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Scientific Analysis of Fine Art
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ANALYSIS REPORT

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OBJECT DESCRIPTION (form, material, color, etc): Archaeological material excavated from the Republic of Kiribati in late 2007: dark brown organic sheet-like material (possible shoe leather), a red wafer, and an unknown beige concretion.

REASON FOR ANALYSIS: Could these objects have an early twentieth-century American provenance? Could they have been manufactured prior to 7/2/37? Specific questions include: Could the dark brown material be shoe leather? Is the red wafer a cosmetic that might confirm the identity of the glass shards as compact shards? What is the beige concretion and does it have any relevance to anthropogenic activity at the site?

SAMPLING: Microgram sized samples were removed from the surfaces of all three objects for FTIR analysis and Raman analysis respectively using a size 11 steel scalpel blade. All samples for chemical analysis were transferred to glass containers to prevent contamination prior to analysis.

ANALYSIS PROTOCOL: Fourier transform infrared spectroscopy (FTIR) was used to identify the red wafer, the beige concretion, and the dark brown material. The red wafer was further studied by x-ray fluorescence and Raman spectroscopy. See Appendix I for experimental details of analyses.

RESULTS and DISCUSSION:

Dark Brown Sheet Analysis: The FTIR spectra for the dark brown sheet revealed two components, a cellulosic material and a gum (see Figures 1 and 2). This suggests that the material is plant-derived rather than an animal skin/leather which would be proteinaceous. The closest matches to reference spectra in our database were to plant roots such as madder root. The fibrous nature of the sample suggests either a root or a husk.

Red Wafer Analysis: XRF analysis of the wafer revealed that it is primarily inorganic and the major components are calcium, barium, iron, and zinc (see Figure 3). Strontium was the only minor component, a geochemical relative of calcium and barium. The only compounds identifiable by FTIR were clay and calcium carbonate (chalk, see Figures 4 and 5). While these are natural compounds, the high barium and zinc content of this wafer suggests that it is a man-made material and that it is likely some sort of pigmented material rather than, for example, a fragment of a brick. Barium and zinc are components of white pigments/fillers that were commonly employed in the nineteenth and early twentieth centuries. Zinc oxides, kaolin clay, iron oxides are common components of cosmetics, with zinc oxide being introduced in the nineteenth century. No binder such as an oil, wax, or gum could be identified through FTIR, and Raman only confirmed the presence of calcite in the wafer.

Beige Concretion Analysis: FTIR analysis of the beige concretion revealed that it is predominately composed of calcium carbonate/chalk/calcite although a small amount of hydrocarbon impurity is also present (see Figure 6). The micro-tubule nature of the concretion and its composition suggest that it is some form of marine life shell or exoskeleton. Typically these are composed of another form of calcium carbonate (aragonite), but pseudomorphic transformations between calcite and aragonite forms of calcium carbonate do occur. Calcite is typically of terrestrial origin while aragonite is the calcium carbonate that forms corals and shells, and so the possibility that this is an exoskeleton of a terrestrial organism cannot be ruled out.

CONCLUSIONS: The dark brown sheet-like material is plant-derived rather than animal-derived, possibly a root or husk based on comparison to FTIR spectra of plant components in the laboratory's database and the fibrous nature of the material. All of the elements and compounds identified in the red wafer are consistent with an early twentieth-century cosmetic. The absence of an organic binder is unusual, but this could be a result of degradation due to burial/environmental exposure. The beige concretion is composed of microtubules of calcite, a form of calcium carbonate typically associated with terrestrial organisms, but the concretion could have been formed from a marine organism exoskeleton and then undergone a pseudomorphic change to calcite.

APPENDIX I. EXPERIMENTAL:

FTIR analysis:

For FTIR (Fourier transform infrared) analysis, samples were transferred directly to a diamond compression cell half. The samples were rolled flat to transparency with a steel roller and then analyzed using the Thermo-Nicolet Magna 560 infrared bench with the Nic-Plan infrared microscope with MCT-A detector (range 4000-650 cm^{-1}, 120 scans, 4 cm^{-1} resolution). Resulting spectra were interpreted with the aid of commercial and art conservation infrared reference spectral libraries.

ED-XRF (Energy-dispersive x-ray fluorescence) analysis:

Non-destructive qualitative energy-dispersive x-ray fluorescence analysis (ArtTAX μ-XRF spectrometer, molybdenum or tungsten tube, 50 kV, 600 μamps, 100 sec, 20) was performed on each metal and glass artifact to determine its elemental composition.

Raman microspectroscopy analysis:

A Renishaw InVia Raman spectrometer was used to conduct dispersive Raman spectroscopy using a 50 mW 785 nm (red) laser , 1200 line/mm diffraction grating, and a spectral resolution of 3 cm^{-1}. Spectra were collected over a 100 cm^{-1} to 3200 cm^{-1} range for 20s collection times with a laser power of 1%.

Figure 1

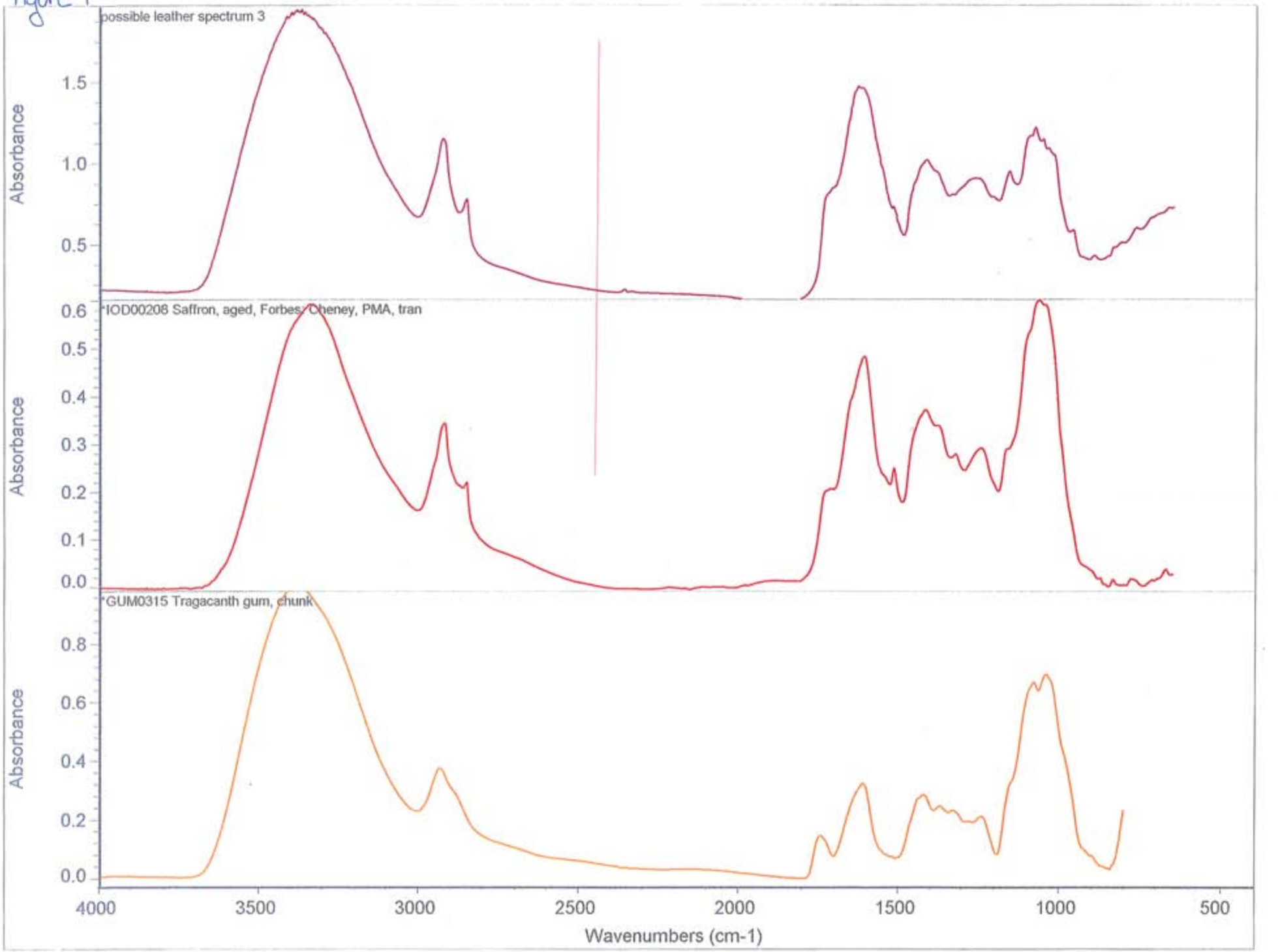

possible leather spectrum 3
IOD00208 Saffron, aged, Forbes, Cheney, PMA, tran
GUM0315 Tragacanth gum, chunk
Absorbance
Absorbance
Absorbance
1.5
1.0
0.5
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.8
0.6
0.4
0.2
0.0
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)

Figure 2

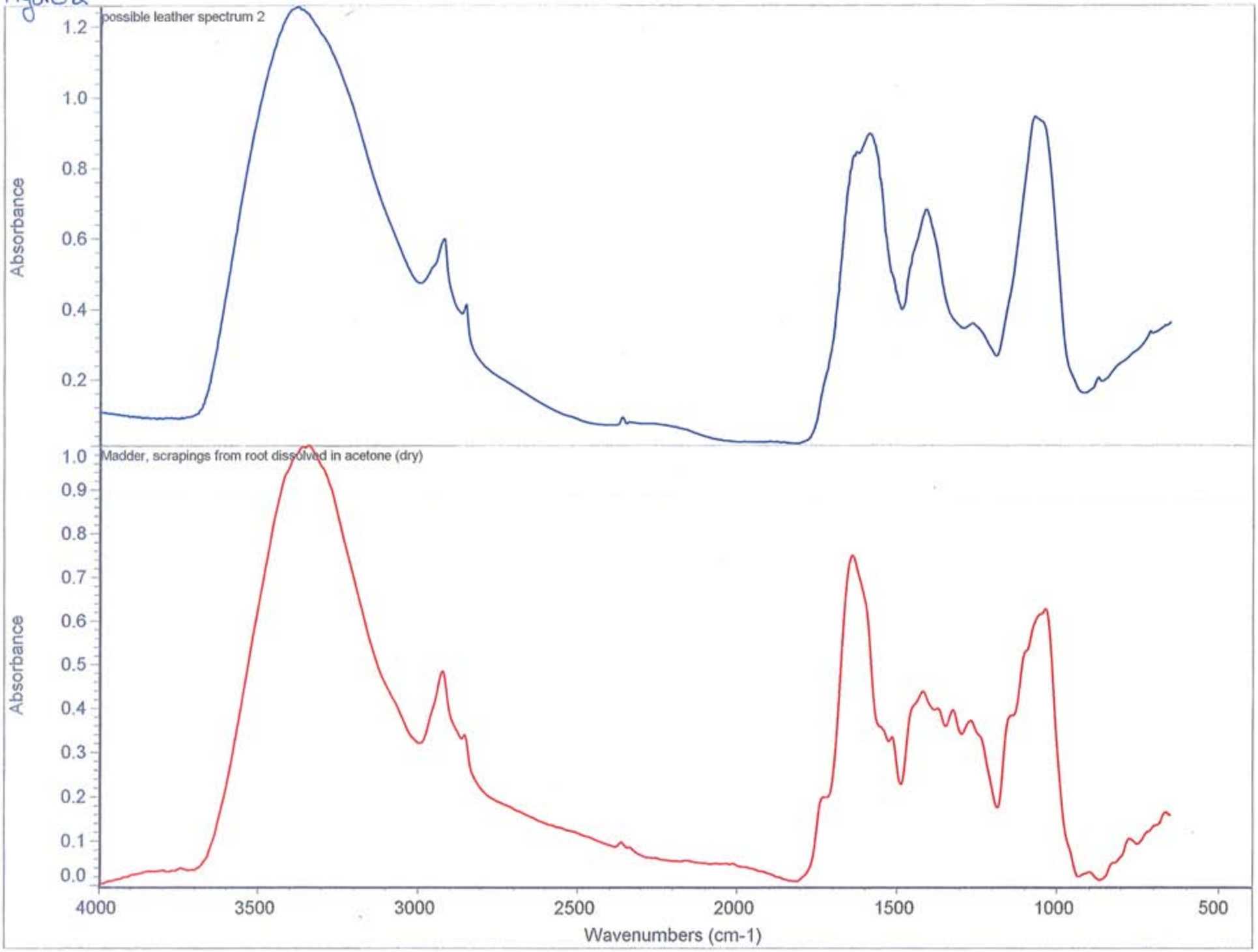

possible leather spectrum 2
Absorbance
1.2
1.0
0.8
0.6
0.4
0.2
Madder, scrapings from root dissolved in acetone (dry)
Absorbance
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)

Figure 3

0710-red-wafer-300s.spx

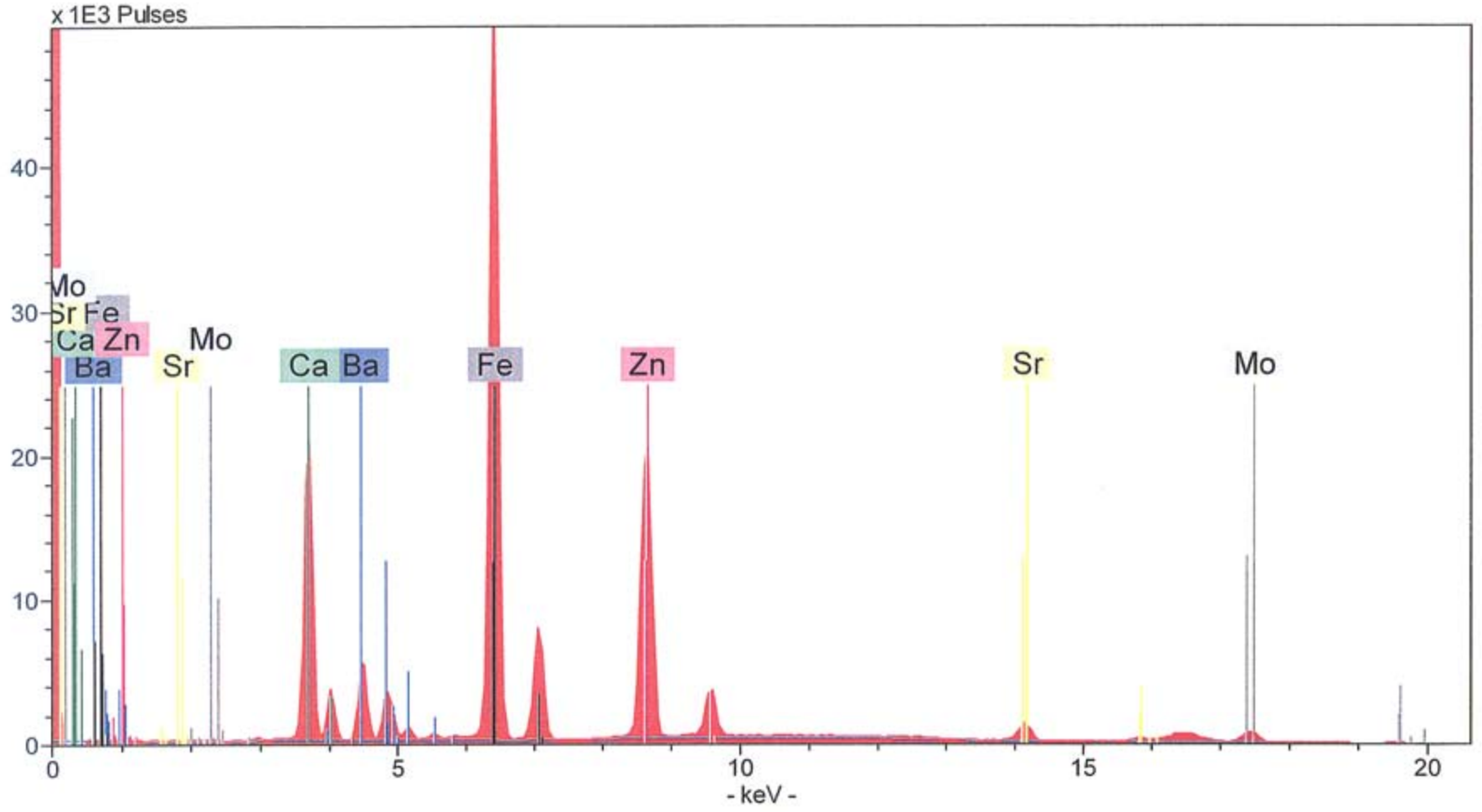


Figure 4

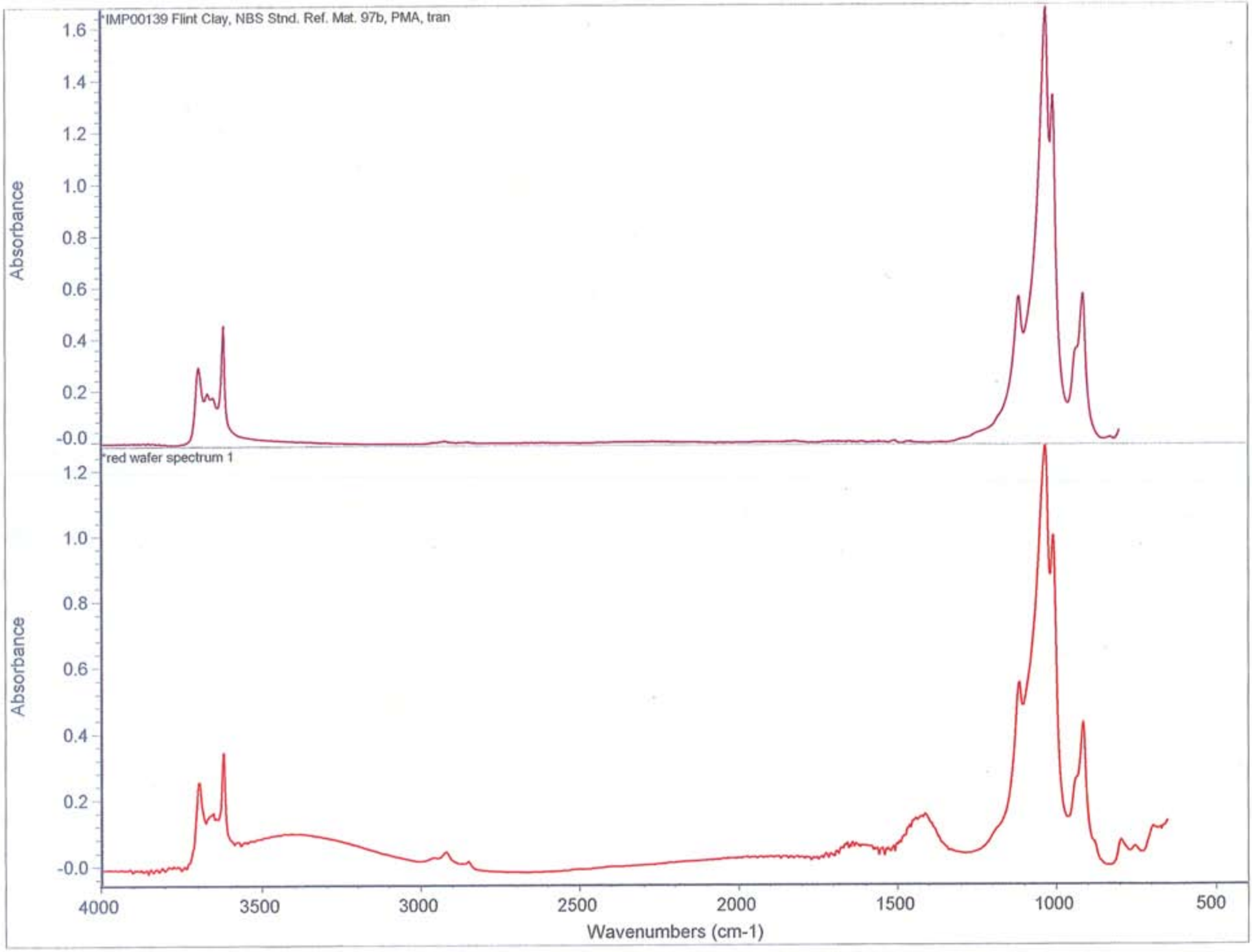

*IMP00139 Flint Clay, NBS Stnd. Ref. Mat. 97b, PMA, tran
*red wafer spectrum 1
Absorbance
Absorbance
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-0.0
1.2
1.0
0.8
0.6
0.4
0.2
-0.0
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)

Figure 4

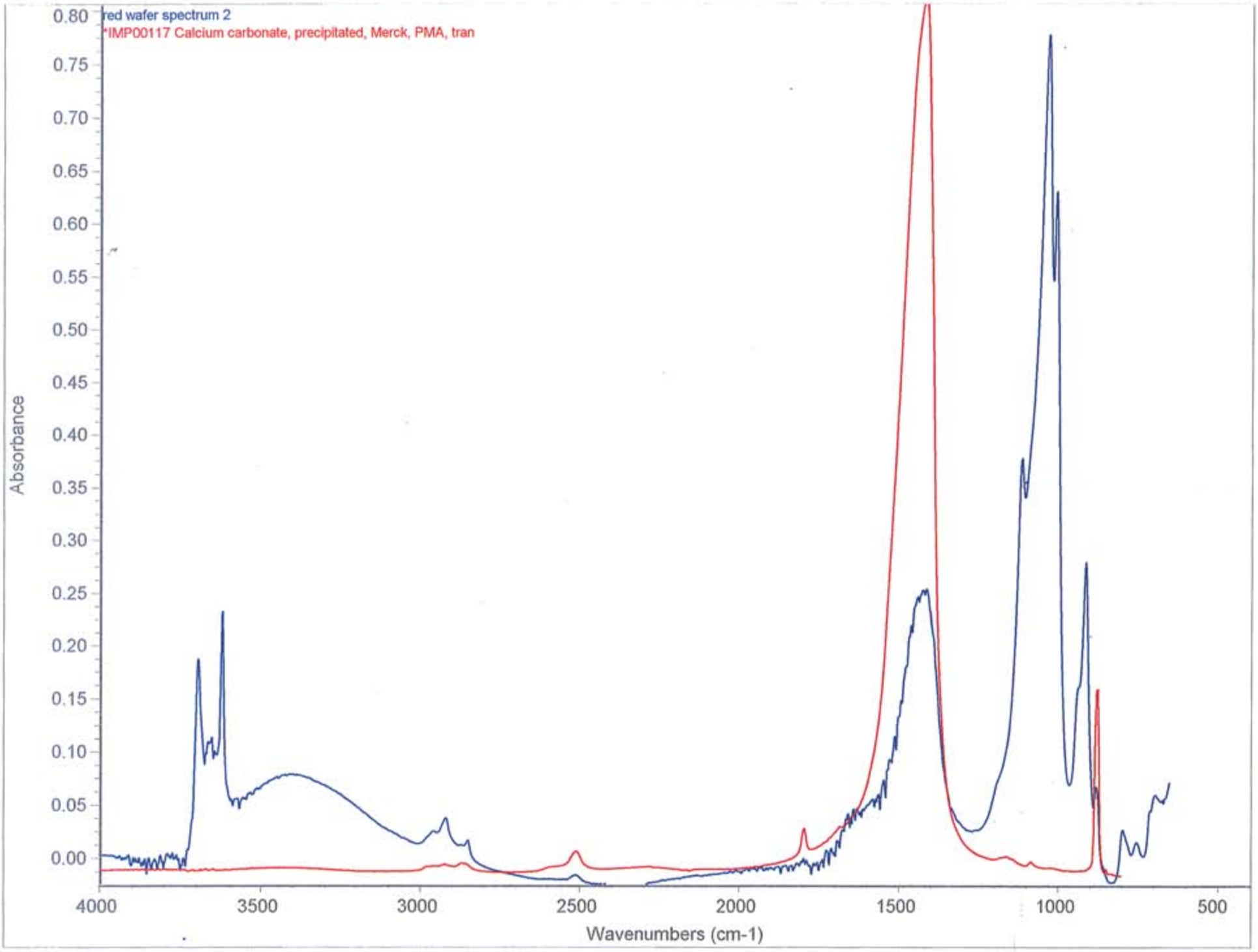
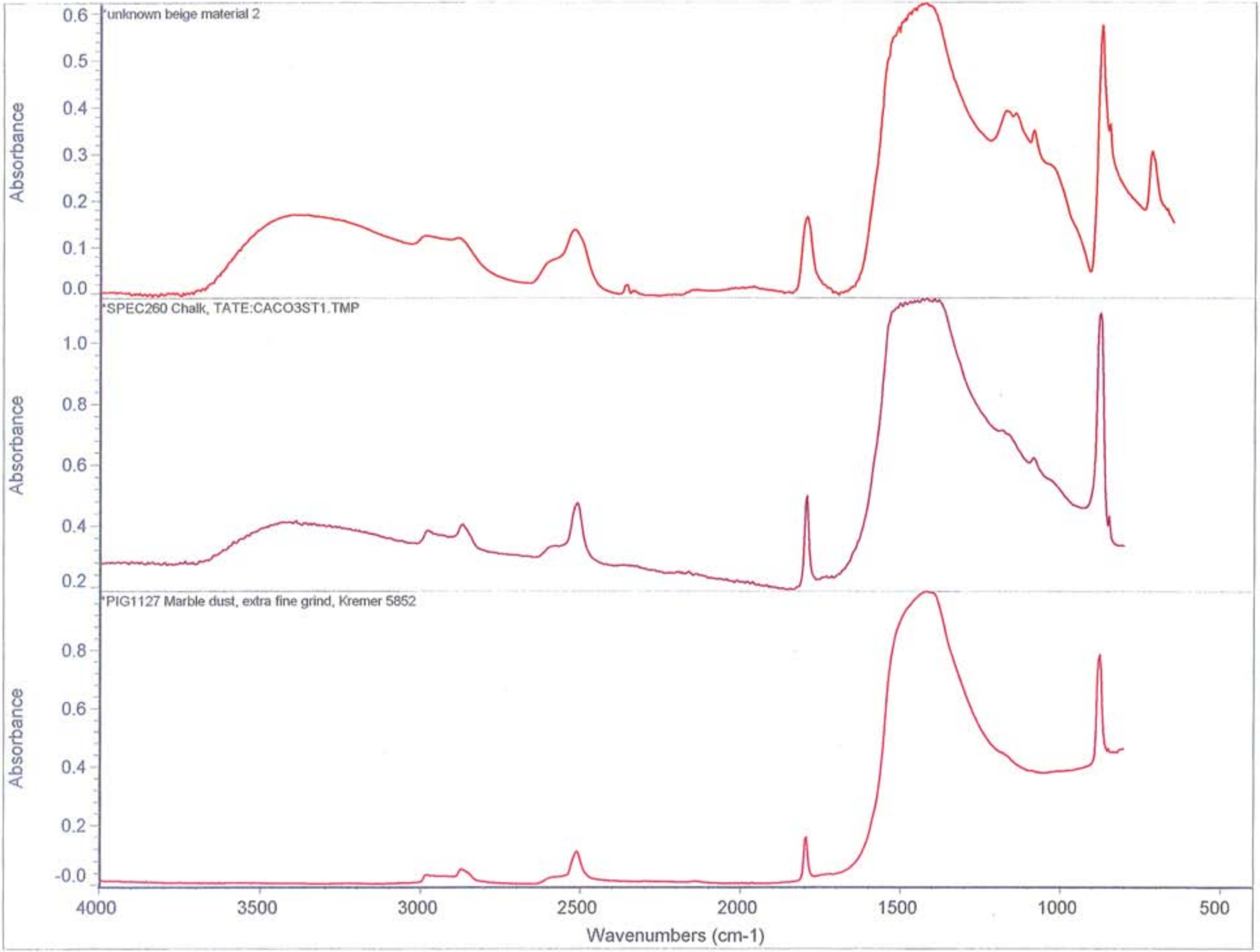

red wafer spectrum 2
*IMP00117 Calcium carbonate, precipitated, Merck, PMA, tran
Absorbance
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)

Figure 6


*unknown beige material 2
Absorbance
0.6
0.5
0.4
0.3
0.2
0.1
0.0
*SPEC260 Chalk, TATE:CACO3ST1.TMP
Absorbance
1.0
0.8
0.6
0.4
0.2
*PIG1127 Marble dust, extra fine grind, Kremer 5852
Absorbance
0.8
0.6
0.4
0.2
-0.0
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)