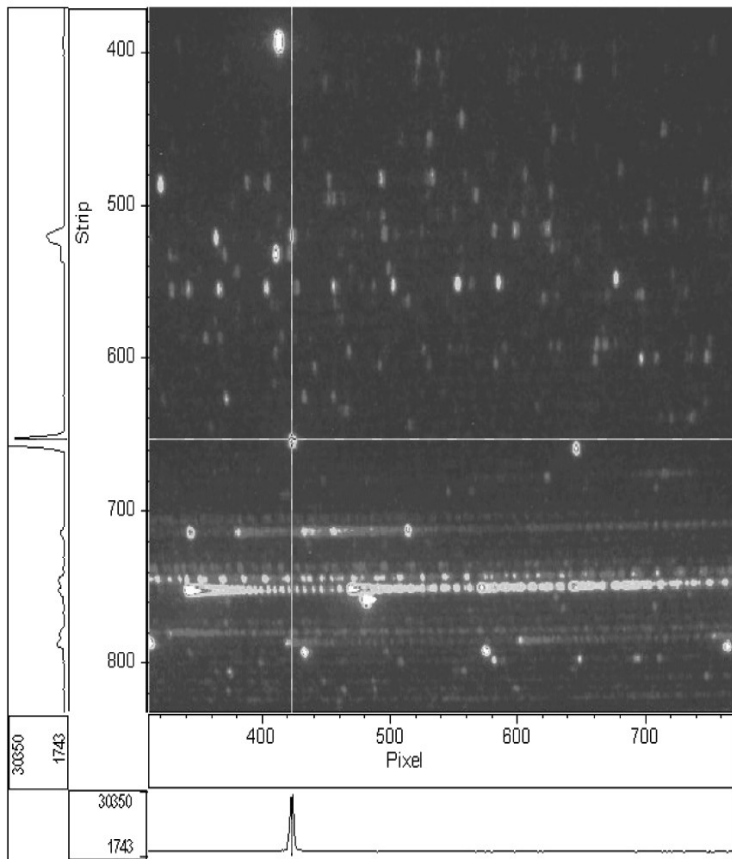


# LIBS

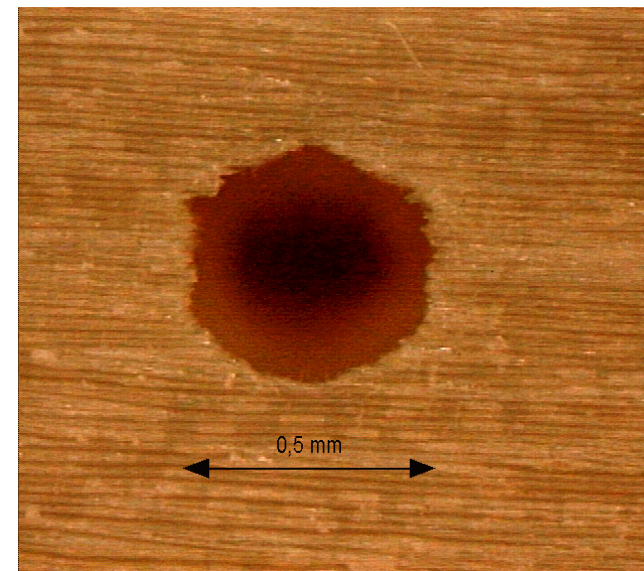
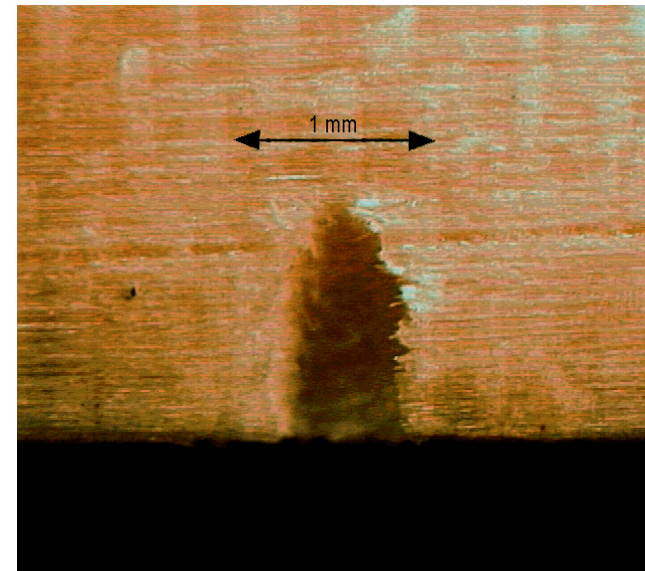
Analýza složení artefaktů

Monitorování laserového čištění

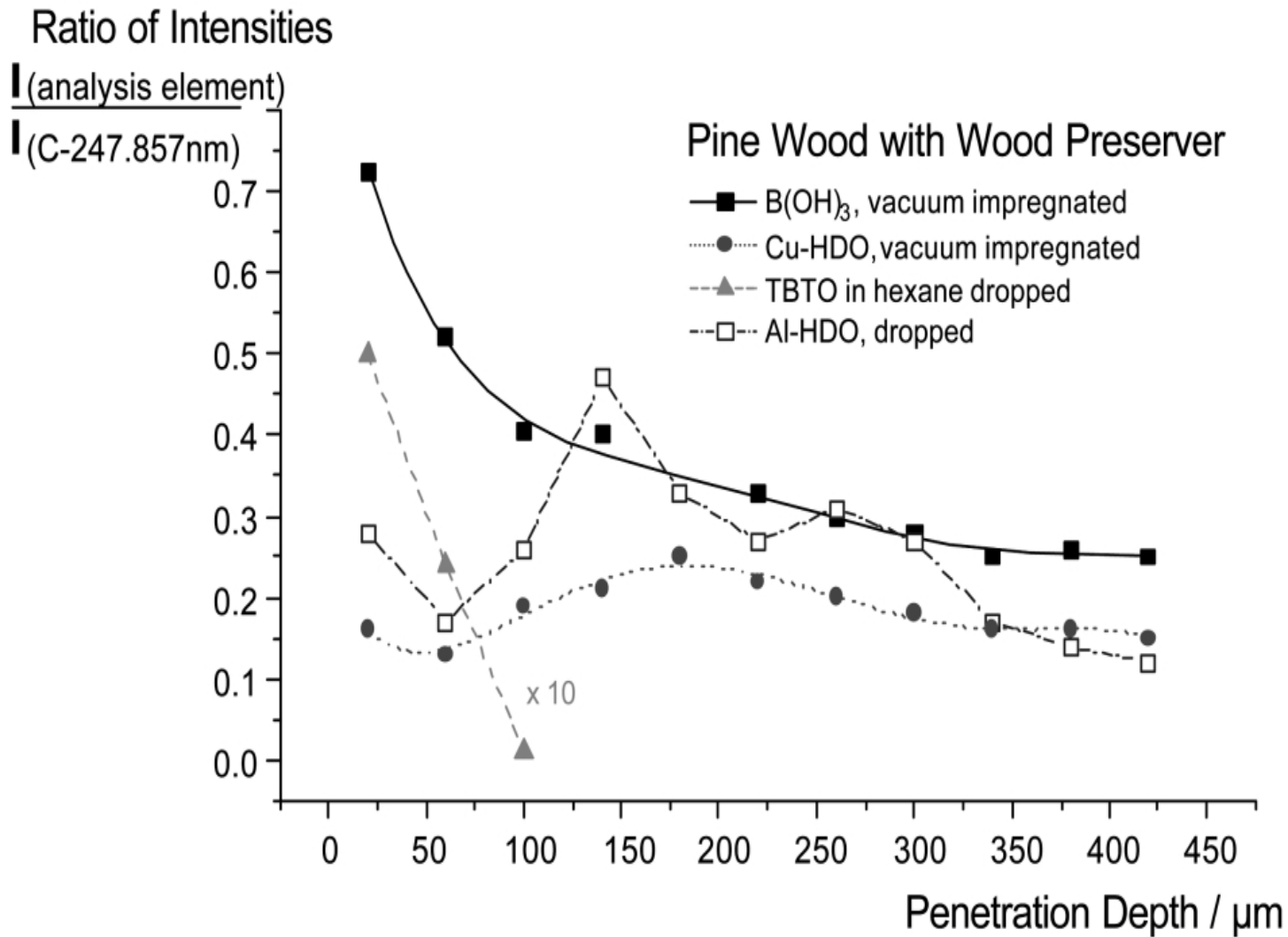
# Konzervace dřeva



Echelle spektrum dřeva obsahujícího chrom-měď-bor (spektrální rozsah 245-700 nm).

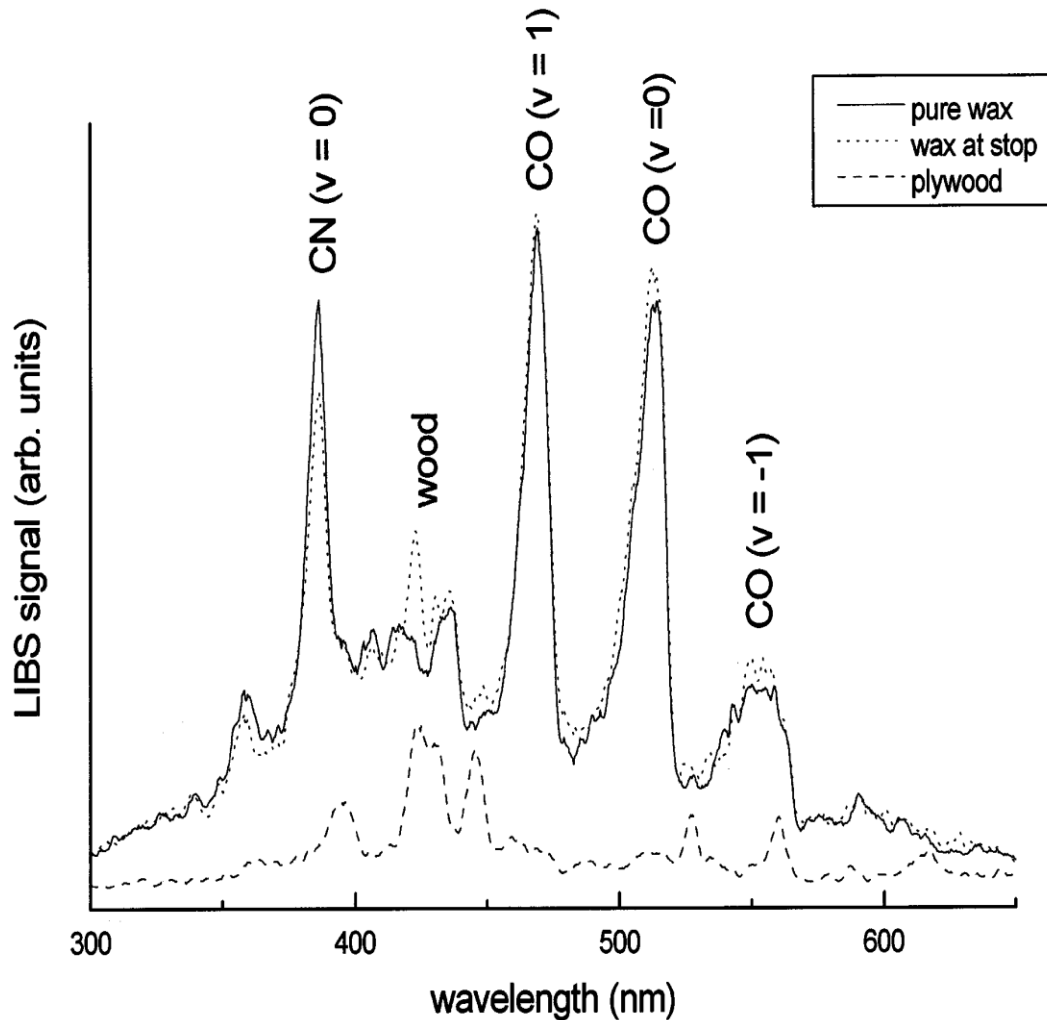


Mikroskopický obraz kráteru po 450, pulsech, energie 55 mJ.



Distribuce ochranného prostředku ve dřevě (penetrační hloubka), energie pulsu 50 mJ.

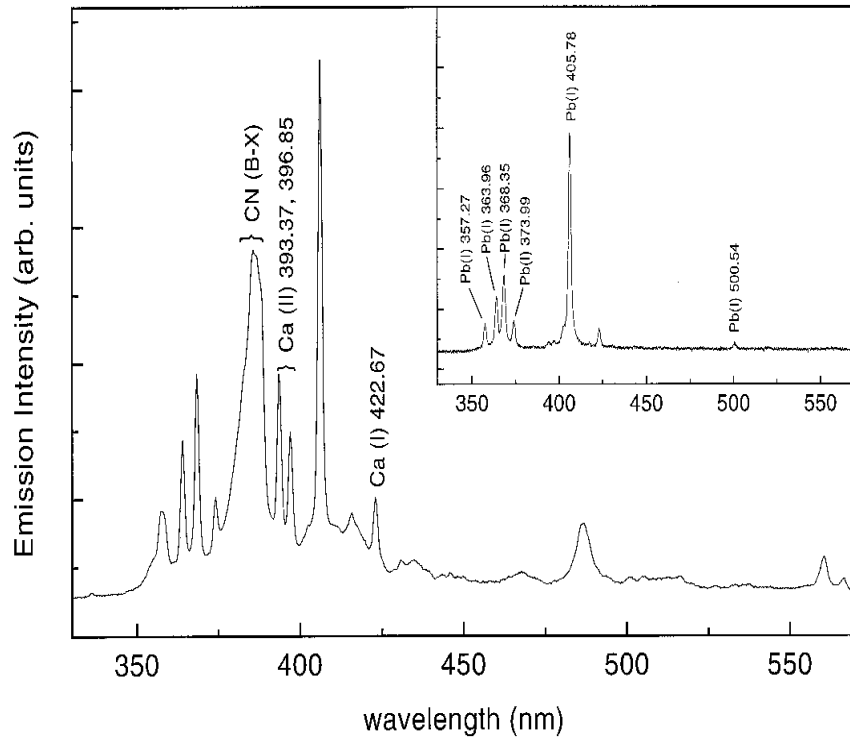
# Monitoring odstraňování starých nátěrů



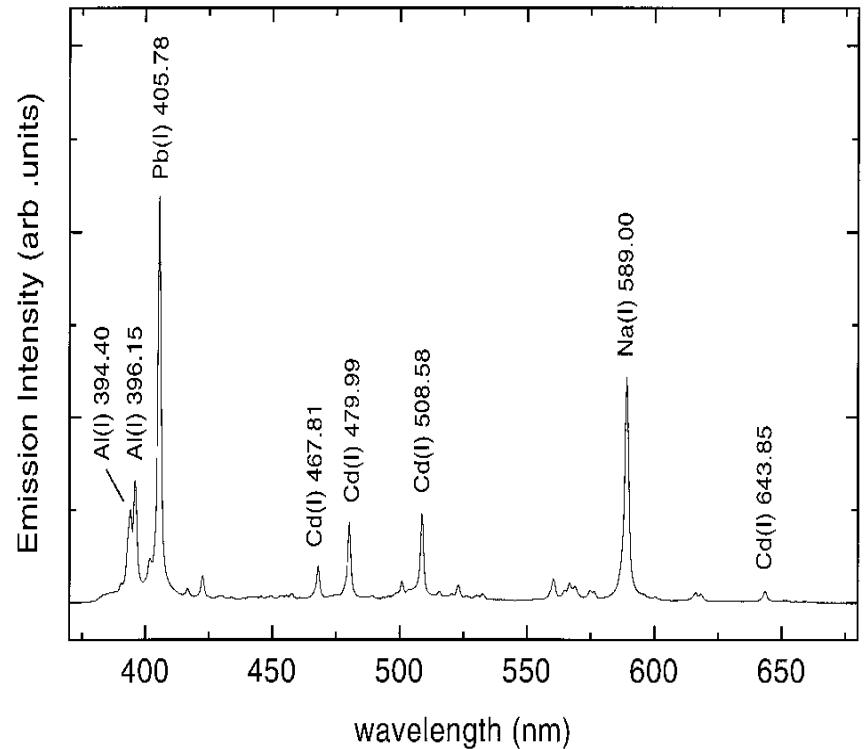
Odstraňování vosku z pláten nebo dřeva (překližka) je časově náročné. Proces lze snadno automatizovat použitím laseru a detekce LIBS.

LIBS spektra vosku vykazují zřetelné pásy CO a CN. Po dosažení spodní vrstvy se objevuje pík 423 nm a čištění je ukončeno.

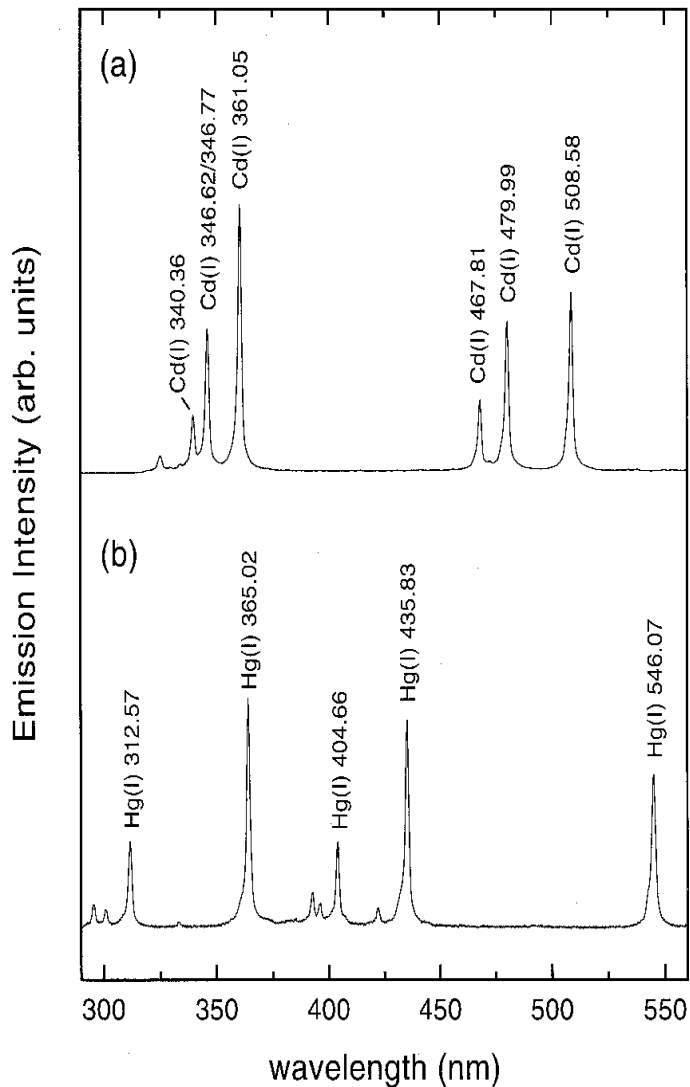
# Pigmenty



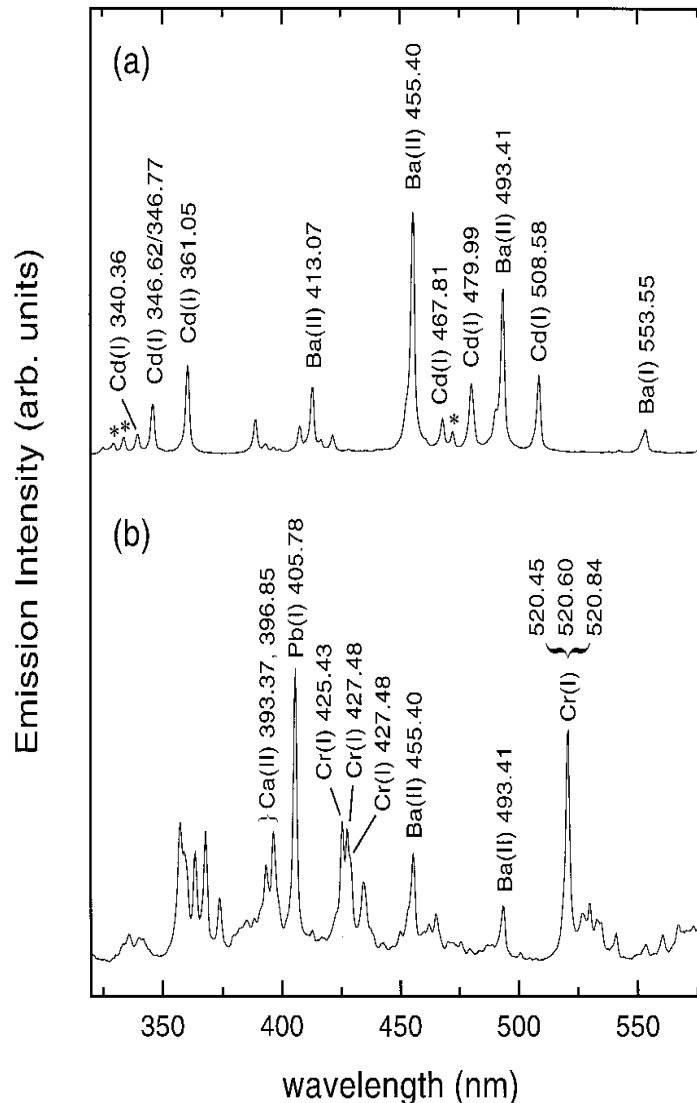
LIBS spektrum olovnaté olejové barvy (olovnatá běloba / Iněný olej). Na vnitřním obrázku spektrum olovnaté běloby. Vlnová délka laseru 1064 nm.



LIBS spektrum směsi pigmentů: olovnatá běloba, kadmiová červeň a ultramarínová modř. Vlnová délka laseru 266 nm.

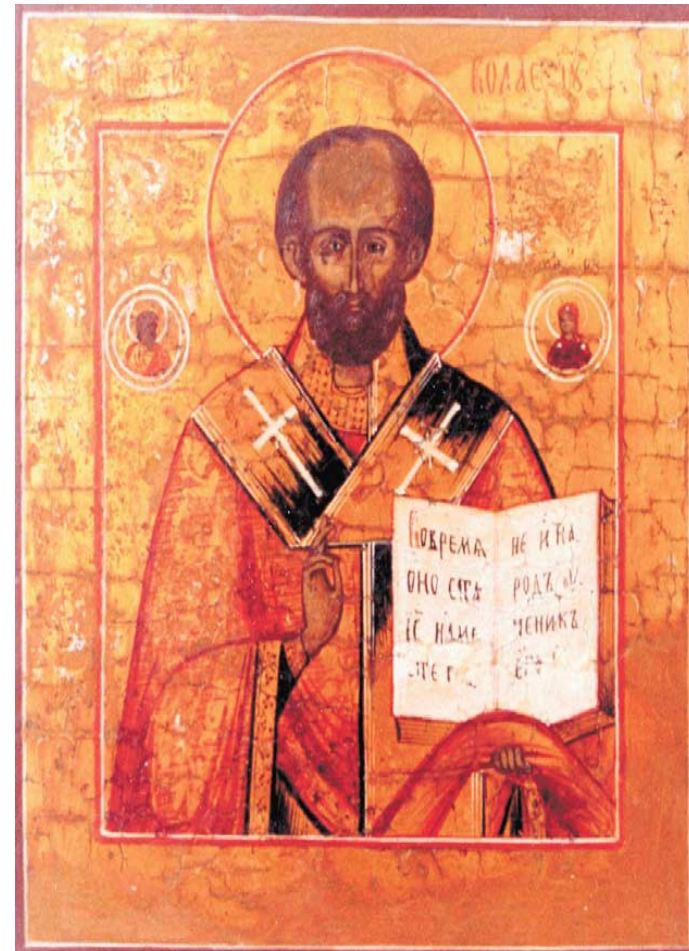
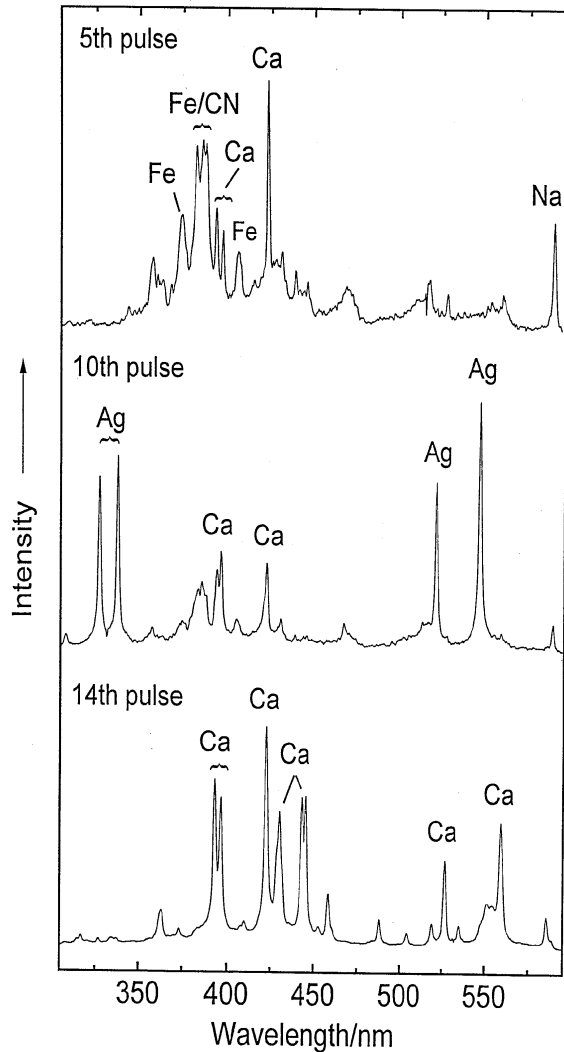


LIBS spektra **(a)** kadmiové červeně (CdSe<sub>0.3</sub>S<sub>0.7</sub>) a **(b)** rumělka (HgS). Vlnová délka laseru 1064 nm.



LIBS spektra: **(a)** kadmiová citronová žlut' (Cd<sub>0.9</sub>Zn<sub>0.1</sub>S BaSO<sub>4</sub>) a **(b)** chromová žlut' (PbCrO<sub>4</sub>). Vlnová délka laseru 1064 nm.

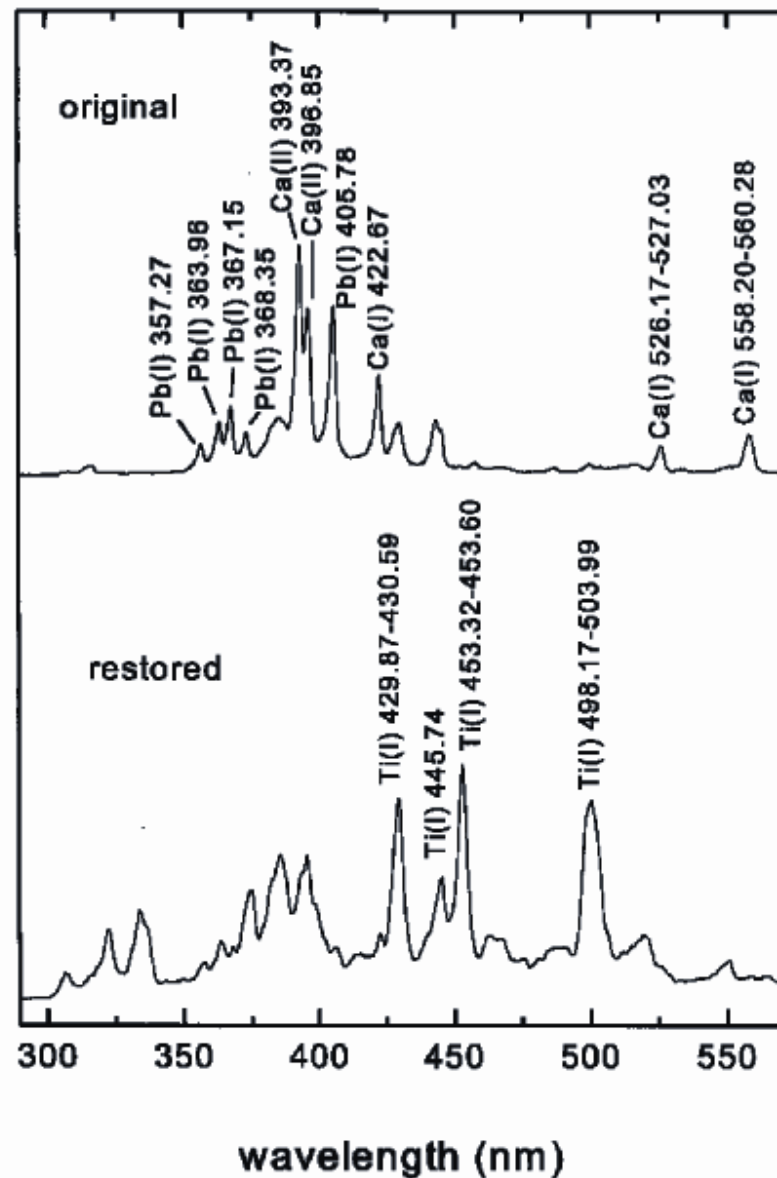
19th c. Russian icon of St. Nicholas.



LIBS spektra malby (horní spektrum), stříbrné folie (střední spektrum) a podkladové vrstvy (dolní spektrum). Malba obsahuje pigment obsahující Fe (hnědý, pravděpodobně FeO), podklad je síran vápenatý.

# Sledování restaurátorských zásahů

LIBS spektra originální malby a  
restaurovaných částí olejomalby.







# Malované omítky



Fragmenty nástěnné malby, Palaikastro  
(Kréta.)

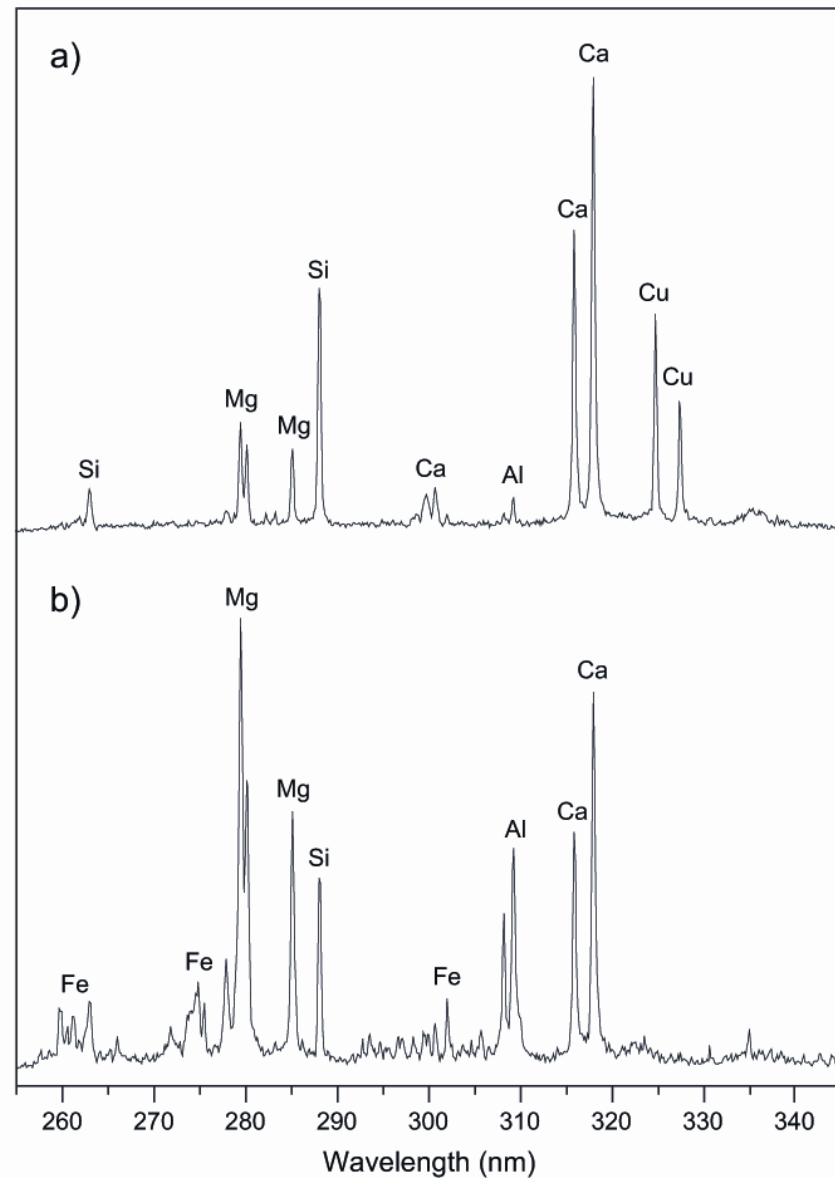


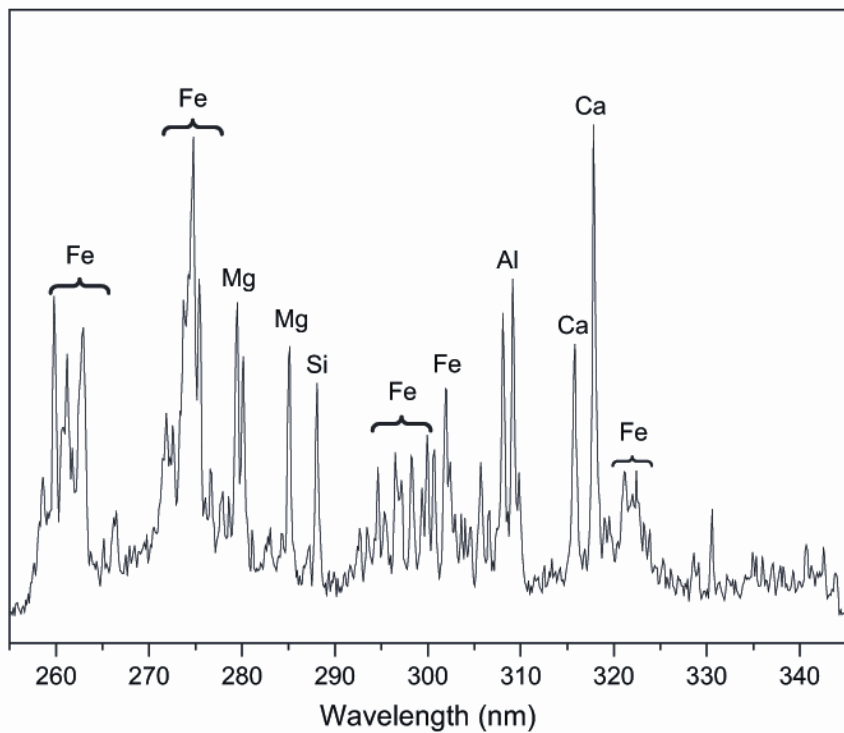
Malovaná omítka, Théby (Řecko).

## LIBS spektra malovaných omítek

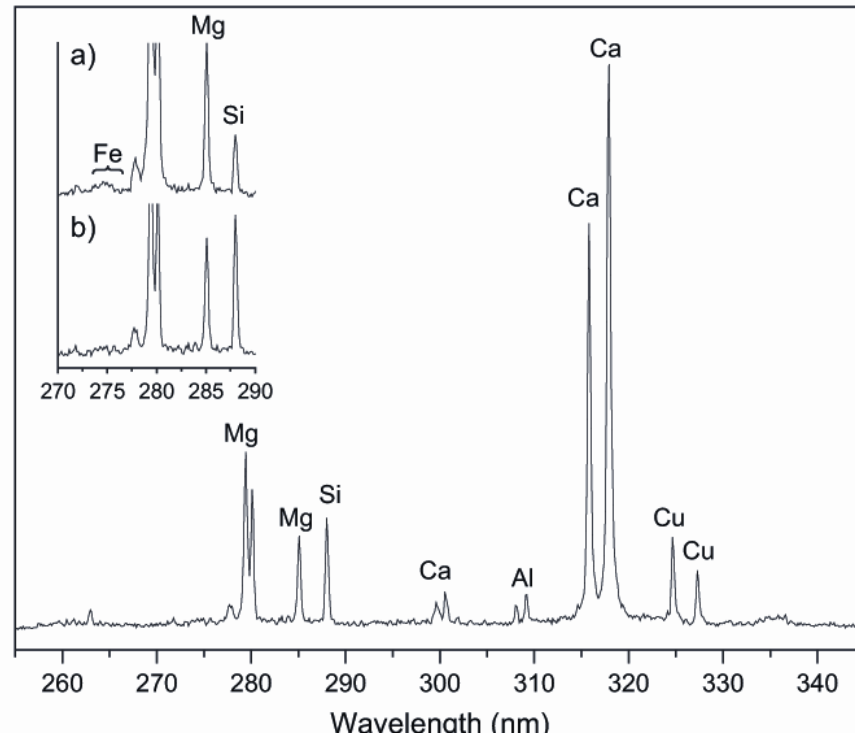
(a) Théby (vzorek THC 2)

(b) Palaikastro (vzorek PK 62)





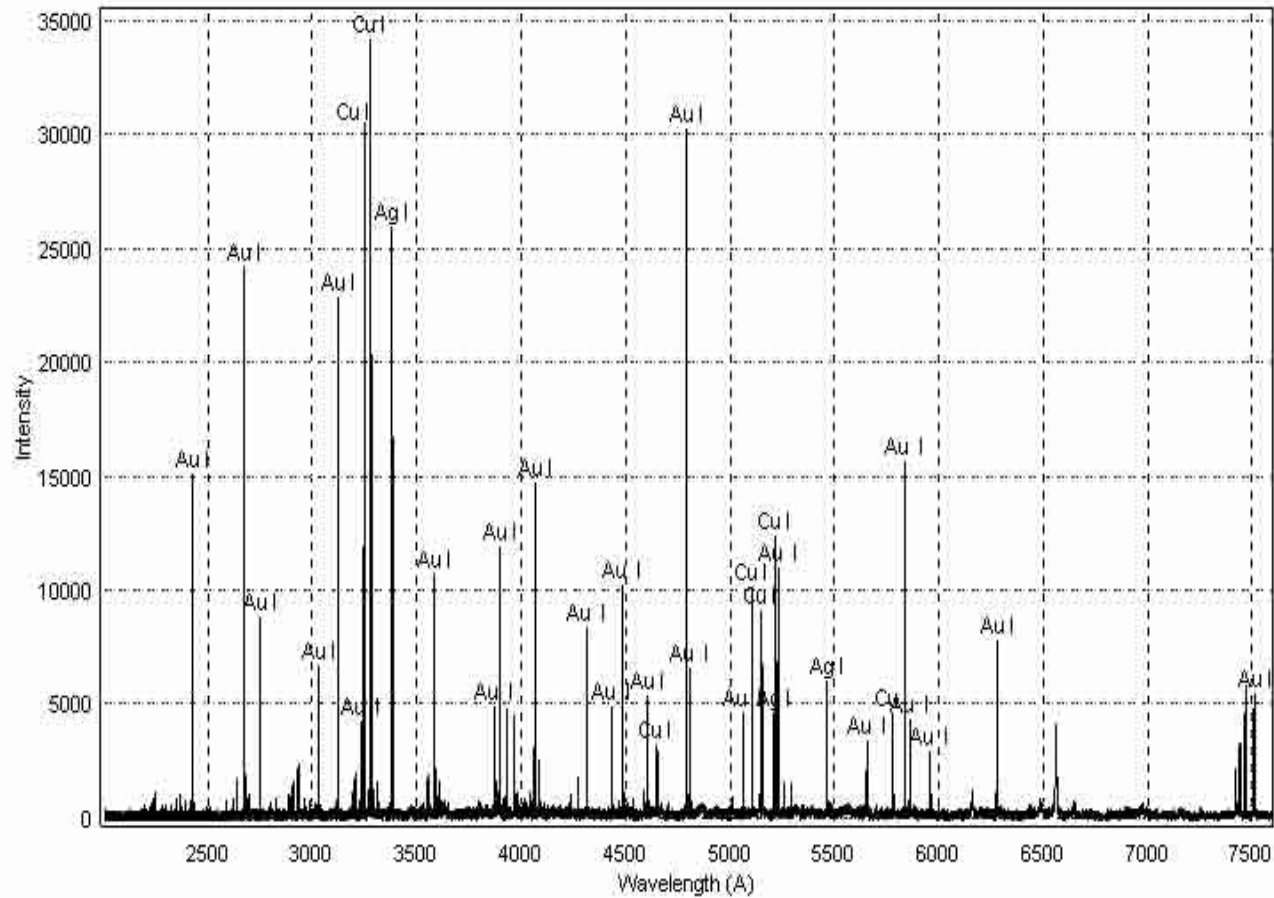
LIBS spektrum tmavě červeného vzorku z Palaikastro(PK 64)



LIBS spektrum zeleného vzorku z Théb (THA 2b).

- (a) první puls (slabá čára Fe)
- (b) druhý puls (nárůst emise Si)

# Kovy a slitiny



LIBS analýza slitiny Au.

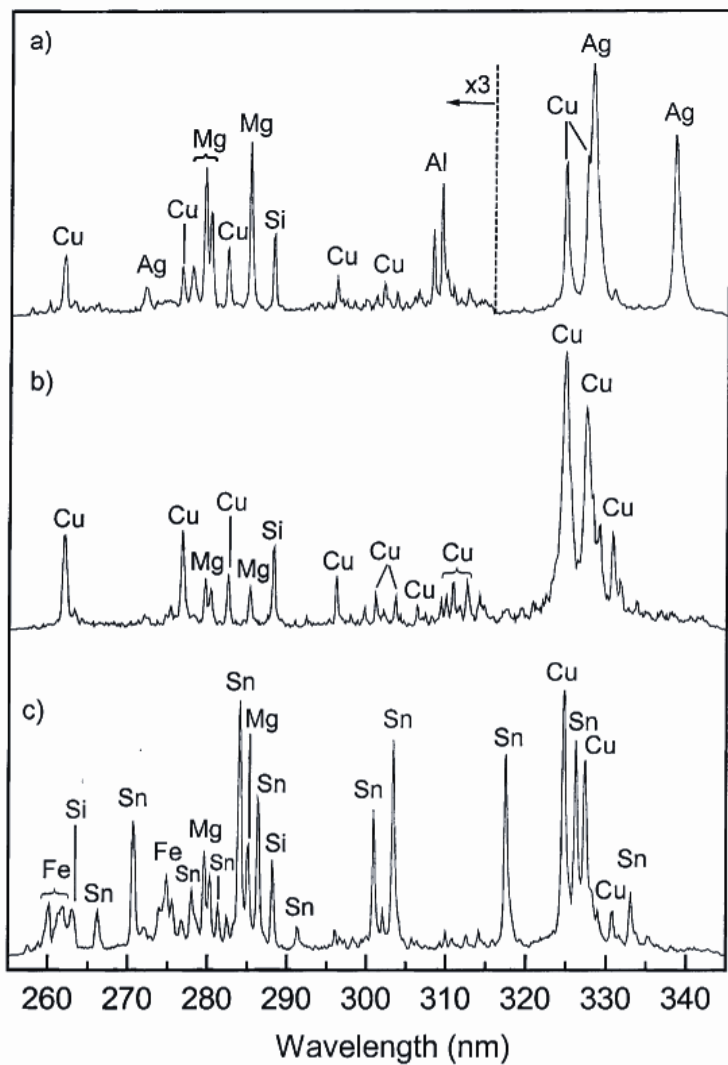


Fig. 4. LIBS spectra of Minoan metal samples obtained: (a) on the flat face of copper rivet; (b) on the outside of metal pin; (c) in the core of the same metal pin.

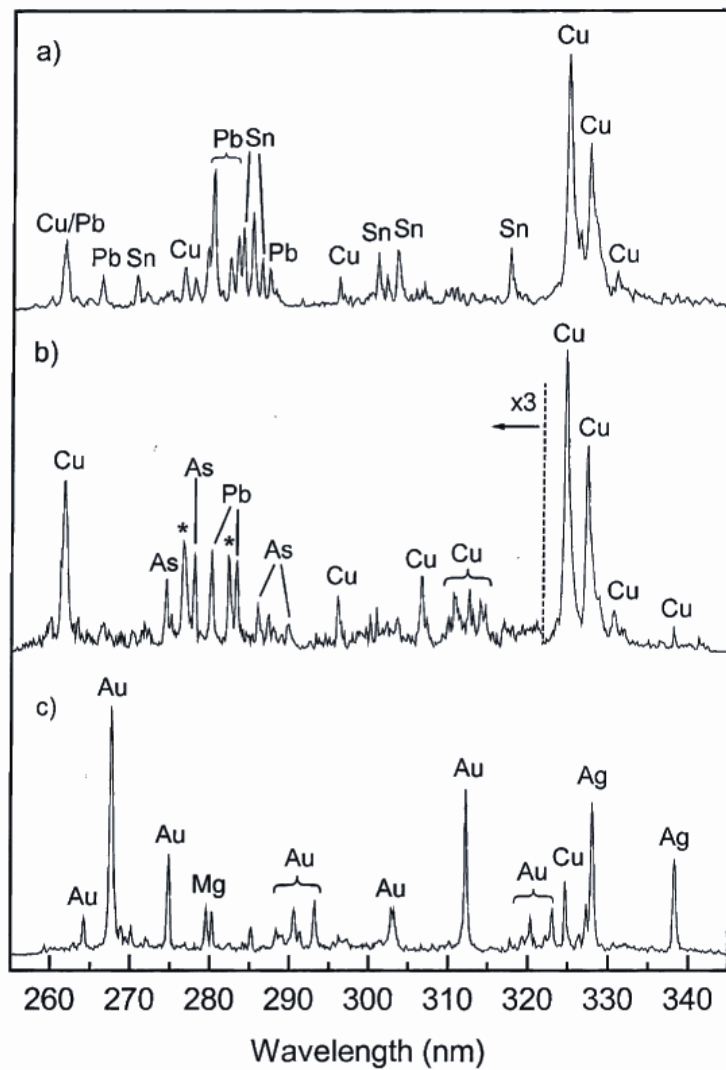
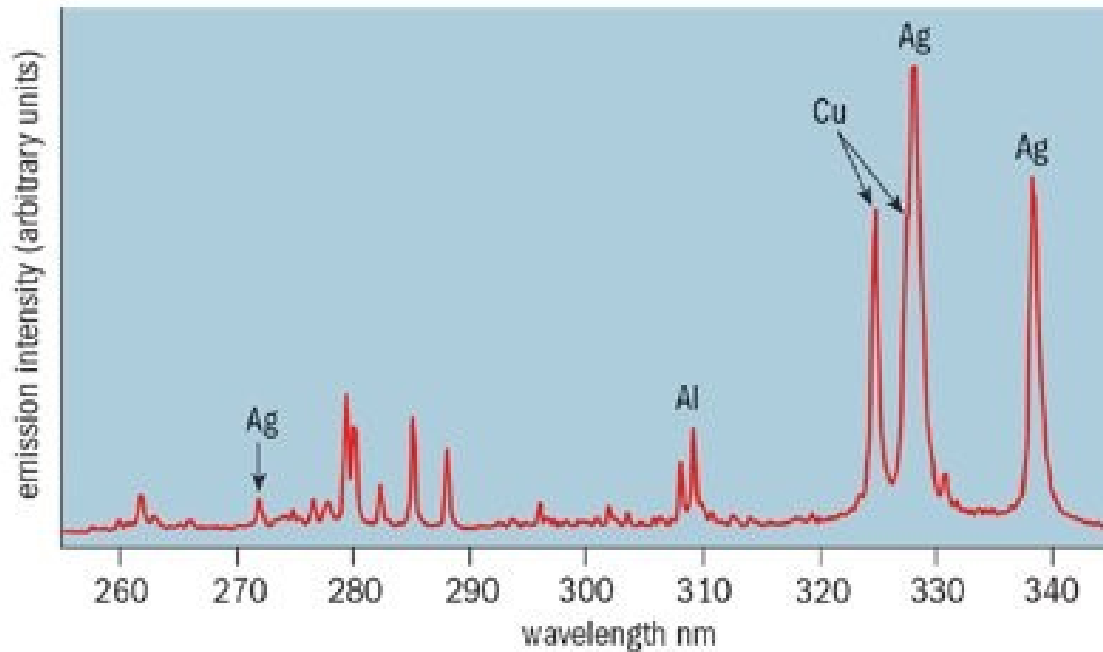


Fig. 5. LIBS spectra from: (a) Byzantine metal ring; (b) Minoan metal chisel; (c) Minoan golden bead.



LIBS rukojeti dýky z ostrova Pseira (late-Minoan period, cca 1600 BC).

LIBS prokázal stopy stříbra na dřevěné rukojeti bronzové dýky (Nd:YAG laser, 1064 nm, 15 ns puls, 3-5 mJ per pulse).

# Výrobní technologie bronzu

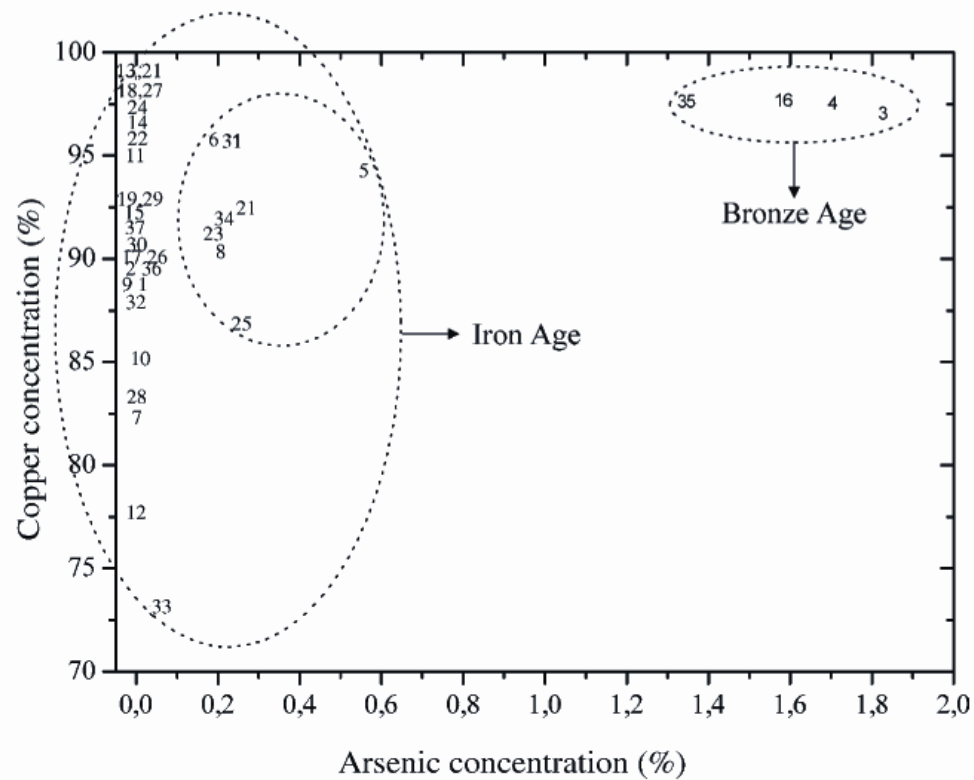
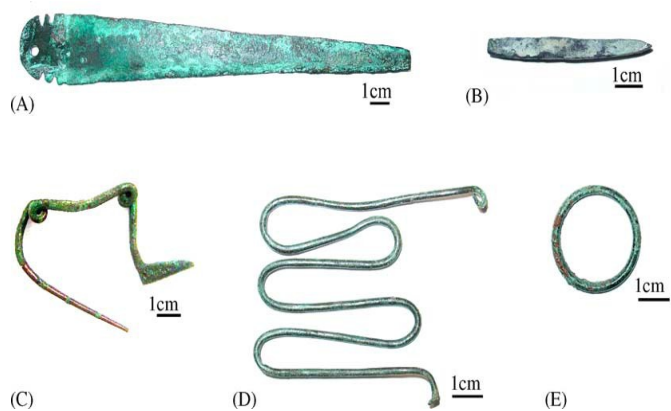
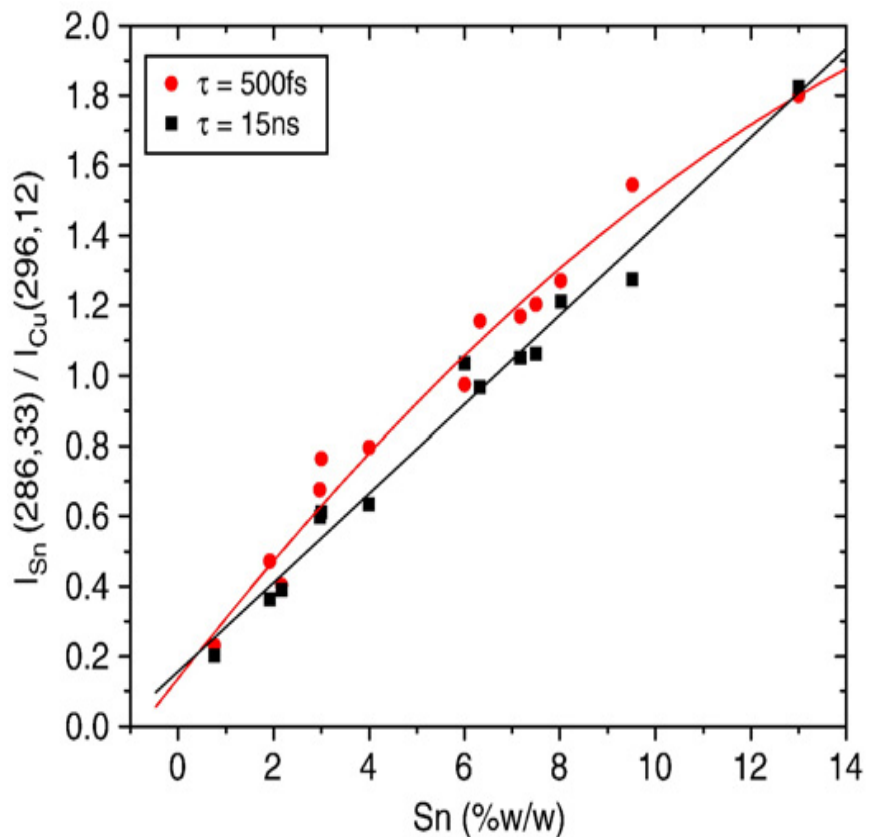
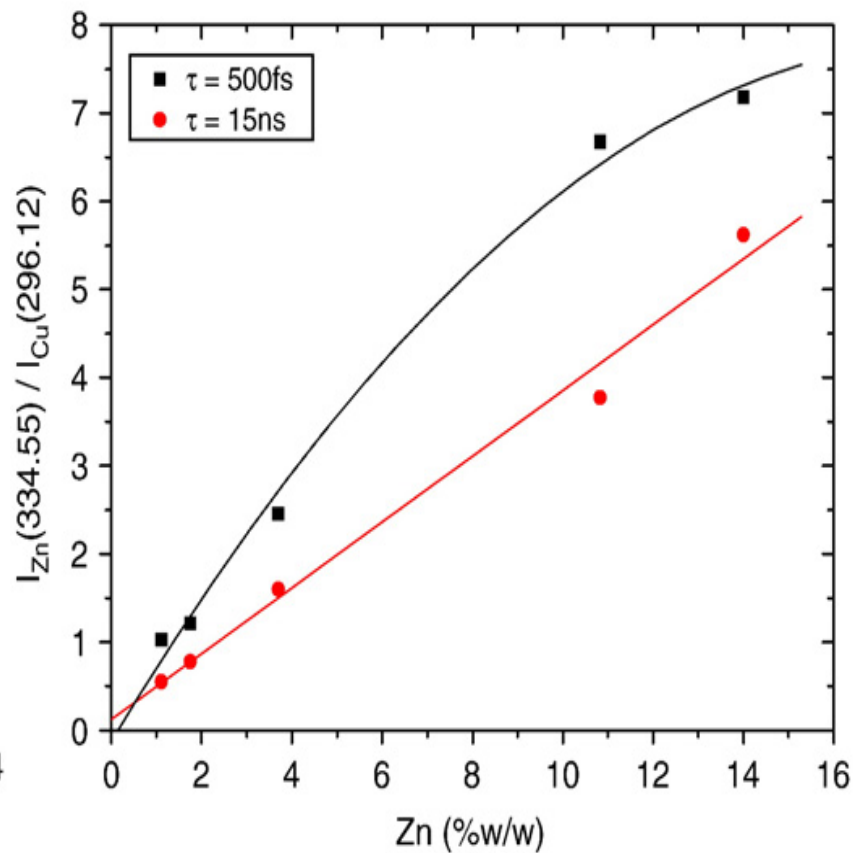


Fig. 7. Comparison of copper and arsenic concentration obtained by LIBS for the set of 37 archaeological samples.

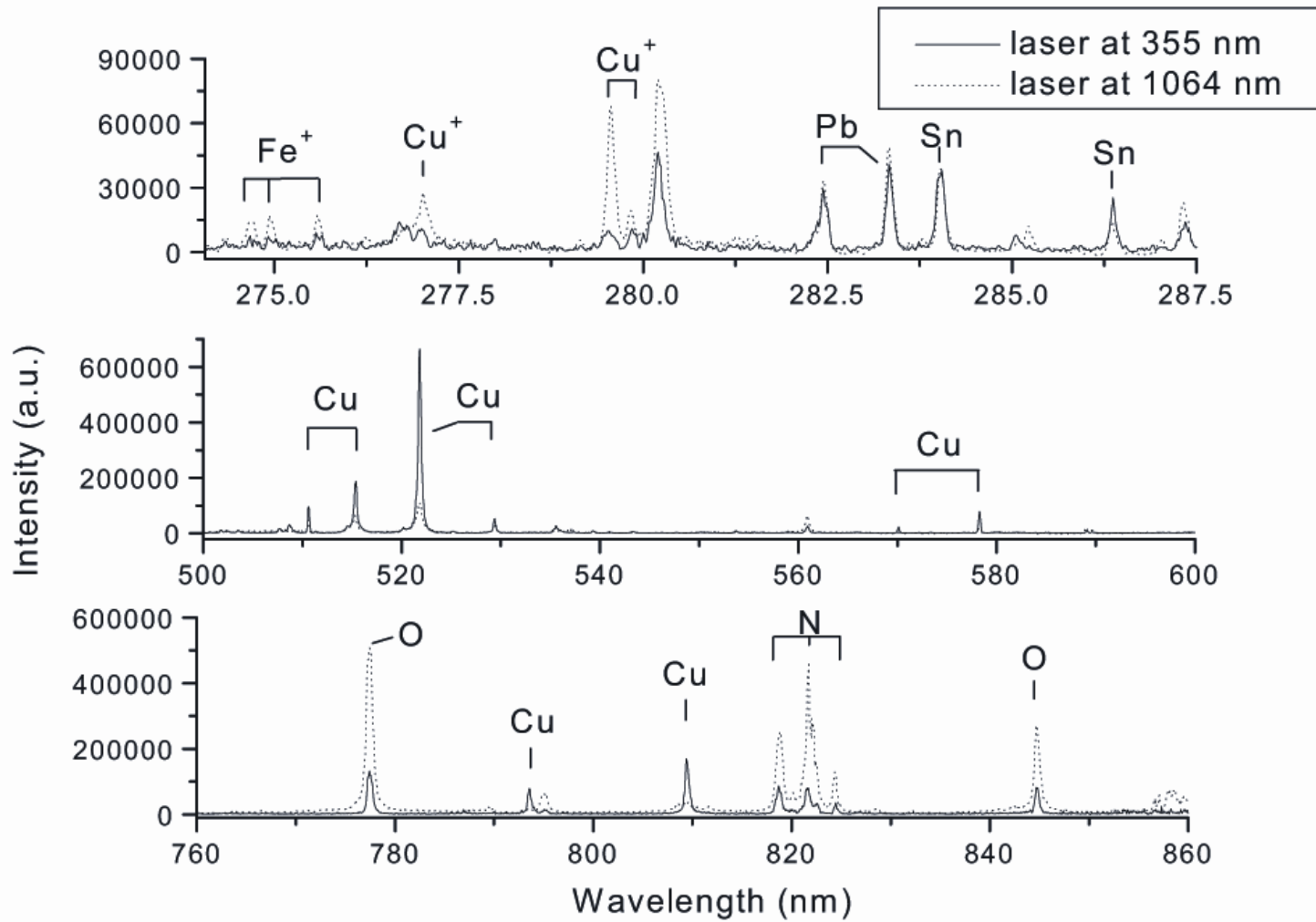




Kalibrační křivky Sn v bronzu pro nanosekundovou a femtosekundovou excitaci.

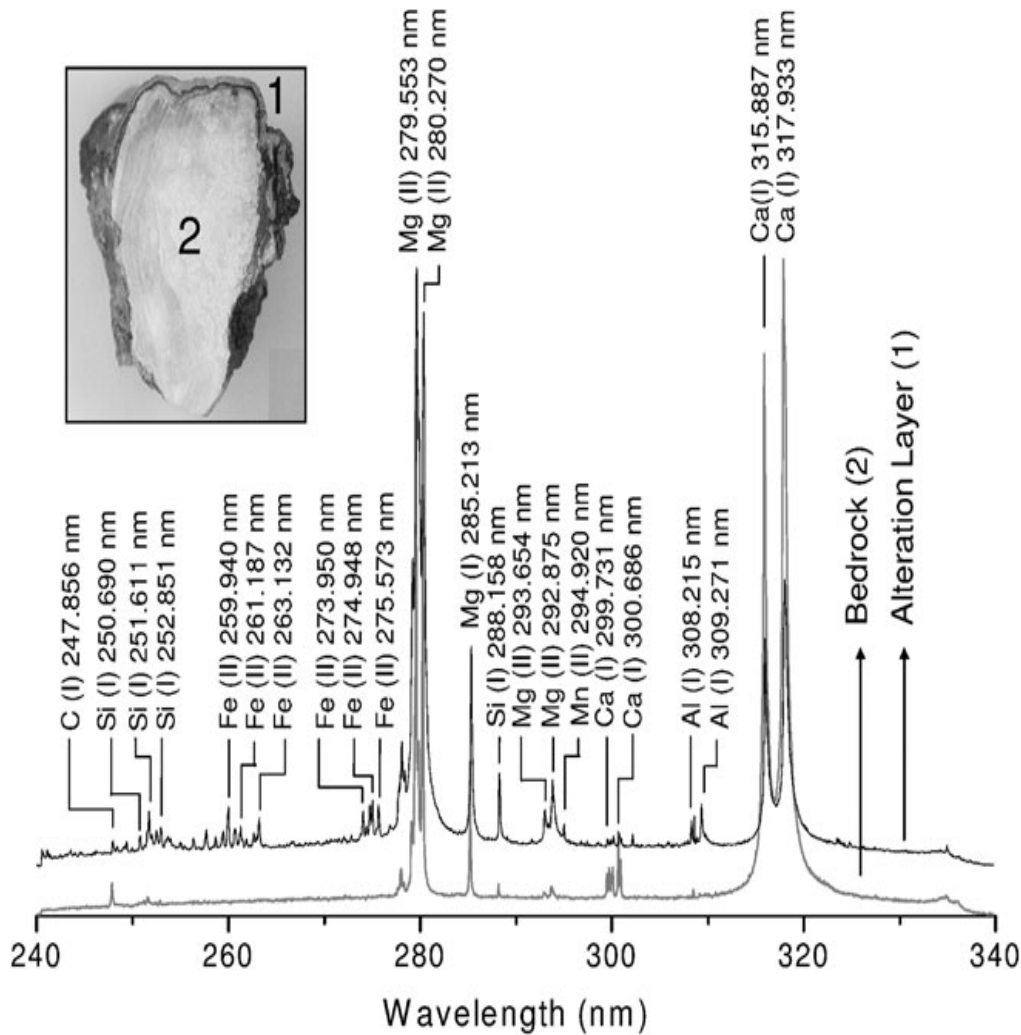


Kalibrační křivky Zn v ternárních a kvarternárních slitinách mědi pro nanosekundovou a femtosekundovou excitaci.

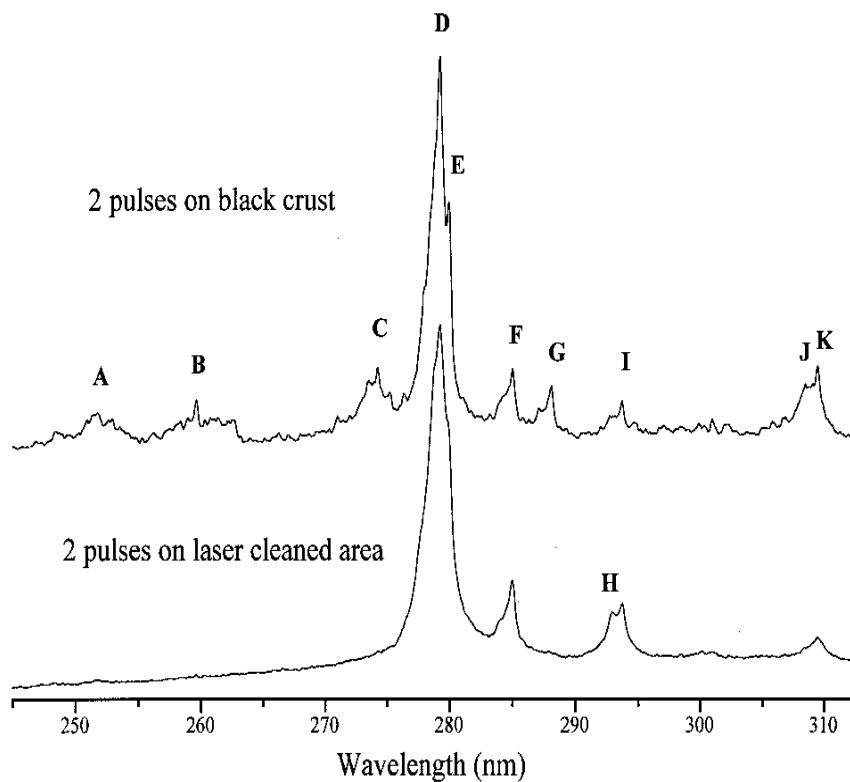


Srovnání spekter pro laser 355 nm a pro laser at 1064 nm.

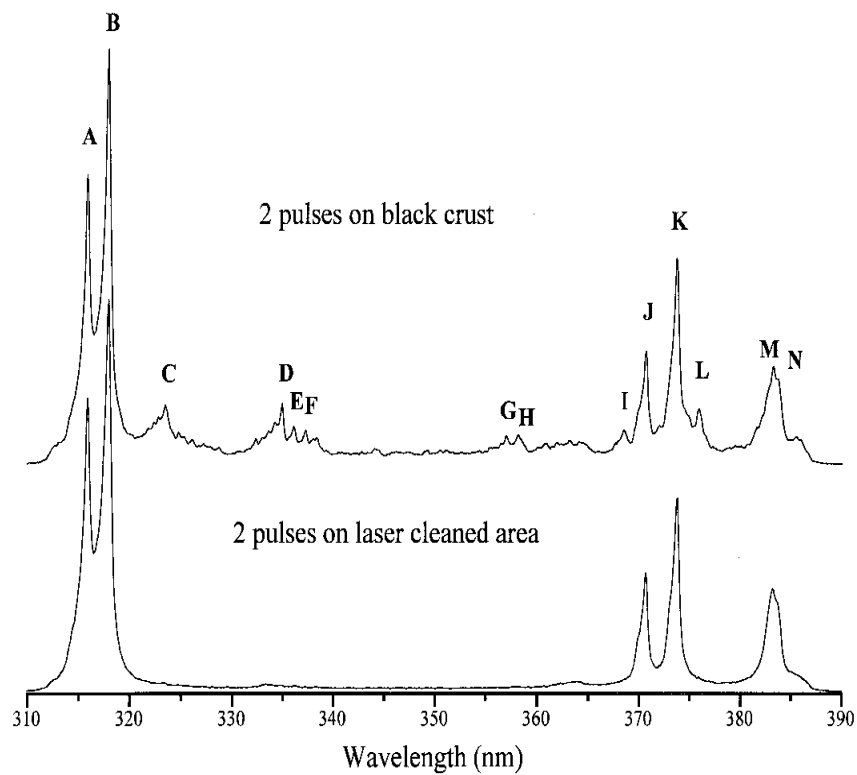
# Čištění kamene



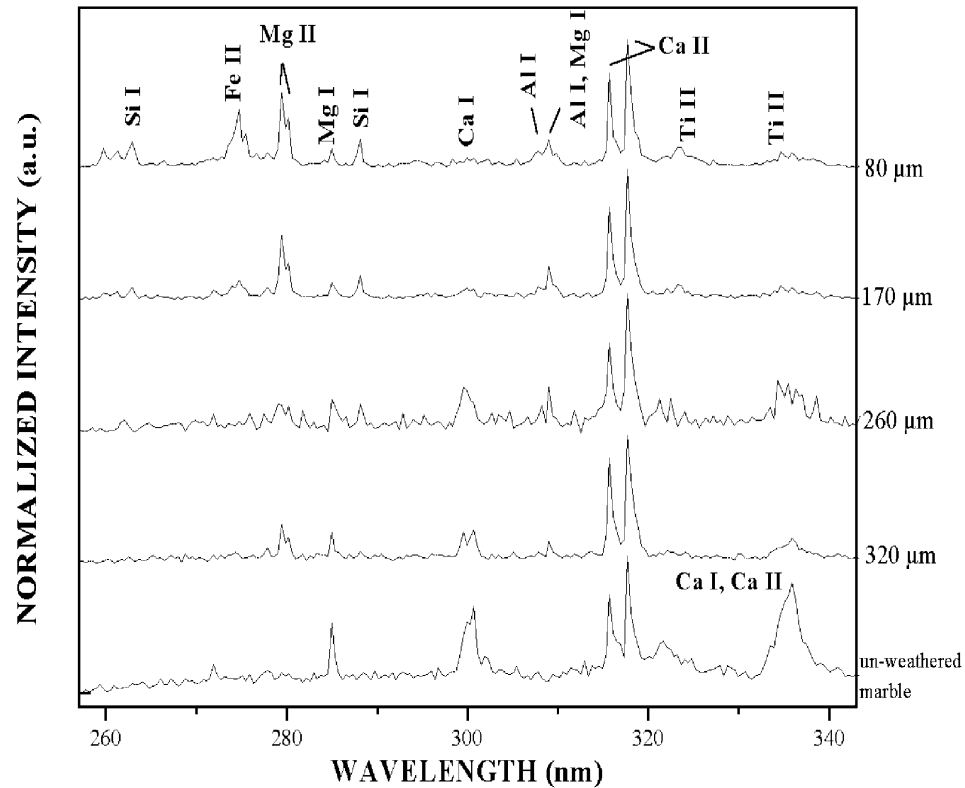
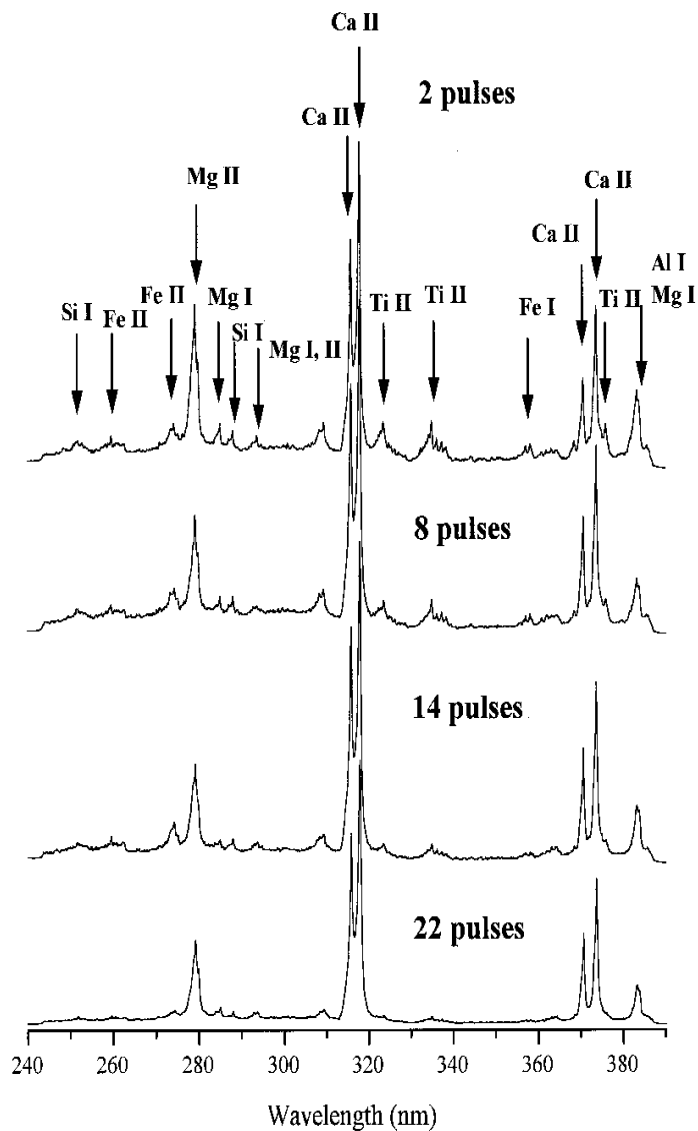
LIBS řezu krápníkem  
(znečištěný povrch)



LIBS spectra in the spectral region from 245 to 310 nm obtained by two laser pulses each on the black crust and the laser-cleaned region.

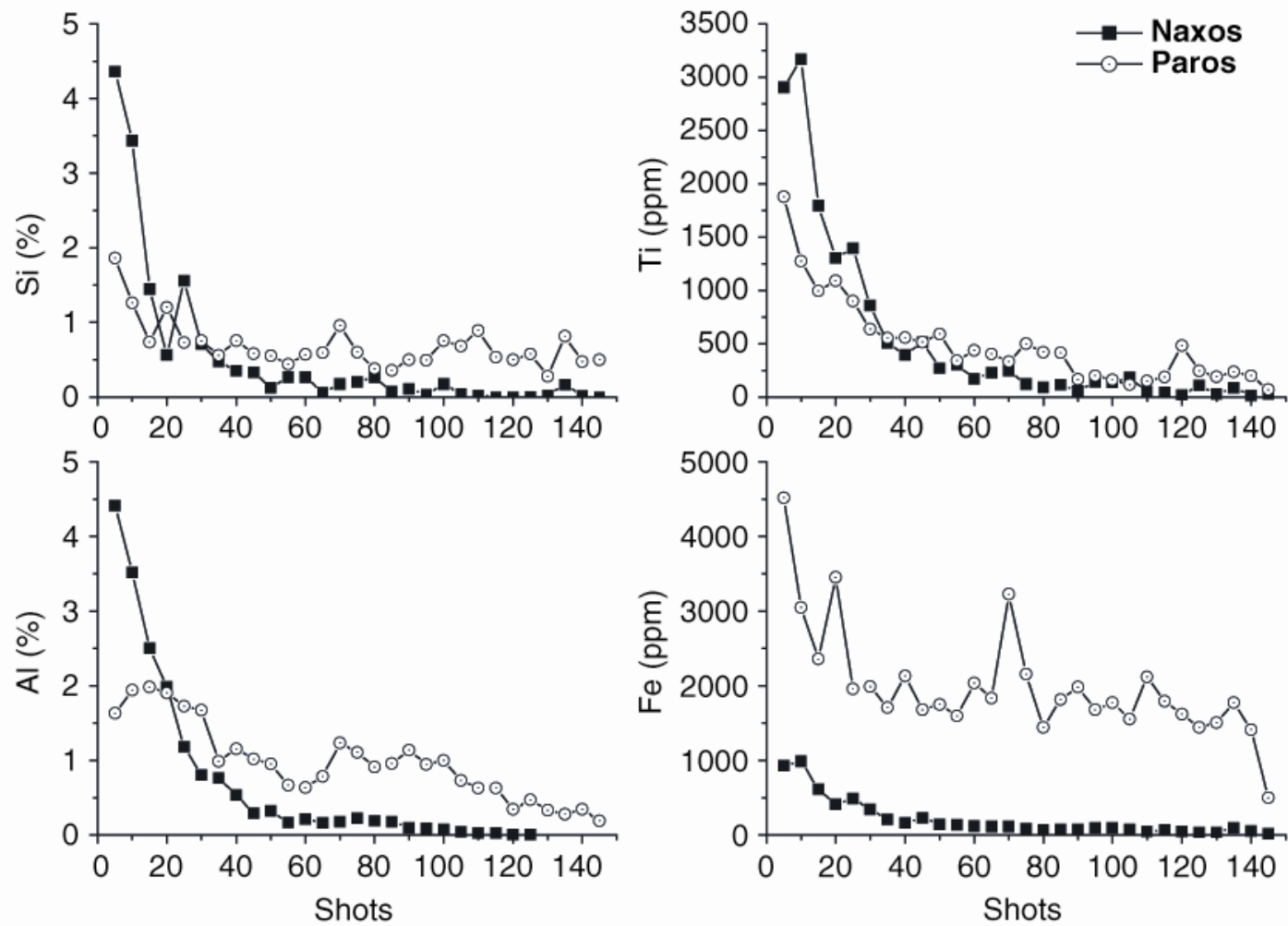


LIBS spectra in the spectral region from 310 to 385 nm obtained by two laser pulses each on the black crust and the laser-cleaned region.



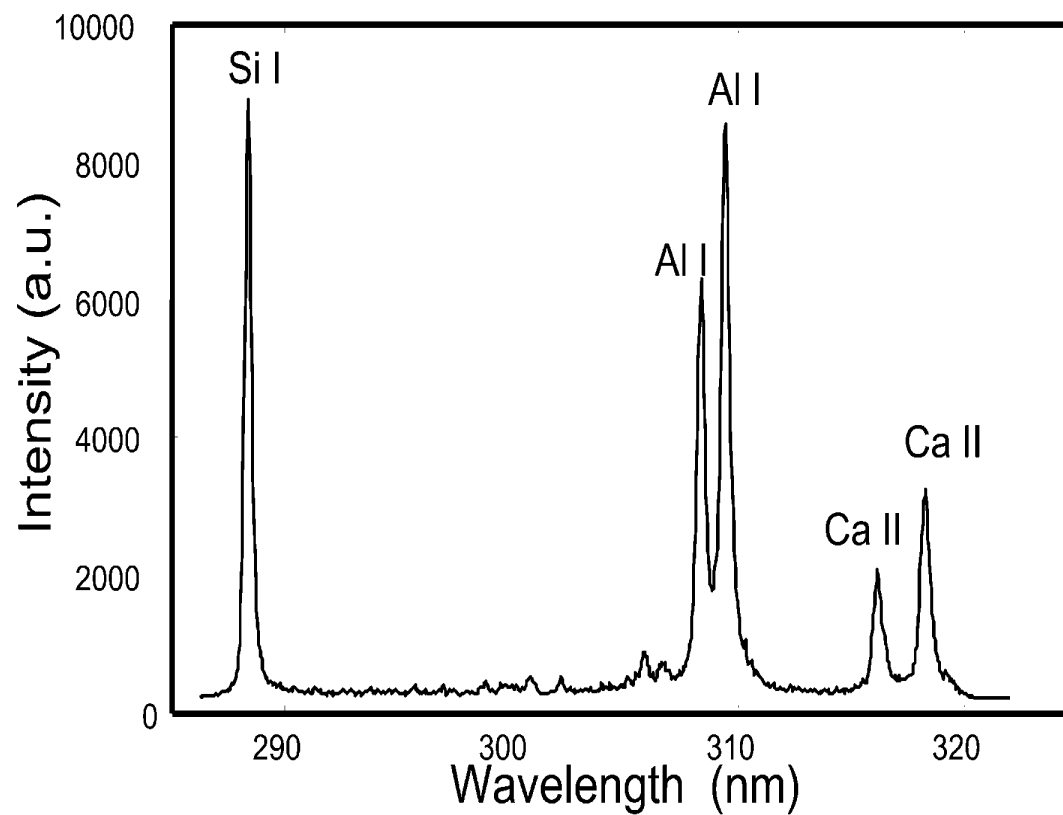
LIBS ablatovaného materiálu z různé hloubky dendritické krusty (Pentelický mramor, normalizováno na Ca II 317.93 nm).

LIBS spektra 2., 8., 14. a 22. pulsu, ablance tmavé krusty.



**Fig. 1.** Concentration change of Si, Al, Ti and Mn during the encrustation removal

# Papír



Single shot spektrum kaolínem pokrytého papíru.

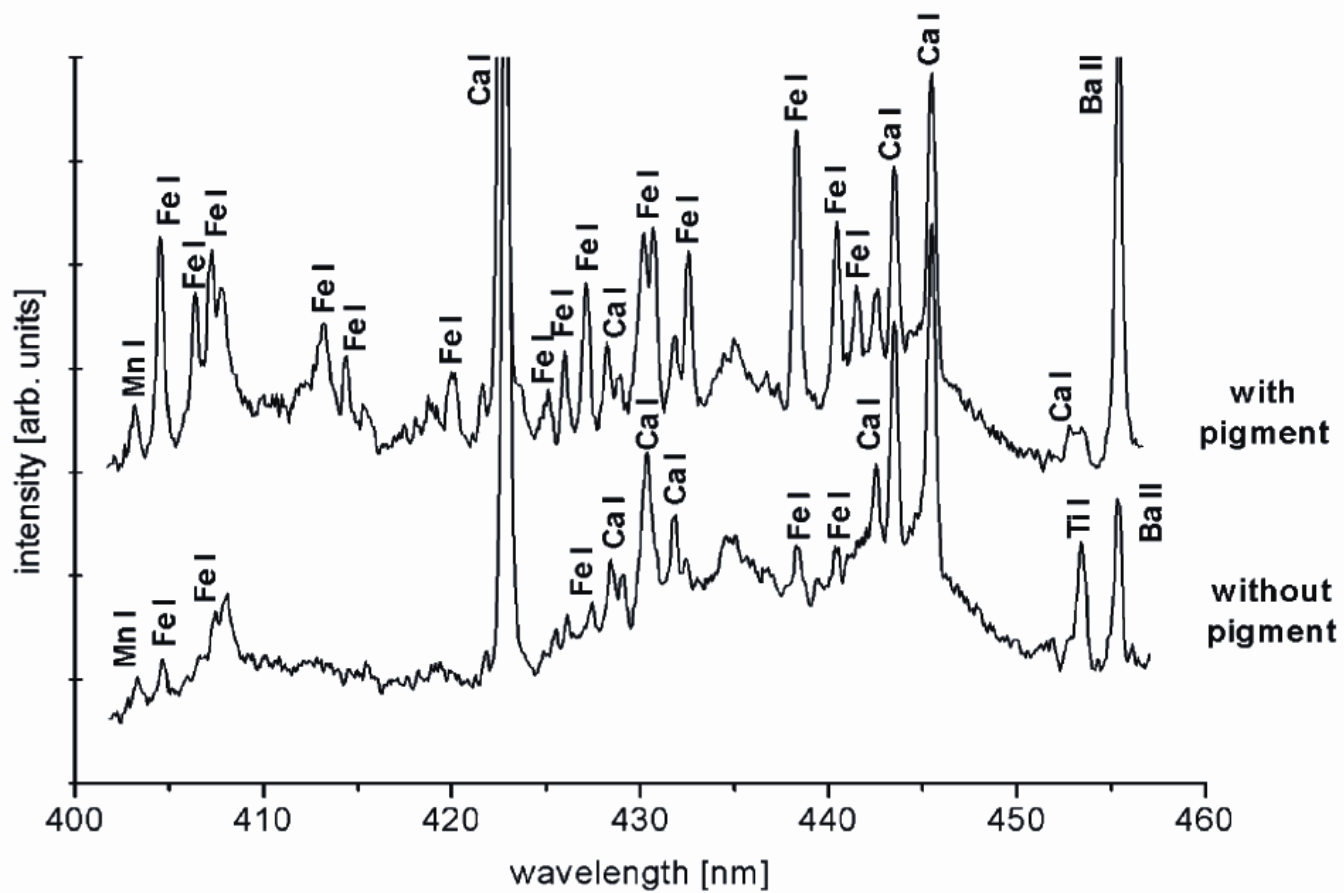


Fig. 6. LIPS spectrum of pigments originating from blue pencil mark on the back cover of Leopolda's Bible, and a spectrum of a non-coloured paper region; plasma induced by a 355 nm laser.



# Keramika



Neolitická malovaná keramika (Itálie)

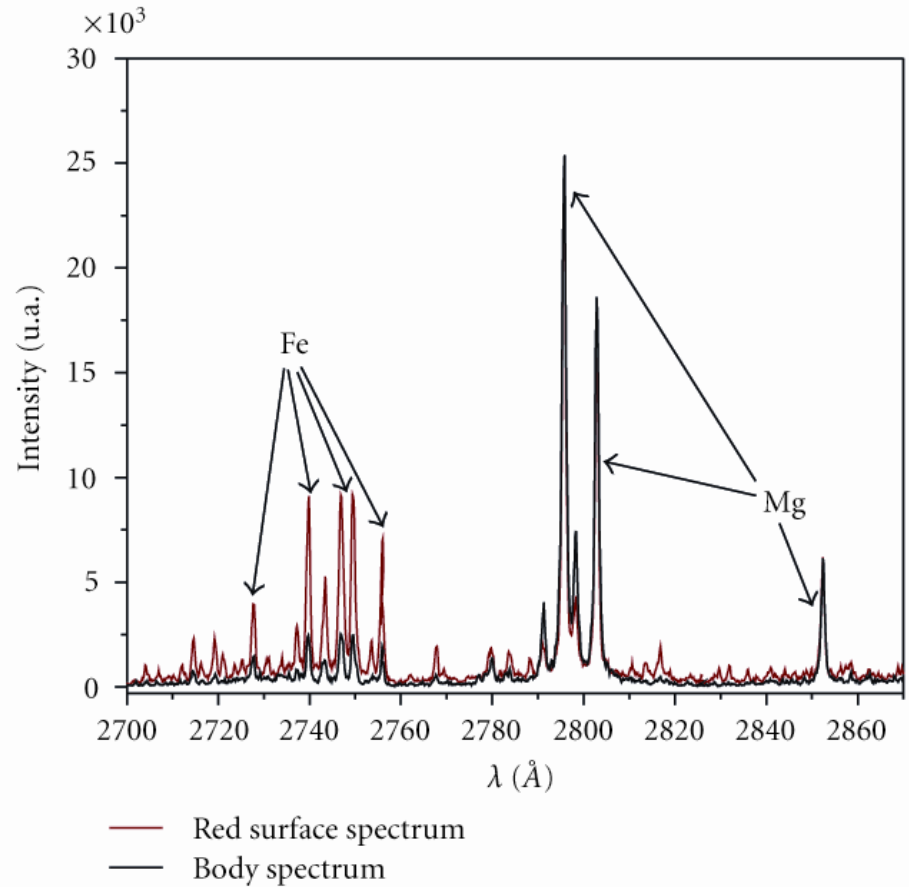


FIGURE 15: LIBS spectrum of the red region (TR13 sample).

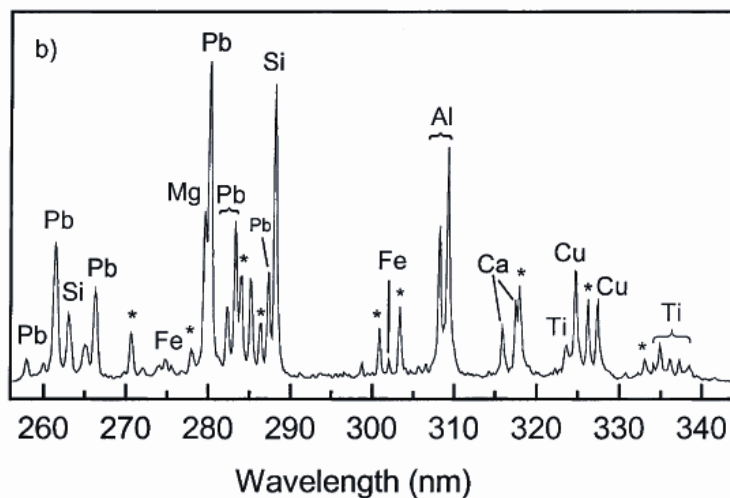
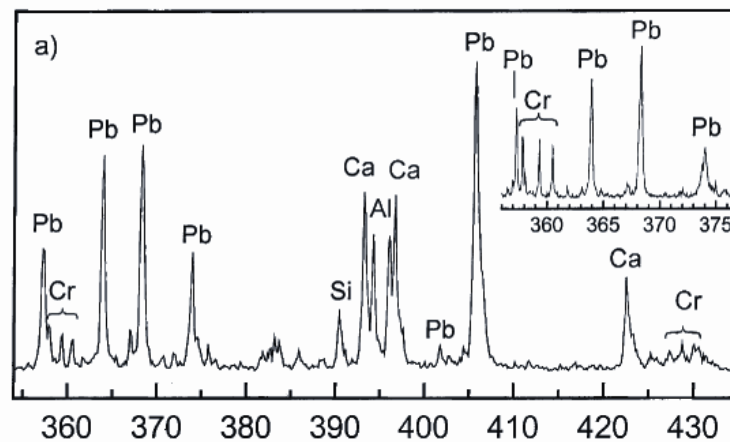
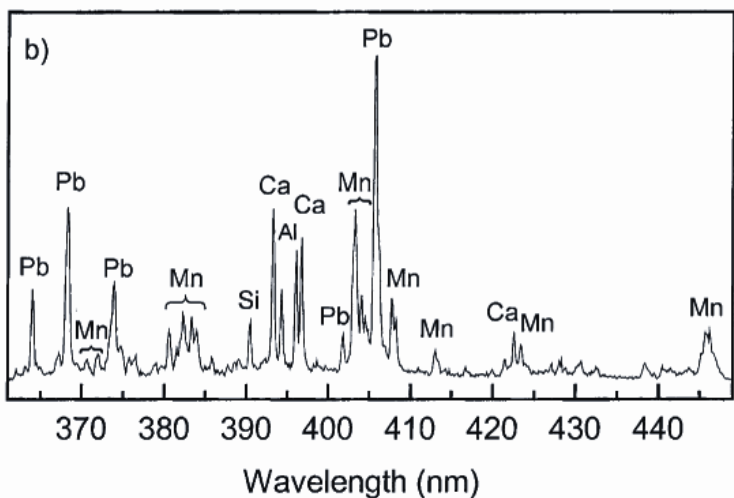
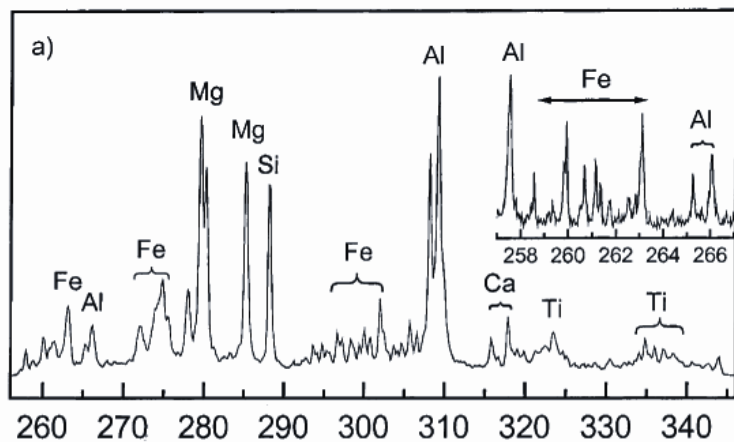
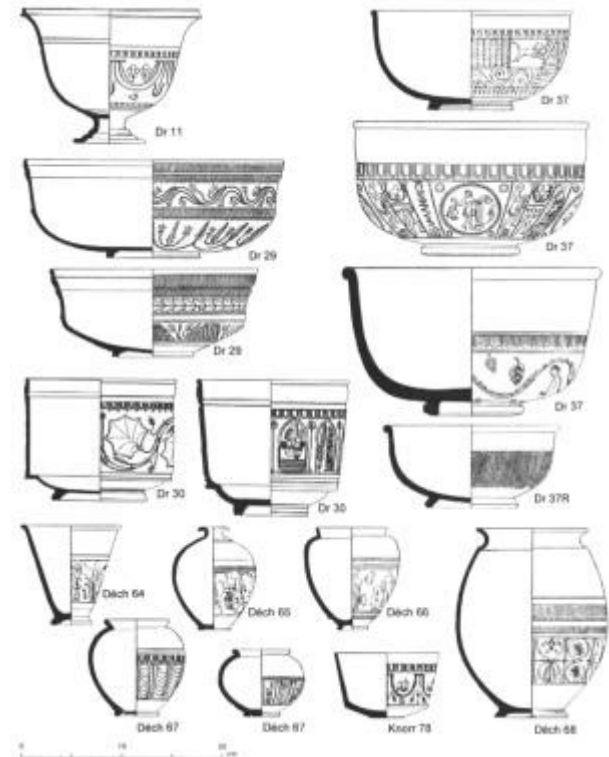
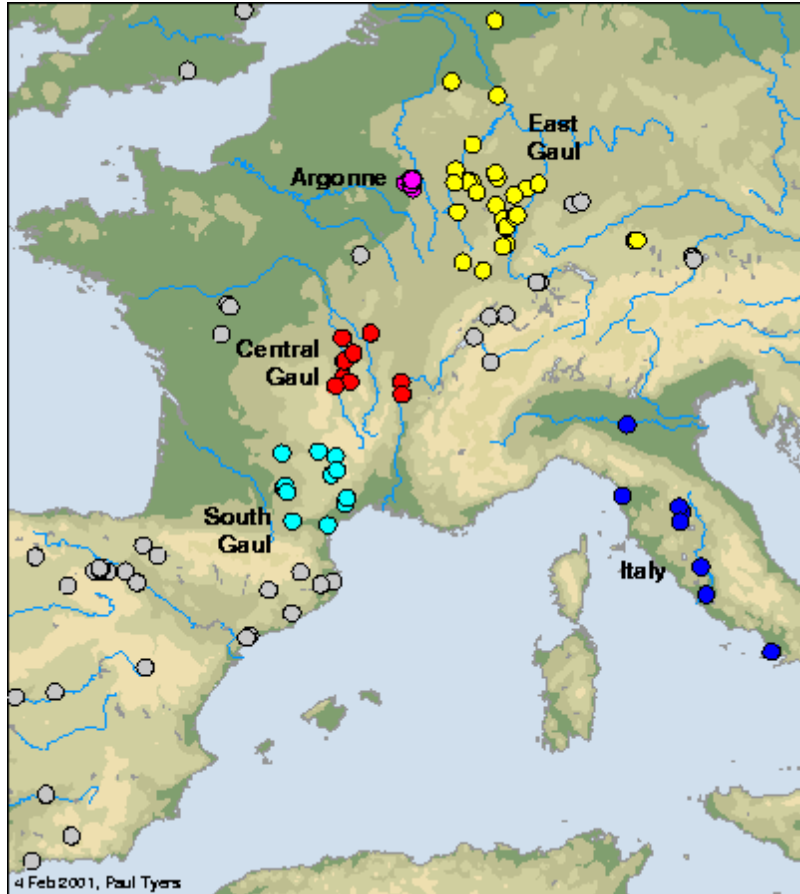
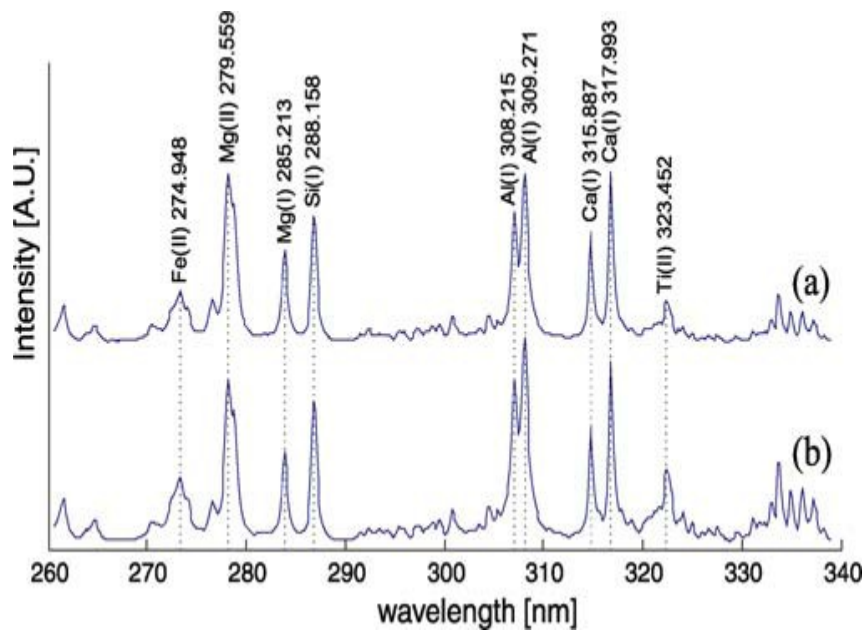


Fig. 2. LIBS spectra of black pigments on: (a) Minoan polychromed sherd (inset: high-resolution spectrum); (b) Byzantine glazed ceramic sherd.

Fig. 3. LIBS spectra from glazed ceramic sherds. (a) Yellow glaze (inset: high-resolution spectrum); (b) green glaze (\* mark Sn emission lines).

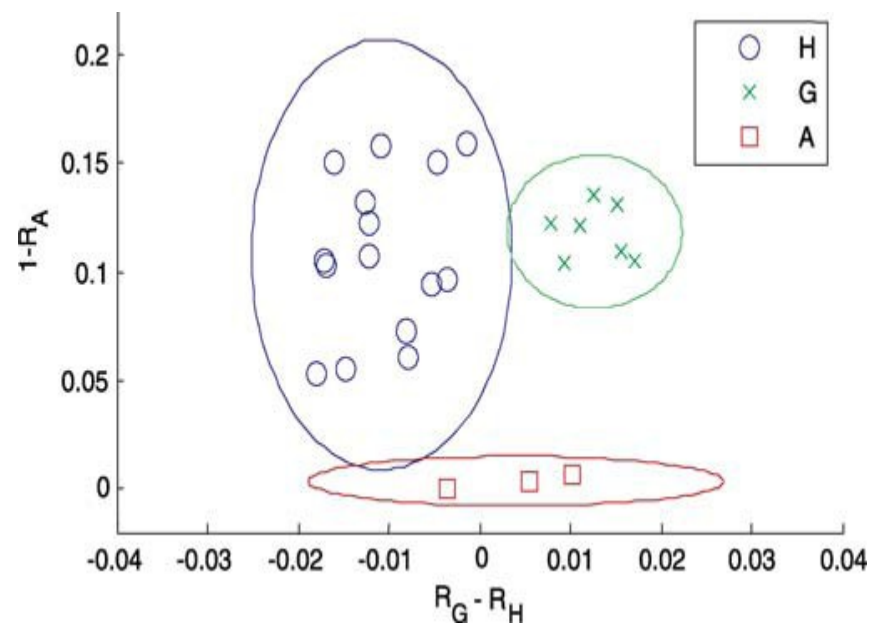
# Terra sigillata





## LIBS spektra

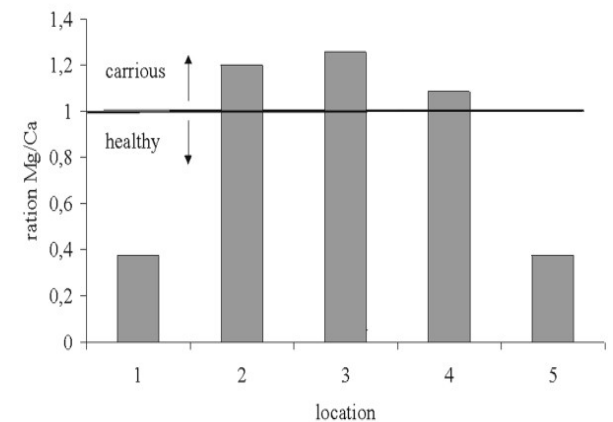
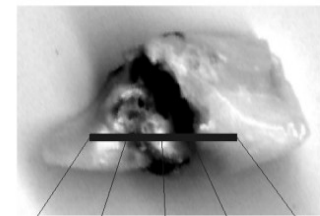
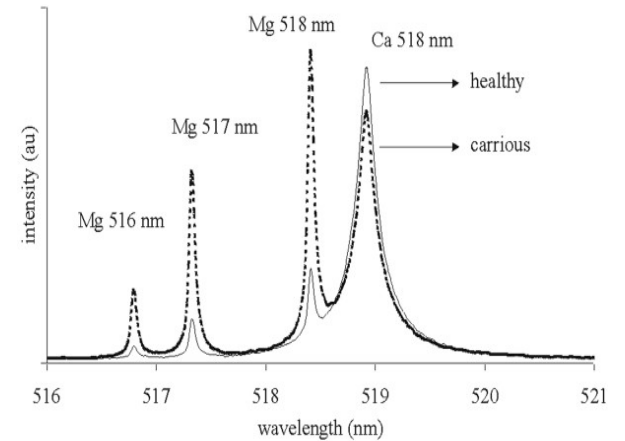
- (a) Hispánský vzorek, H5  
 (b) Galský vzorek G3



Discriminační analýza výsledků (elipsy odpovídají 90% hladiny významnosti)

# Kosti a zuby

Obsah Mg a Ca v zubní tkáni poškozené kazem.  
Zvýšená koncentrace Mg zřetelně indikuje  
postižené partie.



# Autenticita výrobků z korálu



korál vs. vápenec

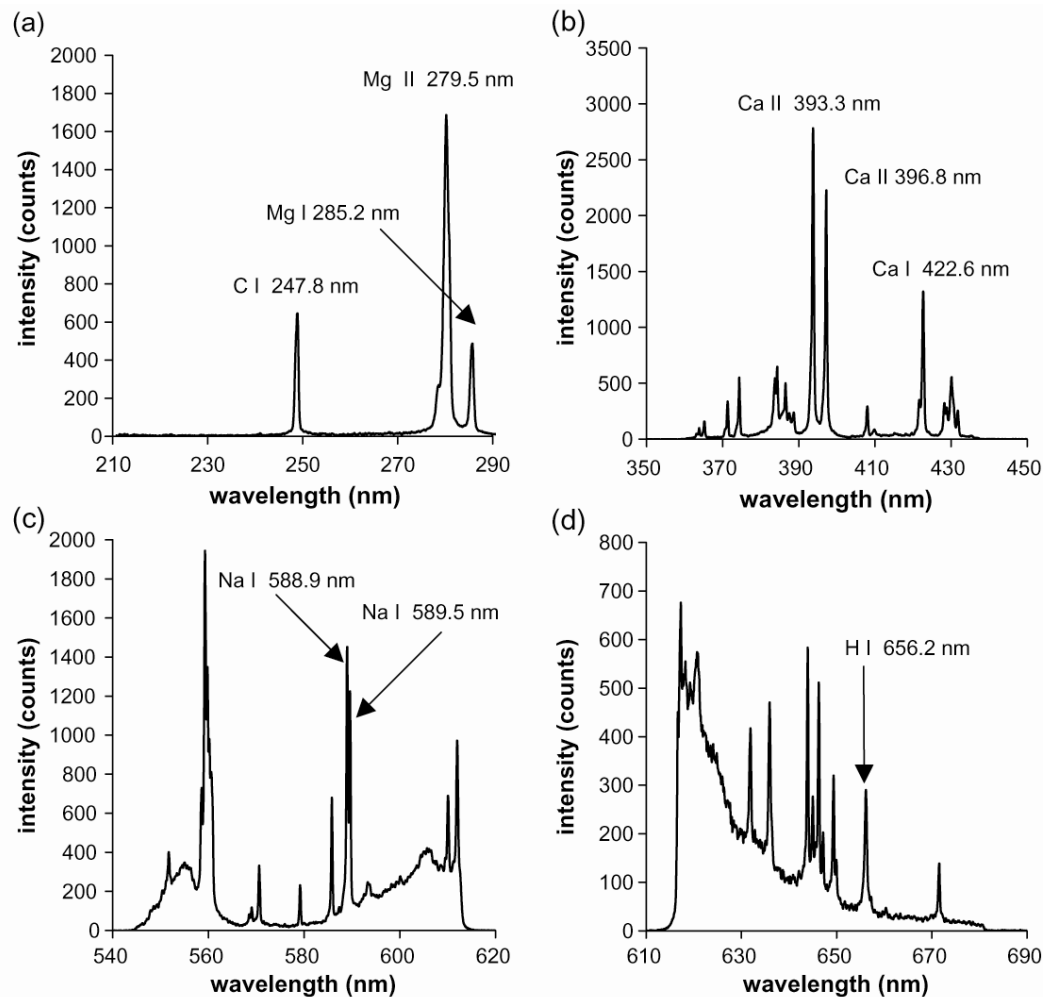
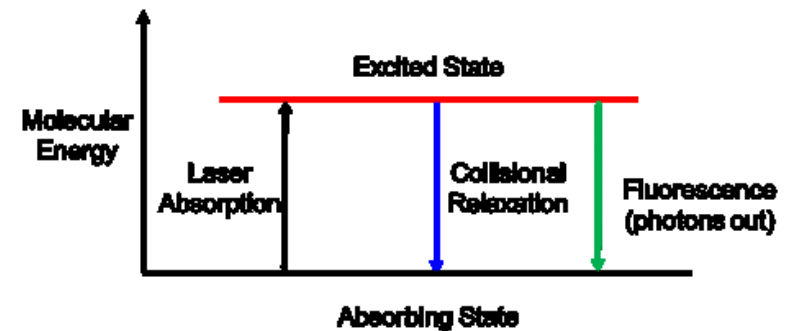
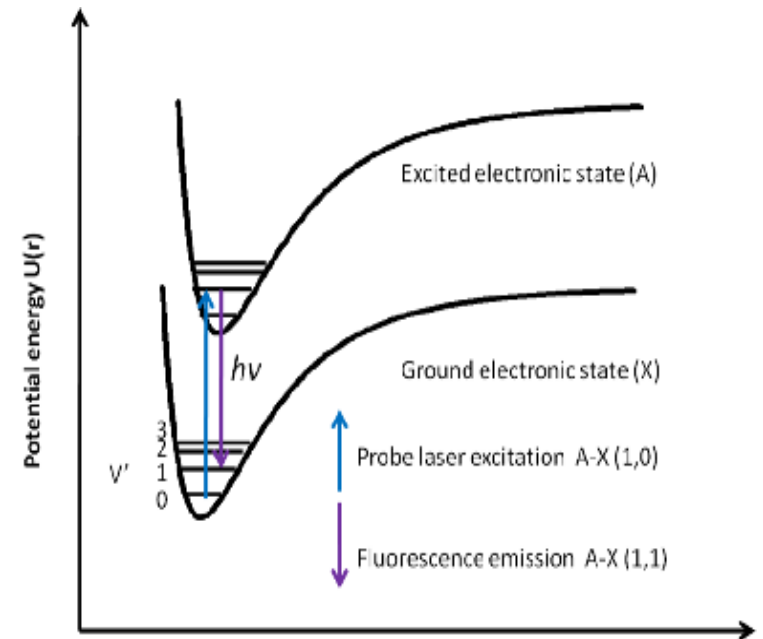
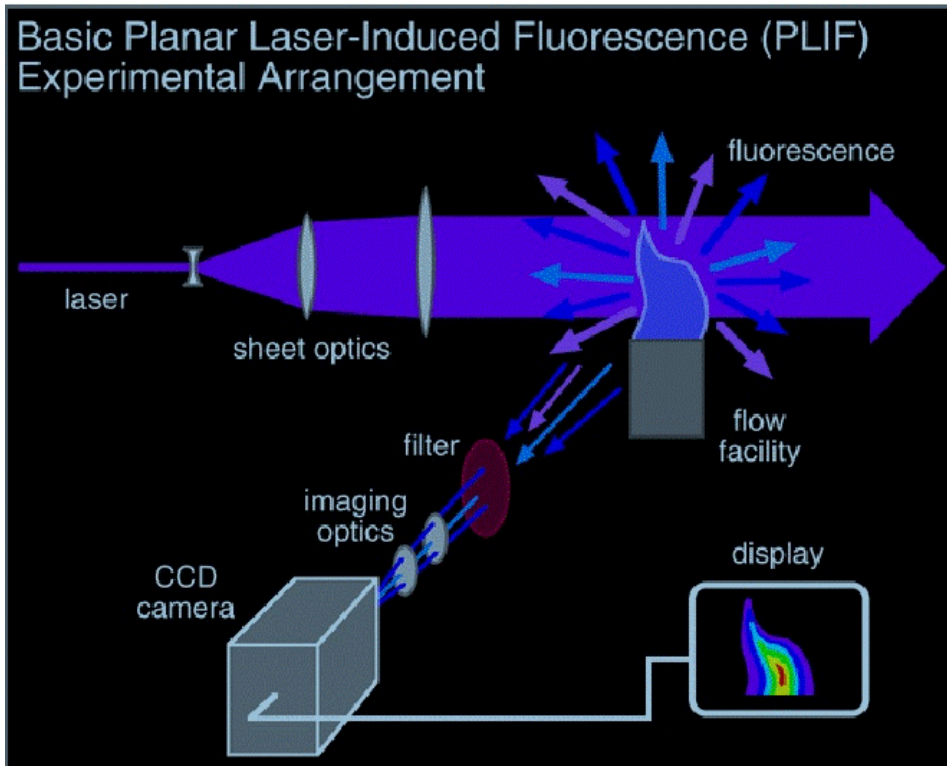


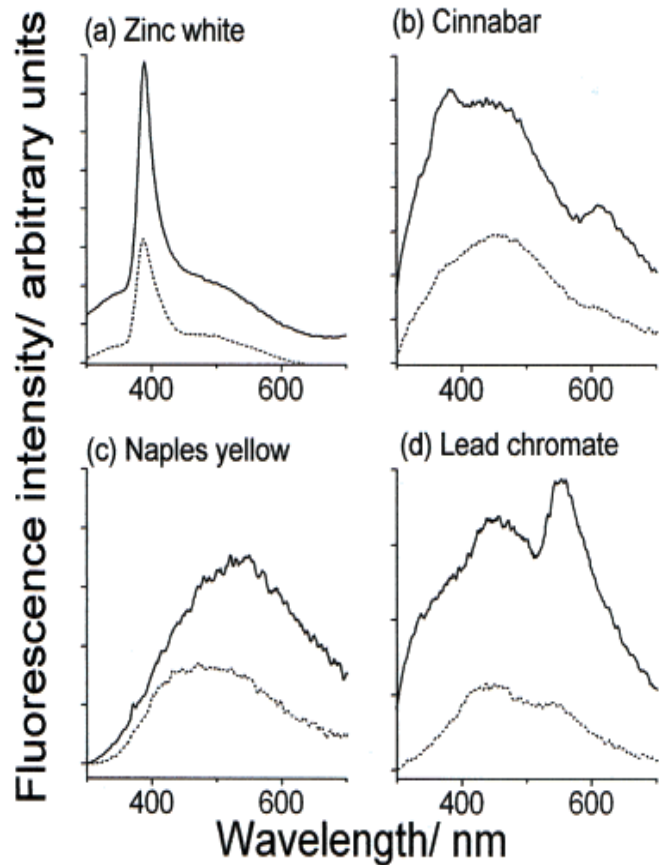
Fig. 5. Emission spectra of a fresh white coral sample in a low pressure plasma of 1.3 kPa in the wavelength region between (a) 220 and 290 nm, (b) 370 and 440 nm, (c) 550 and 620 nm and (d) 620 and 680 nm.

# Laserem indukovaná fluorescence (LIF)

# Laser induced fluorescence





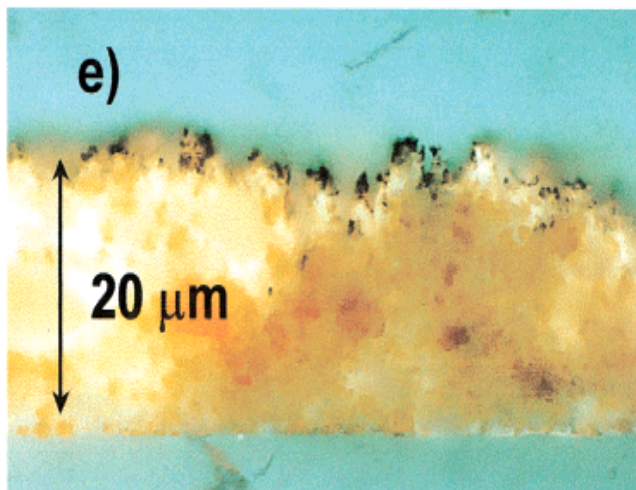


LIF spectra of unvarnished tempera systems taken at a resolution of 1 nm with a laser fluence of  $1.2 \text{ mJ cm}^{-2}$ :

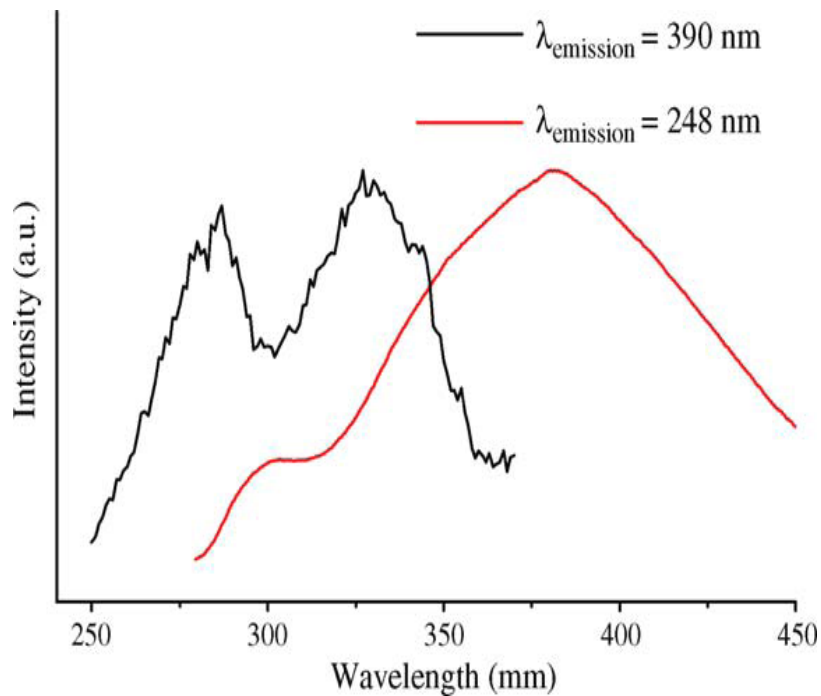
- (a) zinc white,
- (b) cinnabar,
- (c) Naples yellow, and
- (d) lead chromate.

The exciting laser wavelength is 248 nm.

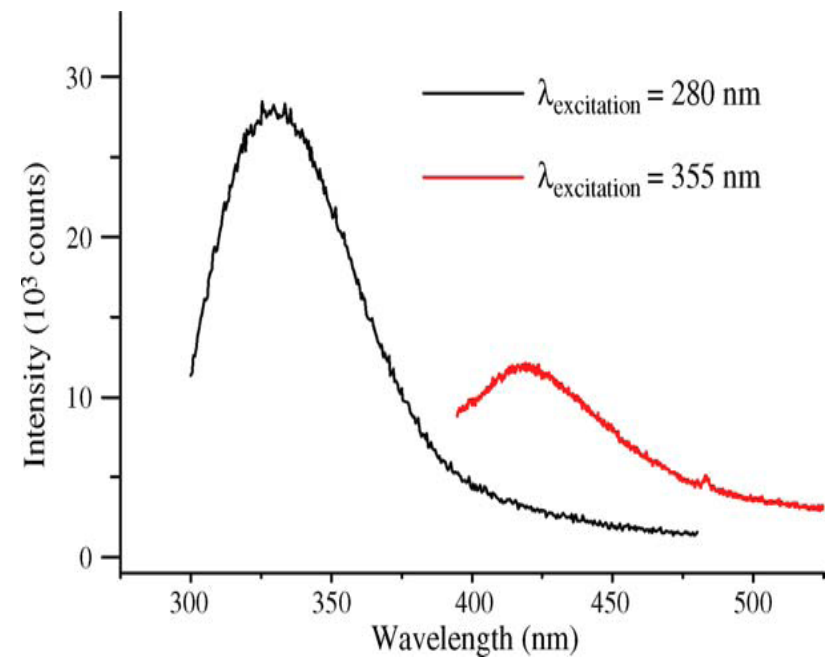
- (e) UV fluorescence image of a cross section of an unvarnished laser-ablated region of a Naples yellow tempera sample. (Magnification is 500).



# Pojiva v malbách

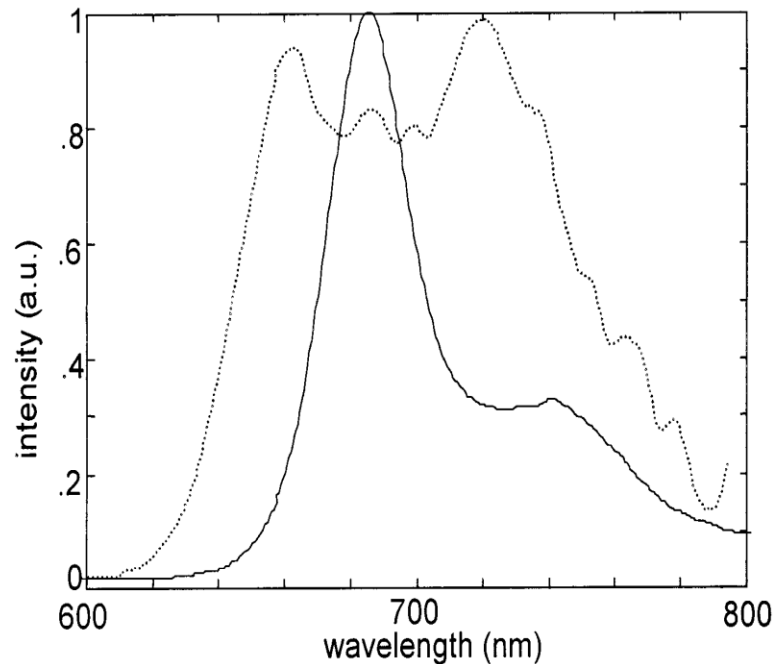


Fluorescence excitation spectrum (390 nm) (emission maxima at 290 nm and 330 nm), and excitation spectrum (emission maximum 385 nm) from 0.1% (w/w) aqueous solution of rabbit skin glue.

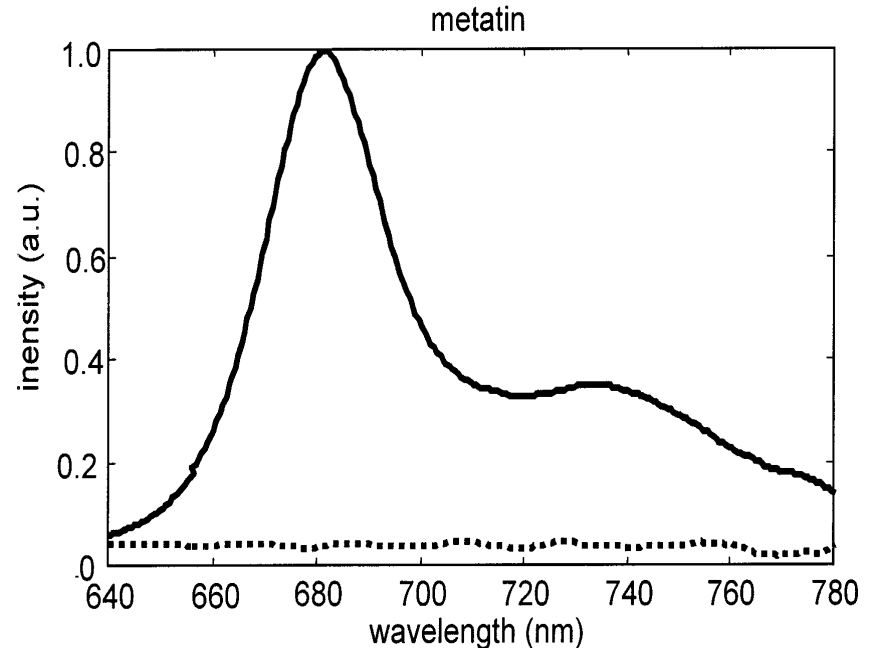


Wavelength dependence of fluorescence emission from films of egg white (excitation at 248 nm, emission maximum 340 nm; excitation at 355 nm, emission maximum 420 nm).

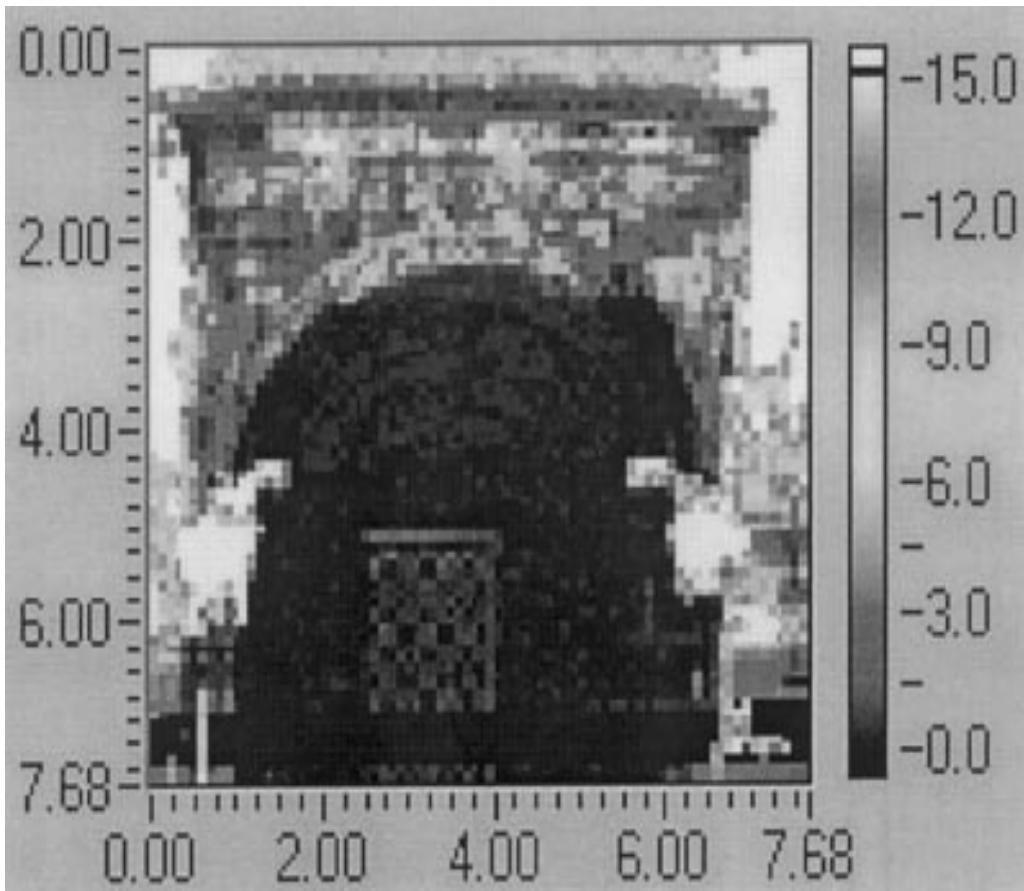
# Detekce mikroorganismů



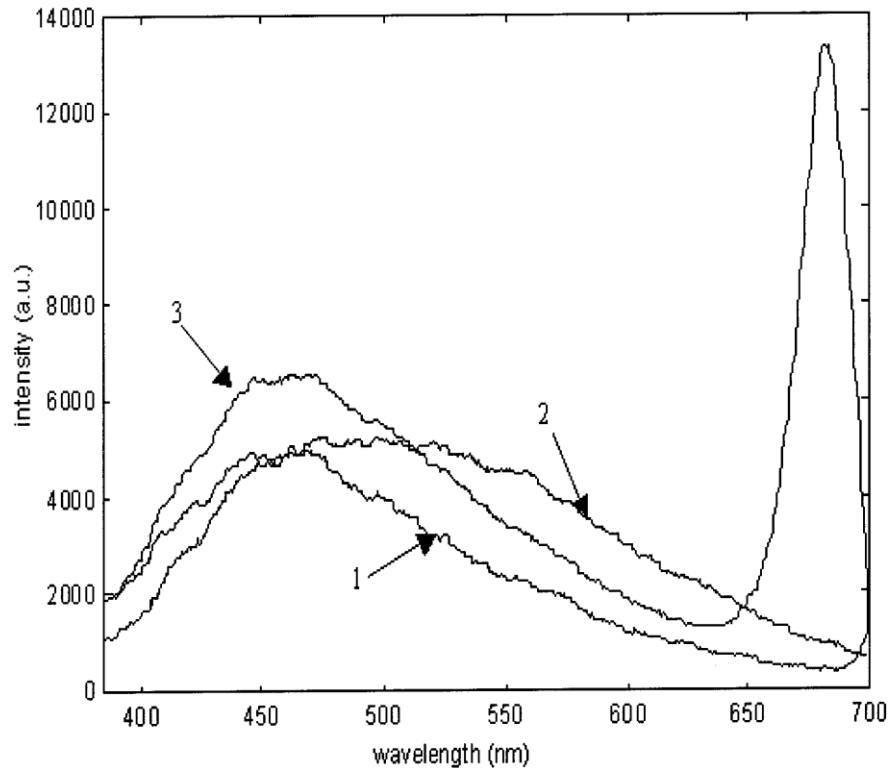
Normalised LIF spectra of green algae (continuous line) and cyanobacteria (dotted line). Excitation 355 nm.



Fluorescence spectra of green algae on a marble substrate. Before a biocidal treatment (continuous line) and after (dotted line). Excitation wavelength 355 nm.



Fluorescence image related to the alga colonisation on the northern portal of **Lund Cathedral**. The intensity of the chlorophyll fluorescence in the band around 685 nm is indicated in grey levels and makes evident the important biodeteriogen colonisation on the stone surface.

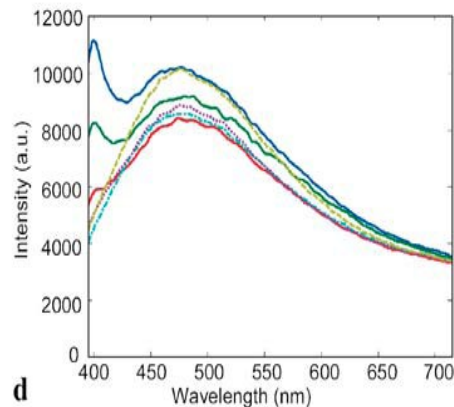
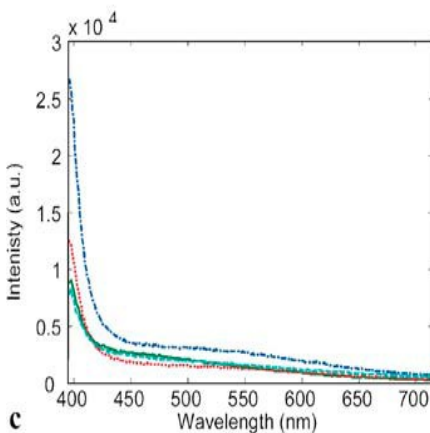
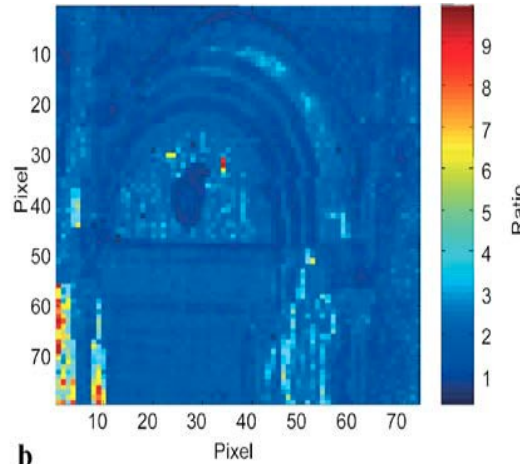
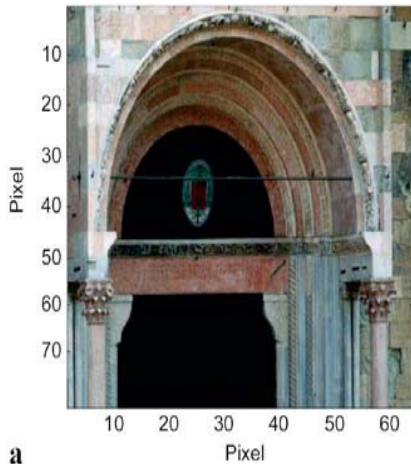


Fluorescence spectra of Hoør sandstone from the external walls of Lund Cathedral:

- 1) 12th century stone;
- 2) 19th century stone;
- 3) 12th century stone with algae.

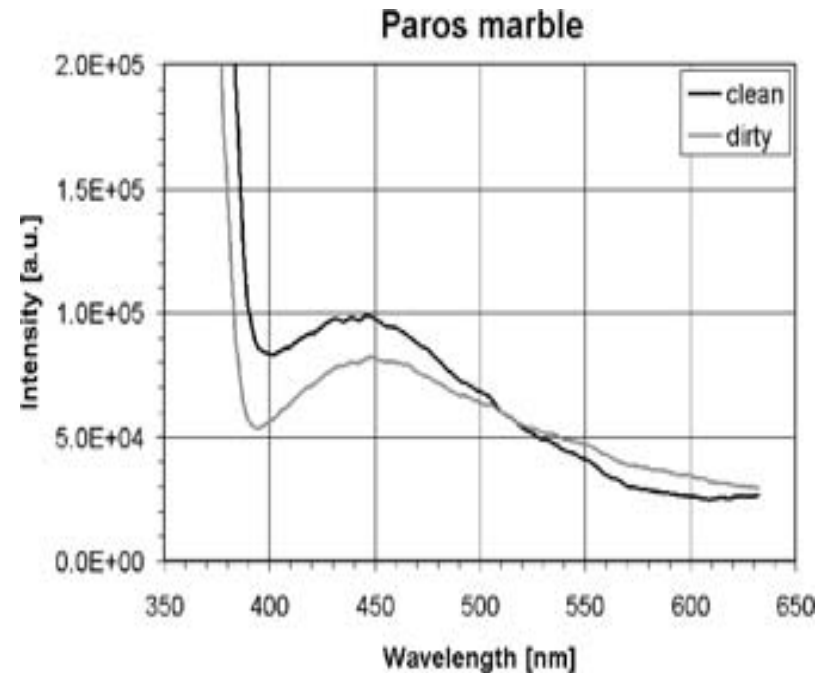
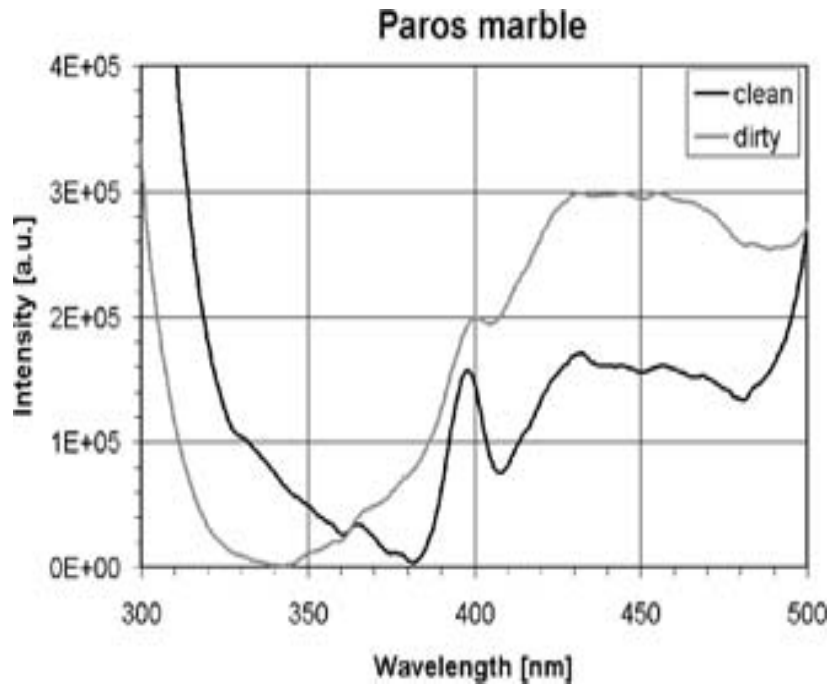
Excitation 337.1 nm. The same behaviour was observed in the remote measurements with the excitation at 355 nm.

# Katedrála v Parmě



**a** a picture of the area investigated;  
**b** the thematic map obtained from the ratio between the integrated area in the range 396 to 408 nm and the integrated area in the range 409 to 450 nm (the *yellow-red areas* in the image indicate areas subject to protective treatment); **c** fluorescence spectra taken from the bottom left area of the protiro and referring to those pixels of the thematic map in **b** where the protective treatment was strongly present (*yellow-red pixels*); and **d** fluorescence spectra taken in the bottom right area of the protiro where the protective treatment is present in a lower degree

# Znečištění kamene



LIF spektra of Parského mramoru: čistý a incrustovaný povrch (266nm (vlevo) a 355nm (vpravo))

# Spektrometrie laserem indukovaného plazmatu (LIBS)

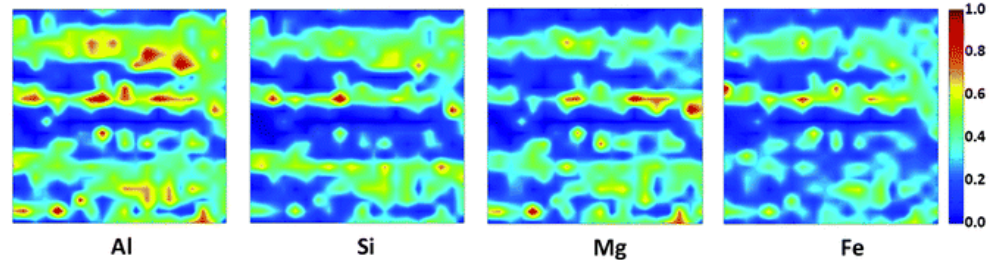
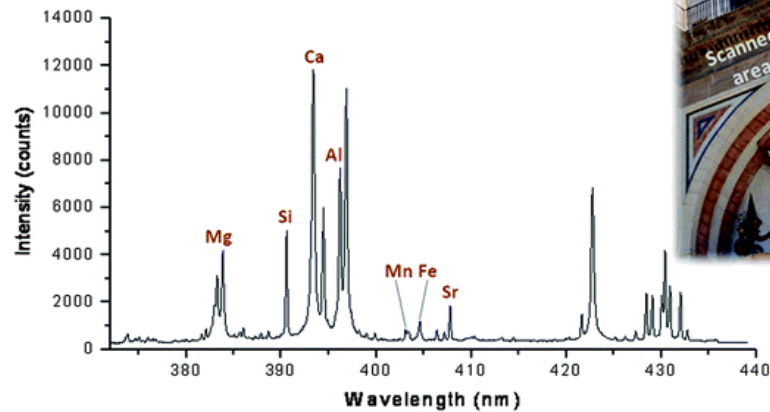
Prvková analýza





# Malaga

Analýza portálu katedrály.



# LIBS

