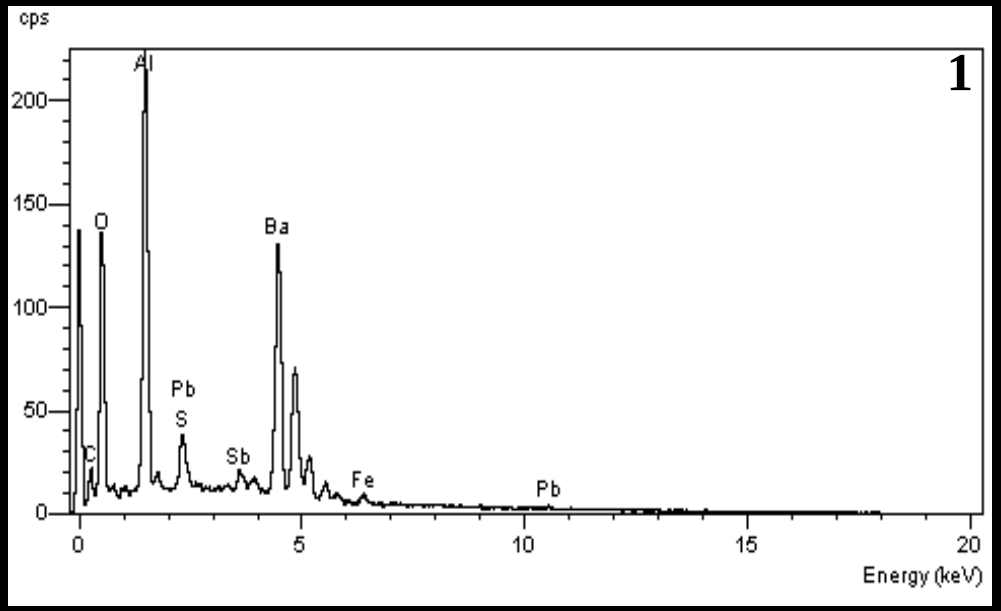
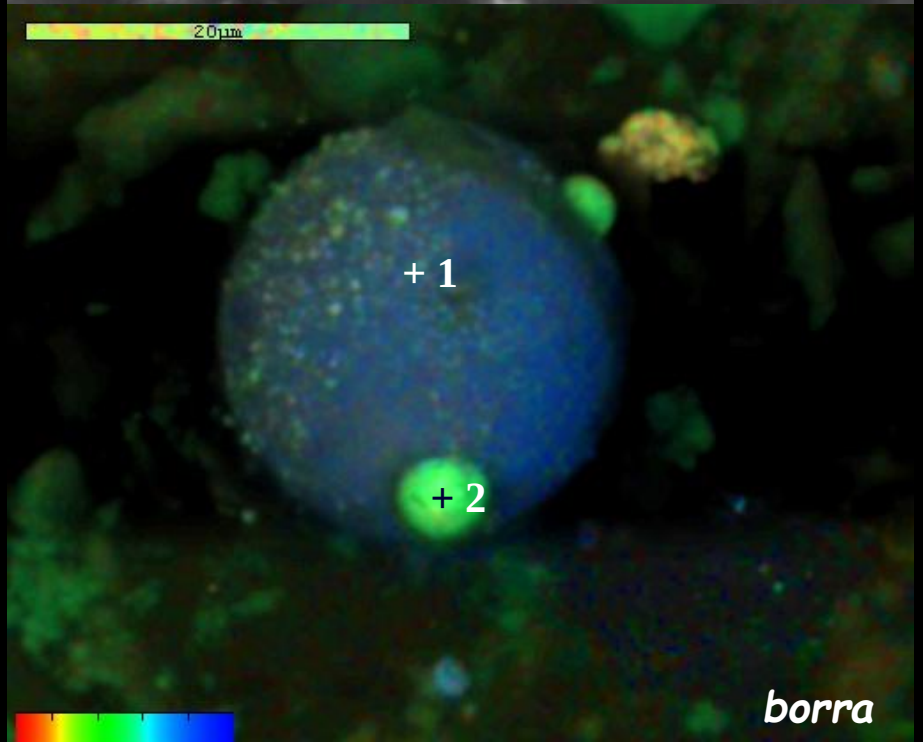
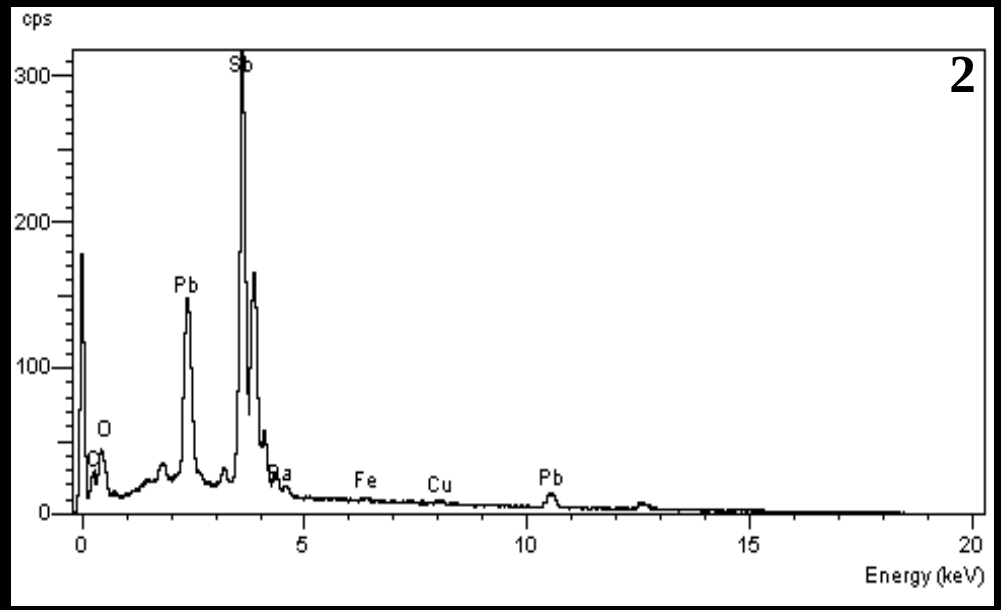

cps
1
Al
O
Ba
Pb
S
C
Sb
Fe
Pb
0
50
100
150
200
0
5
10
15
20
Energy (keV)


20µm
+ 1
+ 2
borra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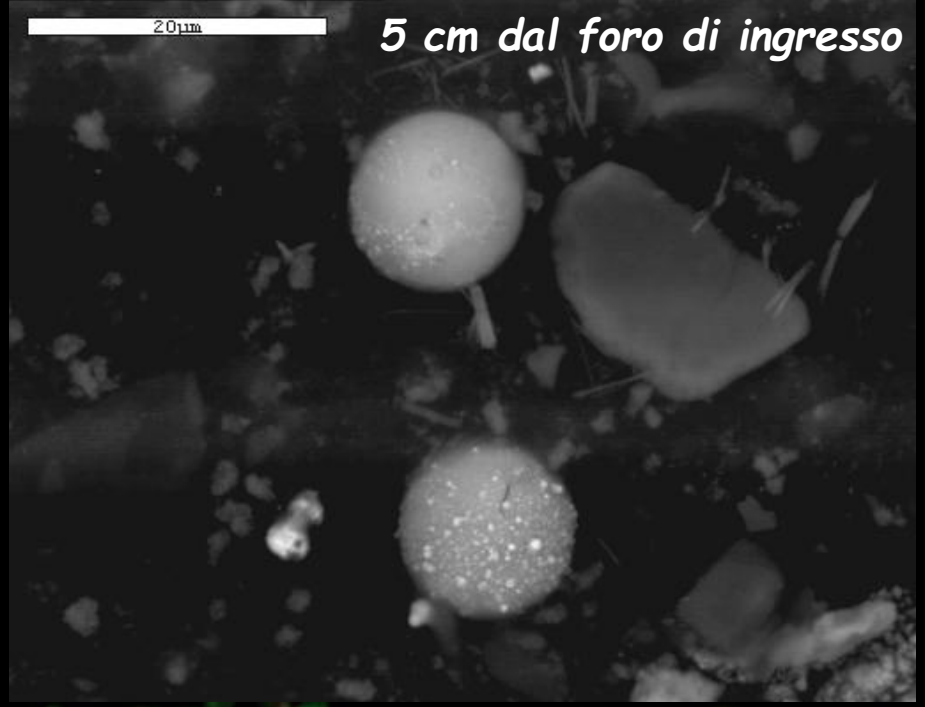
10
15
20
Energy (keV)


20µm
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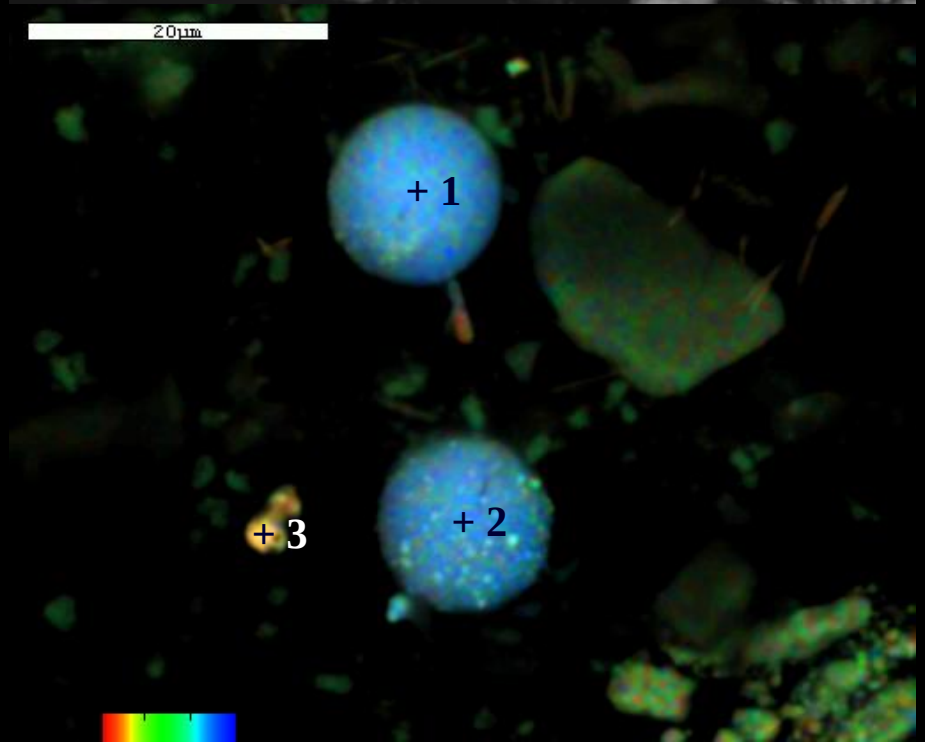
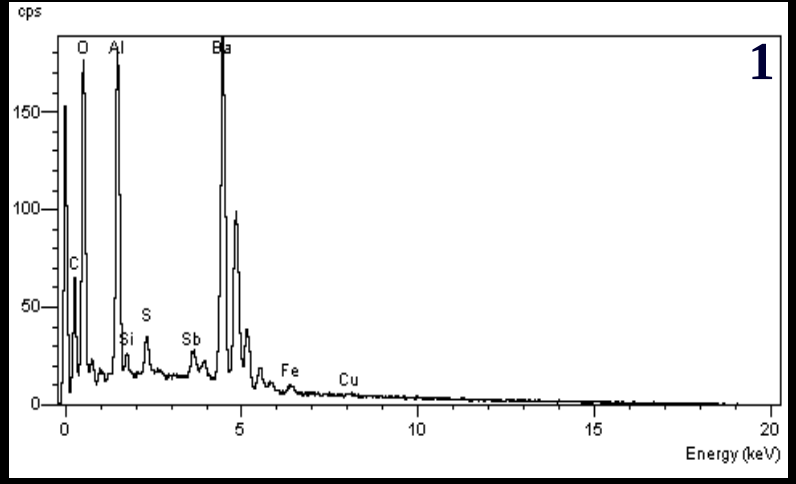
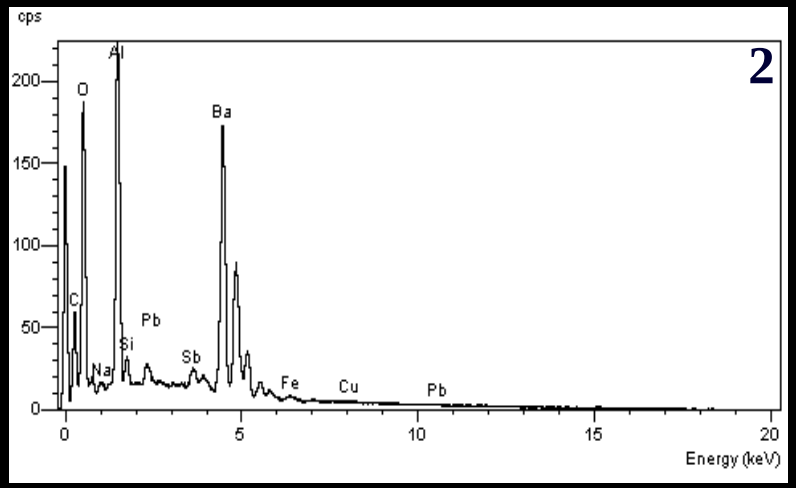
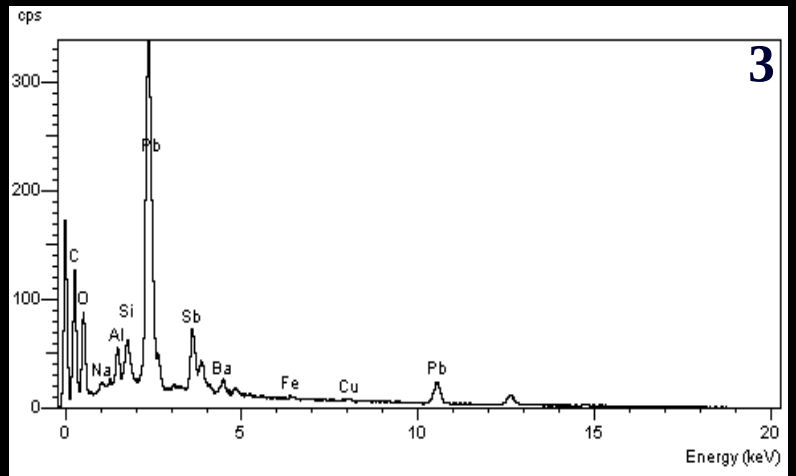

20µm
+ 1
+ 2
+ 3


cps
1
O
Al
Ba
C
Si
S
Sb
Fe
Cu
Energy (keV)


cps
2
Al
O
Ba
C
Pb
Si
Na
Sb
Fe
Cu
Pb
Energy (keV)


cps
3
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C
O
Si
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Na
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Fe
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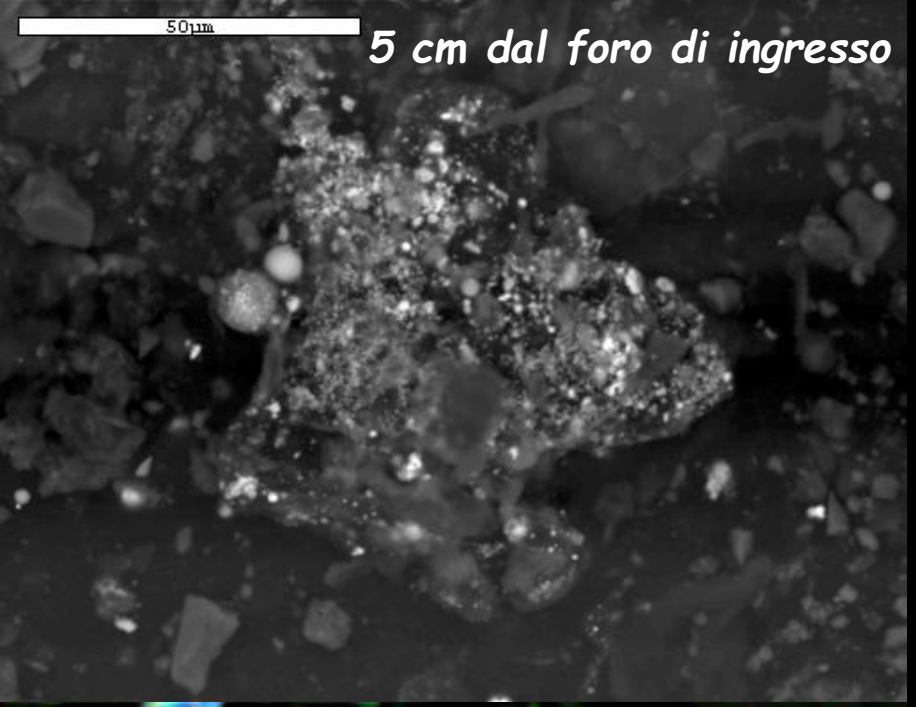
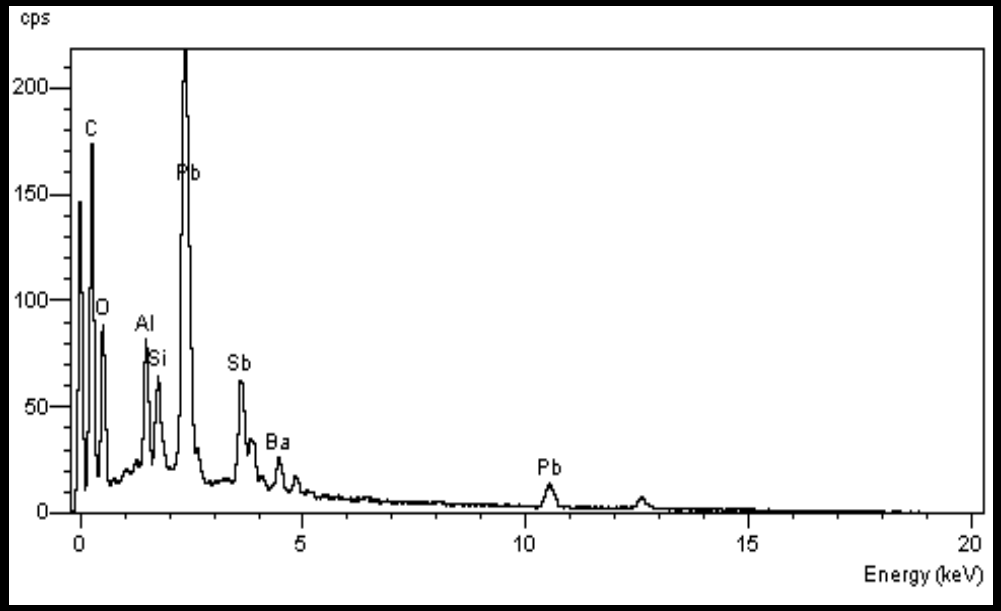
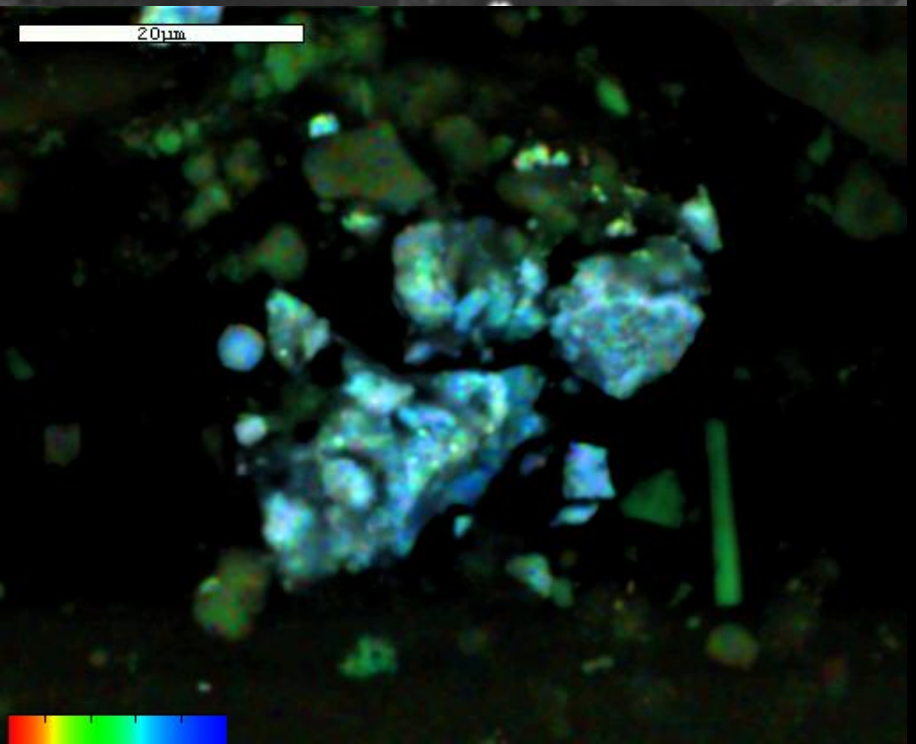
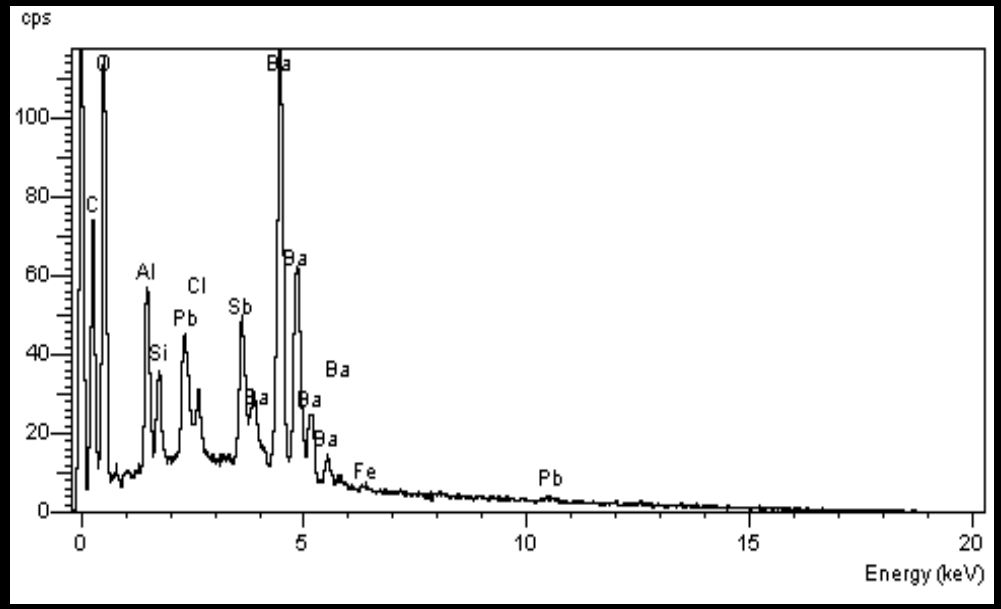
Energy (keV)



5 cm dal foro di ingresso

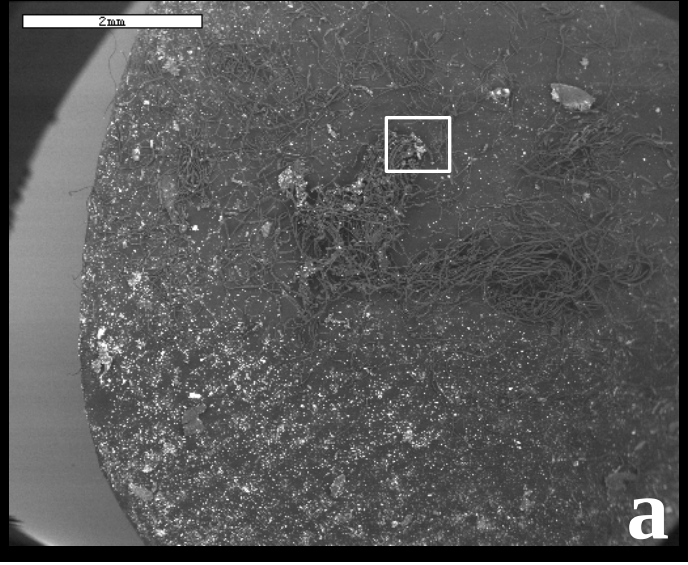


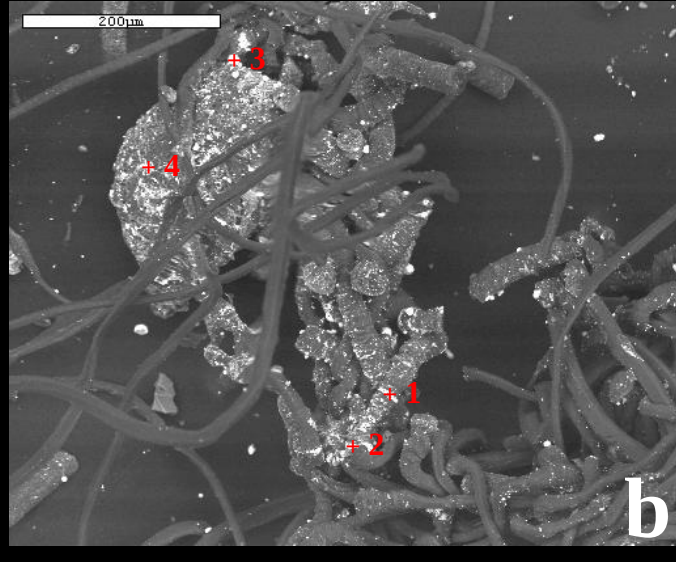


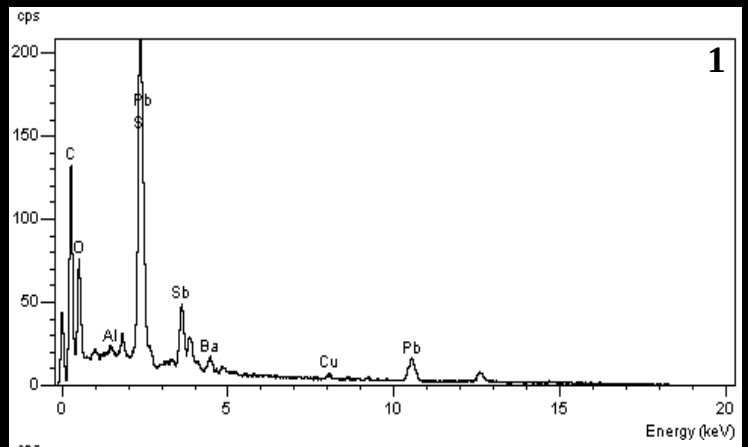


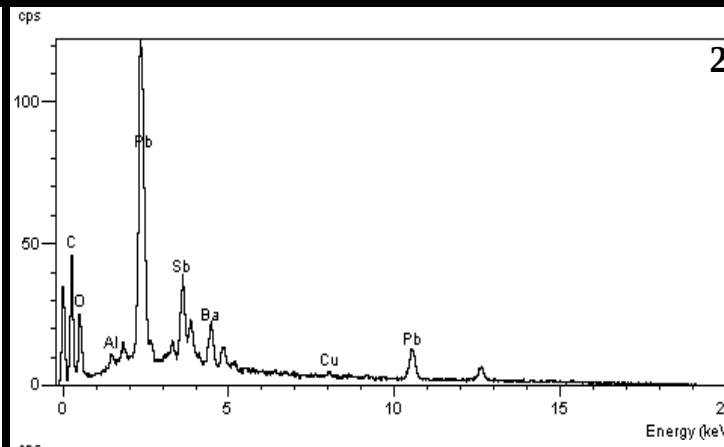
La diagnosi di foro d'ingresso di colpo d'arma da fuoco su indumenti di colore scuro non è sempre agevole …

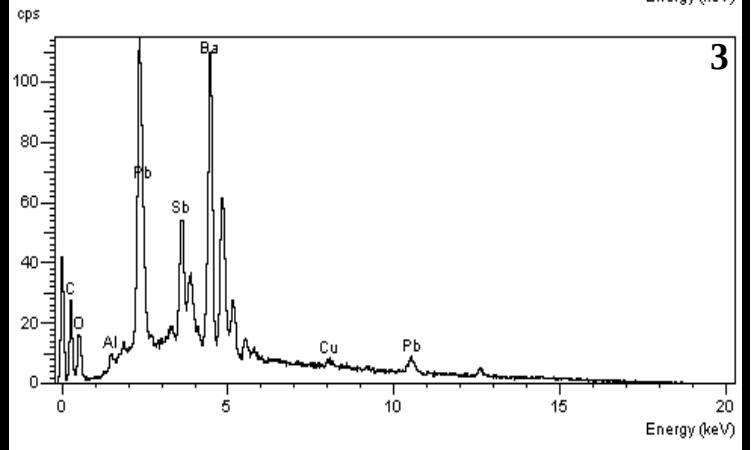
Giubbotto con cappuccio, di colore blu scuro; prelievo eseguito nel foro presente sulla metà destra anteriore

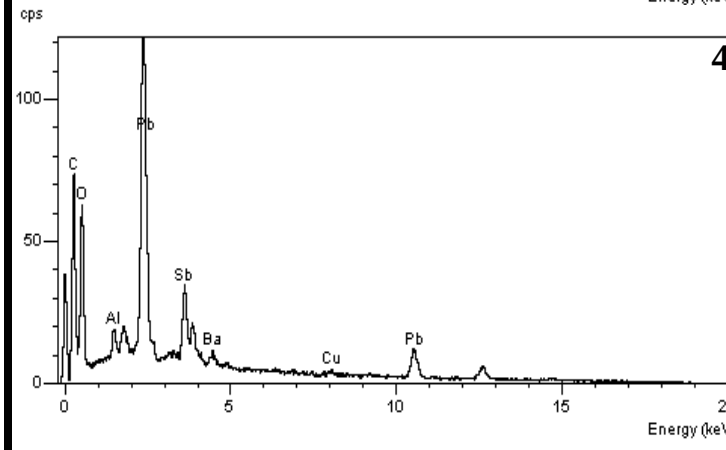




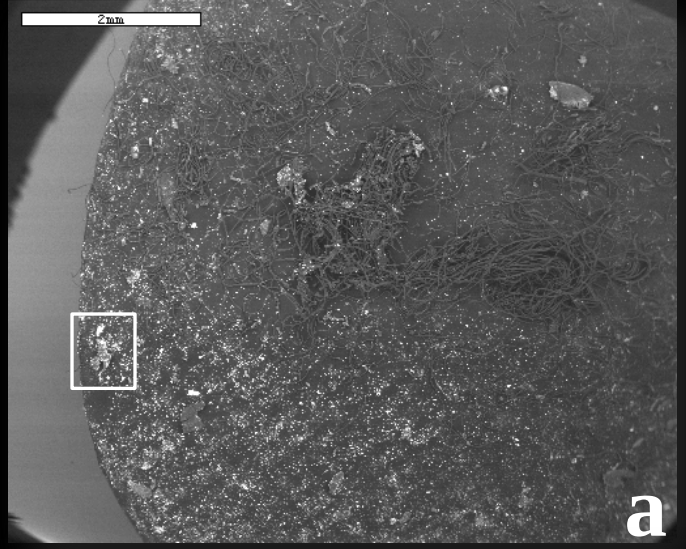


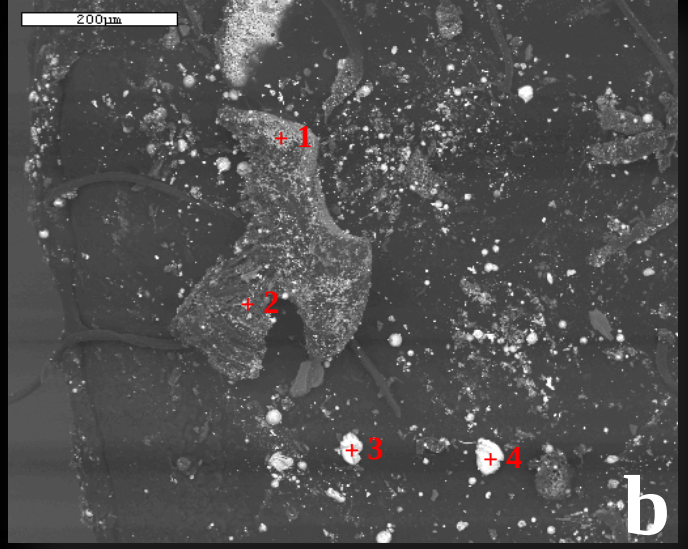


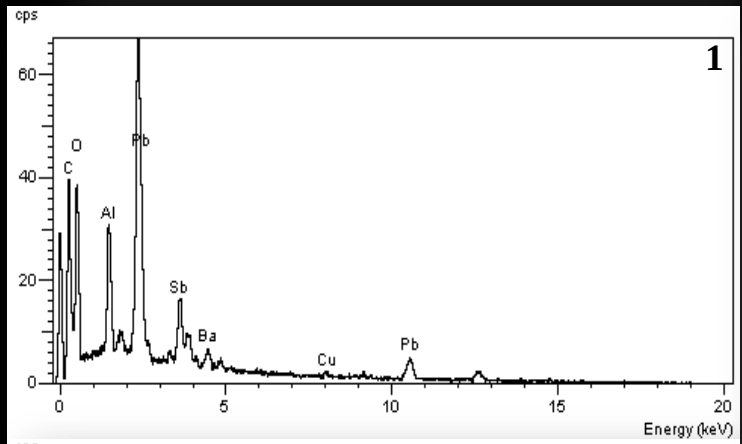


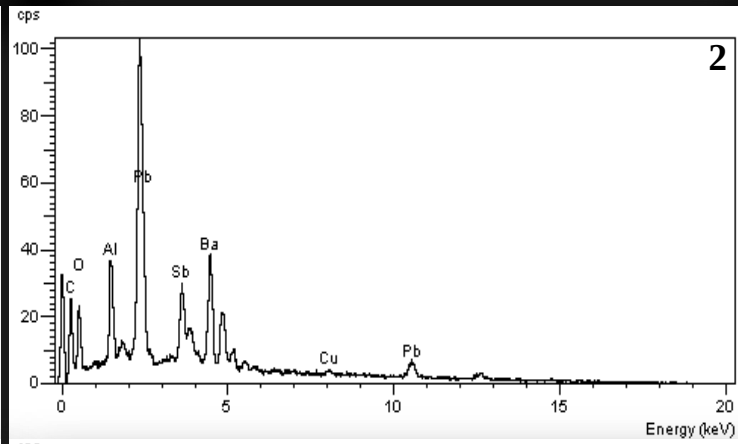


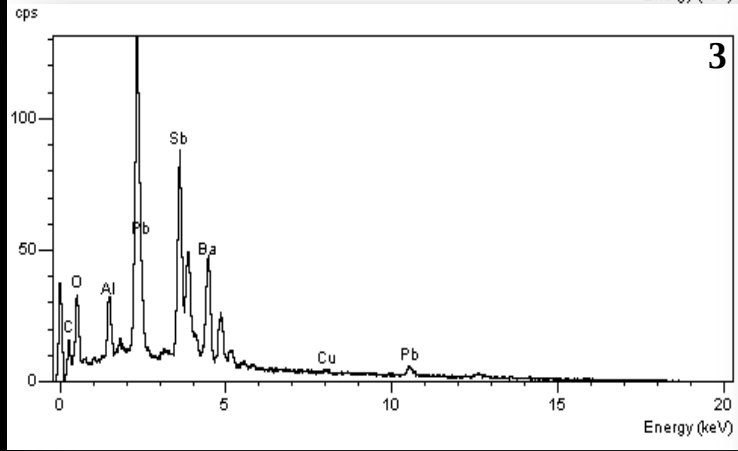
Giubbotto con cappuccio, di colore blu scuro; prelievo eseguito nel foro presente sulla metà destra anteriore

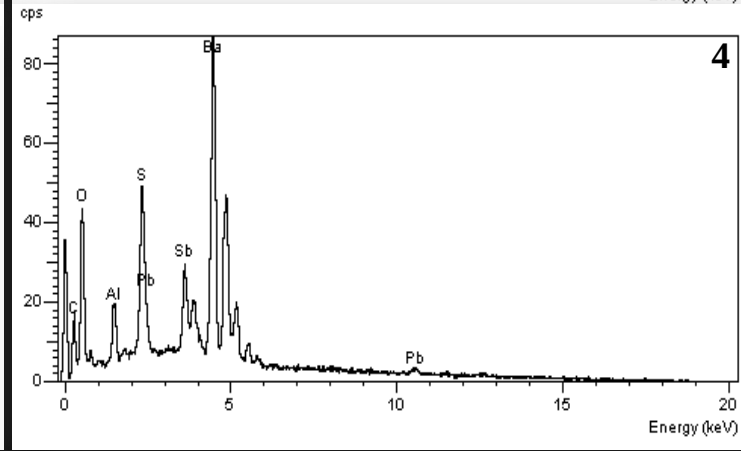




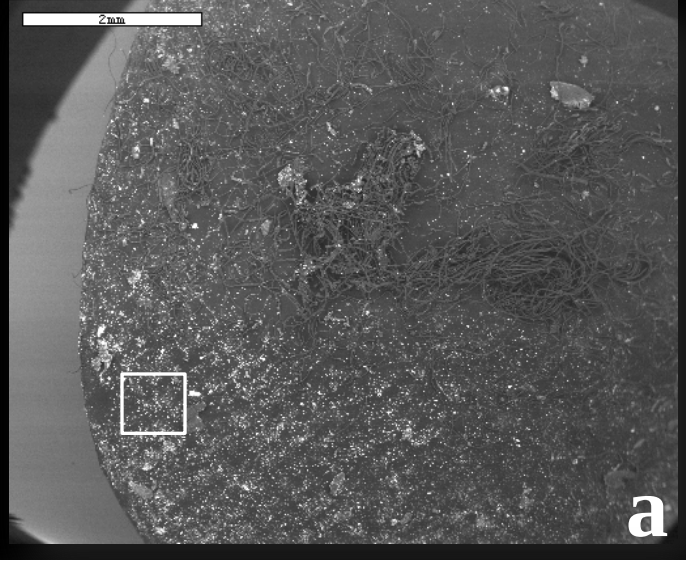


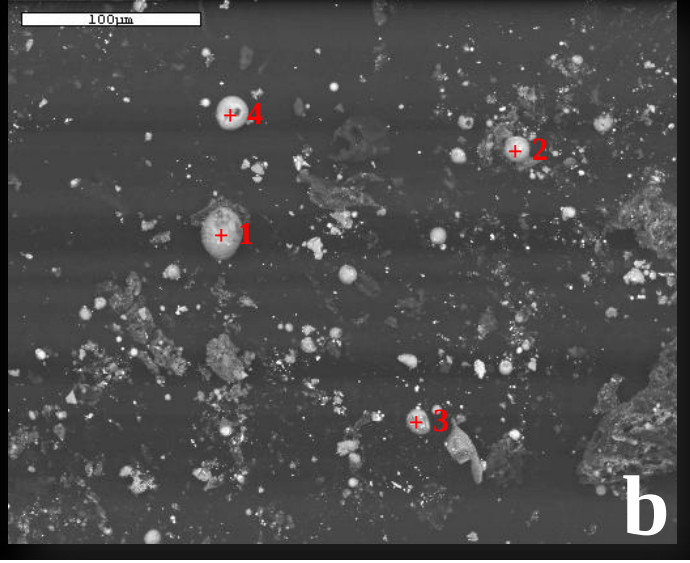


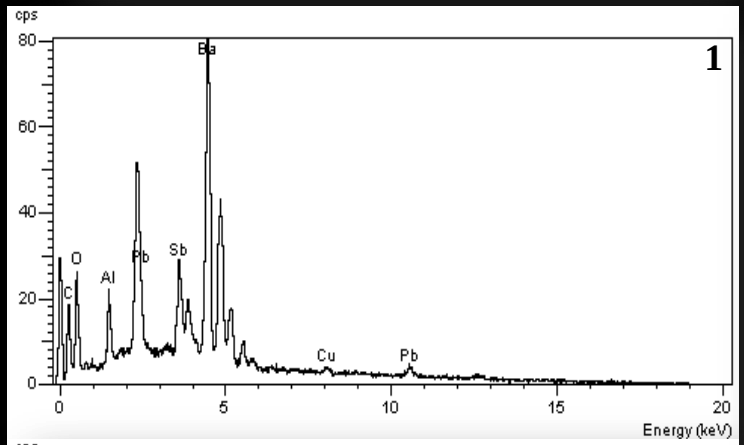


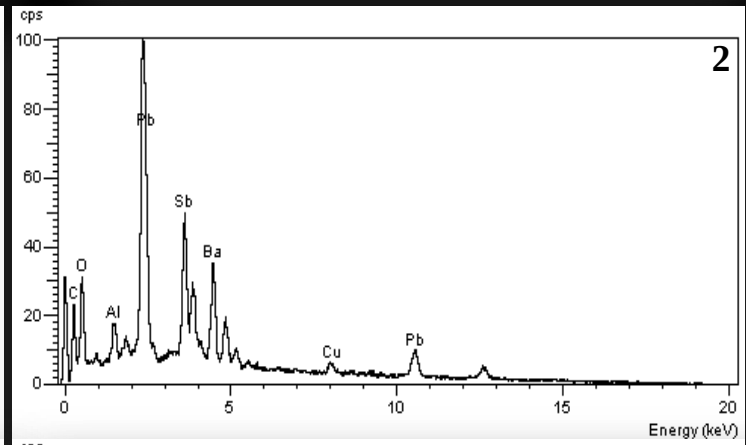


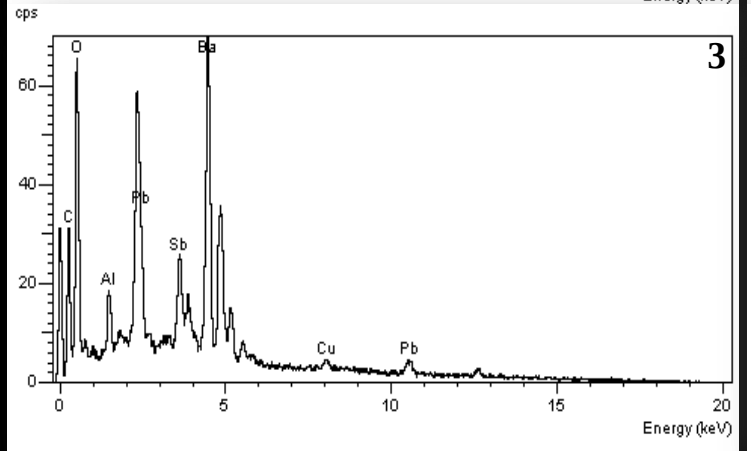
Giubbotto con cappuccio, di colore blu scuro; prelievo eseguito nel foro presente sulla metà destra anteriore

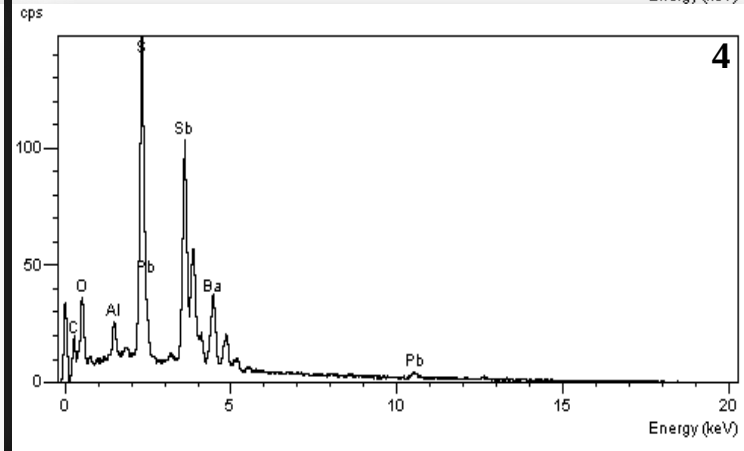




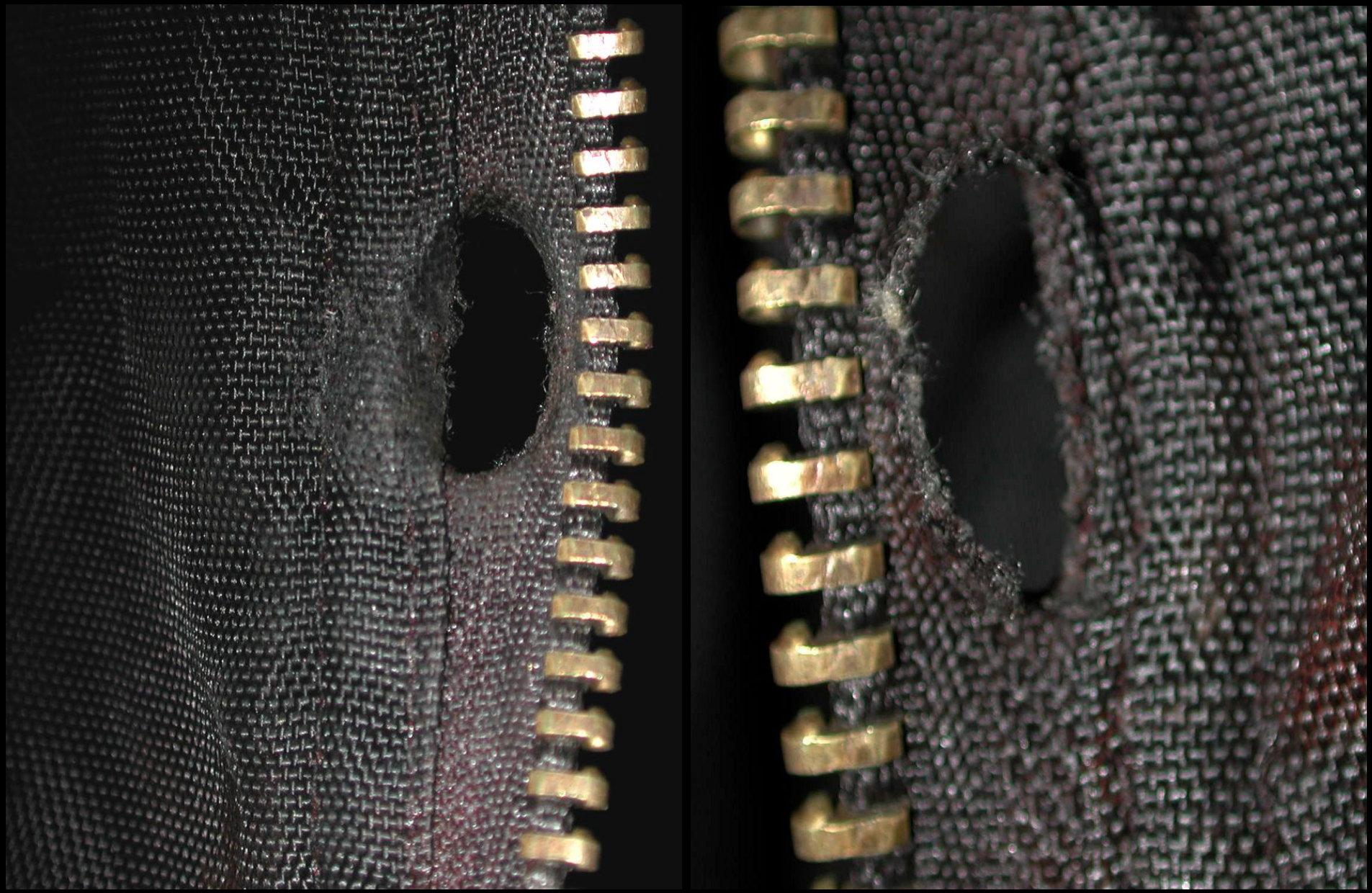


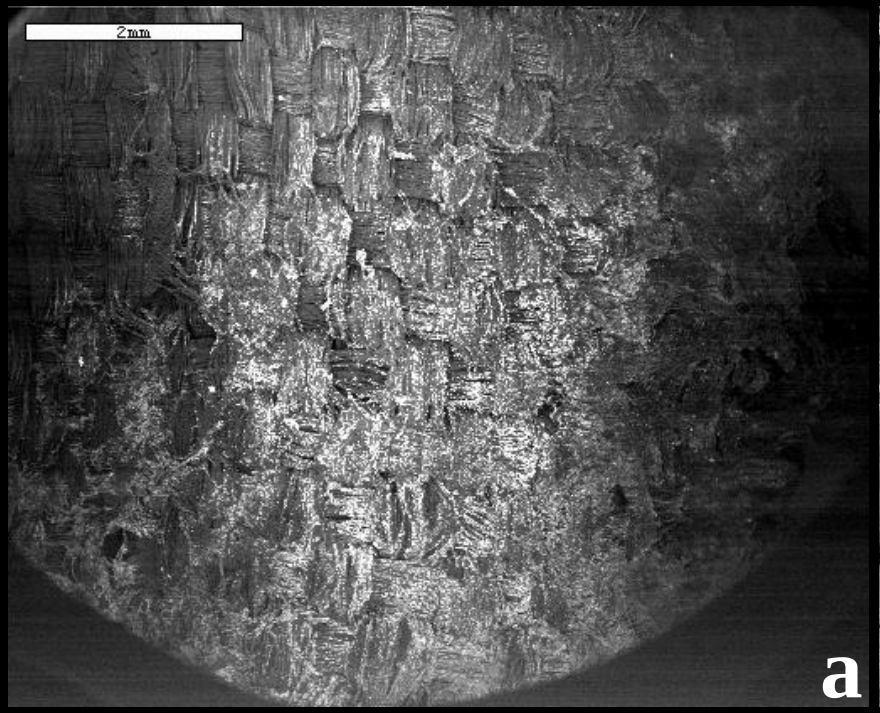


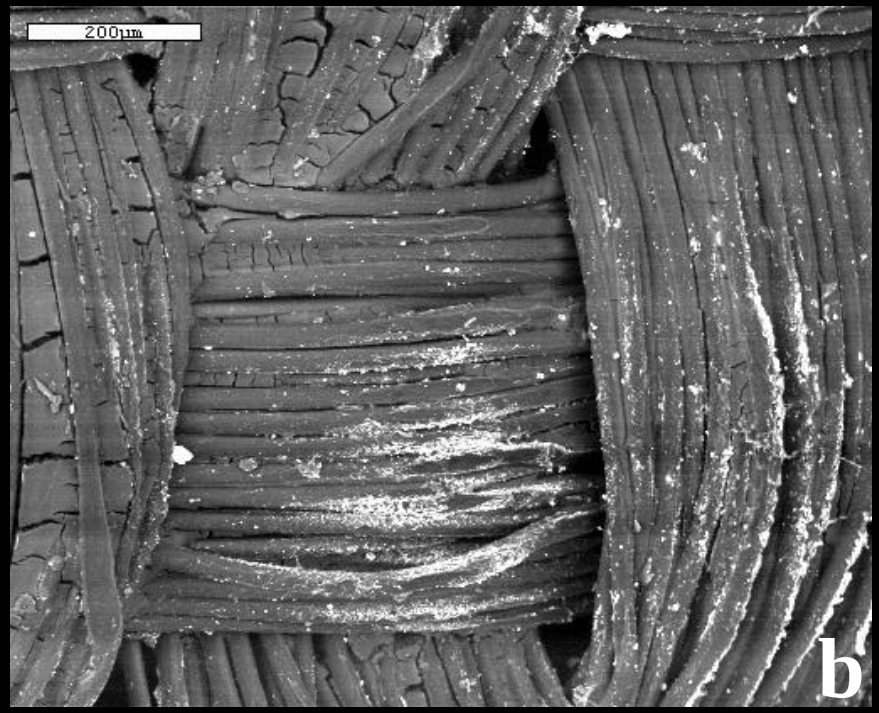




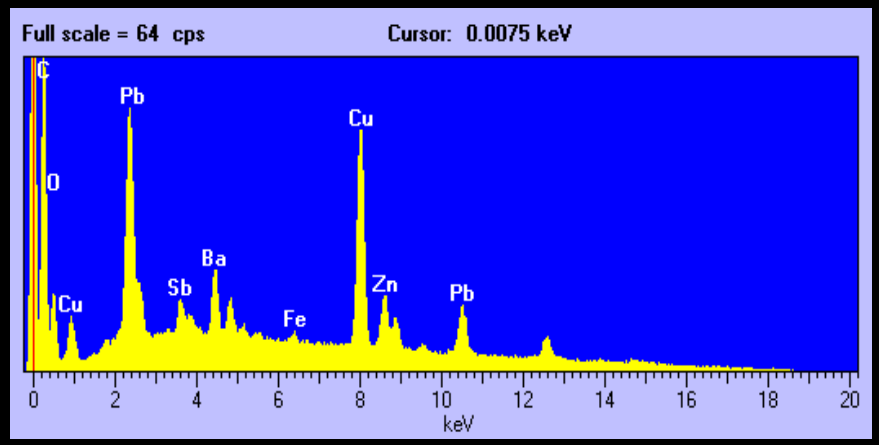
… e quando lo sarebbe ci si complica la vita …



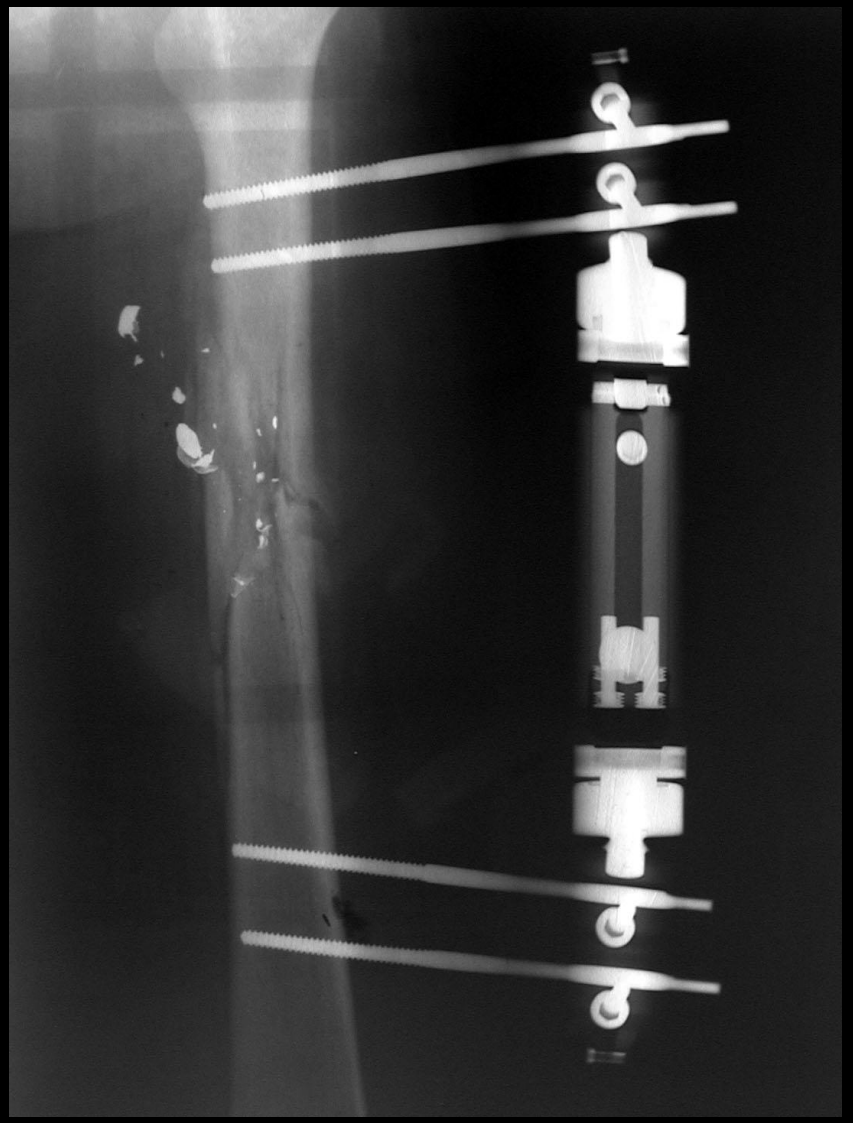

2mm
a

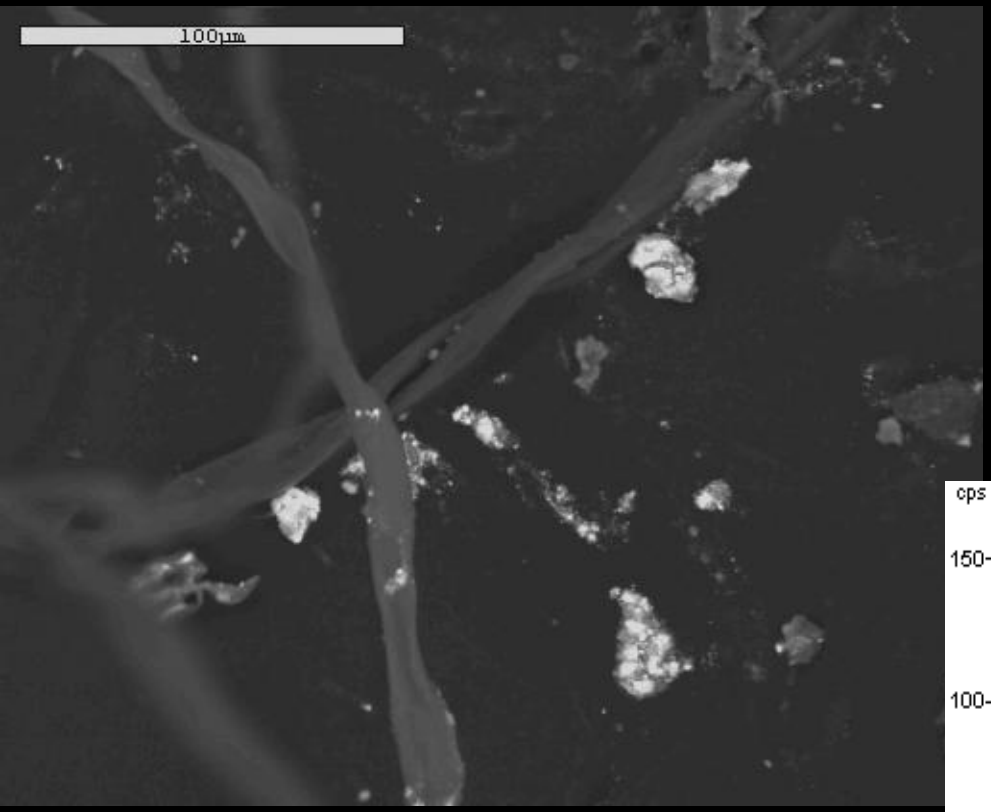

200µm
b

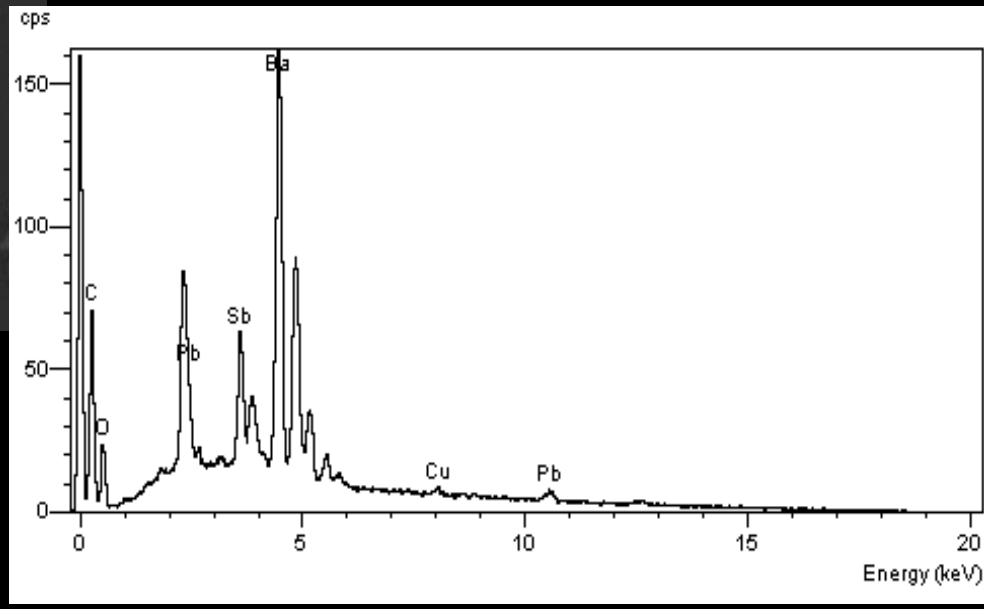

200µm
c

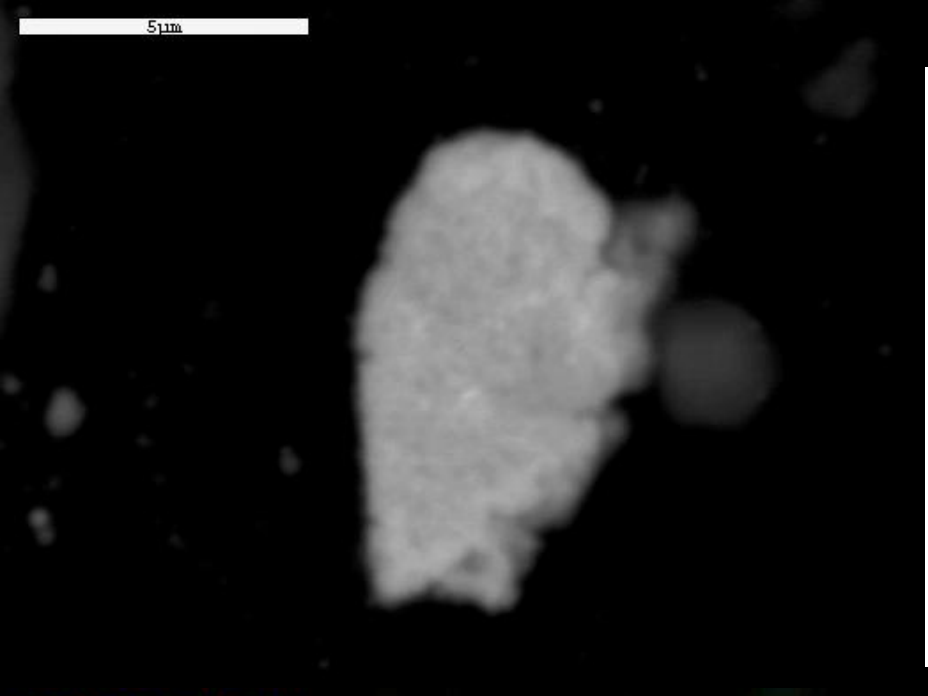

Full scale = 64 cps
Cursor: 0.0075 keV
C
O
Cu
Pb
Sb
Ba
Fe
Cu
Zn
Pb
0
2
4
6
8
10
12
14
16
18
20
keV

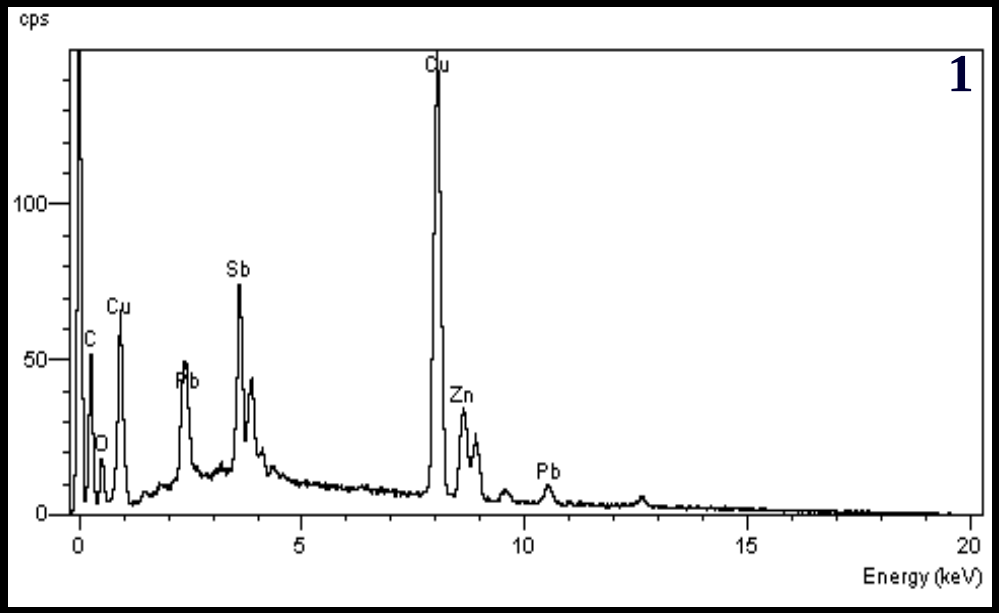
Tentato omicidio o ferimento accidentale?

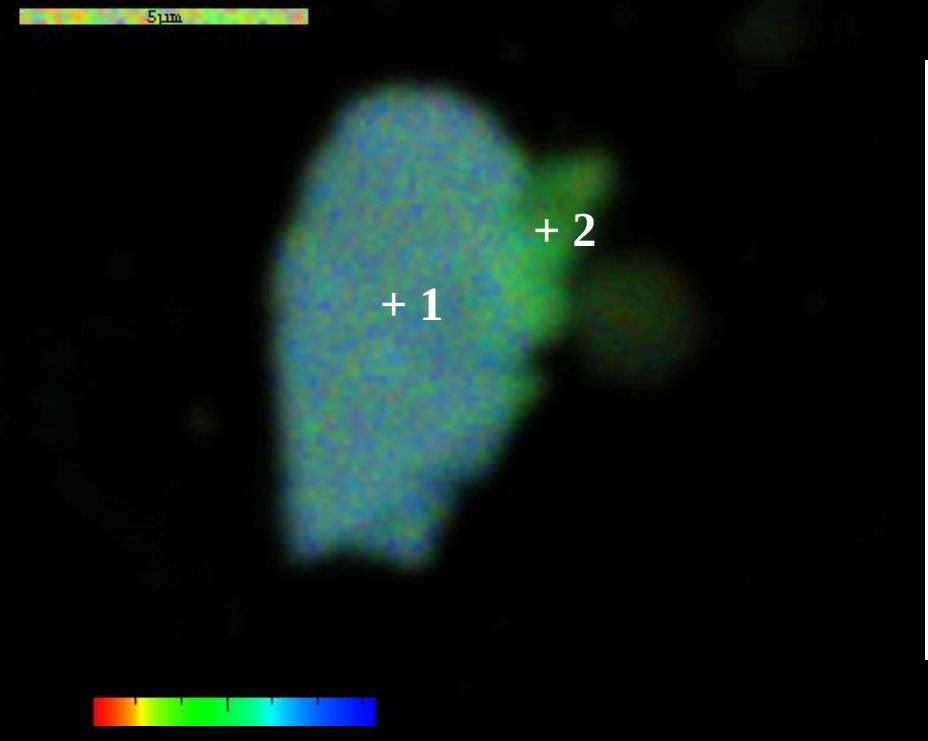


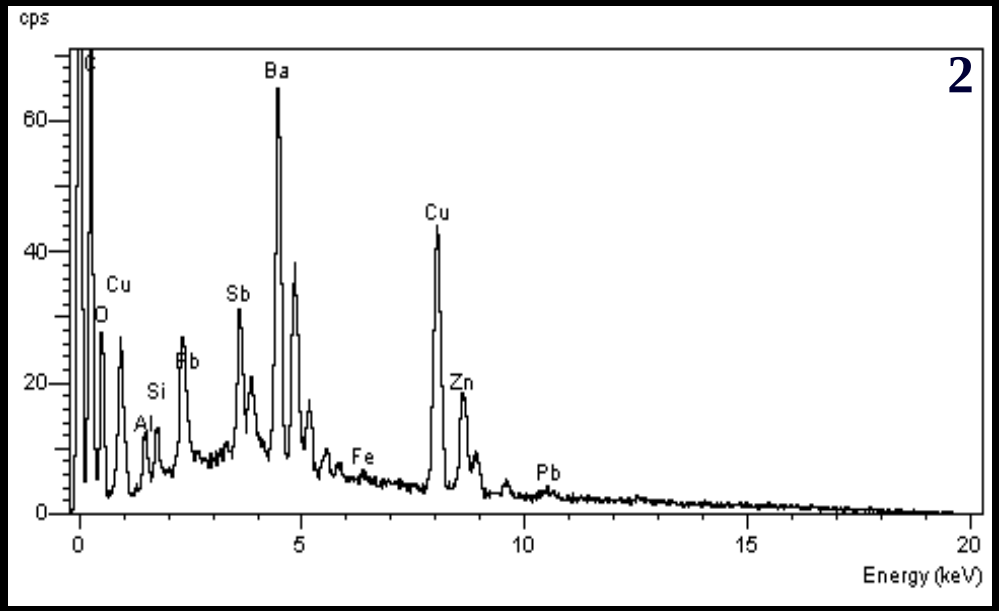

100µm

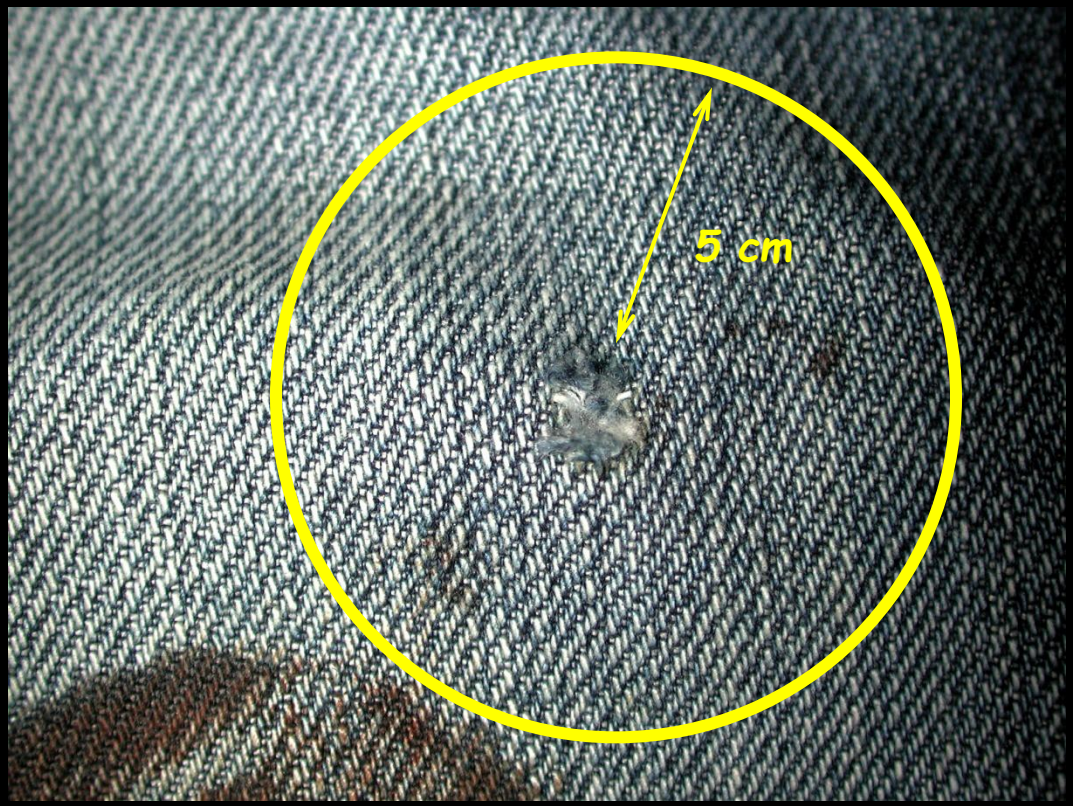

cps
150
100
50
0
Ba
C
O
Pb
Sb
Cu
Pb
0
5
10
15
20
Energy (keV)


5µm


cps
1
Cu
100
Sb
C
Cu
50
Pb
O
Zn
Pb
0
0
5
10
15
20
Energy (keV)


5µm
+ 2
+ 1


cps
2
C
Ba
60
Cu
40
Cu
O
Sb
Pb
Si
20
Al
Zn
Fe
Pb
0
0
5
10
15
20
Energy (keV)

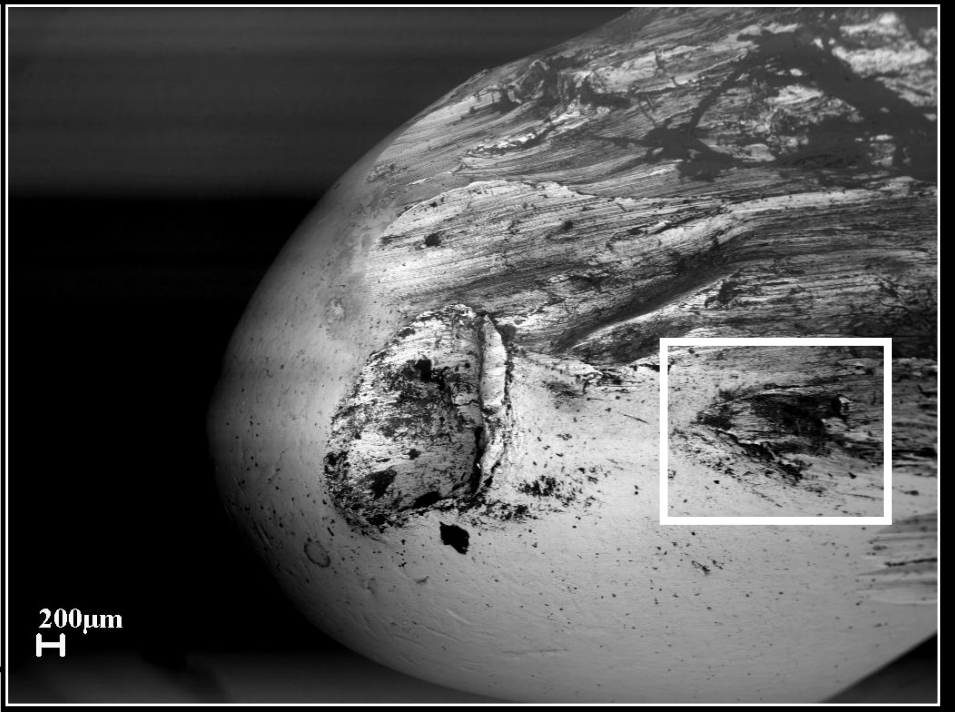


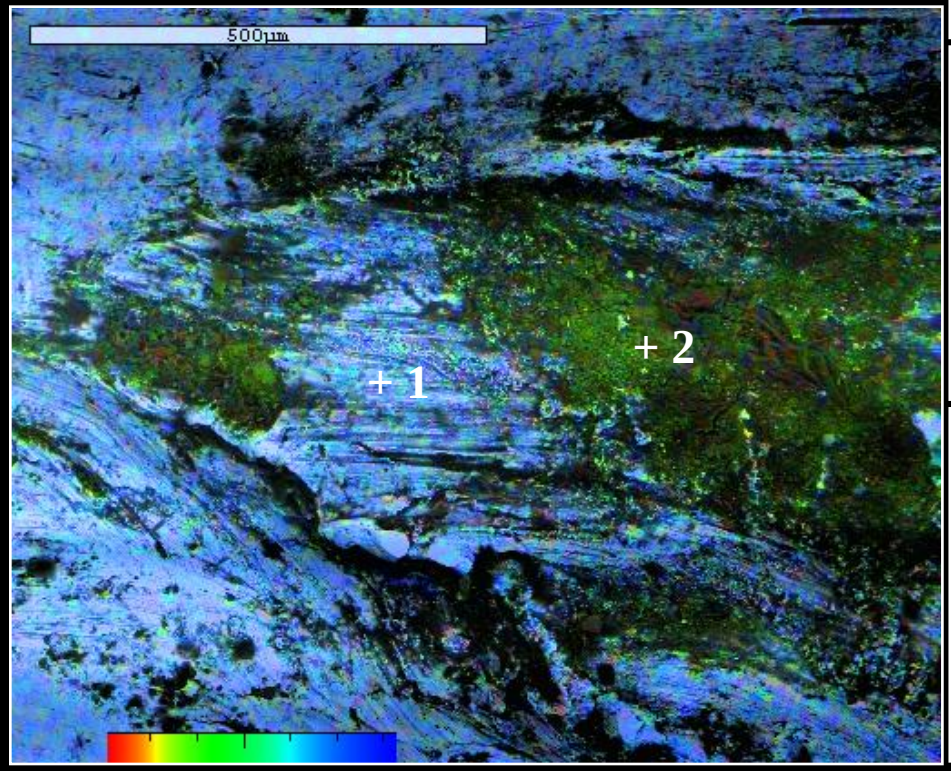
52 particelle di sparo

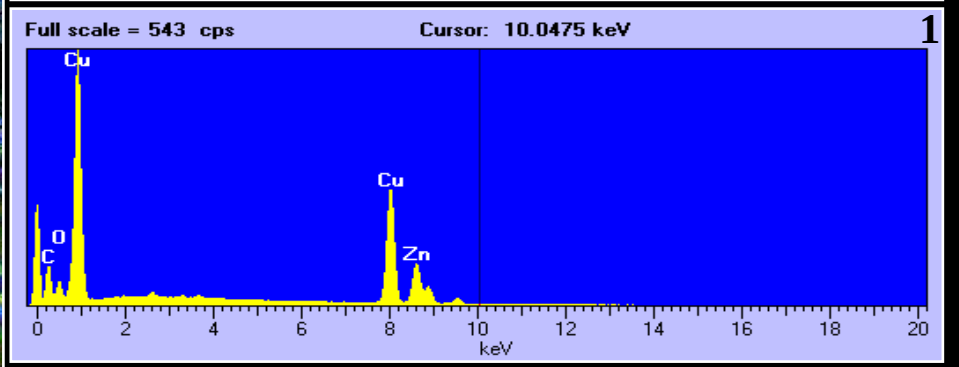
41 Pb-Ba-Sb

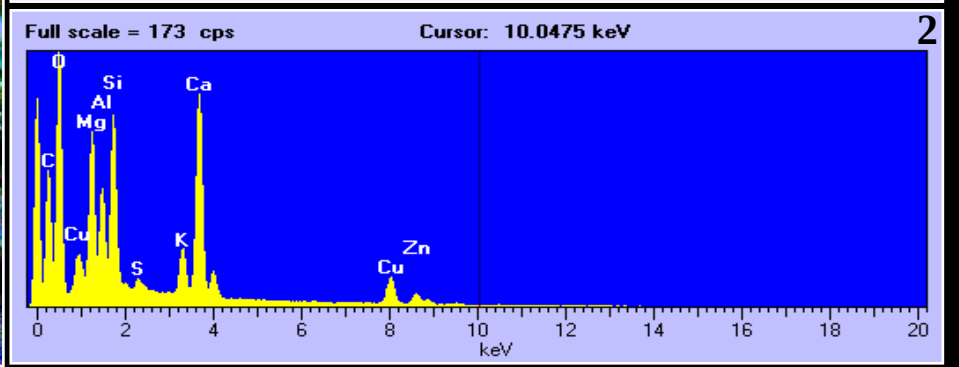
11 Ba-Sb

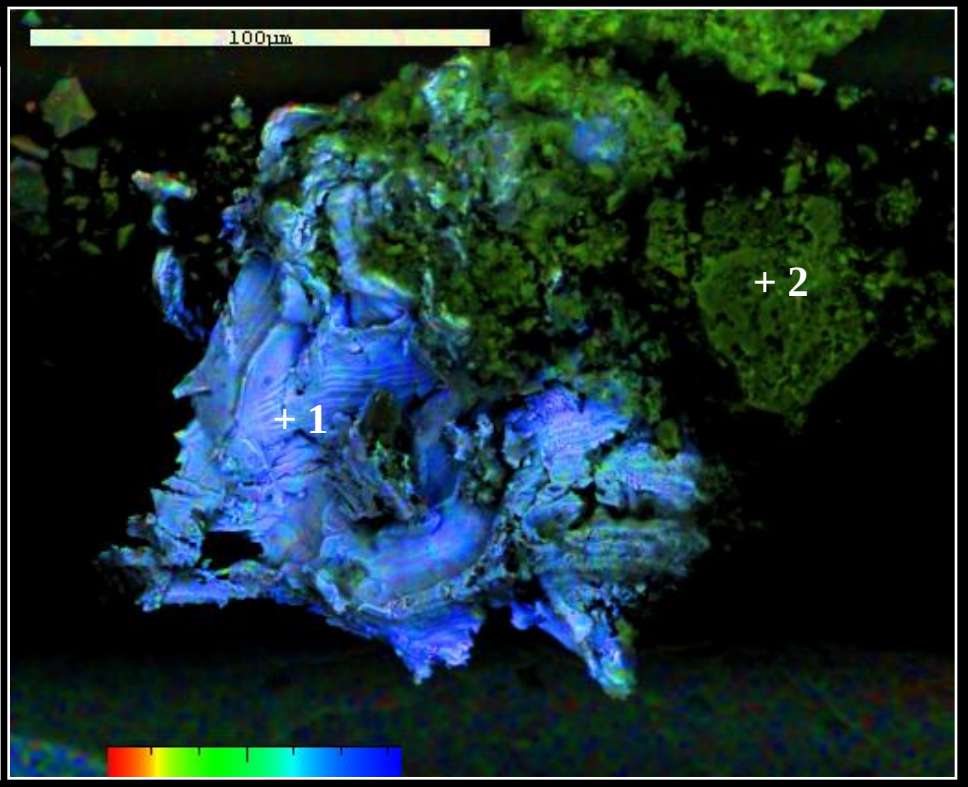
Omicidio volontario
o colpo di rimbalzo?

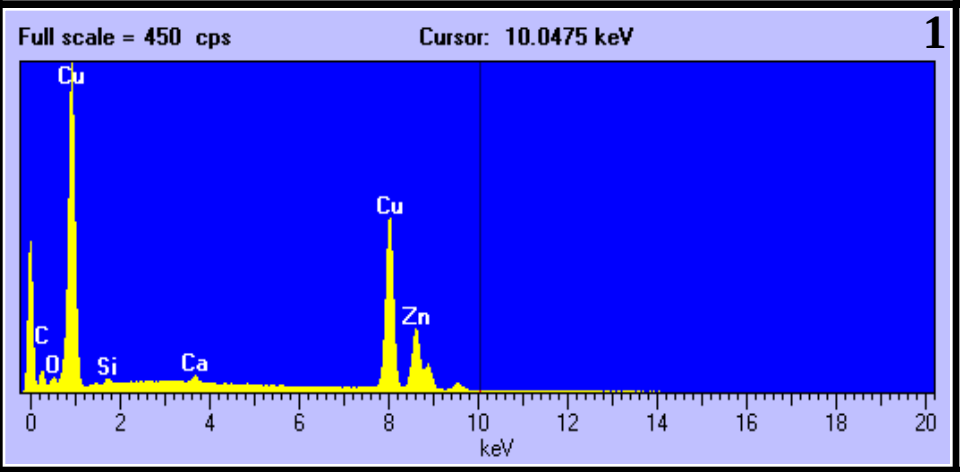

200µm

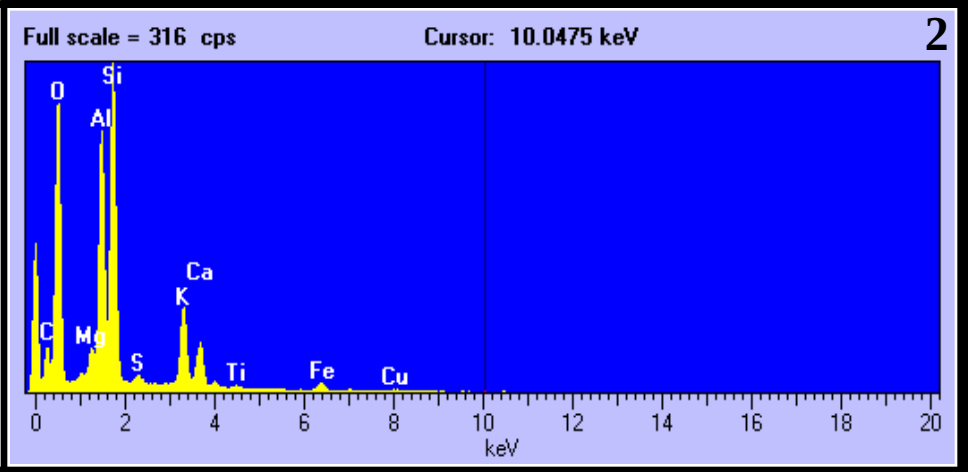

500µm
+ 1
+ 2

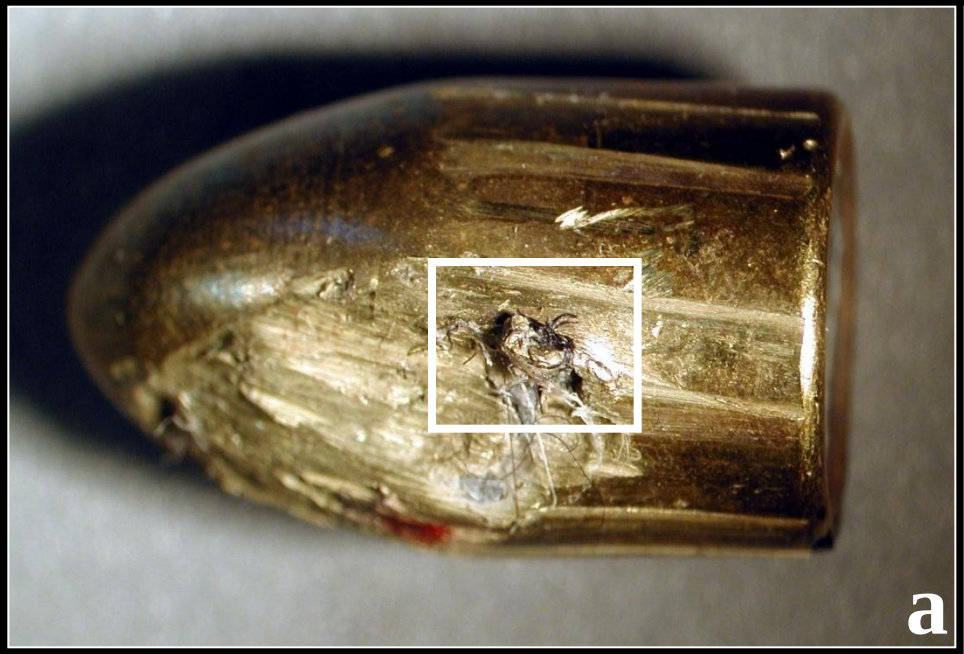

Full scale = 543 cps
Cursor: 10.0475 keV
1
Cu
O
C
Cu
Zn
0
2
4
6
8
10
12
14
16
18
20
keV


Full scale = 173 cps
Cursor: 10.0475 keV
2
O
Si
Al
Mg
Ca
C
Cu
K
S
Zn
Cu
0
2
4
6
8
10
12
14
16
18
20
keV

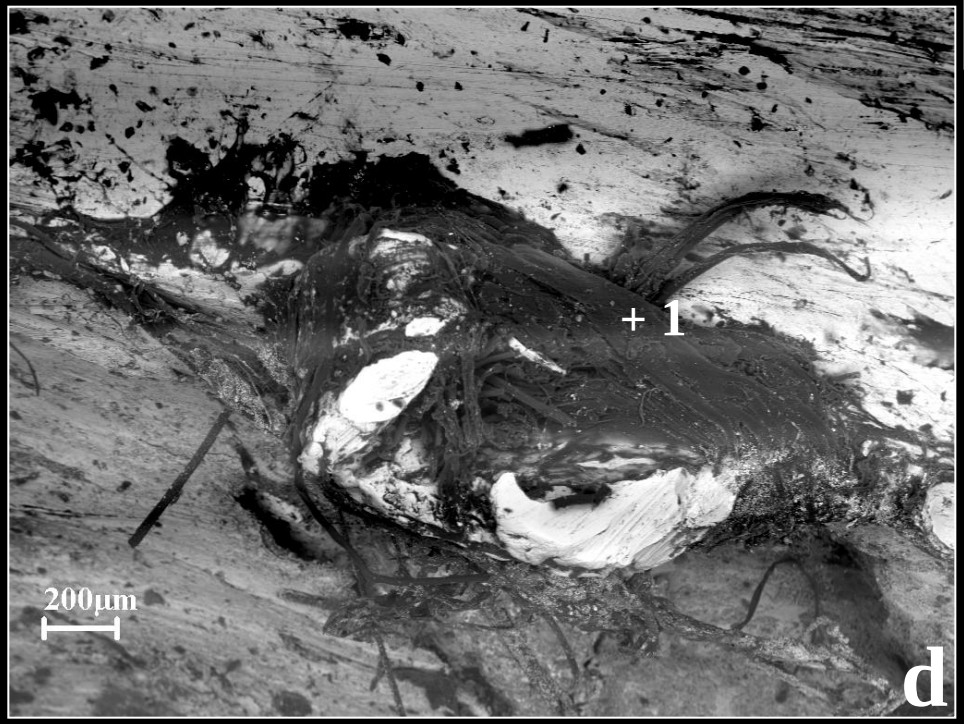

100µm
+ 1
+ 2

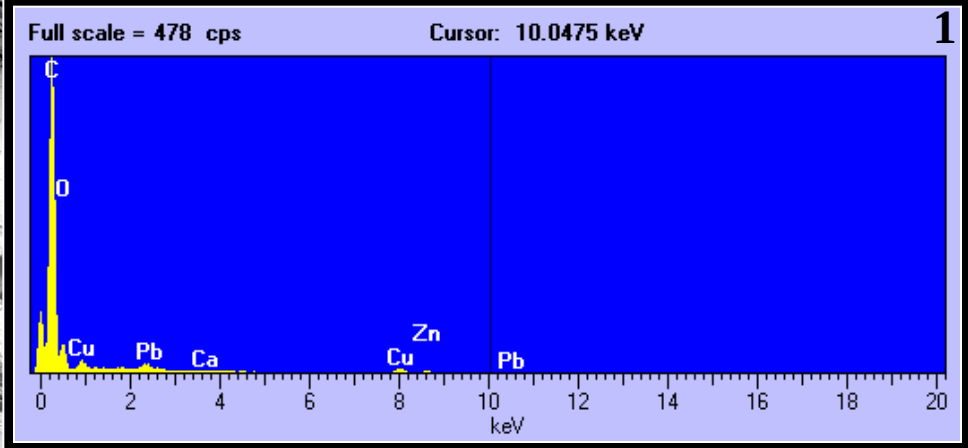

Full scale = 450 cps
Cursor: 10.0475 keV
1
Cu
Cu
Zn
C
O
Si
Ca
0
2
4
6
8
10
12
14
16
18
20
keV

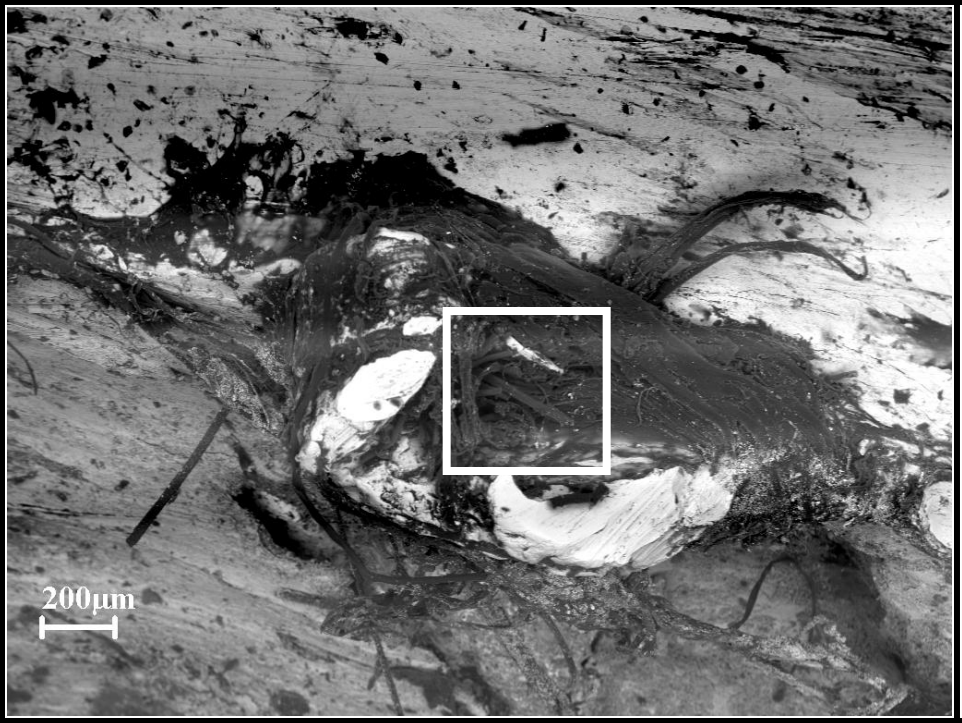

Full scale = 316 cps
Cursor: 10.0475 keV
2
O
Si
Al
Ca
K
C
Mg
S
Ti
Fe
Cu
0
2
4
6
8
10
12
14
16
18
20
keV

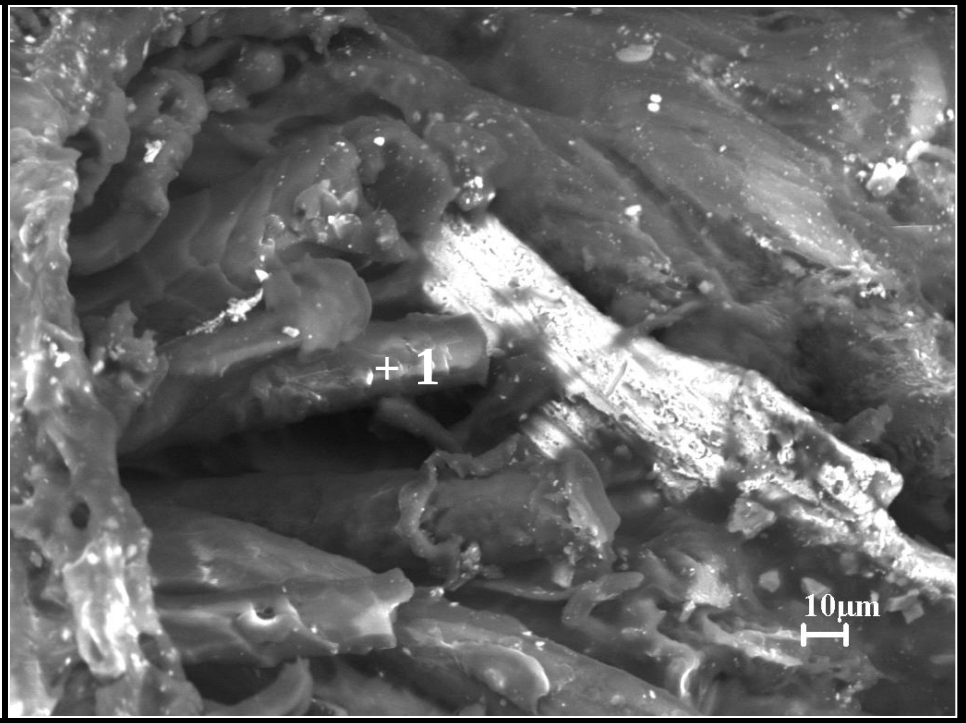

a

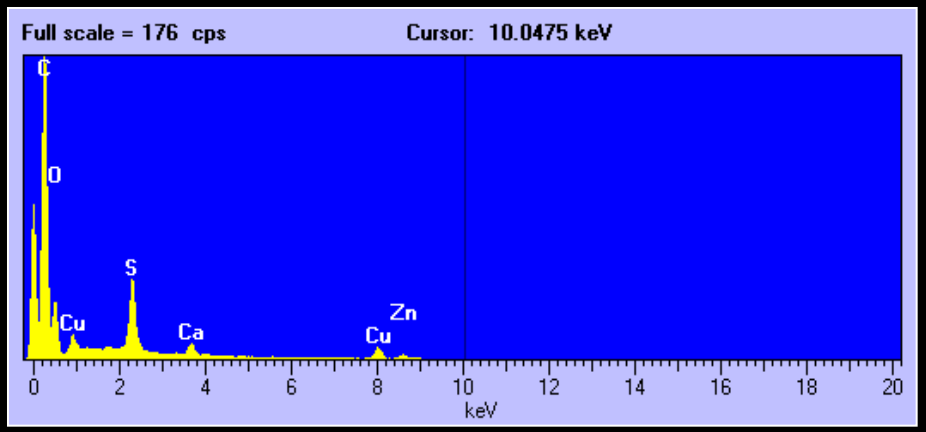

b


+ 1
200µm
d


Full scale = 478 cps
Cursor: 10.0475 keV
1
C
O
Cu
Pb
Ca
Zn
Cu
Pb
0
2
4
6
8
10
12
14
16
18
20
keV

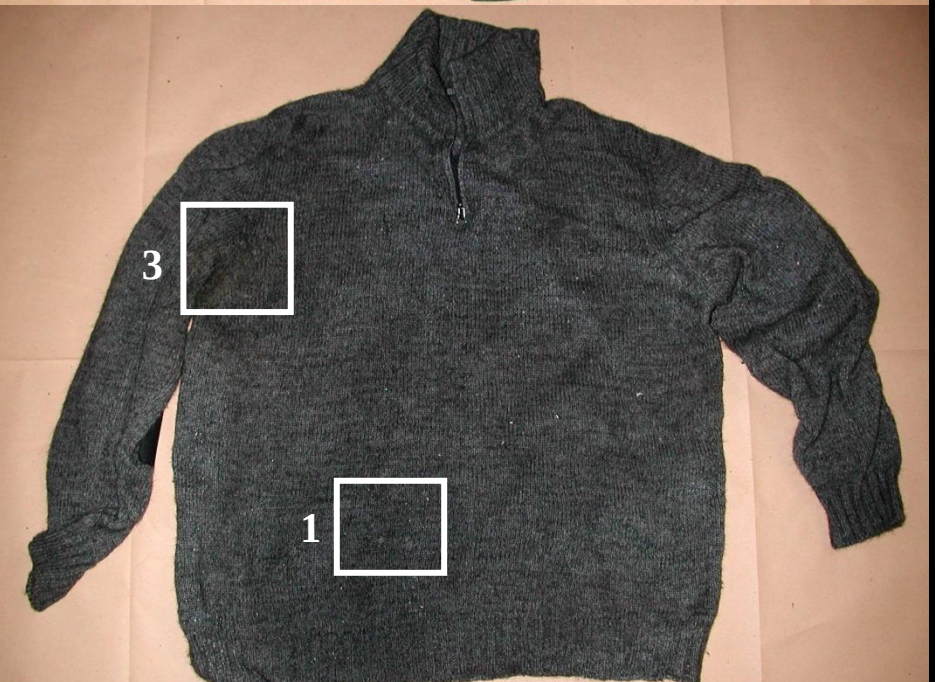

200µm


+ 1
10µm

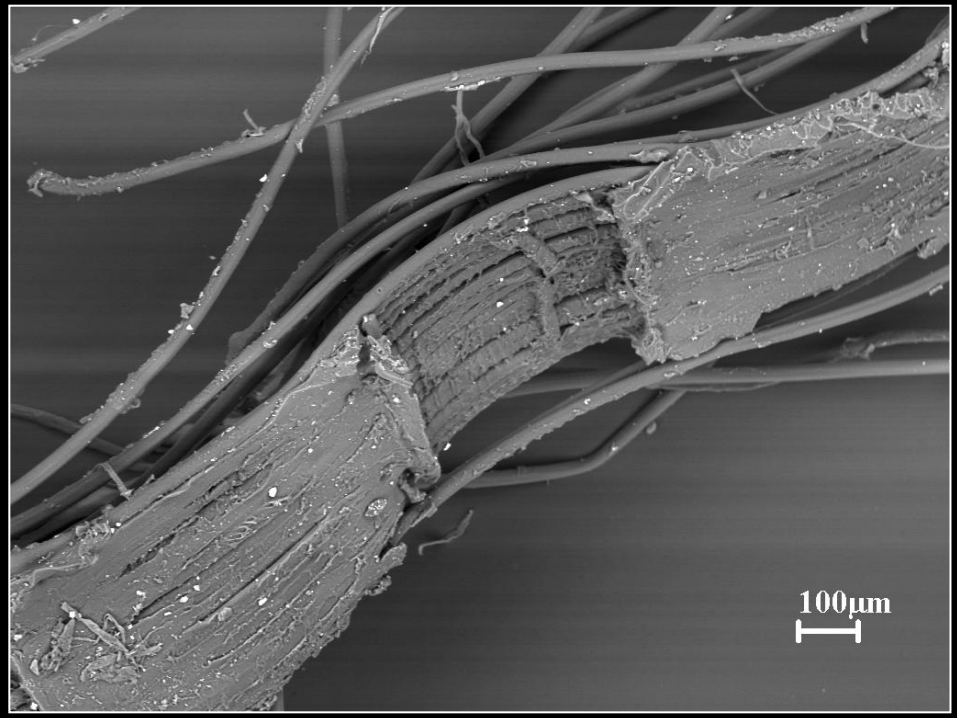

Full scale = 176 cps
Cursor: 10.0475 keV
C
O
S
Cu
Ca
Cu
Zn
0
2
4
6
8
10
12
14
16
18
20
keV

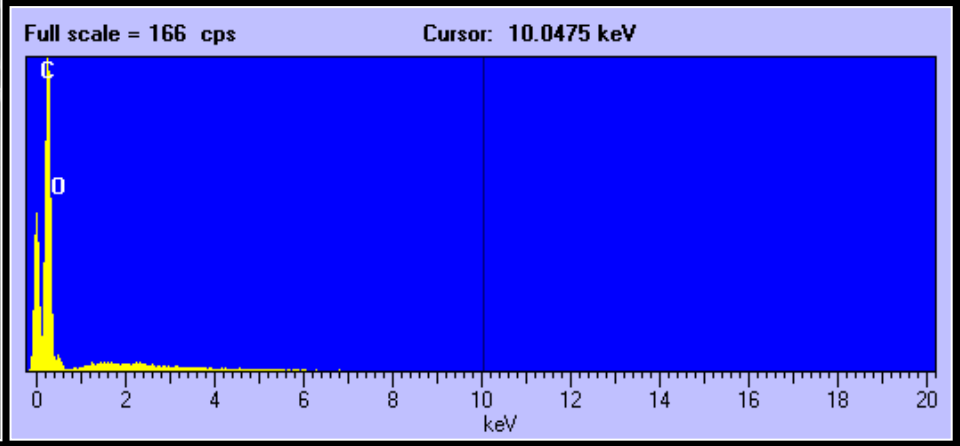

3
1

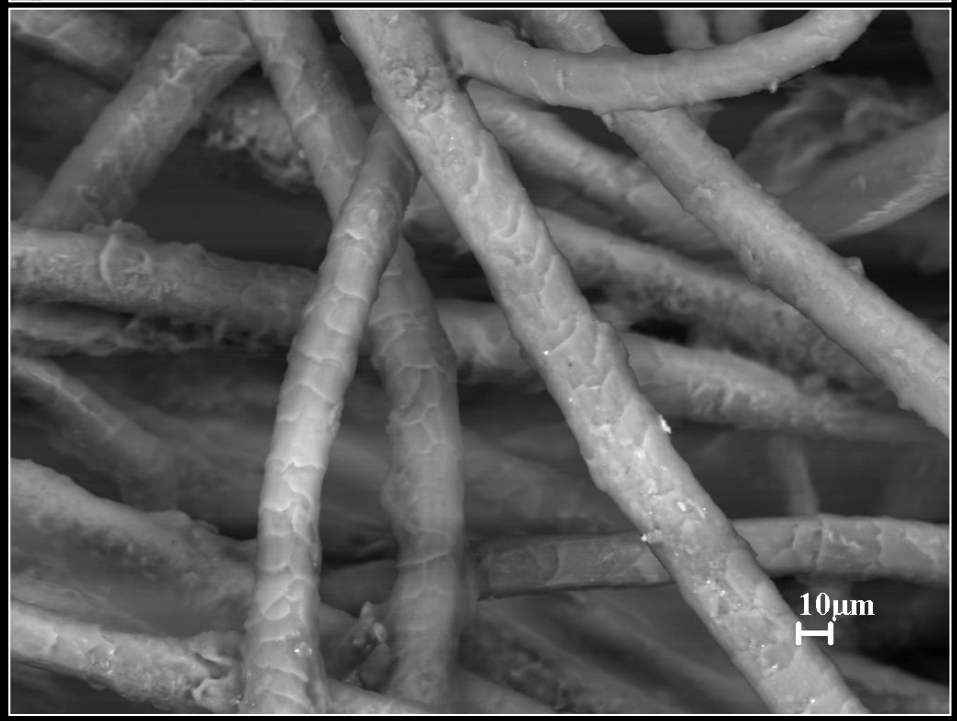

AVIREX

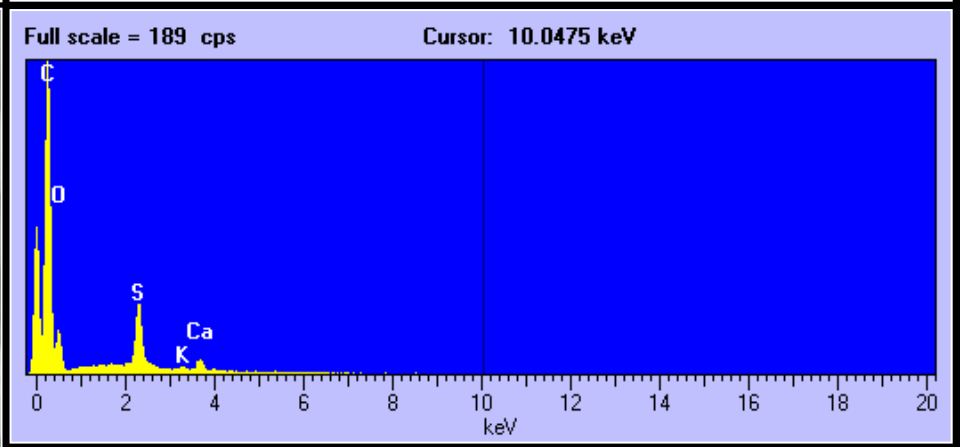

3
1


1

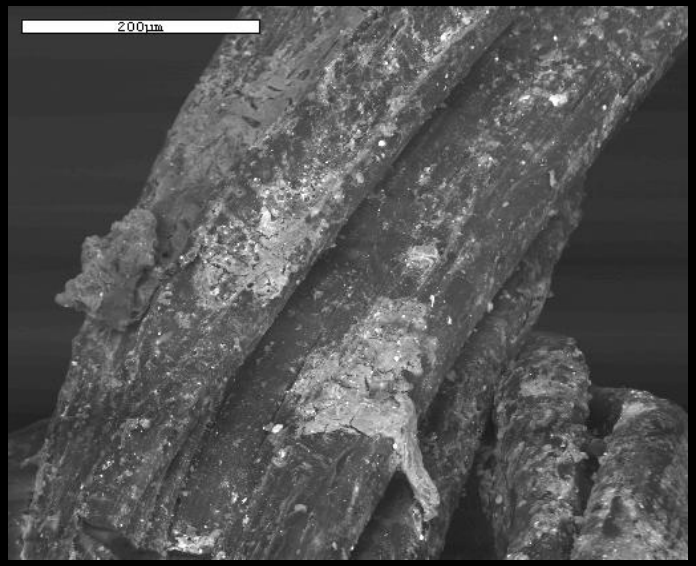

100µm

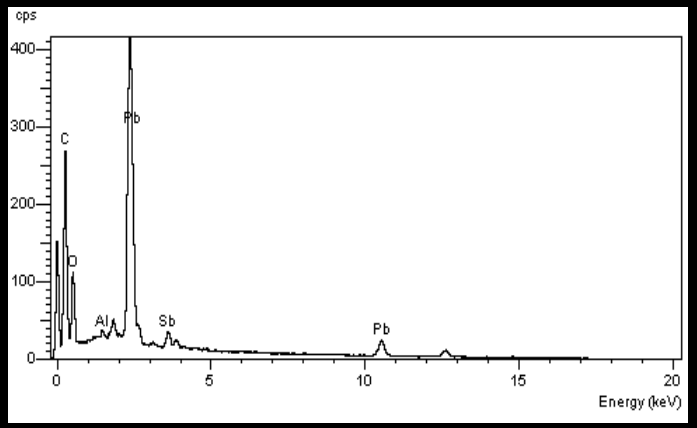

Full scale = 166 cps
Cursor: 10.0475 keV
C
O
0
2
4
6
8
10
12
14
16
18
20
keV


10µm

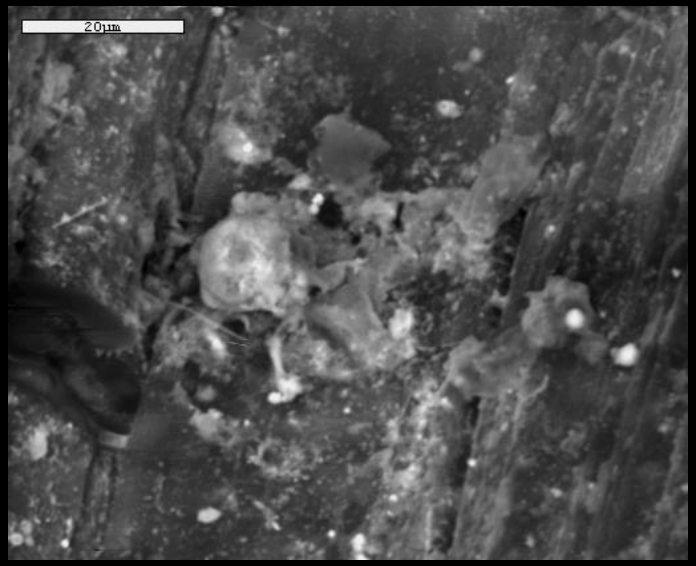

Full scale = 189 cps
Cursor: 10.0475 keV
C
O
S
Ca
K
0
2
4
6
8
10
12
14
16
18
20
keV

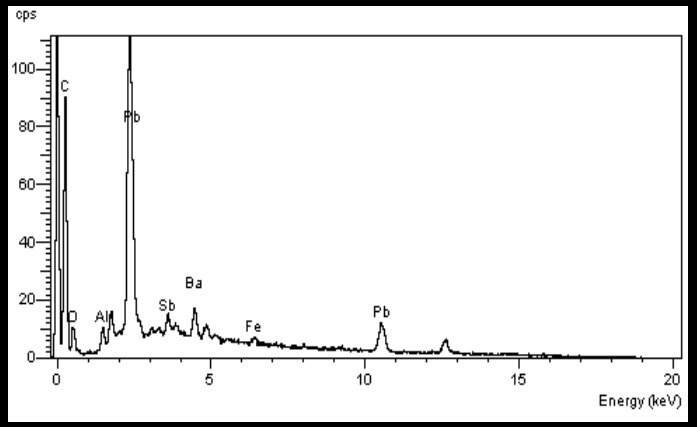
Colpo di fucile da caccia
o rottura accidentale?


200µm

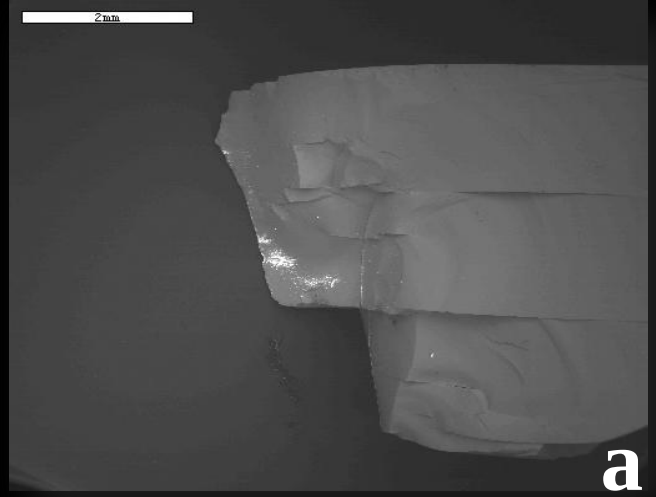

cps
400
300
200
100
0
C
O
Al
Pb
Sb
Pb
0
5
10
15
20
Energy (keV)

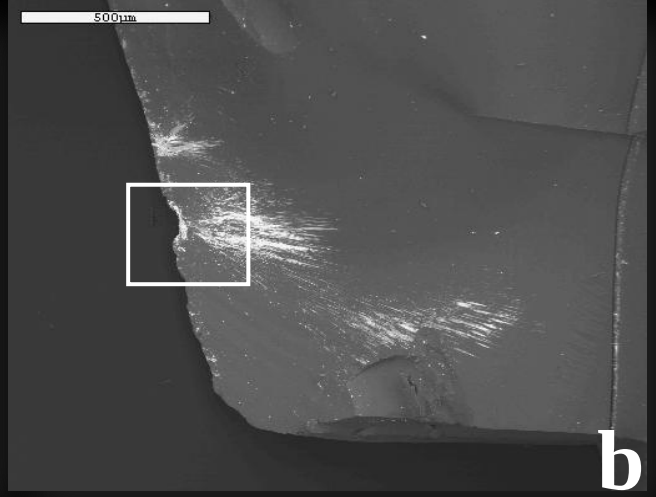

2mm

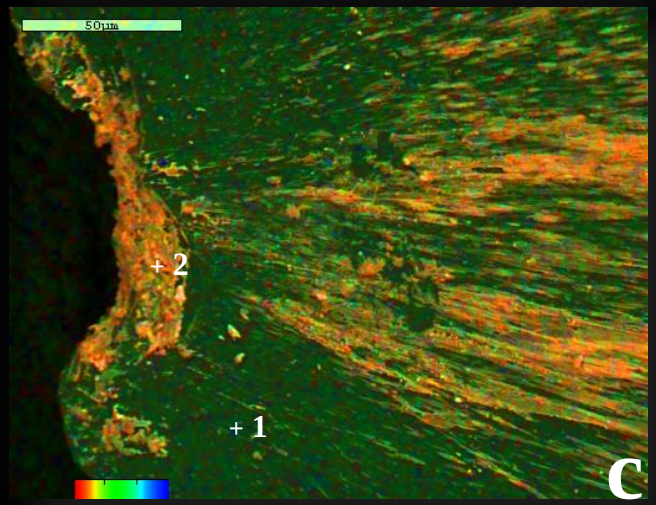

20µm


cps
100
80
60
40
20
0
C
O
Al
Pb
Sb
Ba
Fe
Pb
0
5
10
15
20
Energy (keV)

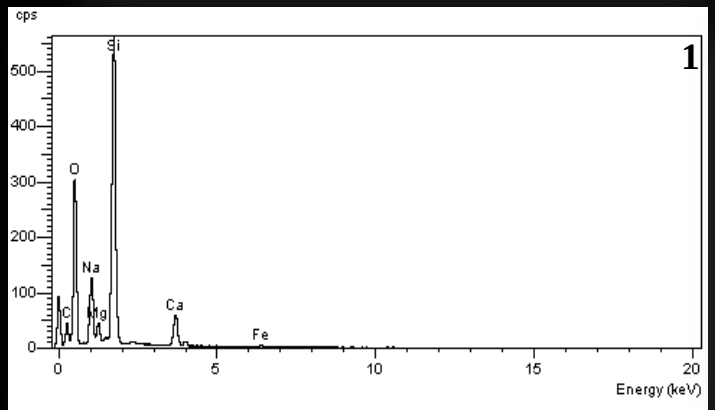
Colpo d'arma da fuoco
o corpo contundente?

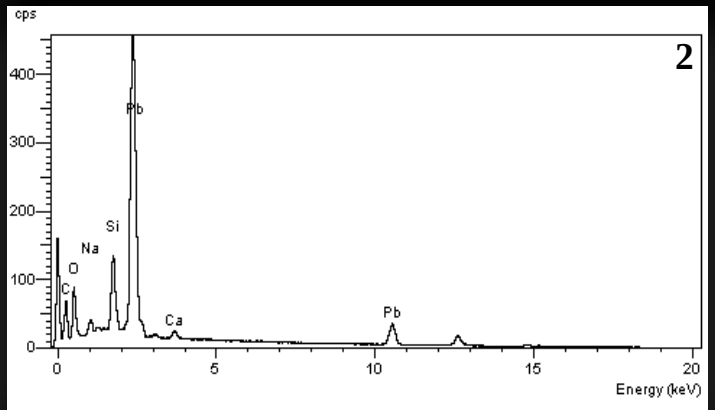

2mm
a


500µm
b

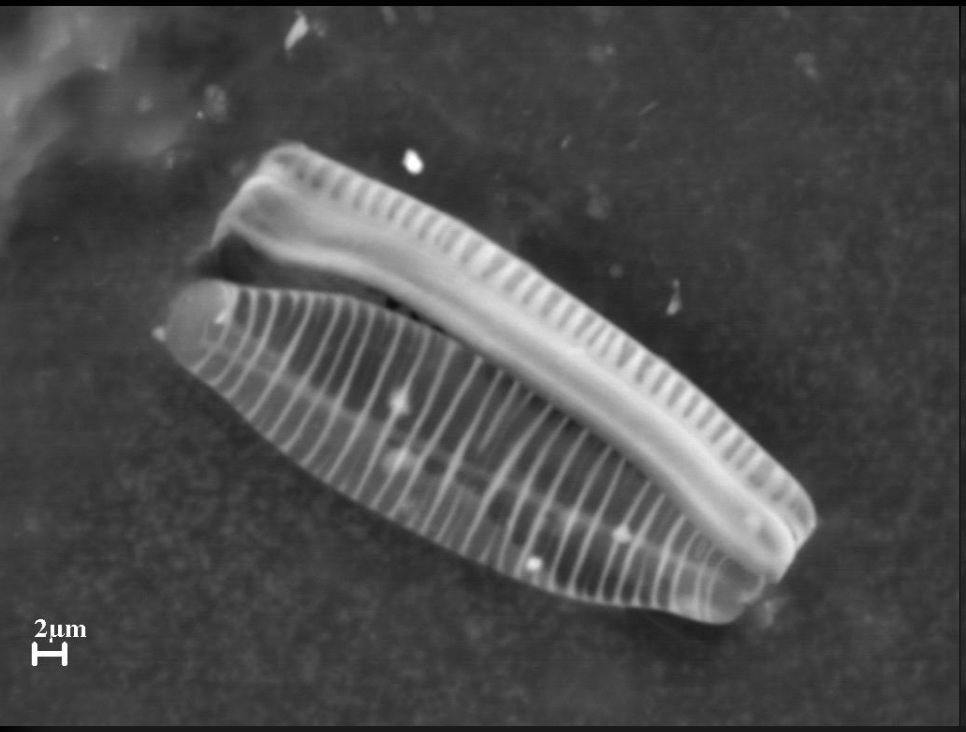

50µm
+ 2
+ 1
c

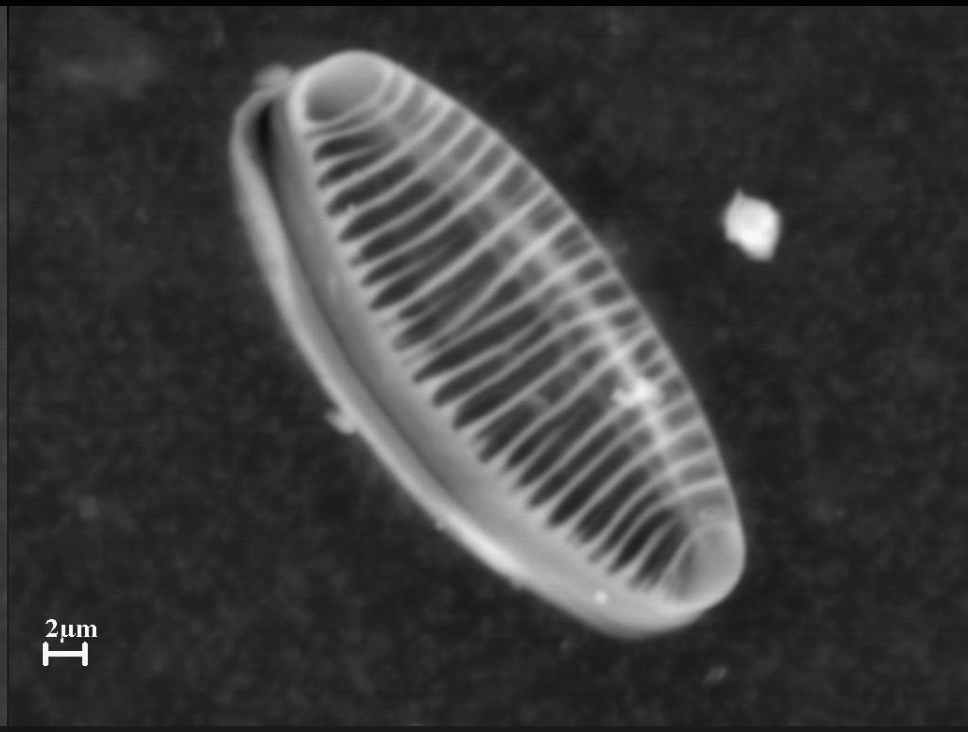

CJ 965KL

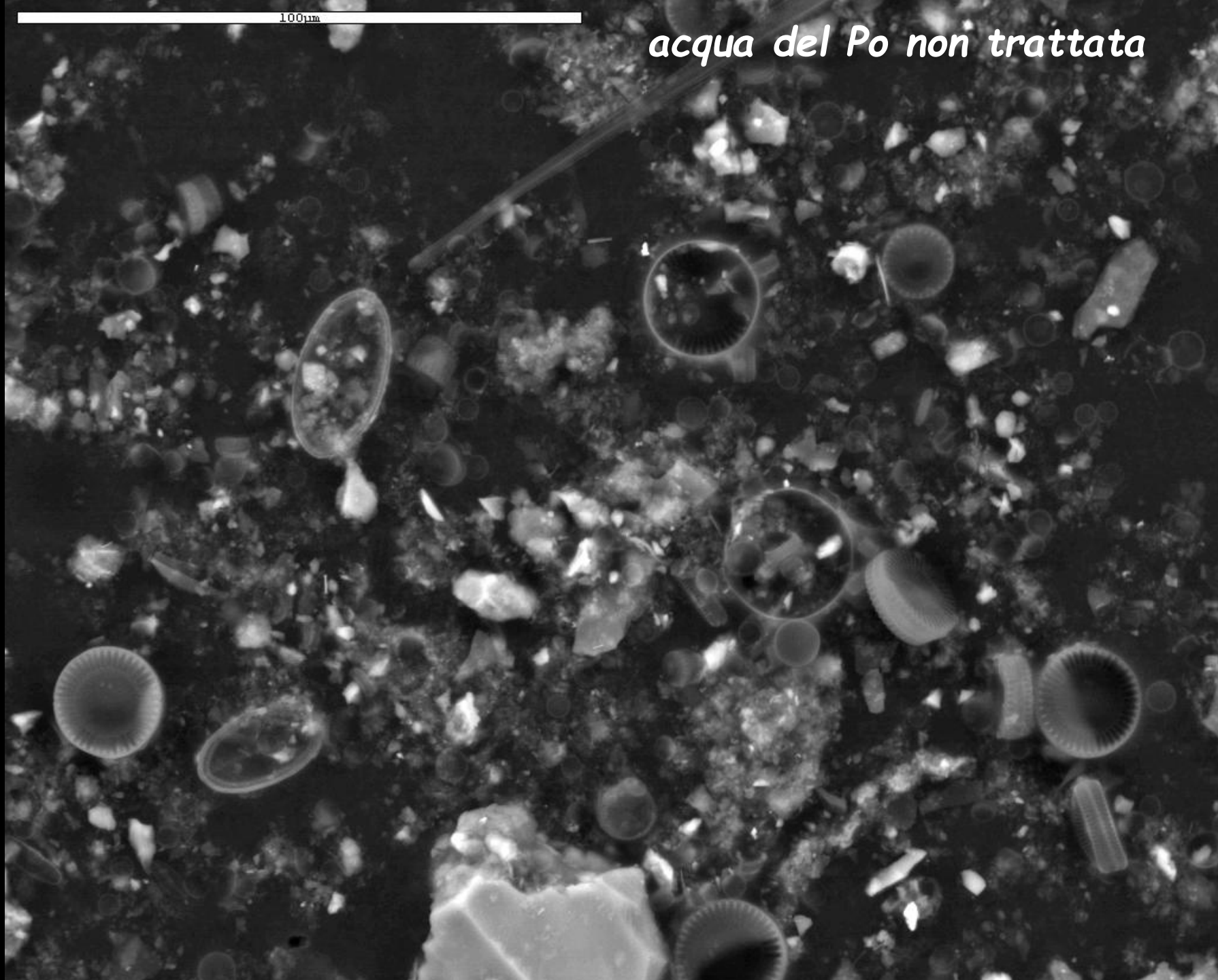

cps
1
Si
O
Na
C
Mg
Ca
Fe
0
100
200
300
400
500
0
5
10
15
20
Energy (keV)

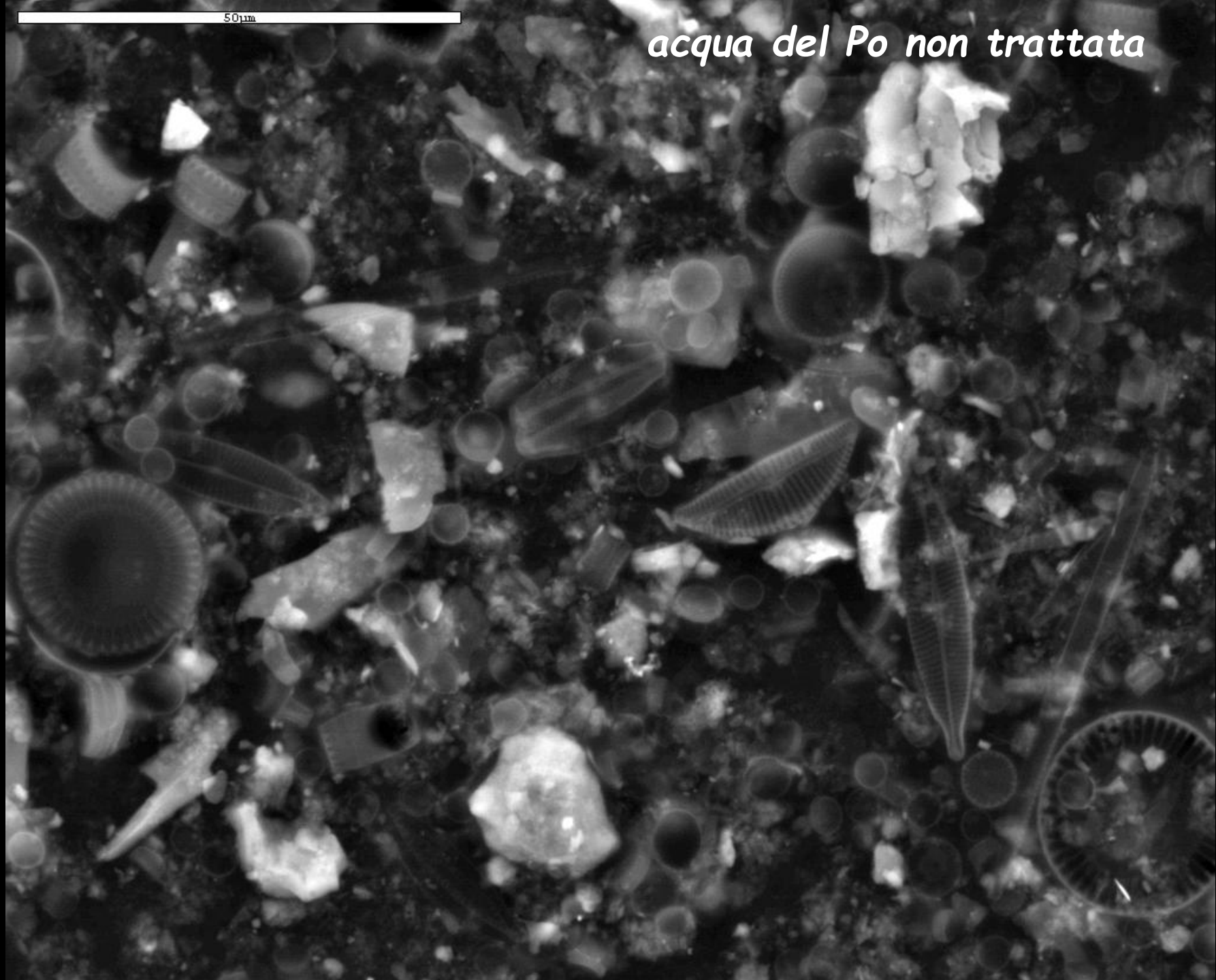

cps
2
Pb
Si
Na
O
C
Ca
Pb
0
100
200
300
400
0
5
10
15
20
Energy (keV)

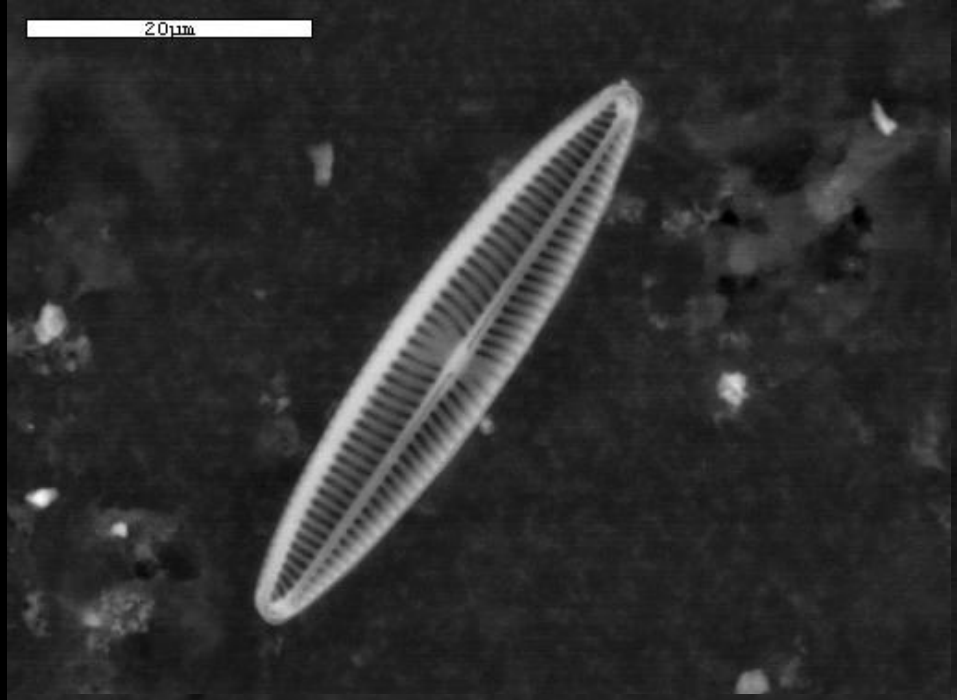
Non solo balistica …

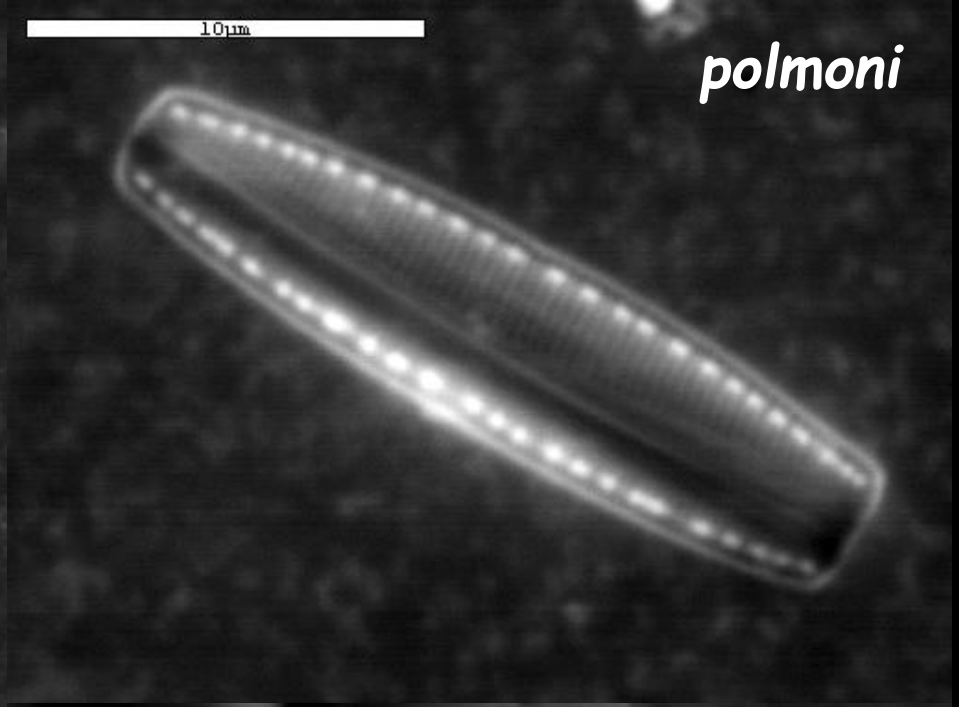

2µm


2µm

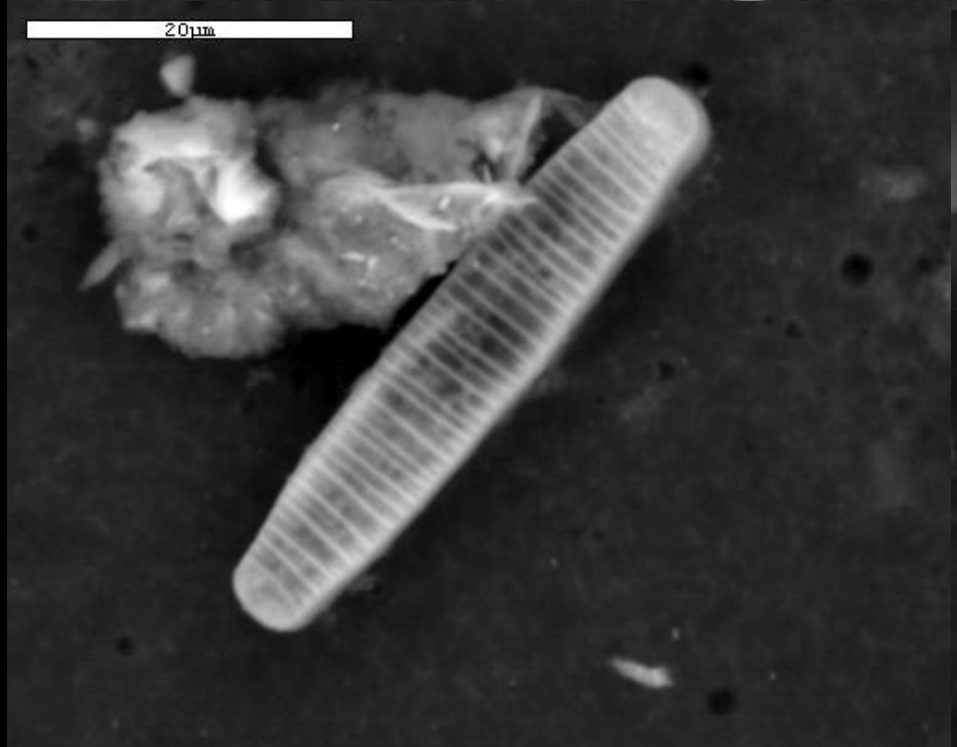

100µm
acqua del Po non trattata

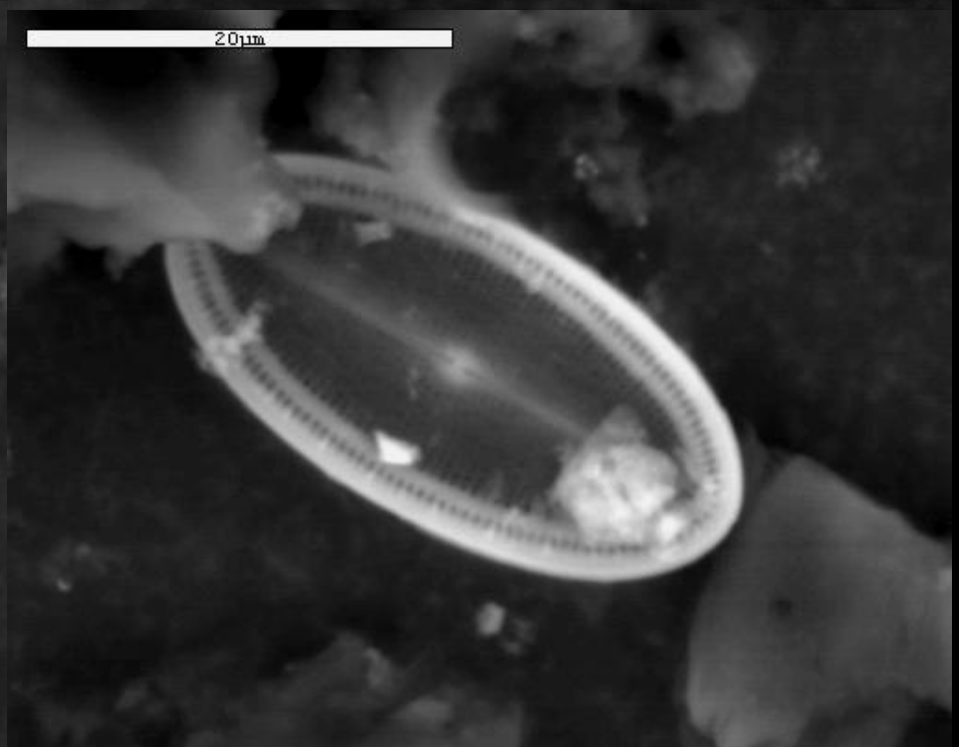

50µm
acqua del Po non trattata

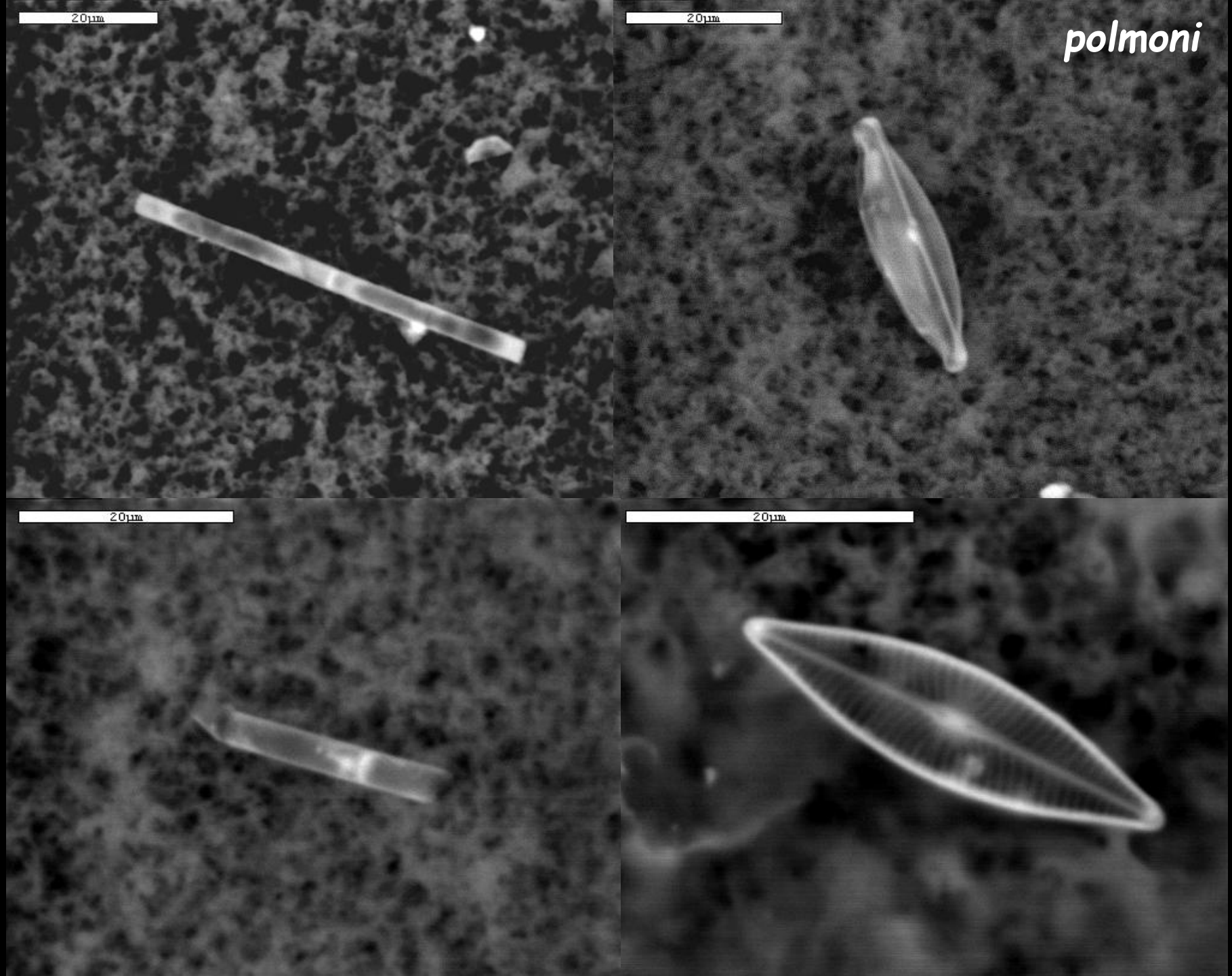




polmoni

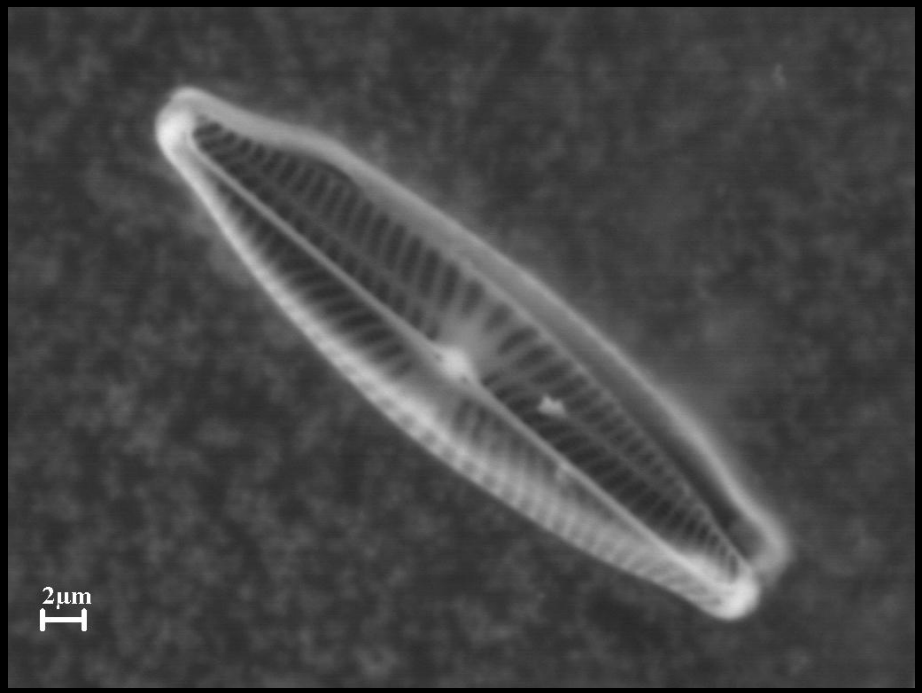


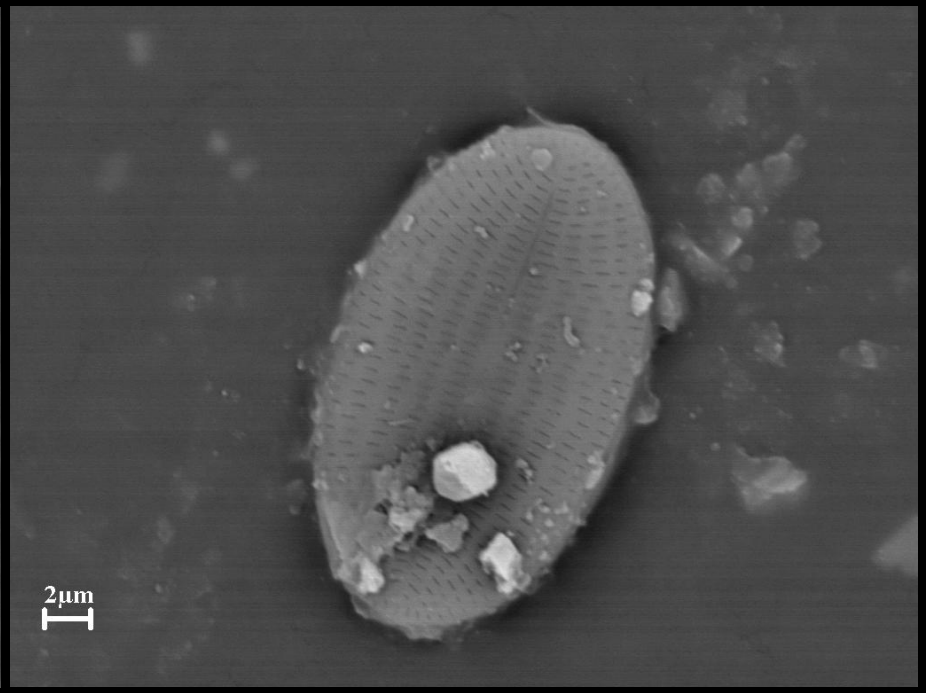


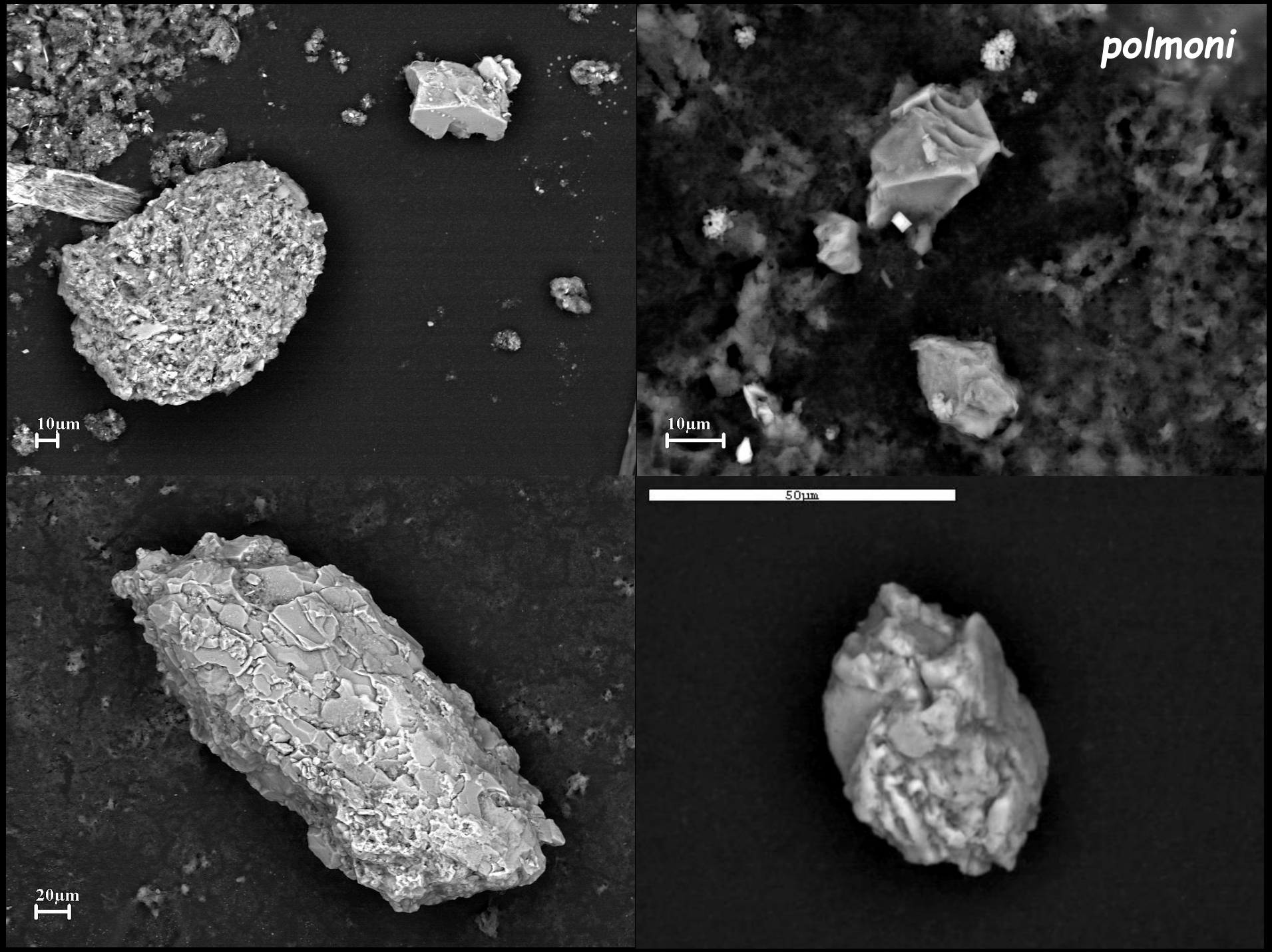

20µm
20µm
polmoni
20µm
20µm


2µm


polmoni
2µm

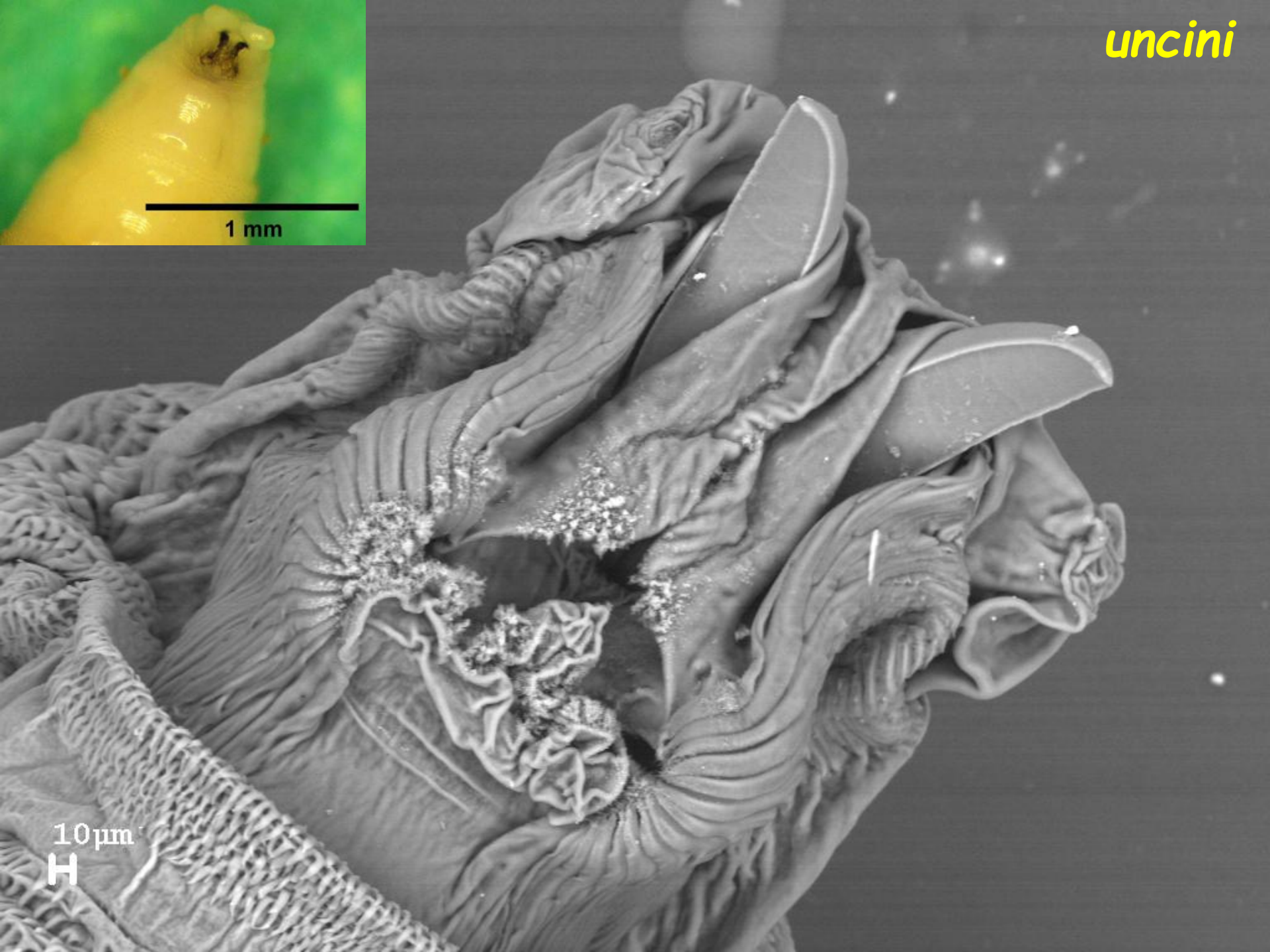

2µm

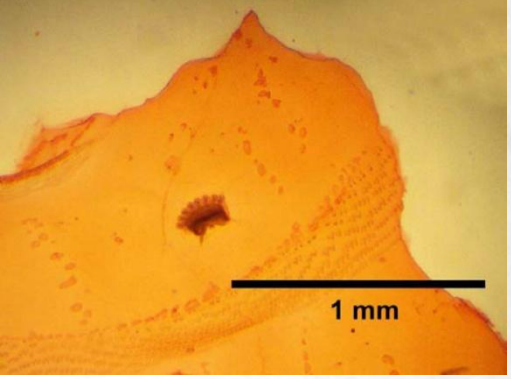

2µm


polmoni
10µm
10µm
20µm
50µm


Lucilia sericata

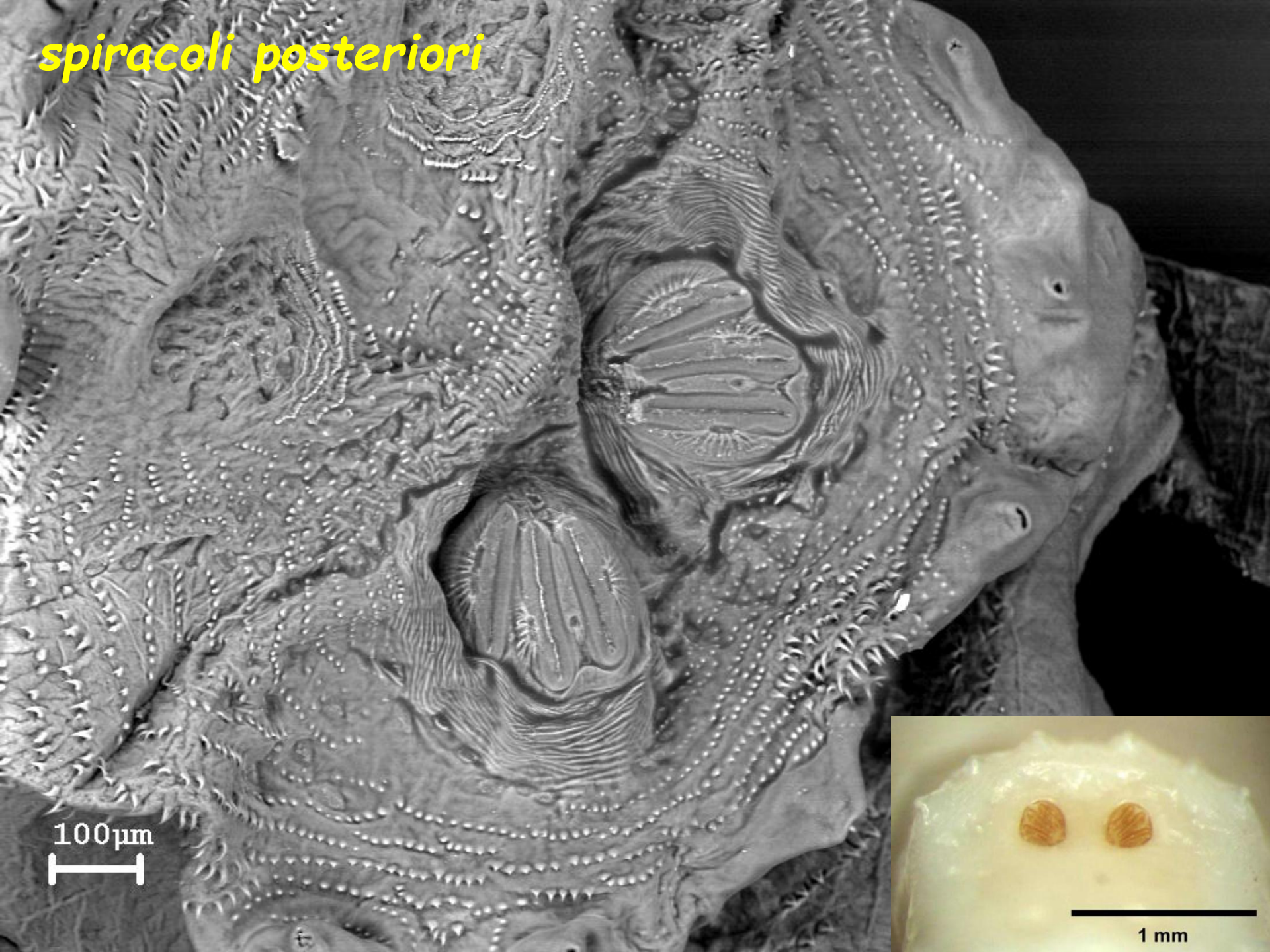

1 mm

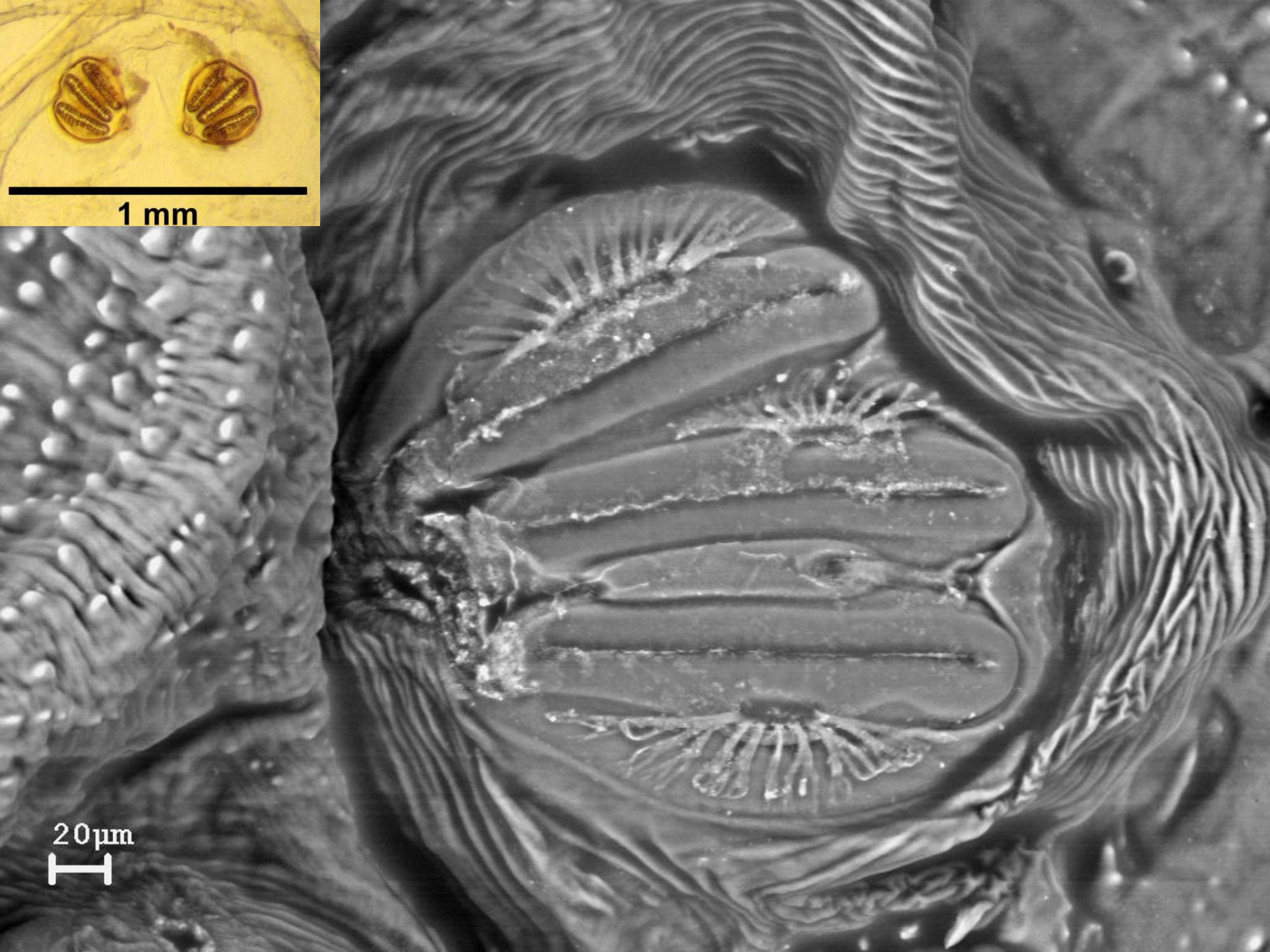

uncini
1 mm
10µm
H

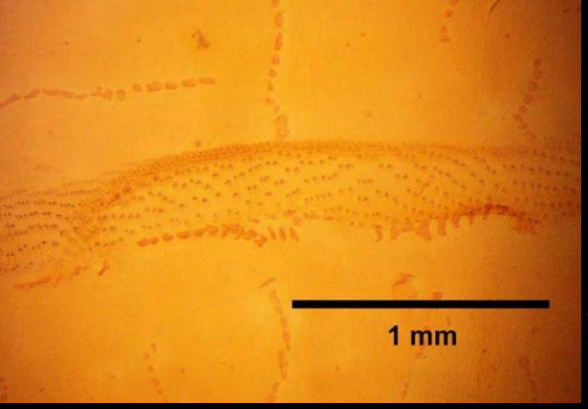


spiracoli anteriori

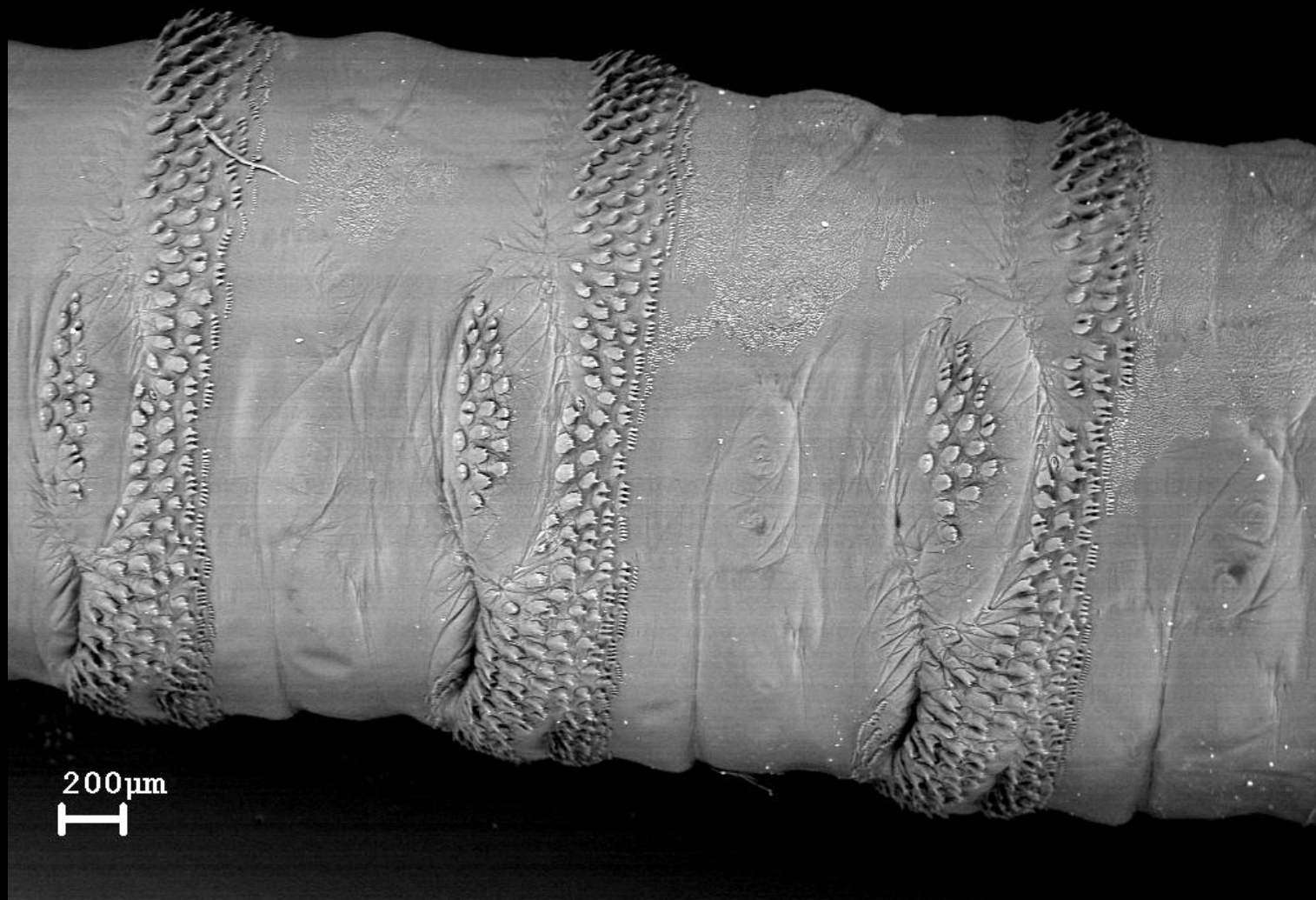

20µm

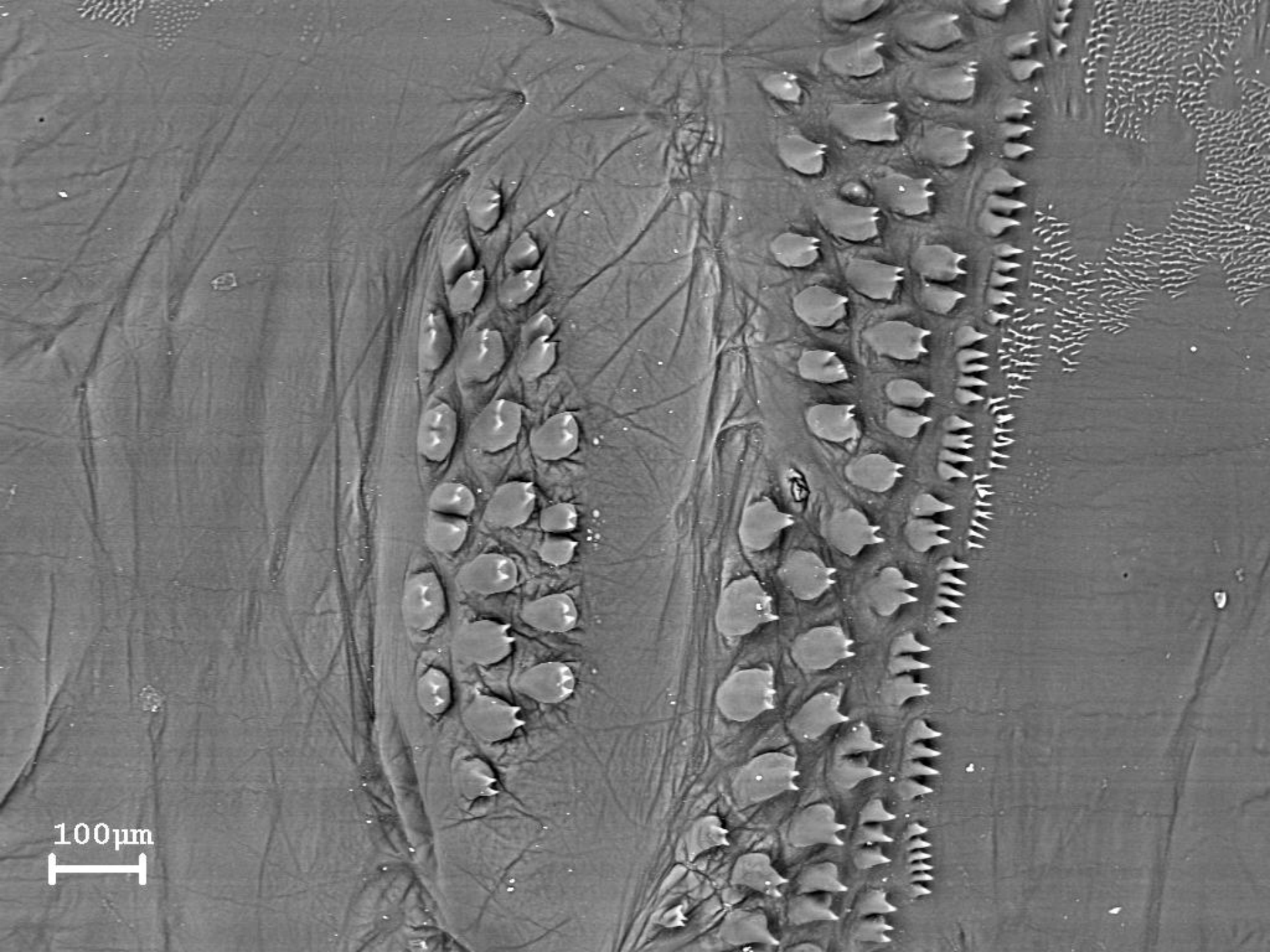

spiracoli posteriori
100µm
1 mm


1 mm
20µm

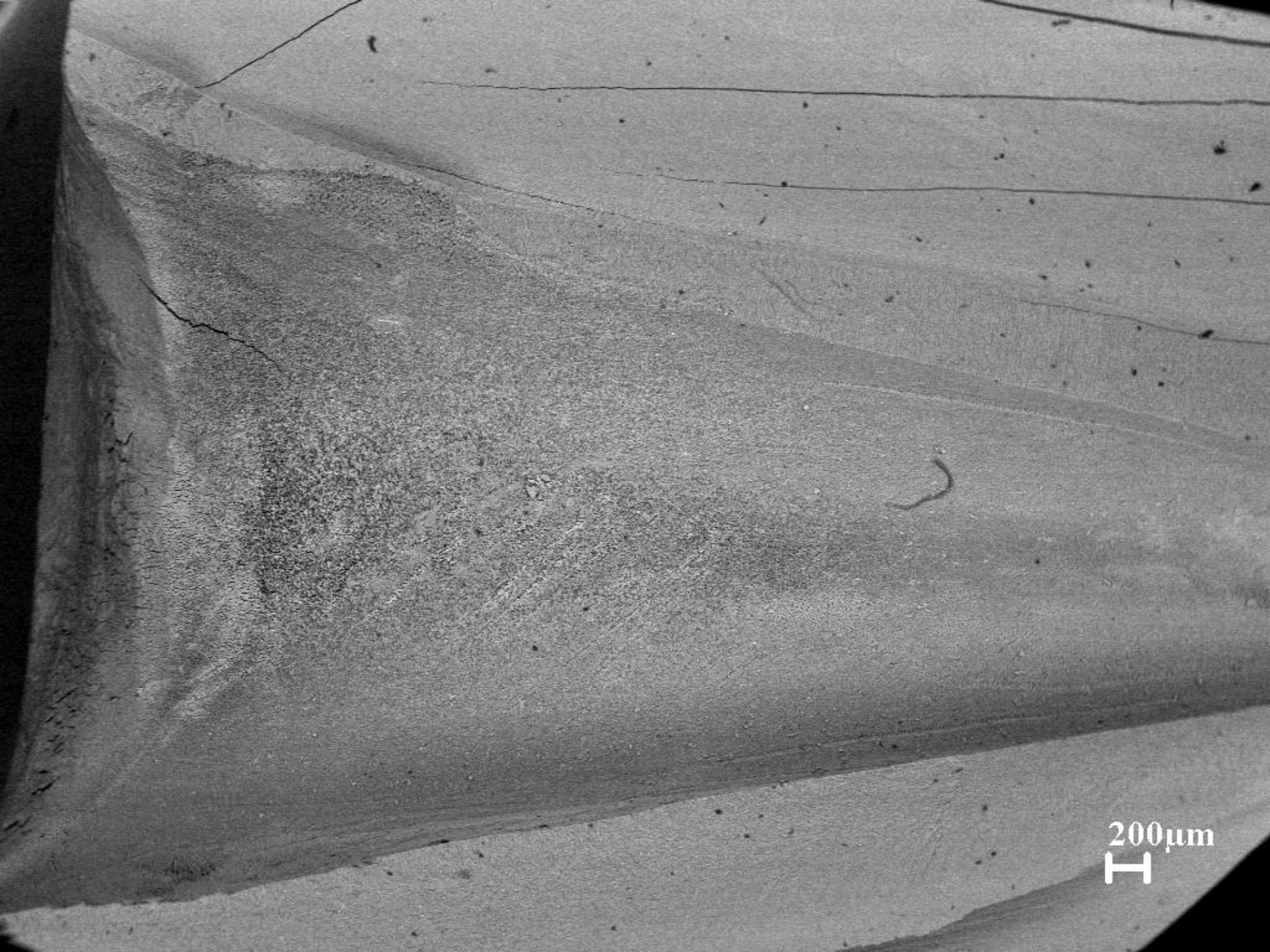


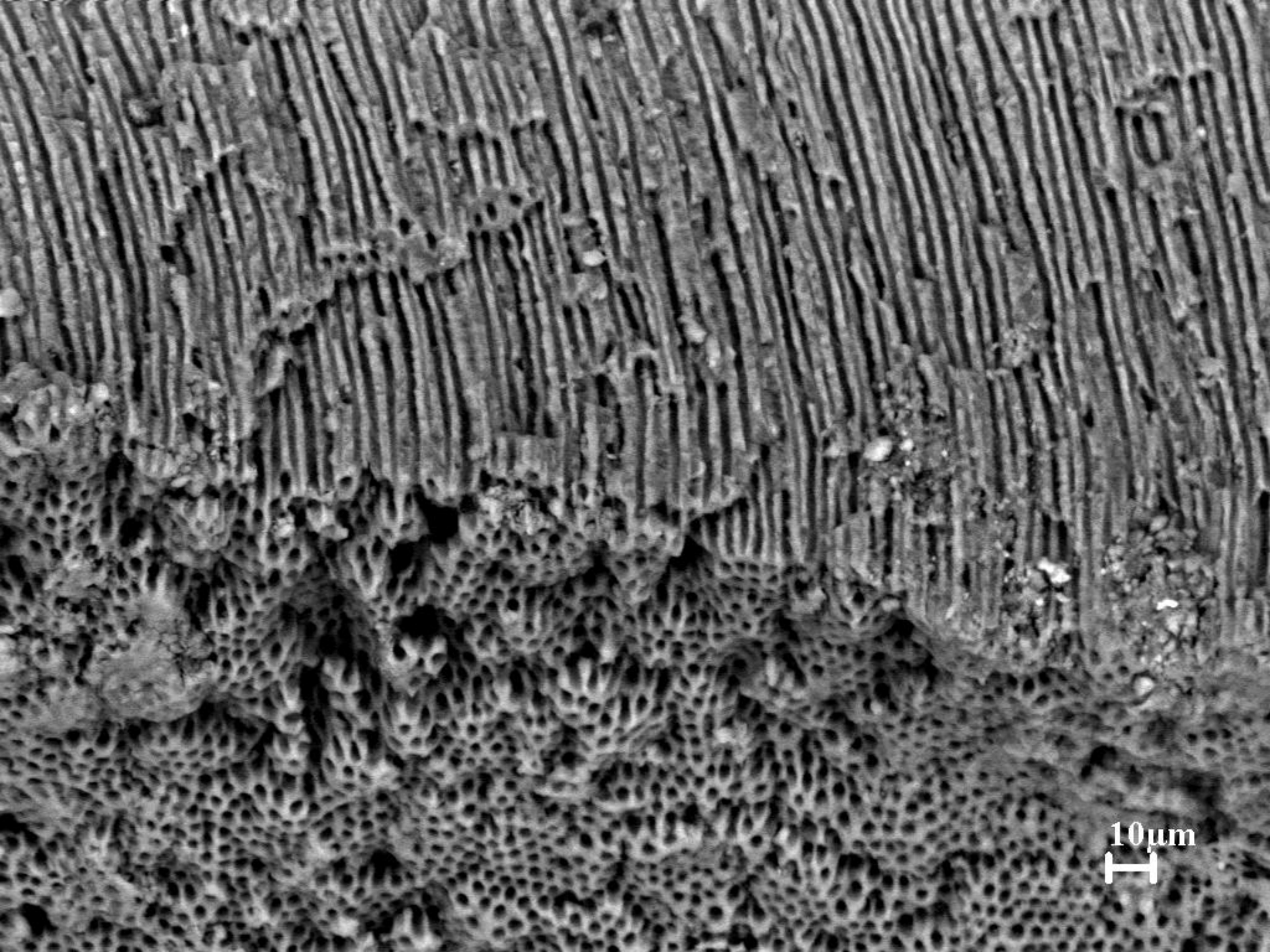
spine



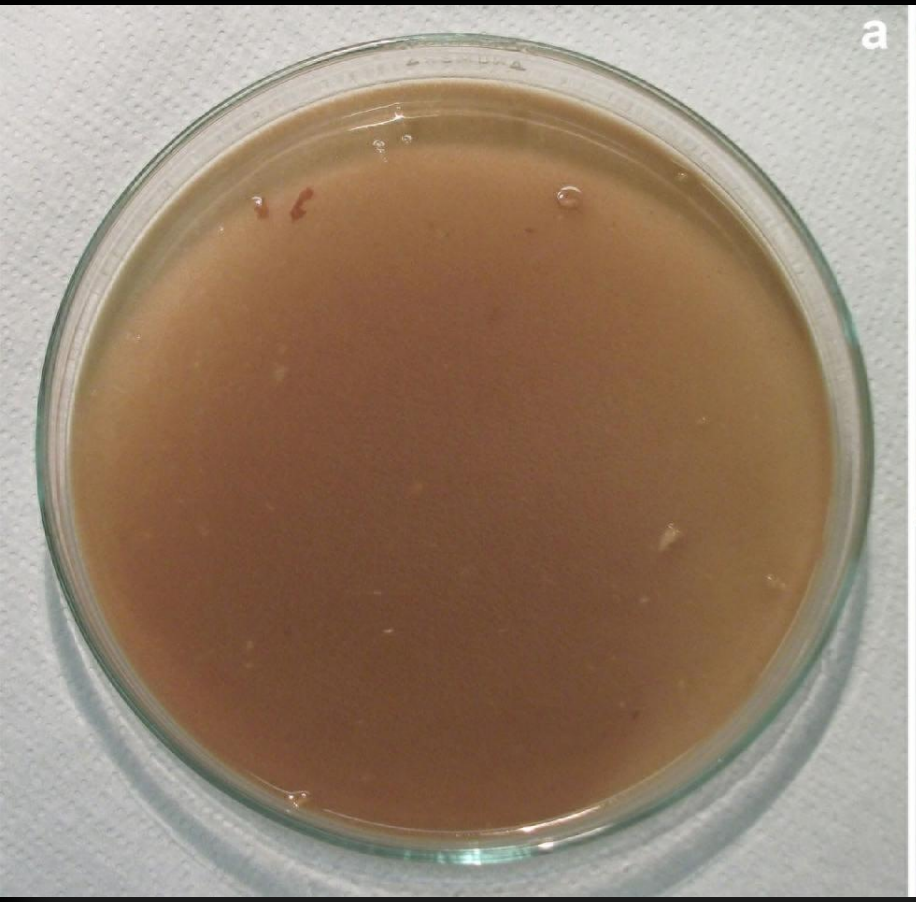

100µm

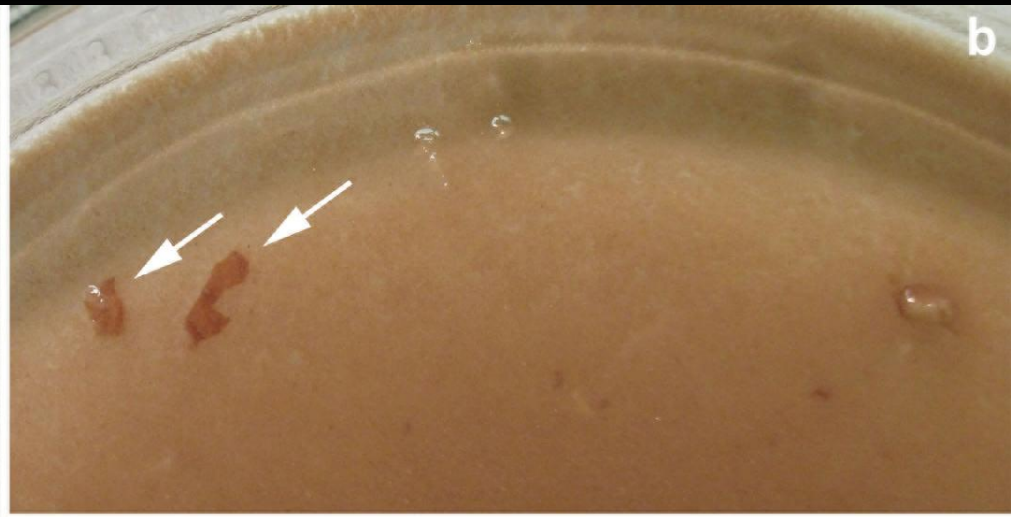
Mal di denti?

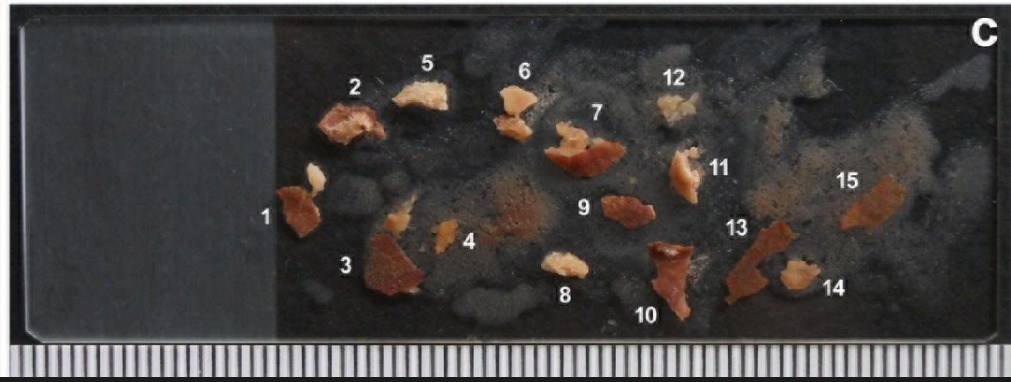

200µm

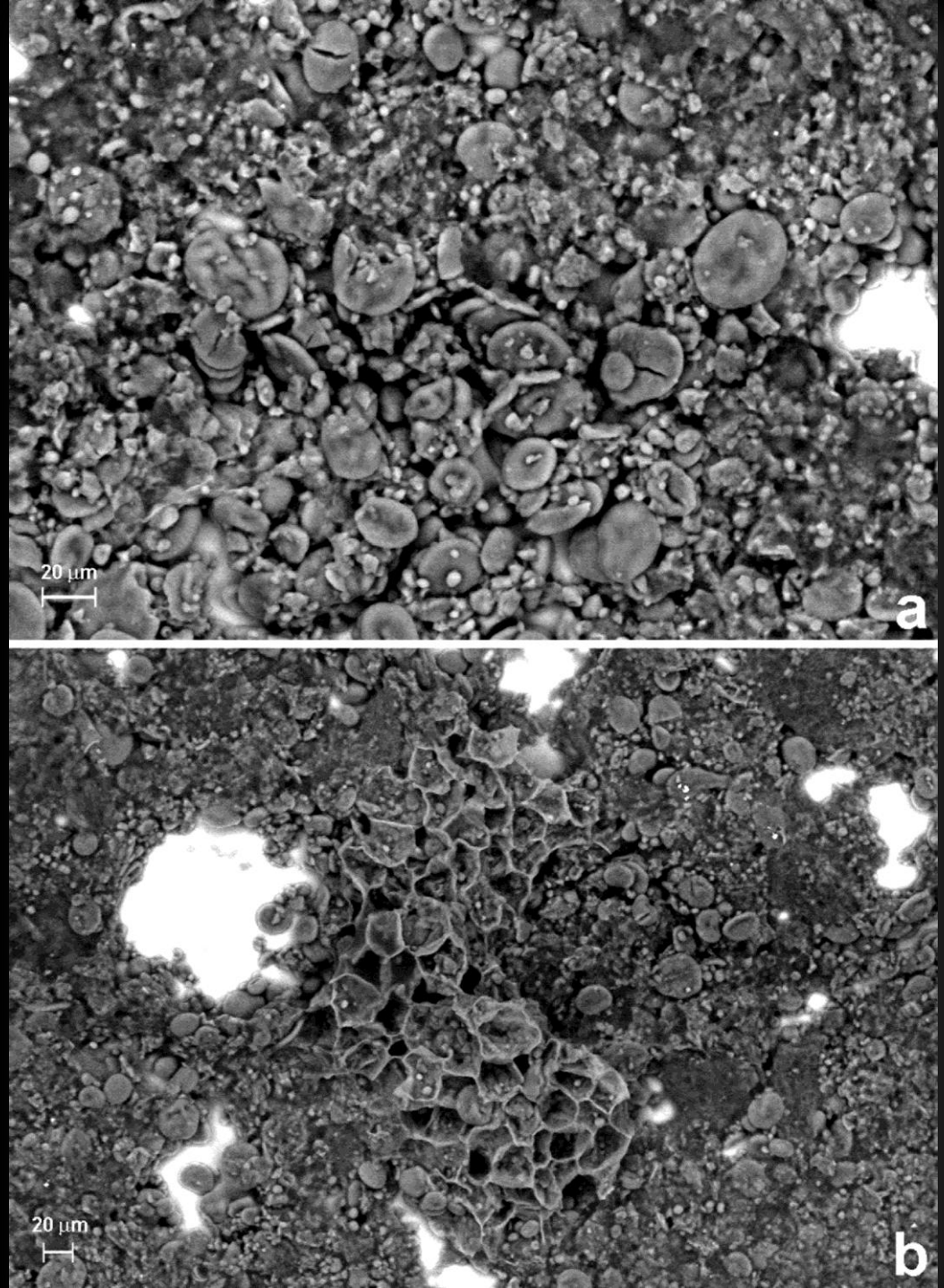

10μm

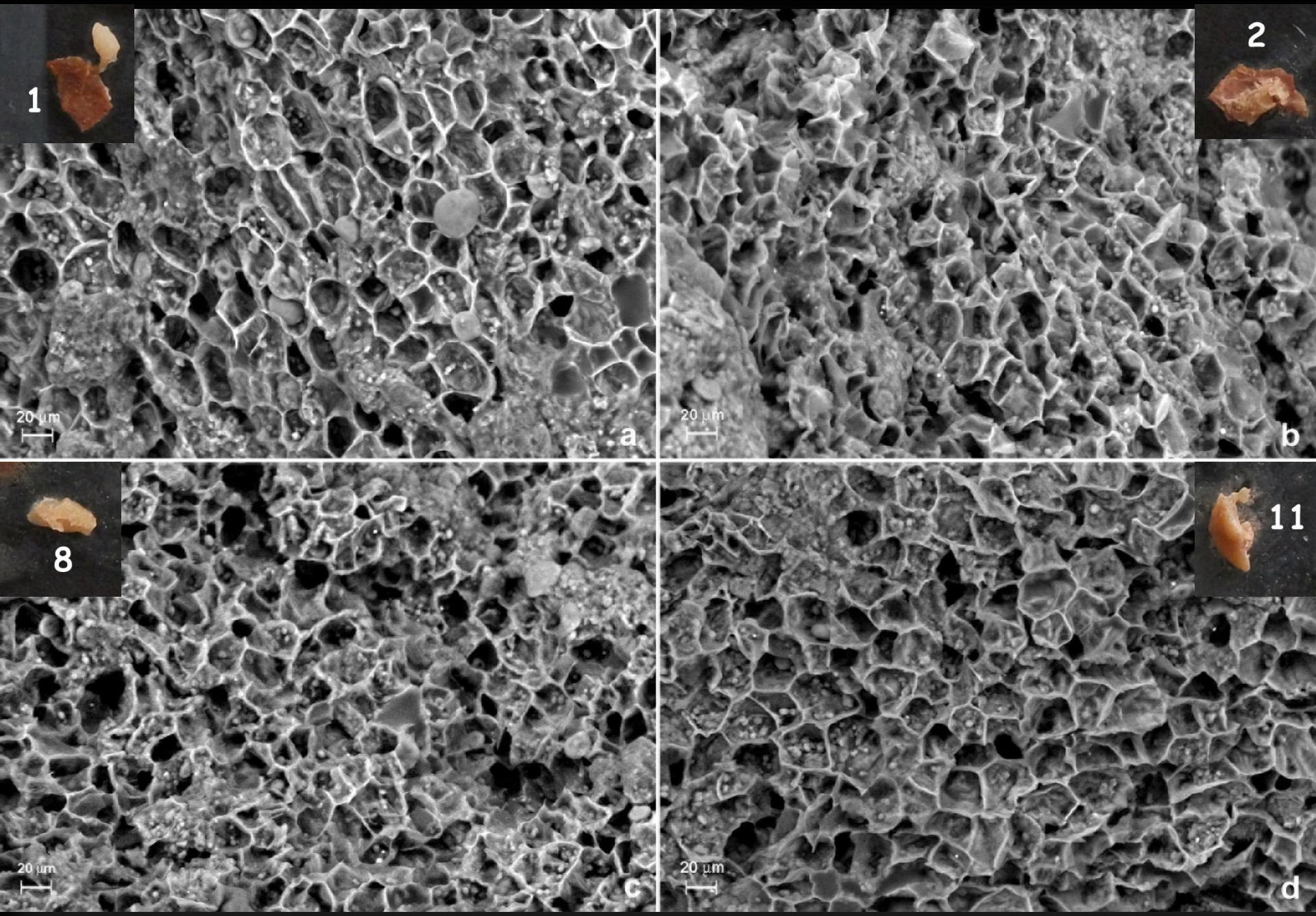
Cos'hai mangiato?

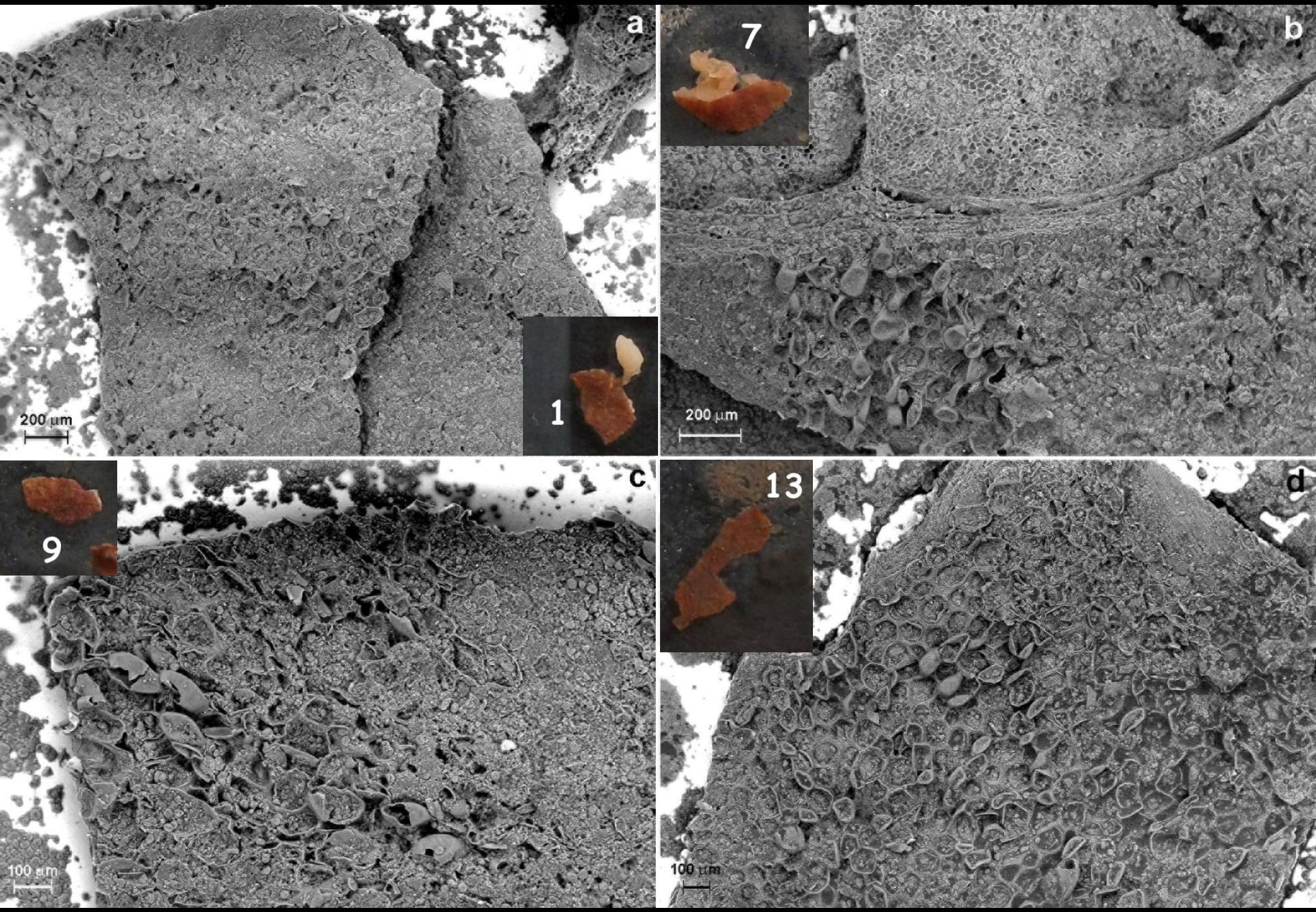

a

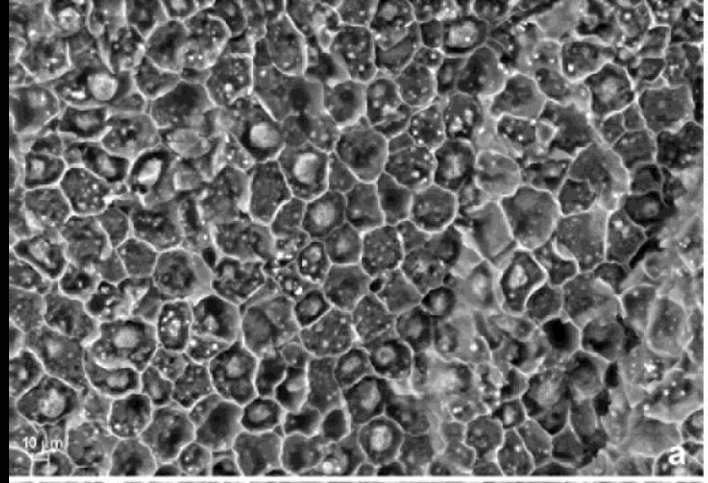

b

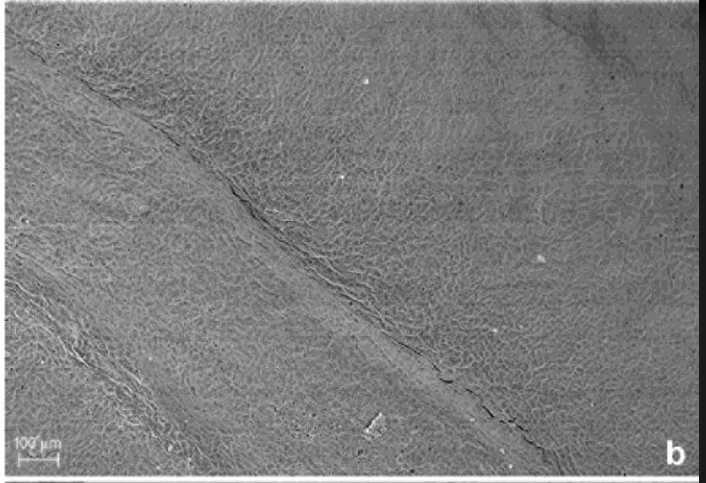

c
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

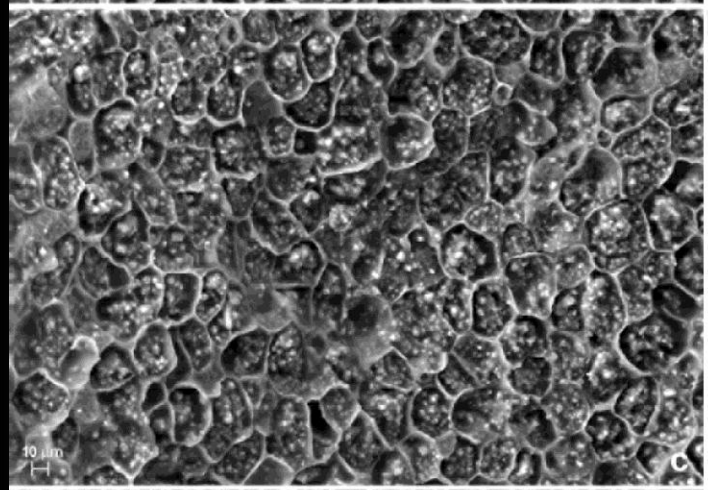

20 μm
a
20 μm
b

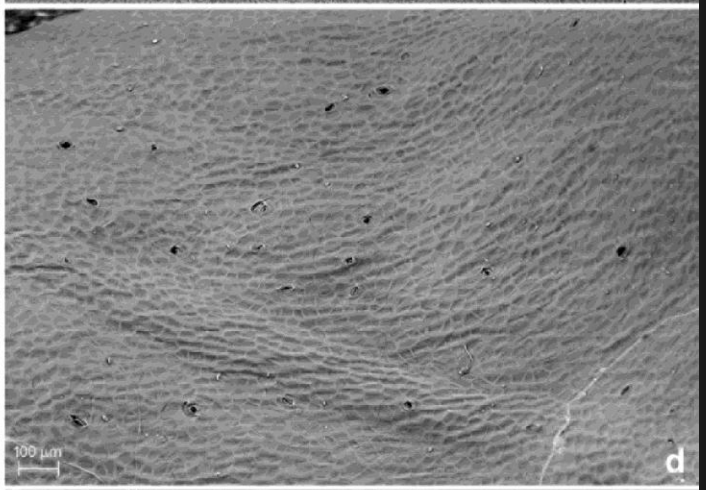

1
2
20 µm
a
20 µm
b
8
20 µm
c
11
20 µm
d

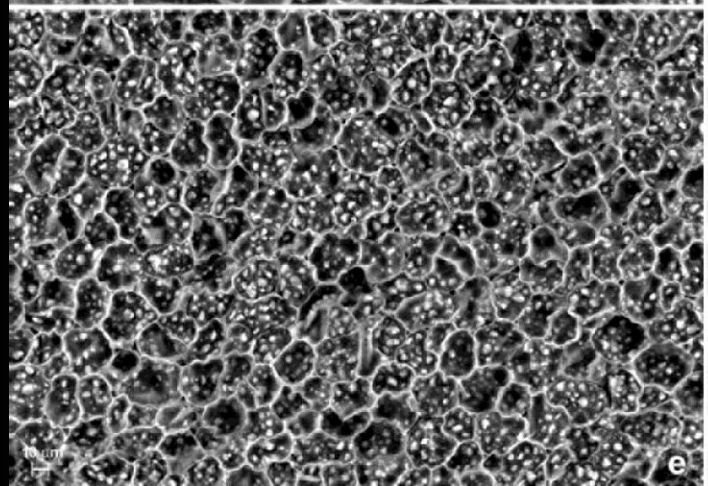

a
200 µm
1
b
7
200 µm
c
9
100 µm
d
13
100 µm


10 µm
a


100 µm
b


10 µm
c

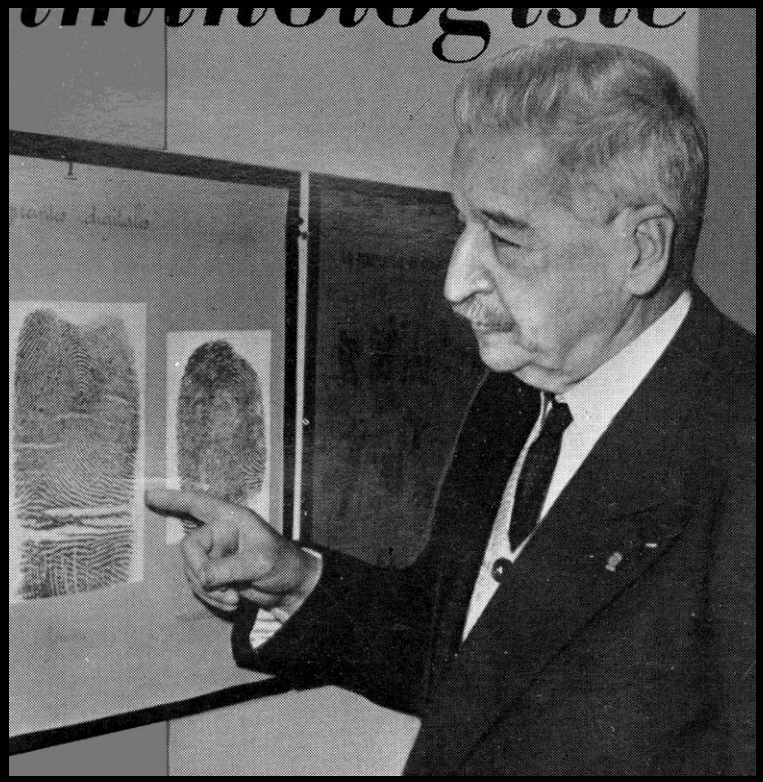

100 µm
d


10 µm
e


100 µm
f

"Una buona prova scientifica deve essere semplice e comprensibile. Lo «spirito del tempo» vuole che la prova scientifica sia ad alta tecnologia ed esprimibile matematicamente. Nulla di più sbagliato. Spesso la semplice osservazione di un fenomeno dà informazioni più corrette della più sofisticata indagine tecnica".

(Carlo Torre)



Edmond Locard
(1877 – 1966)

… l'erreur est tragique
quand [la preuve]
atteint l'honneur, la liberté, la vie.

1931

Federico Oloriz y Aguilera
(1855-1912)

Mio unico interesse
consiste
nel sapere la verità;

sempre son pronto
a dichiarare i miei
errori …

3 novembre 1910

Grazie …

La sala settoria, con la attività che vi si svolge, rappresenta l'ambiente ottimale per chi ha passione per la morfologia e per i fenomeni biologici che questa può svelare.
Chi fa questo mestiere per scelta e non per caso avvertè sensazioni difficilmente comunicabili: quella gradevole trepidazione che precede e accompagna ogni autopsia, dal più scontato riscontro alla più spinosa "giudiziaria"; quella voglia di guardar dentro, di descrivere, di capire; il piacere di una dissezione corretta, con cui a poco a poco riconosci sul "tuo" morto l'anatomia studiata sui libri e riesci a discriminare il normale, con la sua vastissima gamma di variabilità, dal patologico.

C'è, poi, nell'attività medico-legale, qualcosa di più, di esclusivo nei confronti di quella dell'anatomo-patologo, che rende il nostro rapporto con il cadavere insieme umanissimo ed impietoso.
C'è che nella gran parte dei casi abbiamo di fronte chi dalla morte è stato colto di sorpresa, e non ha avuto il tempo o la possibilità di prepararsi neppure un po' per presentarsi a noi; nè ha potuto celare i segni di private, personalissime abitudini, di segrete debolezze.
Ne dovremo descrivere gli abiti e la loro foggia, se son nuovi o logori, puliti o sudici. Dovremo frugare nelle sue tasche. Cercargli sulla pelle, tra i capelli e dentro allo stomaco ogni possibile utile notizia.
È di fronte a noi; un oggetto da studiare, tuttavia ancora caldissimo di viva ed indifesa personalità.
Questo non deve essere dimenticato mai. E la consapevolezza di essere un intruso, un certo imbarazzo, lungi dall'ostacolare la correttezza tecnica della indagine, dovranno accompagnare costantemente la nostra opera.
La stessa consapevolezza è condizione per scacciare la lusinga di cogliere, per la natura di questo strano lavoro, inevitabile oggetto di popolare interesse, una facilissima quanto immeritata notorietà; o, peggio, di barattar con essa serietà e discrezione.

Il morto è indifeso; ed ancor più lo sono i suoi familiari o, comunque, coloro che ebbero con lui consuetudine di affetti.
Noi li incontriamo in circostanze difficili; travolti dagli eventi e dalla burocrazia. Sarà un semplicissimo e gratificante dovere dedicar loro un po' di tempo, una rassicurante parola.
Qui l'arroganza che contrassegna il medico sciocco diviene imperdonabile colpa, e chi ne è contagiato è da condannare con inequivoca fermezza.

Dobbiamo ricordare tutto ciò, sempre. E la nostra condotta dovrà essere uniforme di fronte all'assassino ed alla vittima, alla chiassosa tribù di zingari, agli indisponenti amici del drogato. Di fronte al vincente ed al derelitto, al camorrista in catene, al poeta a tutti noto.
Non sempre sarà facile; certamente sarà giusto.

Carlo TORRE