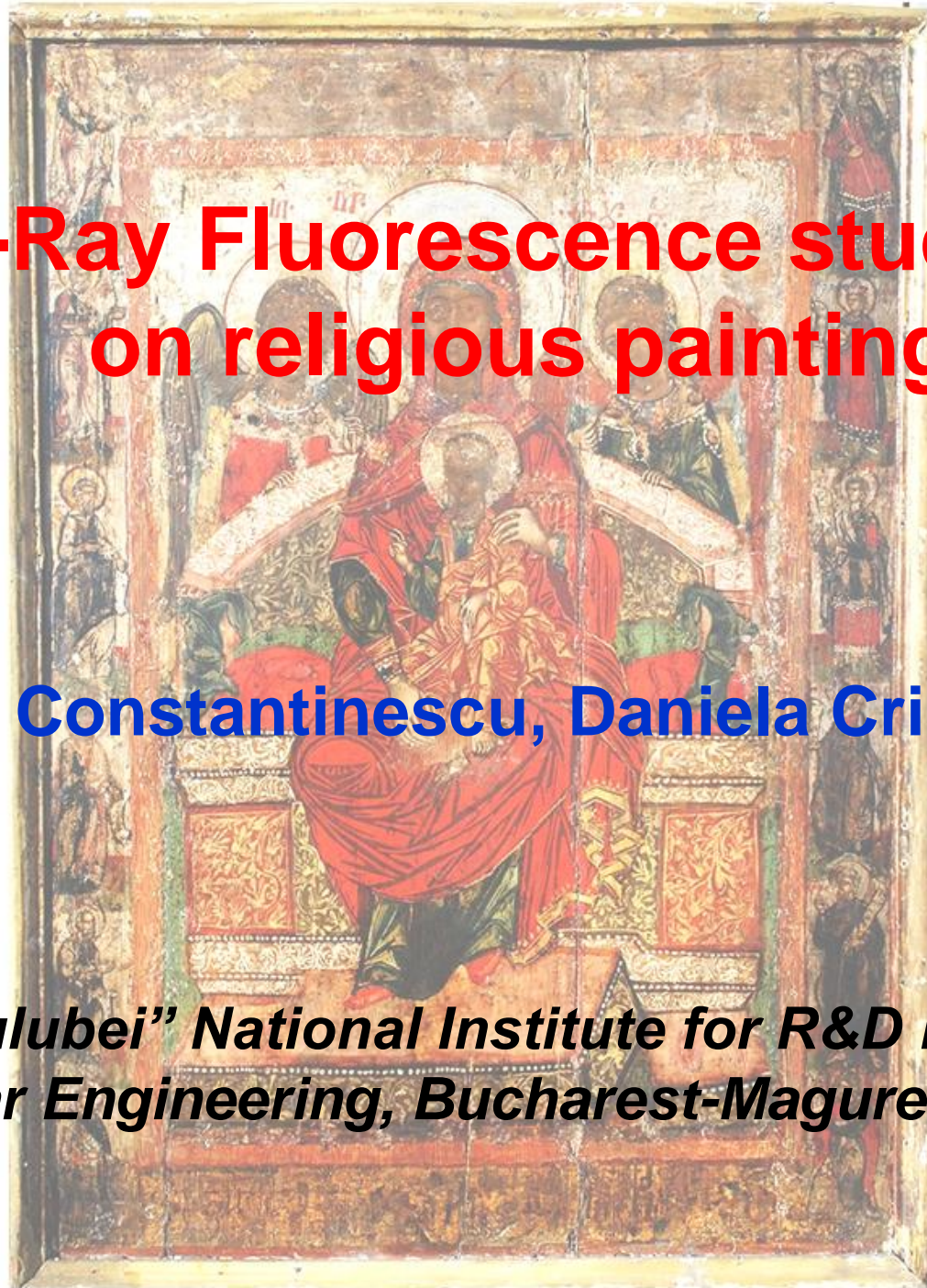


# X-Ray Fluorescence studies on religious painting

**Bogdan Constantinescu, Daniela Cristea-Stan**

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and Nuclear Engineering, Bucharest-Magurele, Romania***



**The XRF elemental analysis method is completely nondestructive and can be performed directly in situ.**

**In our “in-church” study, by scanning of specific areas, we identified inorganic pigments containing Fe, Co, Cu, Zn, As, Pb, Hg, Ag, Au, Sn, Sb, Ba.**

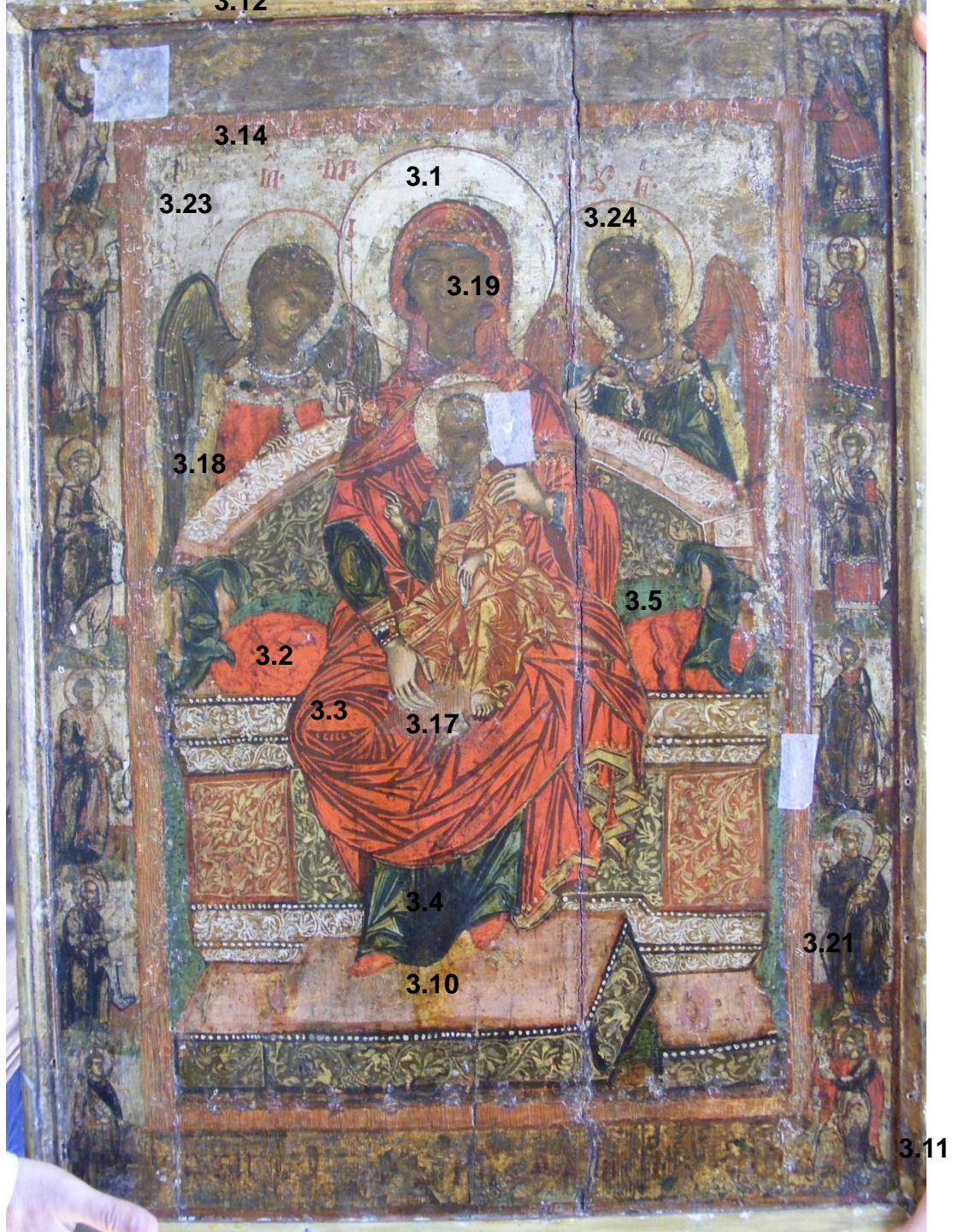


# Biserica Icoanei – 1786









3.12

3.14

3.23

3.1

3.19

3.24

3.18

3.2

3.5

3.3

3.17

3.4

3.10

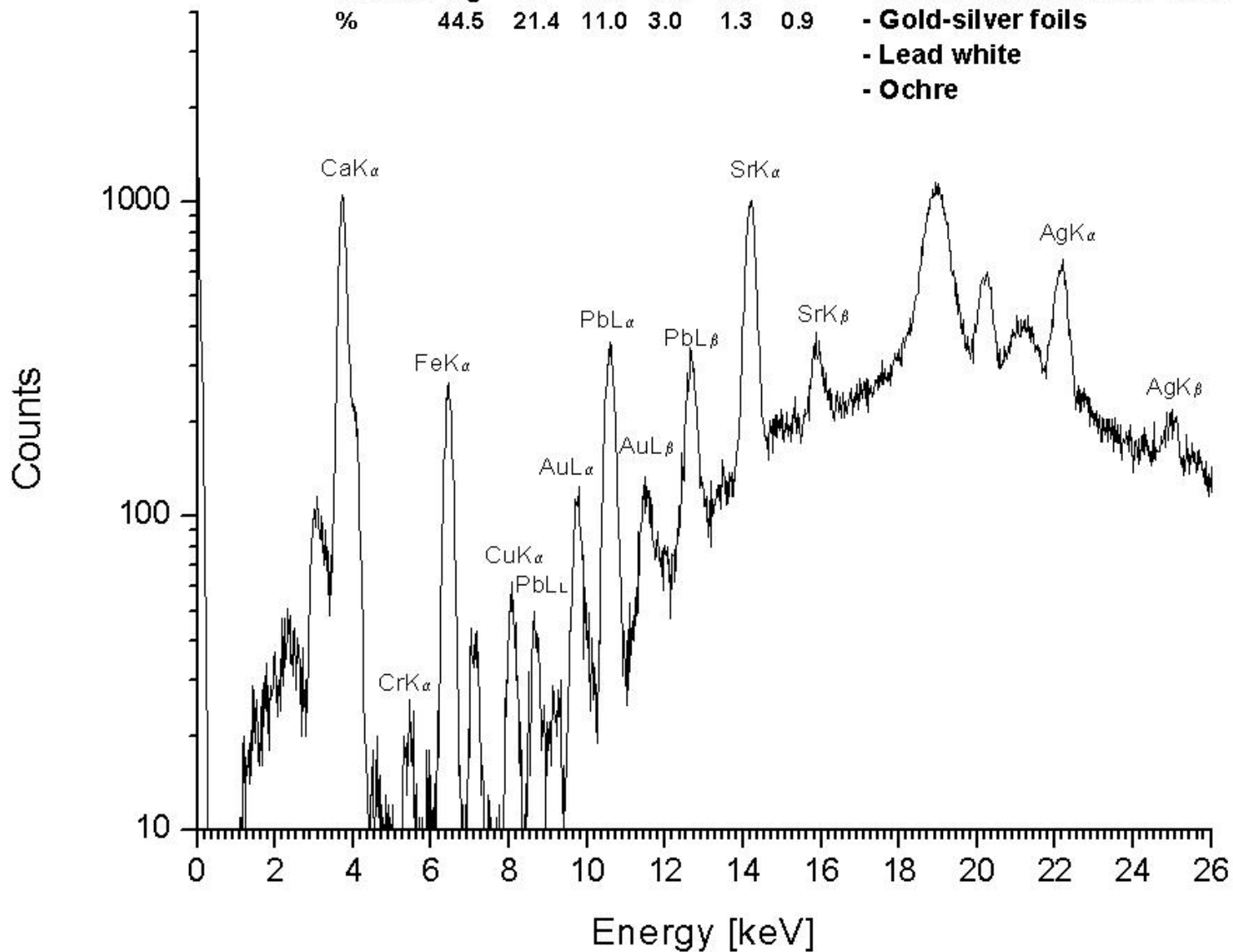
3.21

3.11



# Icon 3\_1 - The Virgin Mary (off-white aureola)

Element	Ag	Fe	Pb	Au	Cu	Cr	
%	44.5	21.4	11.0	3.0	1.3	0.9	- Strong signal from ground - calcium
							- Gold-silver foils
							- Lead white
							- Ochre



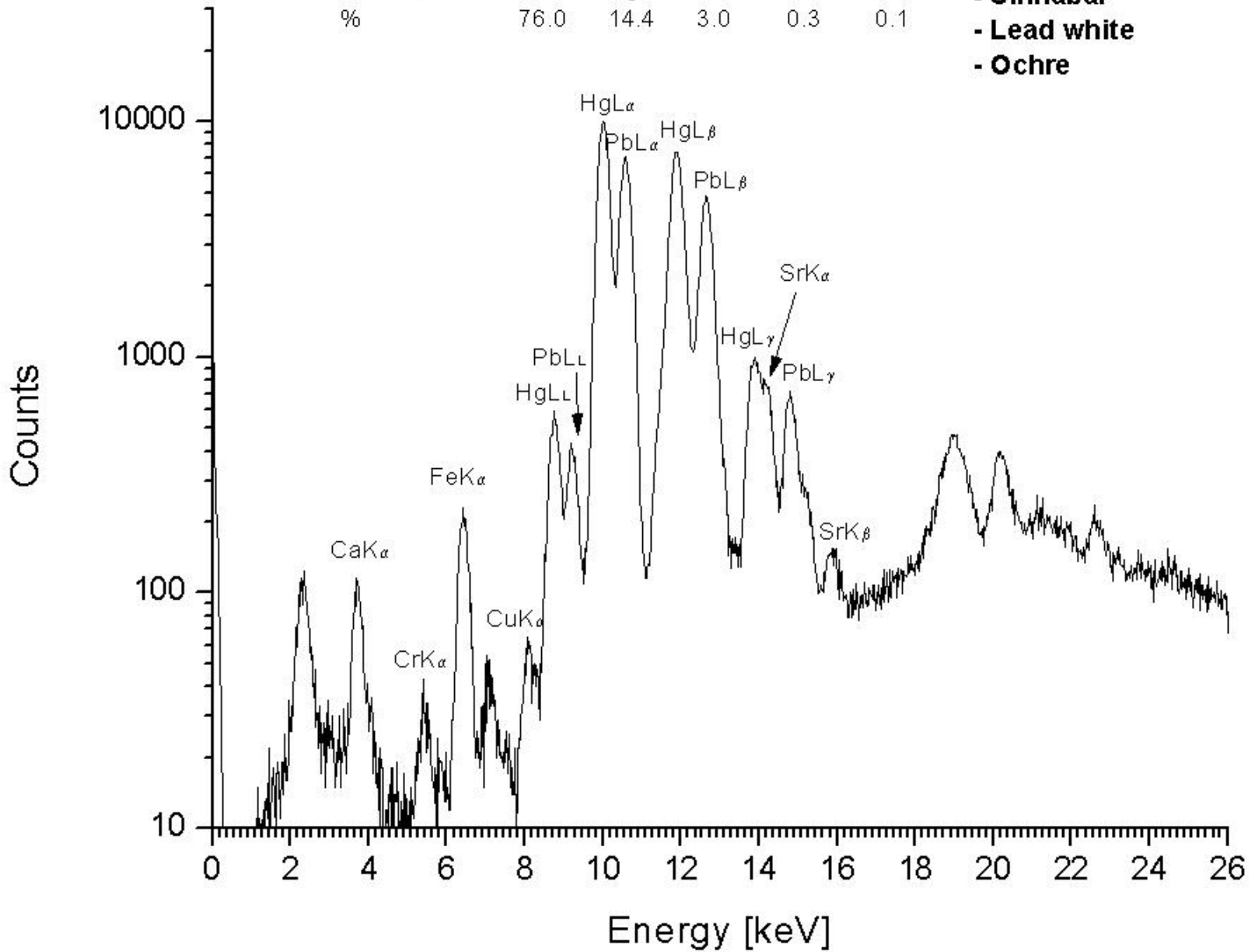




# Icon 3\_2 - red area \_ Angel mantle

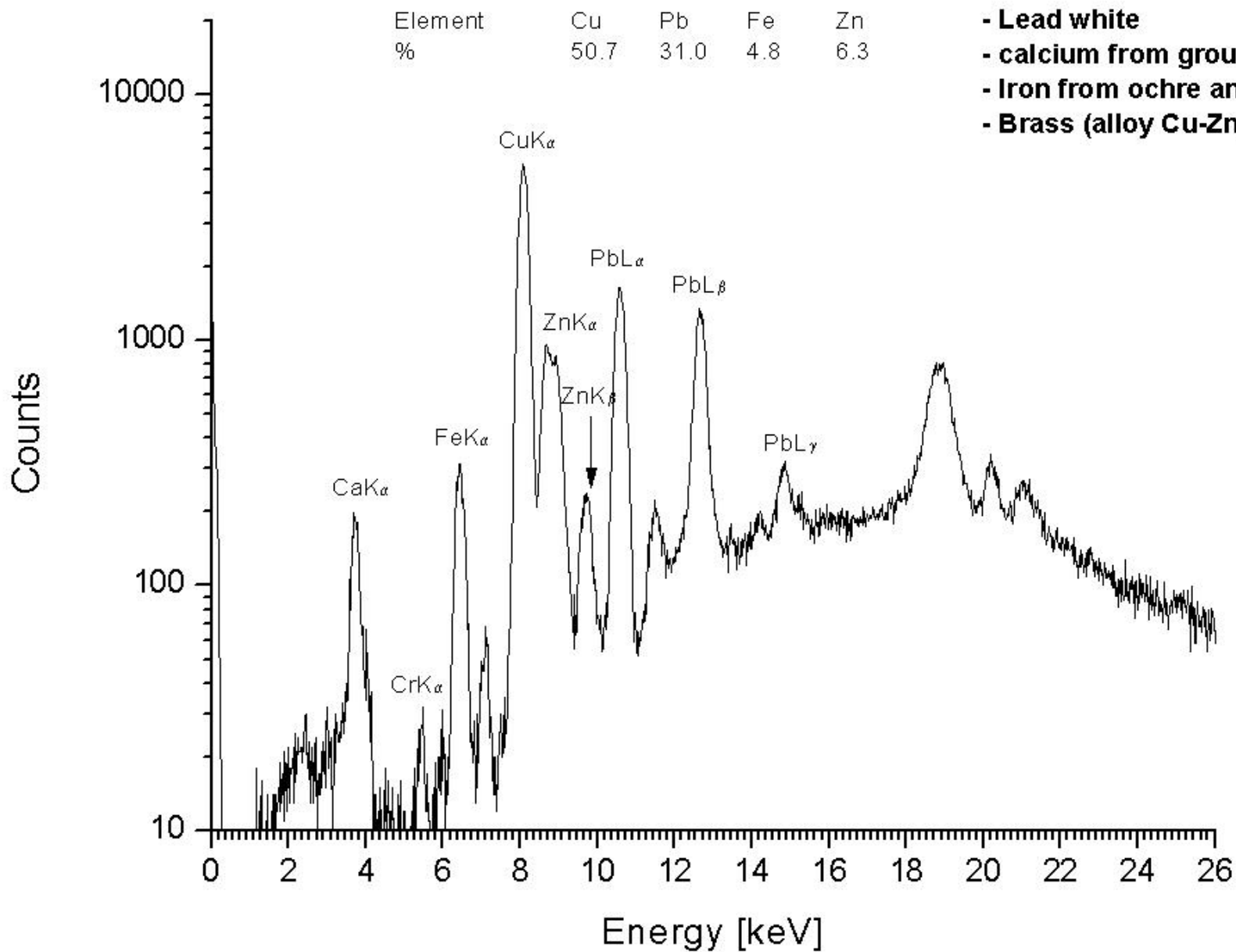
Element	Pb	Hg	Fe	Cr	Cu
%	76.0	14.4	3.0	0.3	0.1

- Cinnabar
- Lead white
- Ochre





# Icon 3\_11 - "Gold" area (frame - right down)

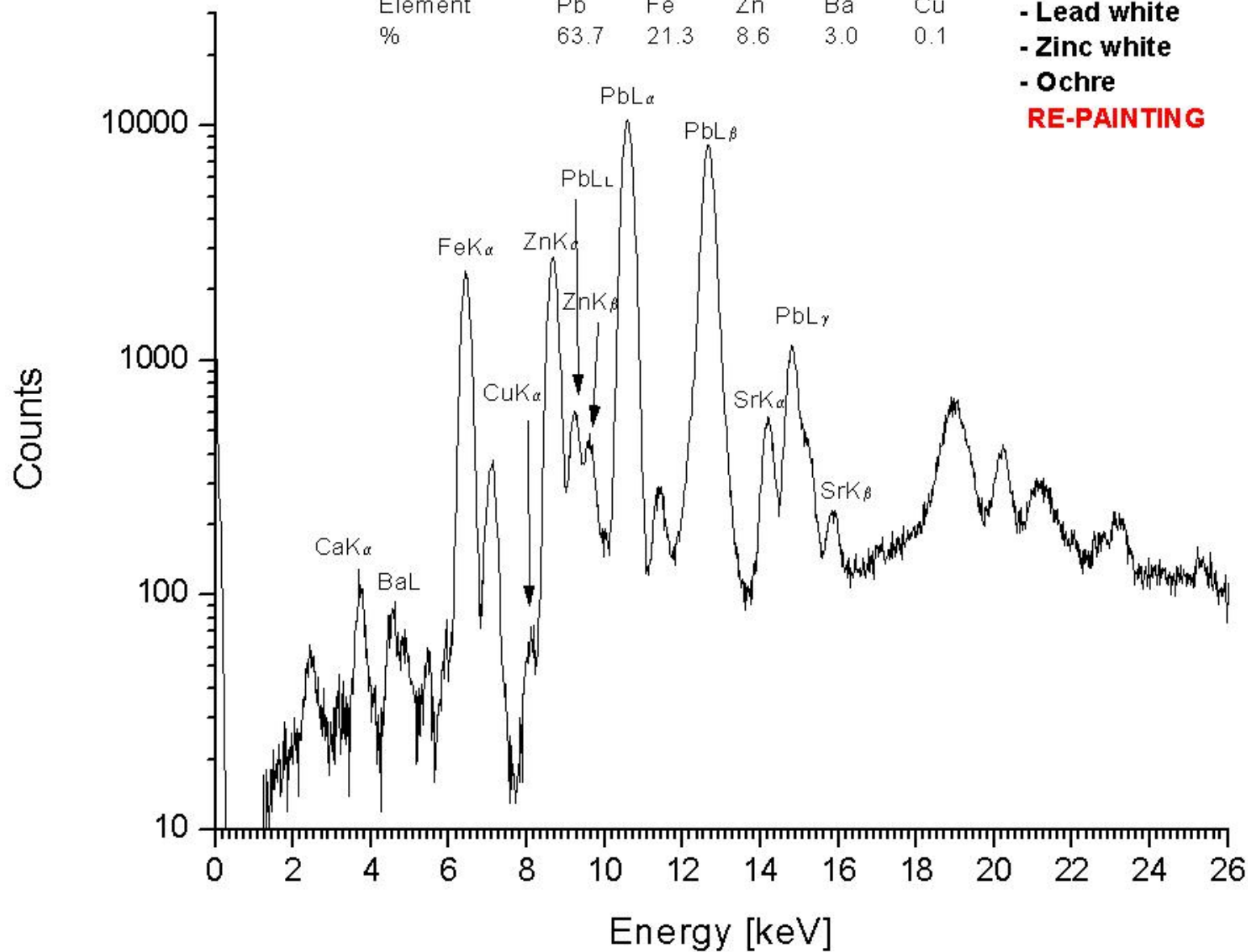




# Icon 3\_19 - The Virgin Mary

Element	Pb	Fe	Zn	Ba	Cu
%	63.7	21.3	8.6	3.0	0.1

- Lead white
- Zinc white
- Ochre
- RE-PAINTING**

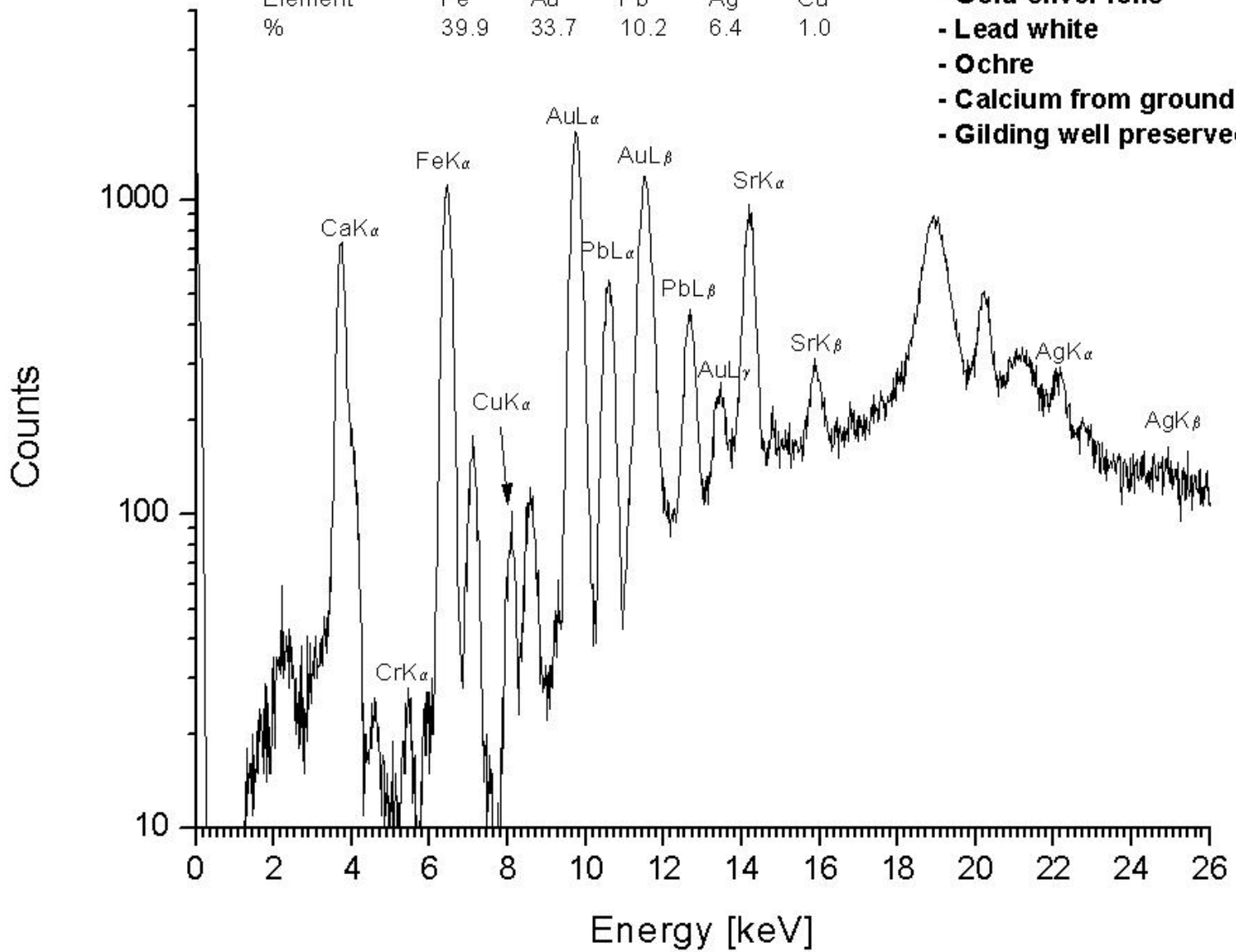




# Icon 3\_24 - Angel - right (gold aureola)

Element	Fe	Au	Pb	Ag	Cu
%	39.9	33.7	10.2	6.4	1.0

- Gold-silver foils
- Lead white
- Ochre
- Calcium from ground
- Gilding well preserved (Au>>Ag)

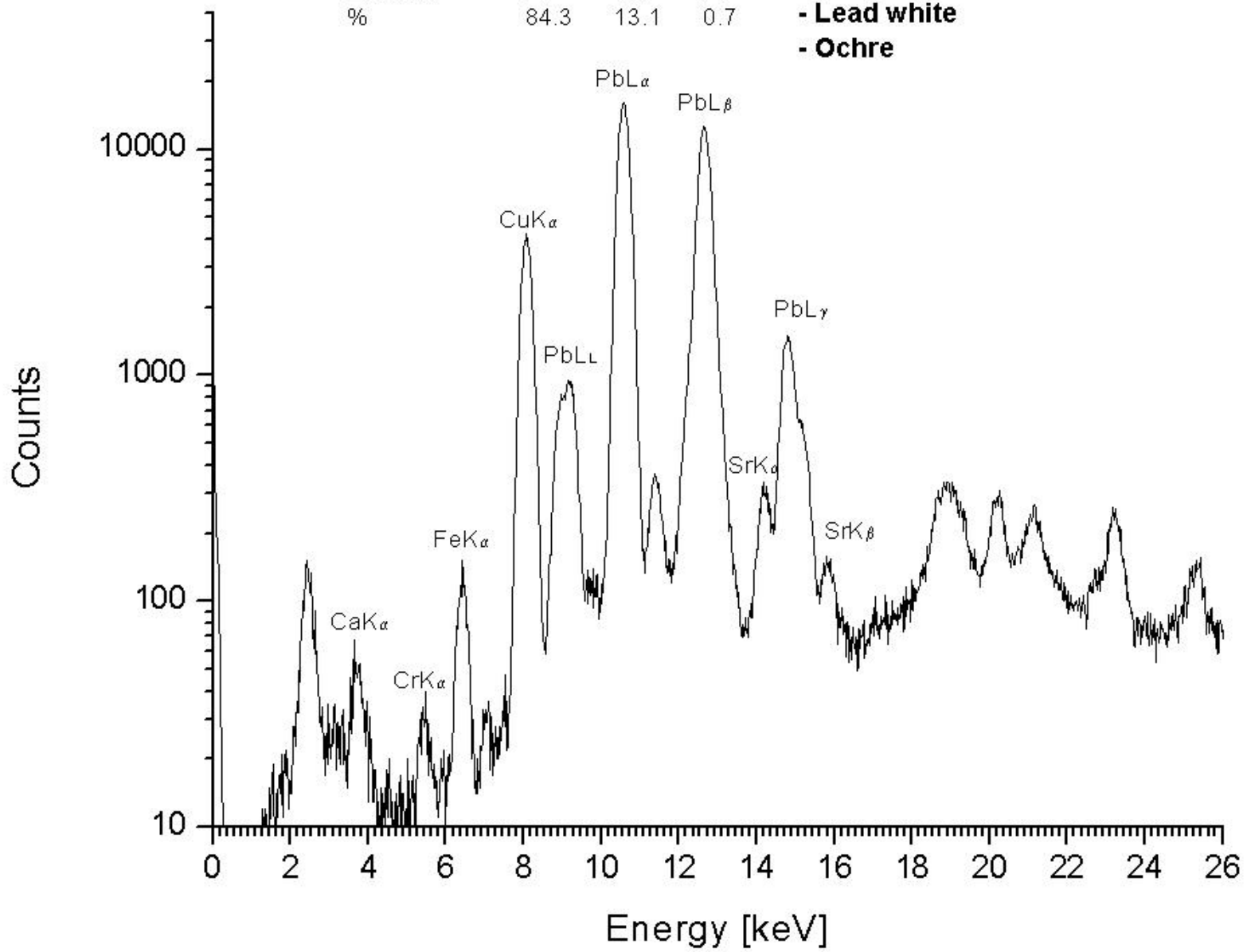






Icon 3\_5 - Light green area (Angel - right)

Element	Pb	Cu	Fe	- Green pigment based on copper
%	84.3	13.1	0.7	- Lead white
				- Ochre



Biserica Icoanei – 1786 **Restorer Gabriela Stefanita**  
Painted 1786 “a fresco”, 1838, 1873+1889 oil re-painting







**Pronaos - nord, ansamblu după îndepărtarea repictării în ulei și conservarea - restaurarea picturii originale**  
Image 1 of 4

CLOSE ✕



**Pridvor, imagini cu scene din Apocalipsa Sf. Ioan Teologul**  
Image 2 of 4

CLOSE ✕



Pridvor, detaliu cu reprezentarea capitolului 8 din  
scenele Apocalipsei Sf. Ioan Teologul  
Image 3 of 4

CLOSE X







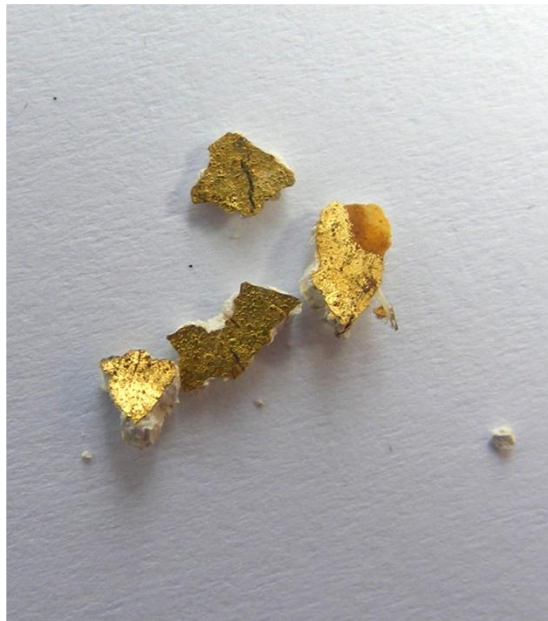
Pronaos - nord, detaliu din timpul îndepărtării  
repictării în ulei și a tencuielilor suprapuse  
Image 4 of 7

CLOSE X



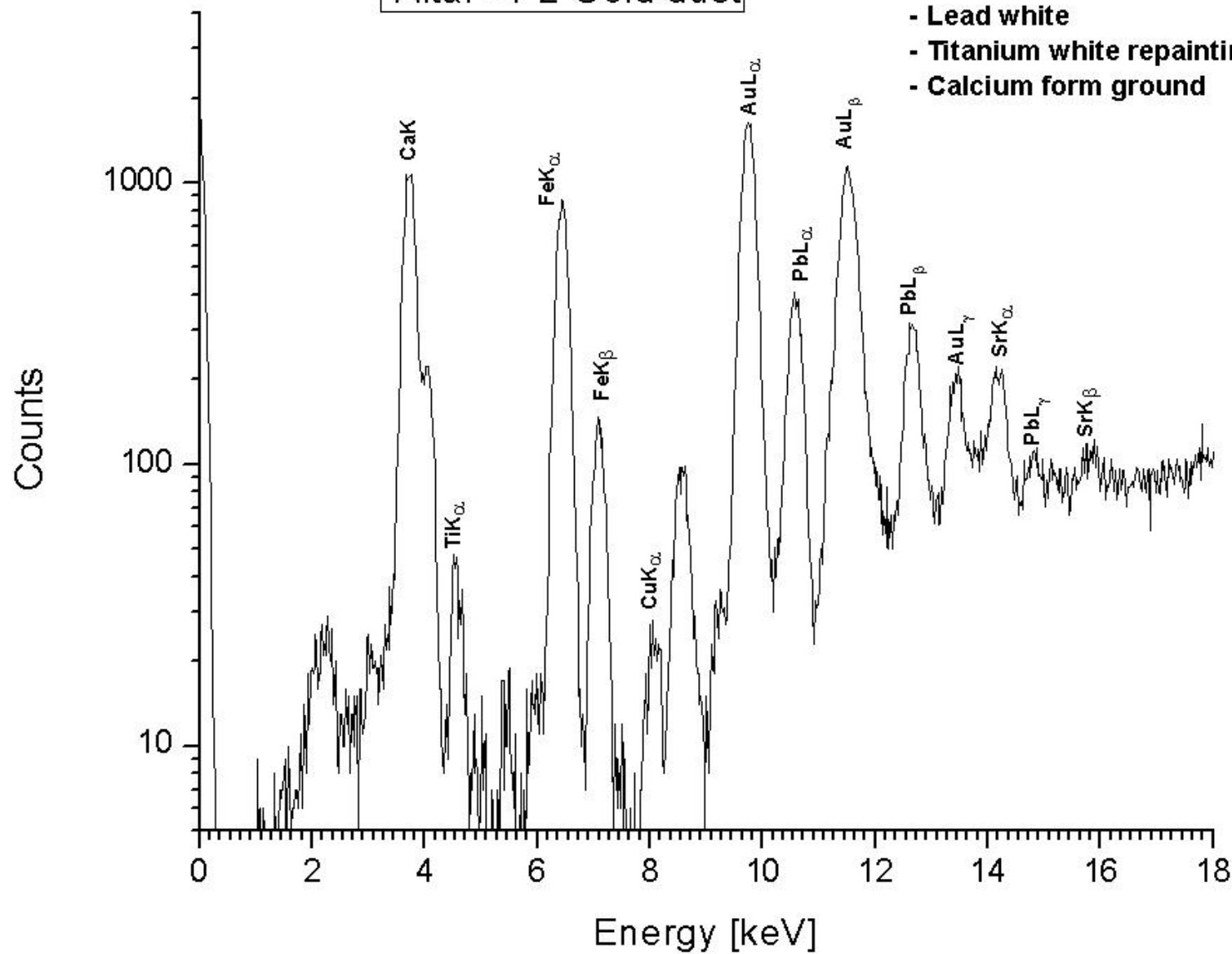
**Pronaos - nord, detaliu în care se observă exfolierile  
repictării în ulei**  
Image 2 of 7

CLOSE ✕



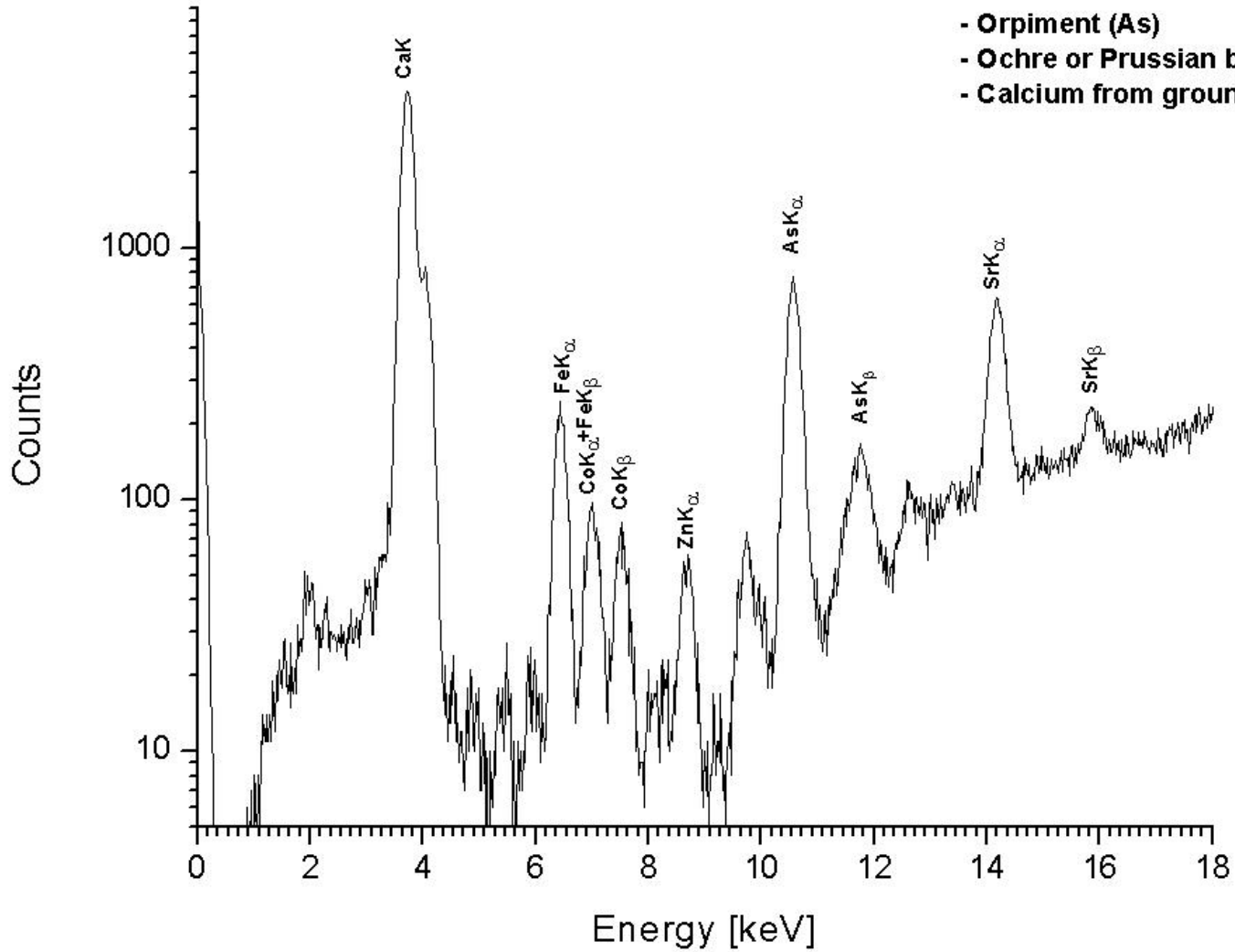
Biserica Icoanei  
Altar - P2 Gold dust

- Gold powder (dust)
- Ochre
- Lead white
- Titanium white repainting
- Calcium form ground



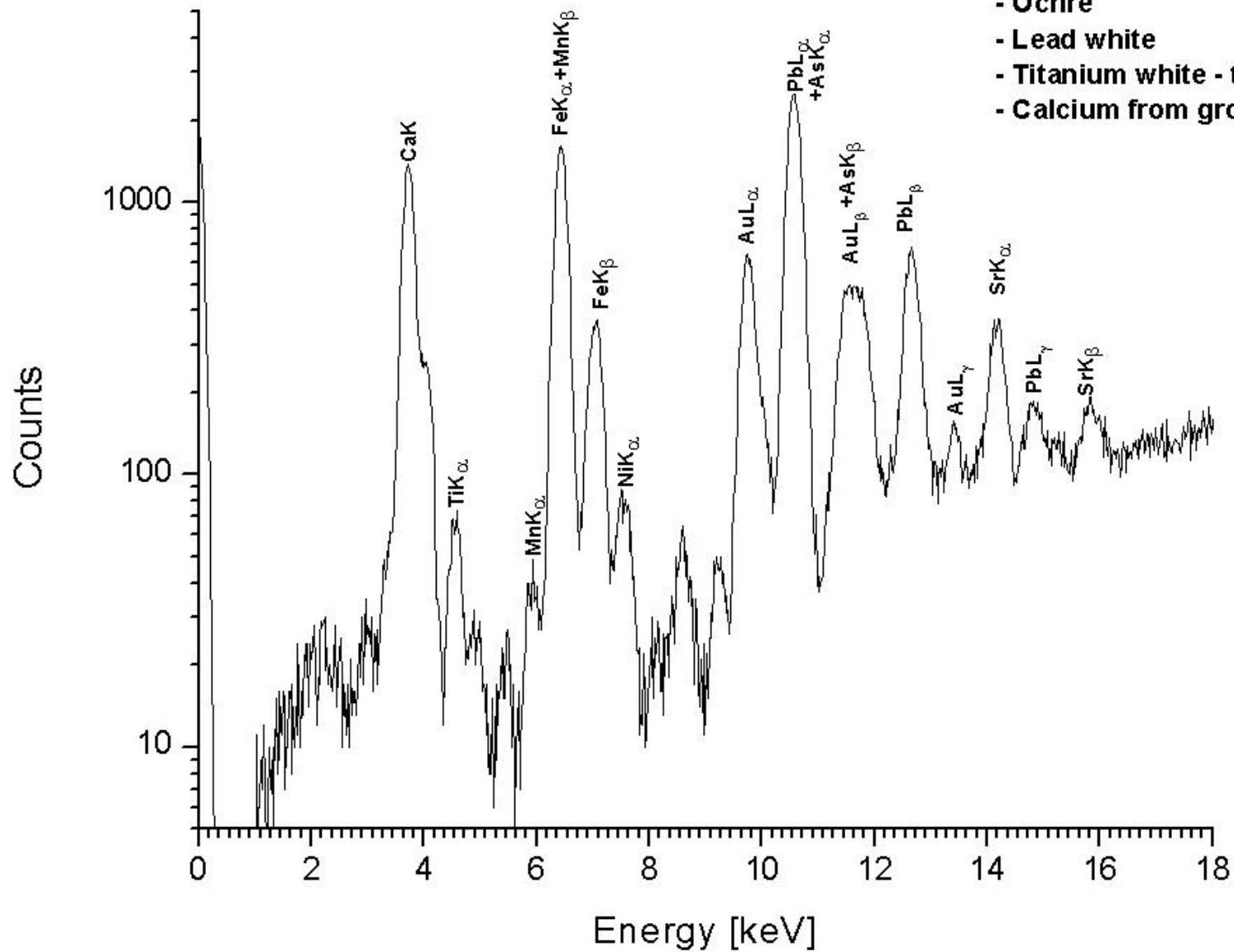
Biserica Icoanei  
P01 - blue sky (Altar abside)

- Zinc white
- Cobalt blue
- Orpiment (As)
- Ochre or Prussian blue (Fe)
- Calcium from ground



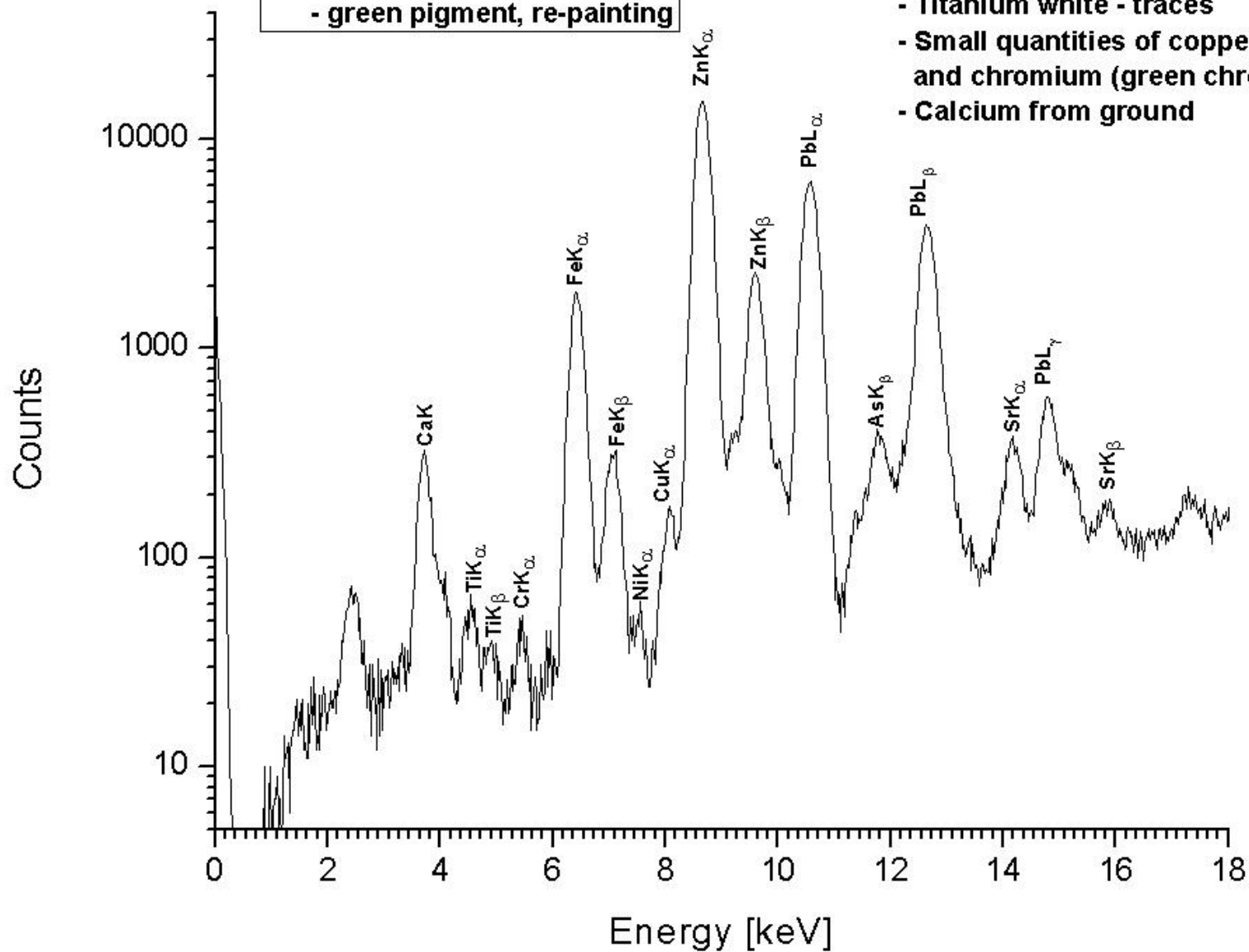
Biserica Icoanei  
P3 Gold dust St. Gabriel - mantle

- Gold powder (dust)
- Orpiment (As)
- Ochre
- Lead white
- Titanium white - traces
- Calcium from ground

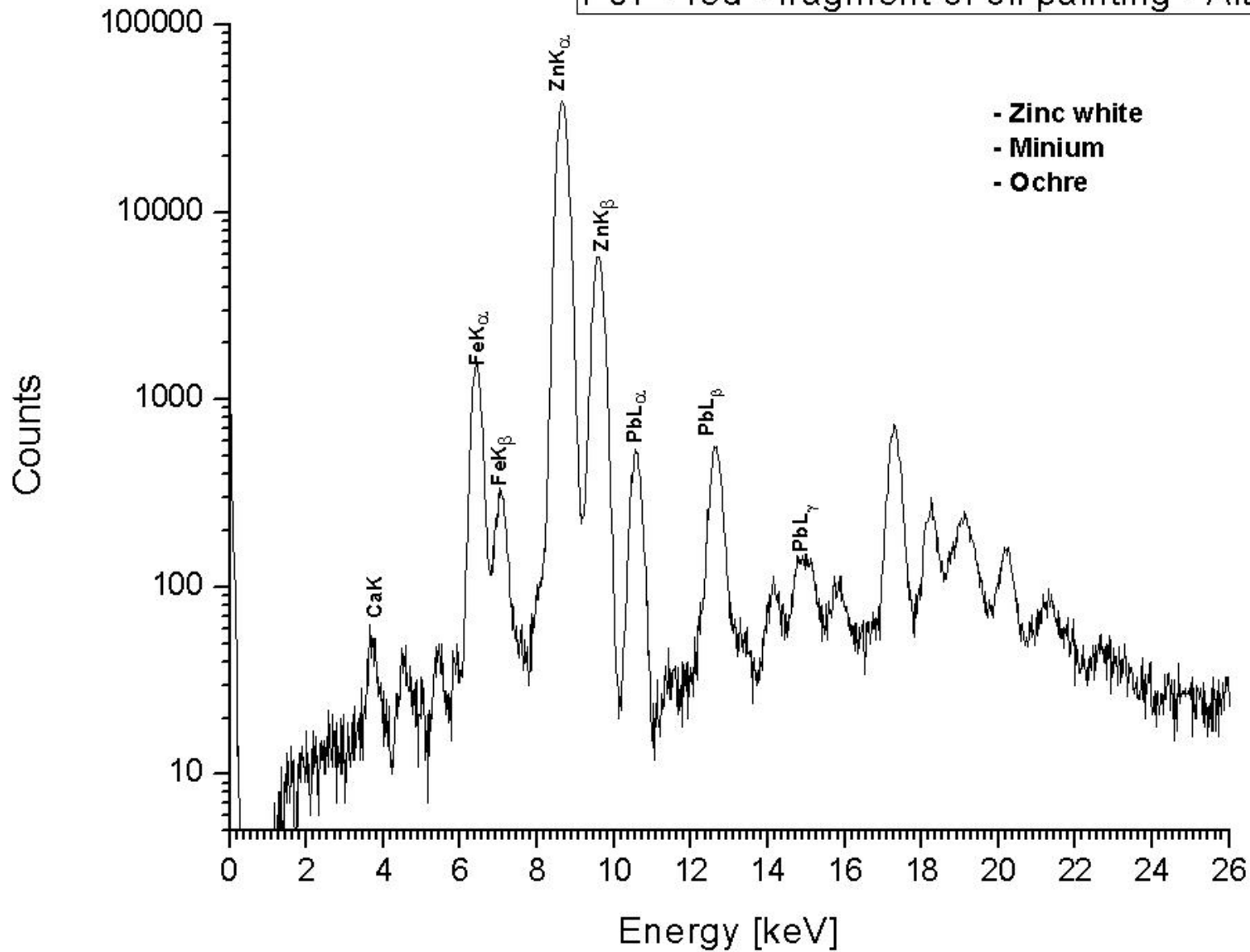


**Biserica Icoanei**  
**P4 - Altar - South wall**  
- green pigment, re-painting

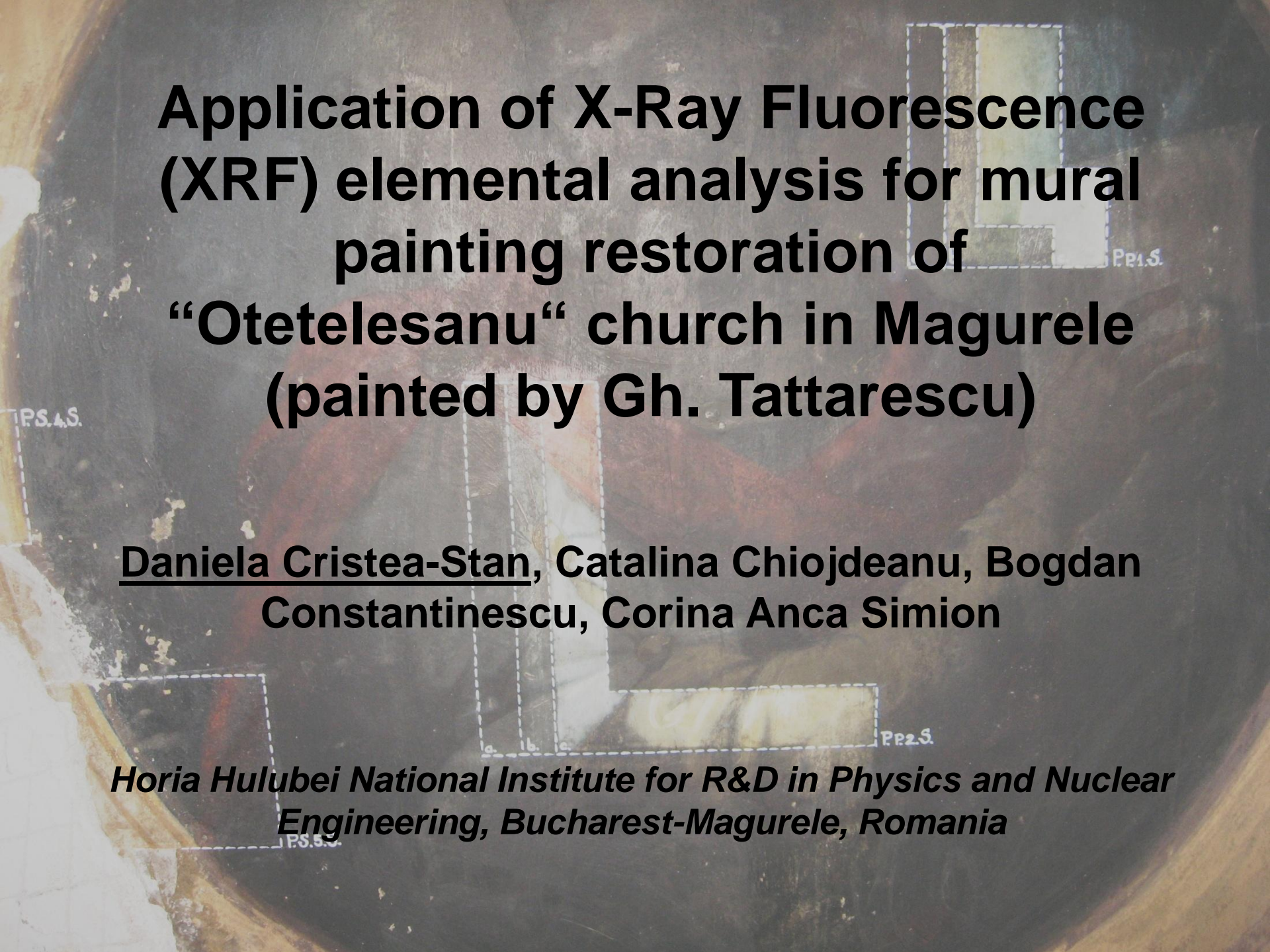
- Green earth
- Lead white
- Zinc white - re-painting
- Titanium white - traces
- Small quantities of copper (Malachite?) and chromium (green chrome?)
- Calcium from ground



Biserica Icoanei  
P07 - red - fragment of oil painting - Altar





The background image shows a dark, textured surface, likely a mural painting, with several white dashed rectangular boxes overlaid. These boxes represent X-ray fluorescence (XRF) analysis areas. The boxes are labeled with alphanumeric codes: 'PS.4.S.' on the left, 'PP1.S.' in the upper right, 'PP2.S.' in the lower right, and 'PS.5.S.' in the bottom left. The mural itself appears to have some lighter, possibly damaged or over-painted, areas.

**Application of X-Ray Fluorescence  
(XRF) elemental analysis for mural  
painting restoration of  
“Otetelesanu” church in Magurele  
(painted by Gh. Tattarescu)**

**Daniela Cristea-Stan, Catalina Chiojdeanu, Bogdan  
Constantinescu, Corina Anca Simion**

***Horia Hulubei National Institute for R&D in Physics and Nuclear  
Engineering, Bucharest-Magurele, Romania***











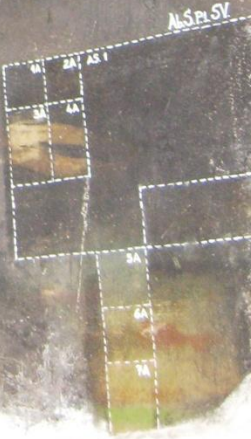
Pes.N

Pes.N

Pes.N

Pes.N

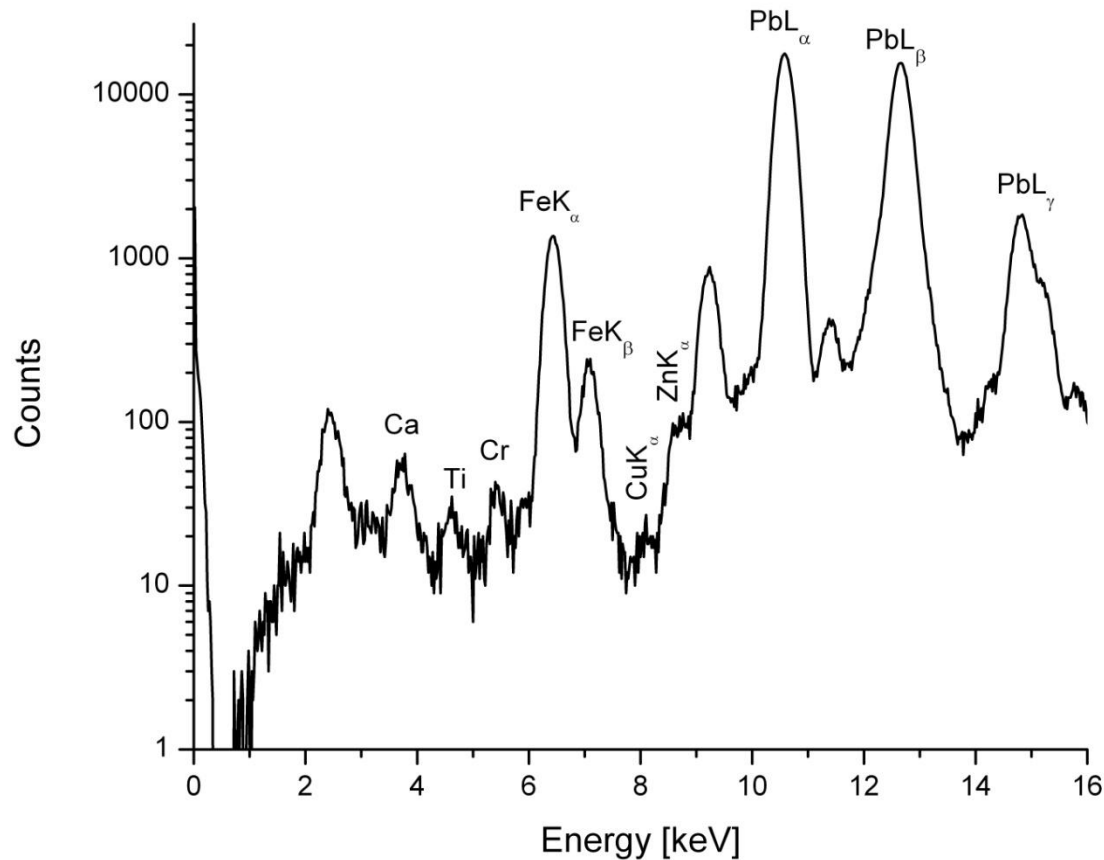
Pes.N



In order to be easily identified, areas were photographed and marked with letters. For St. George wall picture, we measured the area of his legs: carnation, golden shoes, red jacket and blue mantle.



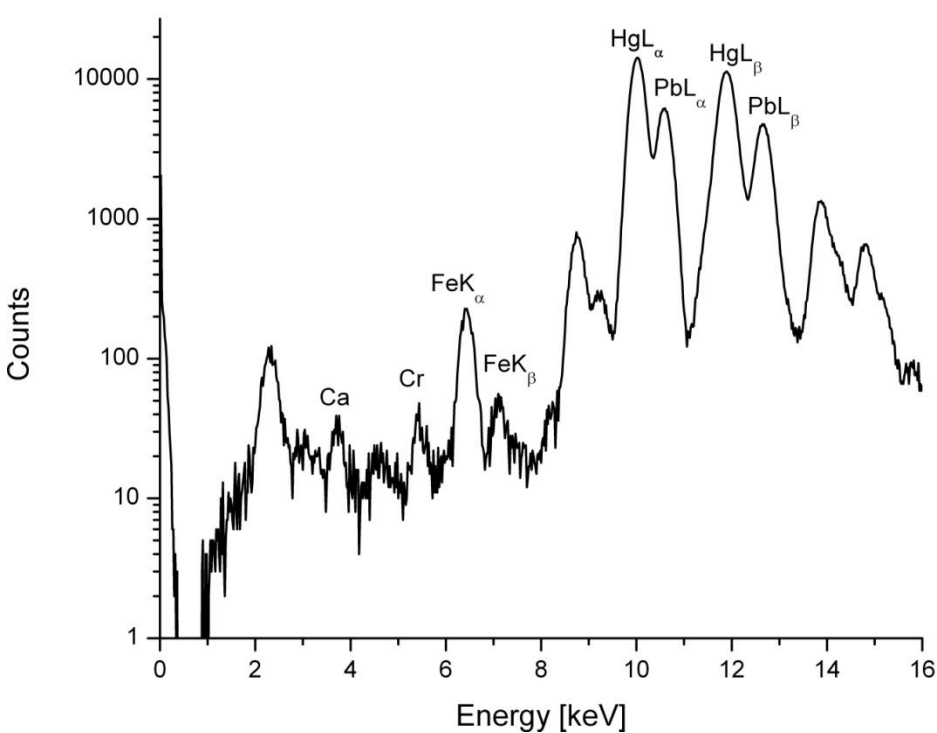
St. George's leg area



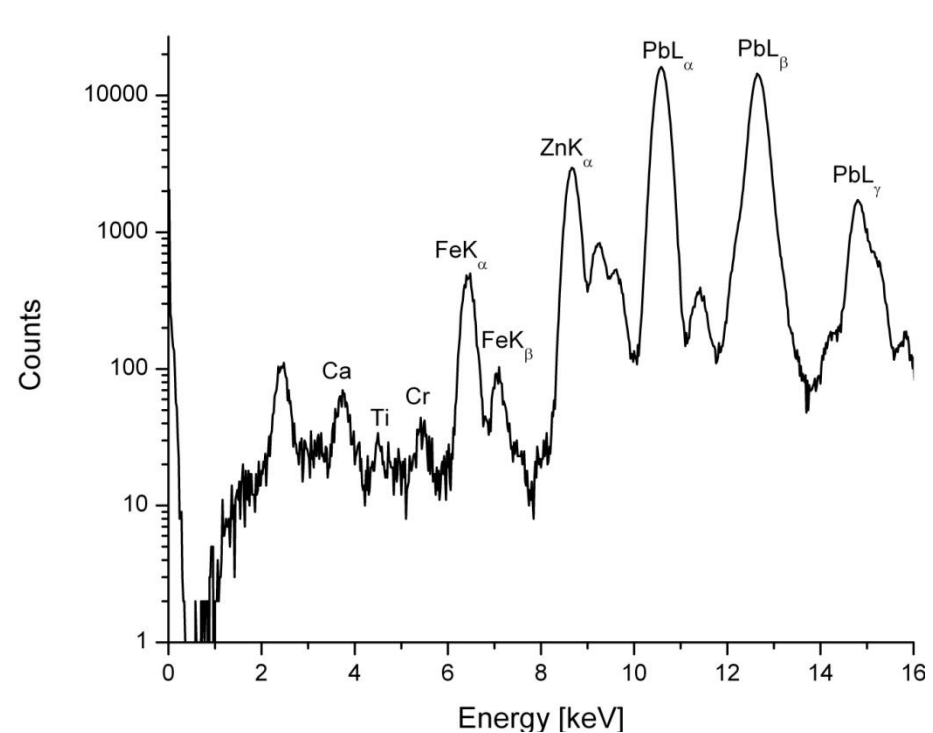
XRF spectrum - yellow area  
(no. 2 in St. George's leg area)

Yellow pigment - was probably made from a mixture of chrome-yellow + ochre.





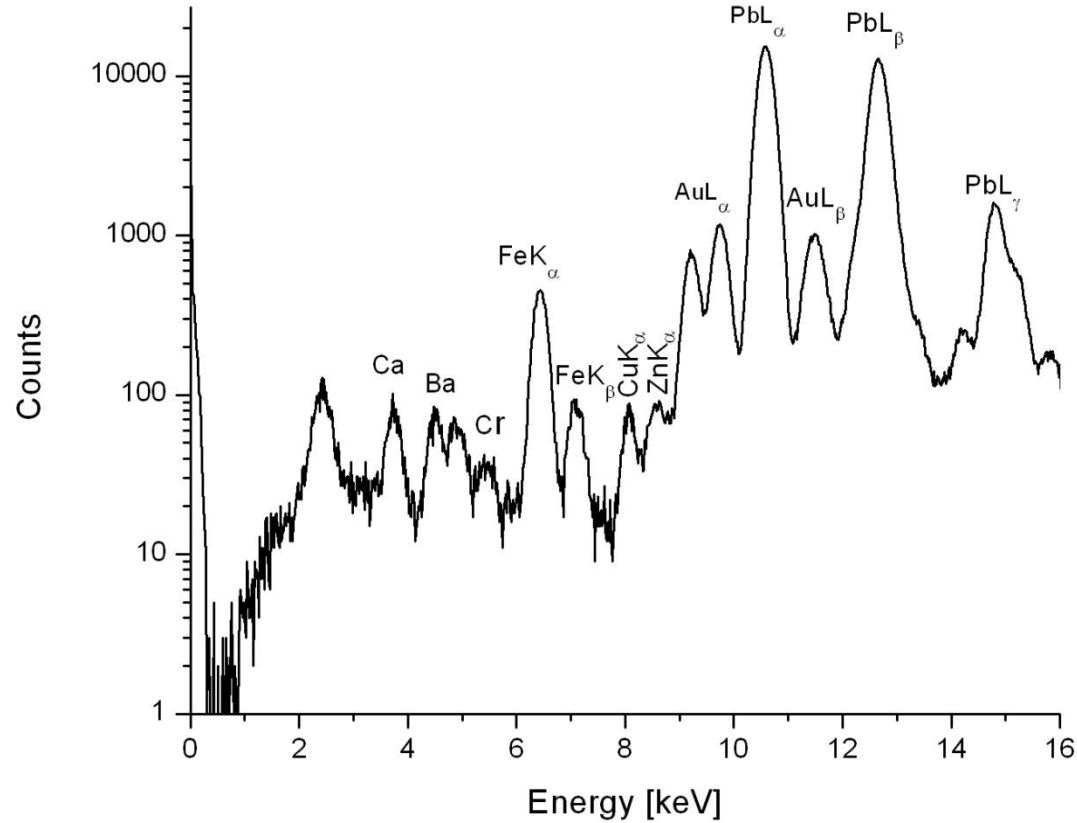
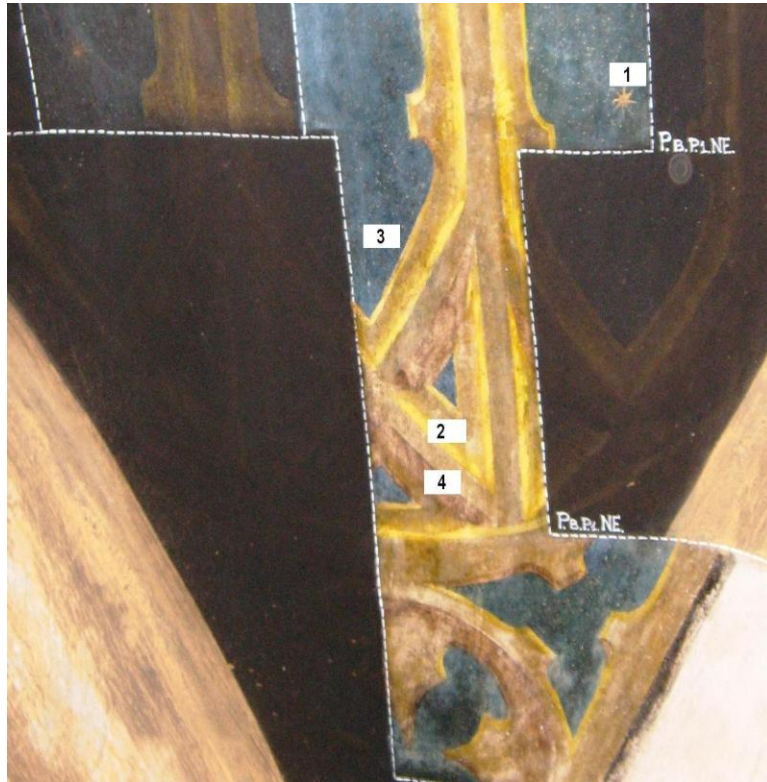
**XRF spectrum - red area  
(no. 3 in St. George's leg area)**



**XRF spectrum - blue area  
(no. 4 in in St. George's leg area)**

**Red is still on a mercury-based pigment (probably cinnabar) which is found in small quantities also in carnation.**

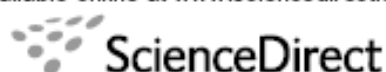
**Blue is an iron-based pigment (Prussian blue?). Note the presence of chrome yellow in all areas and the presence of iron - an indicator of ochre - in all colors. In the blue we detected a relatively high zinc content which means a later repainting, covering the original lead white layer (20<sup>th</sup> Century?) because in Church's icons Tattarescu used only white lead.**



Ornamental star – apse area

XRF spectrum - gold area (no. 1 in apse area)

**Gold was detected in one area - an ornamental star; probably it is gold powder. Significant presence of iron in this spectrum shows the use of red iron oxide in the preparation of the last layer of gilding.**

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Nuclear Instruments and Methods in Physics Research B xxx (2008) xxx–xxx

[www.elsevier.com/locate/nimb](http://www.elsevier.com/locate/nimb)

## Micro-SR-XRF and micro-PIXE studies for archaeological gold identification – The case of Carpathian (Transylvanian) gold and of Dacian bracelets

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<sup>c</sup> *Centre de Recherche et de Restauration des Musées de France, CNRS UMR 171, Palais du Louvre, Paris Cedex 01, France*

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<sup>e</sup> *National Museum of Romania History, P.O. Box 1-97, Bucharest 030026, Romania*

Available online

### Abstract

Trace-elements are more significant for provenancing archaeological metallic artifacts than the main components. For gold, the most promising elements are platinum group elements (PGE), Sn, Te, Sb, Hg and Pb. Several small fragments of natural Transylvanian gold – placer and primary – were studied by using micro-PIXE technique at the Legnaro National Laboratory AN2000 microbeam facility, Italy and at the AGLAE accelerator, C2RMF, Paris, France and by using micro synchrotron radiation X-ray fluorescence (micro-SR-XRF) at BESSY synchrotron, Berlin, Germany. The goal of the study was to identify the trace-elements, especially Sn, Sb and Te. A spectacular application to five Dacian gold bracelets authentication is presented (Sn and Sb traces).

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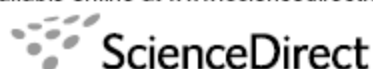
*PACS:* 29.30.Kv; 82.80.Ej; 07.79.–v; 68.37.Yz

*Keywords:* Micro-PIXE; Micro-SR-XRF; Gold; Dacian bracelets; Transylvania





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with Materials & Atoms[www.elsevier.com/locate/nimb](http://www.elsevier.com/locate/nimb)

## Compositional studies on Transylvanian gold nuggets: Advantages and limitations of PIXE–PIGE analysis

Roxana Bugoi<sup>a,\*</sup>, Viorel Cojocaru<sup>a</sup>, Bogdan Constantinescu<sup>a</sup>, Thomas Calligaro<sup>b</sup>,  
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### Abstract

Minute fragments from nine gold nuggets from Transylvania – two belonging to placer deposits and seven to primary deposits – were analyzed by PIXE and PIGE at the AGLAE tandem accelerator of the Centre de Recherche et de Restauration des Musées de France (C2RMF) with a 3 MeV proton beam extracted into air. This study was triggered by some archaeological provenance issues for which the elemental characterization of the Transylvanian gold source, exploited from the Antiquity, was required. All analyzed Transylvanian gold nuggets are characterized by a consistently high amount of Ag (18% on average). Au and Ag add up to roughly 99%, the other elements – Cu, Fe, Te, Pb – being detected only at a trace level. The obtained results are in good agreement with the previous analyses of Transylvanian gold.

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Keywords: Gold; PIXE; PIGE; Provenance; Elemental composition

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Contents lists available at [ScienceDirect](#)

## Nuclear Instruments and Methods in Physics Research B

journal homepage: [www.elsevier.com/locate/nimb](http://www.elsevier.com/locate/nimb)

## IBA investigations of loose garnets from Pietroasa, Apahida and Cluj-Someșeni treasures (5th century AD)

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## ABSTRACT

This paper reports the archaeometric investigations of 418 loose garnets from Pietroasa and Cluj-Someșeni treasures and Apahida II and III princely grave inventories (5th century AD). The chemical composition of the gems was determined by external beam micro-PIXE technique at the AGLAE accelerator of C2RMF, Paris, France. Complementary observations made by Optical Microscopy revealed details on the gemstones cutting and polishing and permitted to identify certain mineral inclusions. The compositional results evidenced several types of garnets from the pyrospite series, suggesting distinct provenances for these Early Medieval gems.

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