Observations on a concentrate sample from Moore Creek

I describe here my observations on a small concentrate sample from Moore Creek under the light and electron microscopes, and under the electron microprobe. This sample has been collected and prepared in 2006 by Michel Zavadsky.

It consists of a small quantity of powder concentrated from the dump materials collected at the locality. The preliminary concentration was made by panning in water, followed by the extraction of the most ferromagnetic materials, and finally by the hand-picking under the stereomicroscope of the gold particles. The remaining, composed of very small particles of black, brown and colourless particles, has been studied, with the aim of finding some non-gold particles.

It should be stressed that the results here presented are only indicative, since they are devoid of any statistical value, considering the small quantity available at the onset.

The most observed particle type are the light brown and colourless particles. They deserve certainly a more in-depth study, since a large proportion of the gold remaining at the Moore Creek locality is probably still present in that type.

Brown and colourless particles, unpolished (Plates 1 and 2)

The most remarkable feature of this particle-type is that it is at all present in the concentrate, which should not have contained such a large quantity of what was seemingly quartz grains partly coated by iron hydroxide. A preliminary examination of a powder mount of such particles, selected by eye under the stereomicroscope, was made under the scanning electron microscope (SEM) operated under the back-scattered mode (BS-mode), and the attached electron microprobe (EMP).

This SEM-examination combined with EMP-chemical analyses showed that if the grains were indeed composed of quartz or more rarely of felspars, they were quite always coated partly or entirely by a mixture of iron hydroxide and native gold.
It became also quickly obvious that the iron coatings gave frequently a strong signal of non-particulate gold, in addition to silicon and aluminum.

Plates 1 and 2 depict unpolished particles, as-found in the concetrate. What appears in dark grey is quartz, felspar or kaolonite. Iron hydroxide appears in lighter grey, but is frequently indiscernable in the conditions of contrast chosen for the pictures.

What appears as isolated spots and as grained areas is generally a mixture of native gold and cinnabar. The latter is a subordinate component in the dust deposited on the quartz grains, compared to gold. Other minerals occur also on the surfaces of the same: larger electrum (Ag,Au) particles (Plate 2, 13: white area to the north), acanthite Ag_2S (Plate 2, 29: white dots in circle), and rare gold amalgam (Au,Hg).

It should be noted that the gold particles and their concentrated areas are unevenly distributed on/in the grains, which indicates that they donnot come from free gold dust just deposited during sample processing. One observes nevertheless a higher frequency of particles with an outer crust of gold/iron, rather that isolated inclusions of the latter inside quartz grains.

Plate 2, Figs. 27 shows a quartz particle in which two iron-hydroxide areas devoid of particulate gold spots at the highest magnification a and b were analysed under the EMP-spot. These areas showed from 12 to 41 wt. % gold. Darkest iron areas on the same particle showed regularly 10 wt % gold.

Light brown and colourless particles, polished (Plates 3, 4, 5 and 6)

A series of light brown particles has been hand-picked under the stereomicroscope, mounted in araldite, and polished. Each particle has been examined and photographed under the reflected light microscope (a-particles) , and then examined and analysed under the SEM/EMP.

One observes several features which confirm those observed on the surfaces of the rough, unpolished particles.

The native gold is indeed present as small separated particles embedded in iron-hydroxide crusts (Pl. 3, 1484; Pl. 4, 1482). They occur also as cavity fillings, either associated with iron, or as unsupported fillings (Pl. 4, 1482b; 1486b). Particles 4,1478 and 5,1477 show two quartz grain with an iron-gold crusts and inclusions of electrum (in white, well polished). These inclusions are good evidence that electrum is a preserved primary mineral.

Plate 5,1475 shows a quartz grain with a nearly complete iron crust devoid of particulate gold, at first sight. However, a close examination under the SEM(BS) shows a concentration of lighter inclusions, mostly fading out as a diffuse cloud in the iron (square enlarged in 1475c). The lighter areas are gold with minor iron, whereas the light grey diffuse areas are composed of iron with lower gold.

One observes sometimes fillings of negative crystals (Pl. 6, 1480b-c). The latter series of pictures, and especially Pl.6, 1480d, shows also an intermediate state of occurrence of native gold, between the larger-than-micrometer particles, and the sub-micrometric ones, only detectable by chemical analysis: in this homogenous iron hydroxide area, the measurable gold particles are of 0.5 µm at most, and there are certainly smaller ones.

Other noteworthy minerals found in the concentrate (Plate 7)

A few other mineral species have been found:

-Platinum (Plate 7, 1a-SEM and 1b-SEM(BS): one grain composed of ferroplatinum (1b,b) and osmiridium (1,b,a).
-A few grains of native bismuth (Plate 7, 2): Composed of Bi and Te (about 1,5 wt.%). No Sulfur present.
-A few grains of wolframite FeWO4 (Plate7, 3). No Manganese present.
-Abundant ilmenite (Plate 7, 4a and 4b): Frequently as hexagonal platelets. Contains sometimes native gold in cracks (4b.)
-cinnabar (not depicted): in millimetric and sub-millimetric grains, abundant. No association of cinnabar with native gold has been observed at the macroscopic level.
-chromite (not depicted): in sub-millimetric octahedral crystals.

Complex alloy particle (Plate 8)

When observing the sample, a unique particle seemingly composed of gold was noted, since its habit was quite unusual. Indeed, instead of presenting a convex or platy shape, it was spiny, squamous, and presented several concavities. When picked up among the other grains, a loosely attached small piece fell off from the main body, and both were mounted close together (Pl. 8,1a and 8,2). A qualitative analysis showed a complex and variable composition of Au, Ag, Sn, Pb.

It has been possible to embed the grain and to polish it, in order to see "inside" (Pl.8, d, e, f.) Very complex textures are revealed under the reflected light and the scanning microscopes, corresponding to the following compositions: (Ag=Au), (Au>Ag), (Au>Ag>Sn), (Au>Sn>Pb), (Au>Pb>Sn).

The Fig. 8,f shows clearly that one has to do with an alloy or mixture of alloys. The natural origin of this particle is ascertained by its loose and spiny shape. Inclusions of monazite (Rare Earth Element phosphate) and galena have been found deep inside the gold alloys.

It is also noteworthy to notice that a similar alloy has been found in 1965 in Yukon by D.A. Mustart, but I have not yet been able to access the original paper.

D.A. Mustart: A spectrographic and mineralographic investigation of alluvial gold from the Central Yukon. B.Sc. Thesis, Univ. B.C., 46 pp.

(Quotation from R. Boyle: "...an AuSnPb compound of unspecified name [has been observed] in the gold placers of Bonanza Creek, Klondike distr., Yukon").

Similar alloys have also been observed in Siberia.

CONCLUSIONS

This study draws the attention on the abundance of coated quartz grains, separable by panning. The coating is mainly composed of iron hydroxide, which hosts itself large quantities of gold. The latter is present either as discrete particles, resolvable by the SEM, and as invisible (sub-microscopic) gold, which presence is only revealed by the EMP.

A few other Precious Metal species are also present: electrum, ferroplatinum and osmiridium. Au-Sn-Pb alloys, as well as native bismuth could present some interest as provenance tracers.

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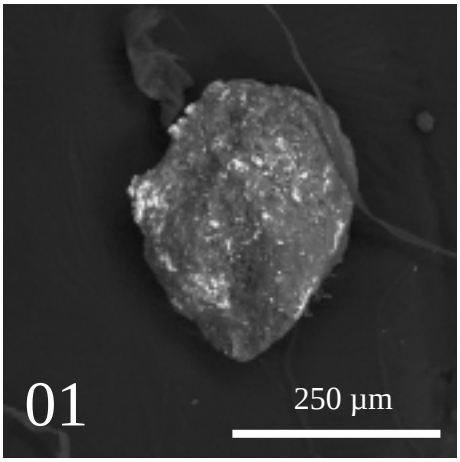
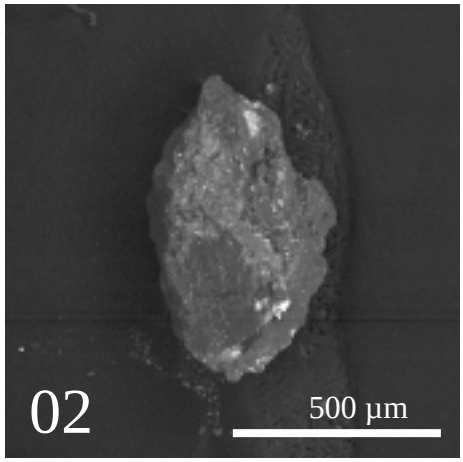
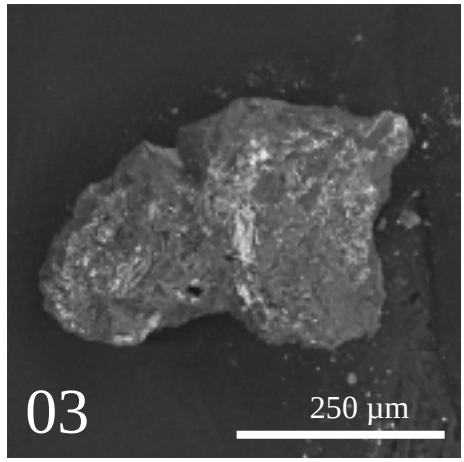
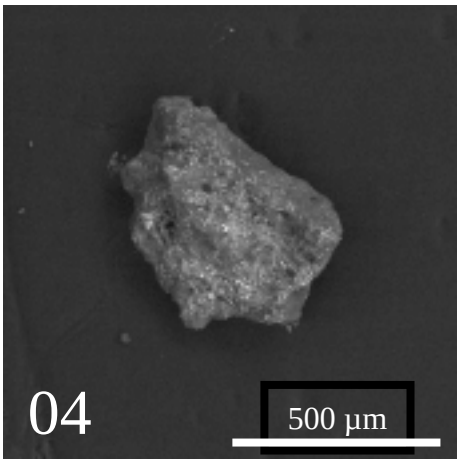
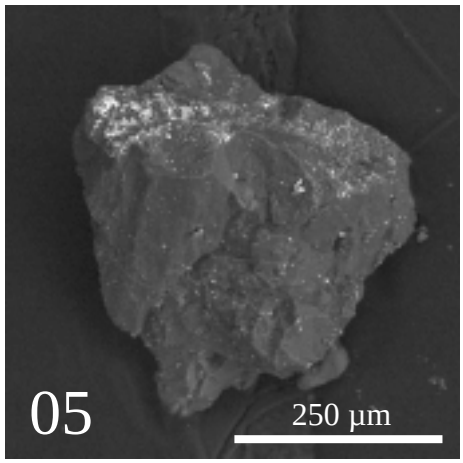
Plate 1-Grains 01 to 09

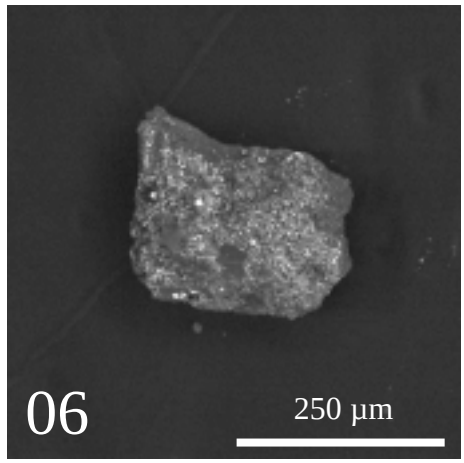


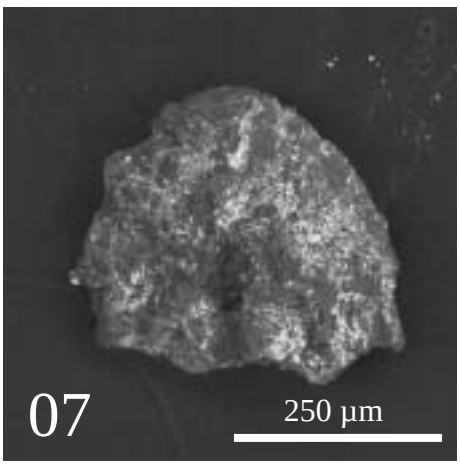


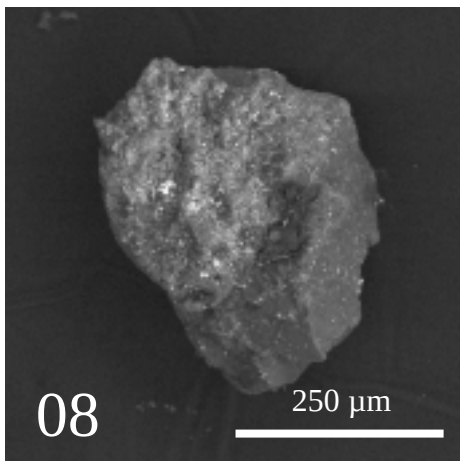












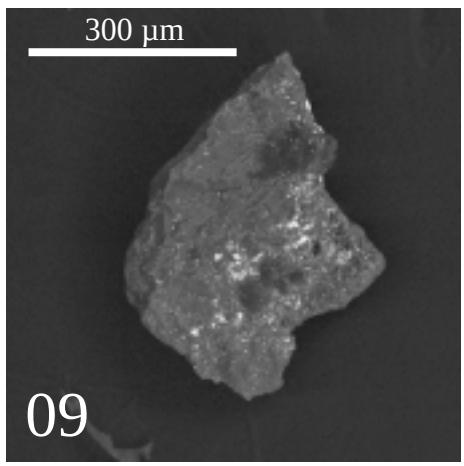
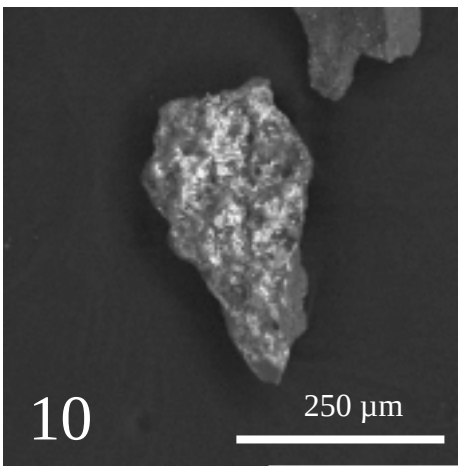
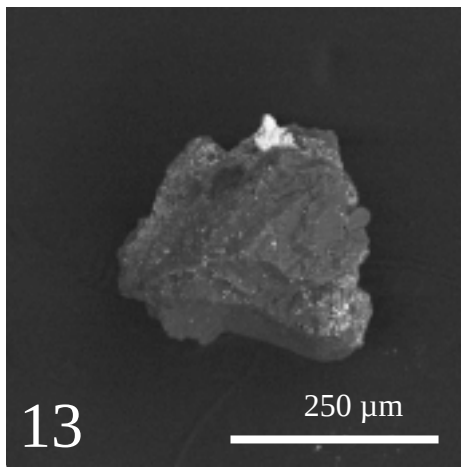
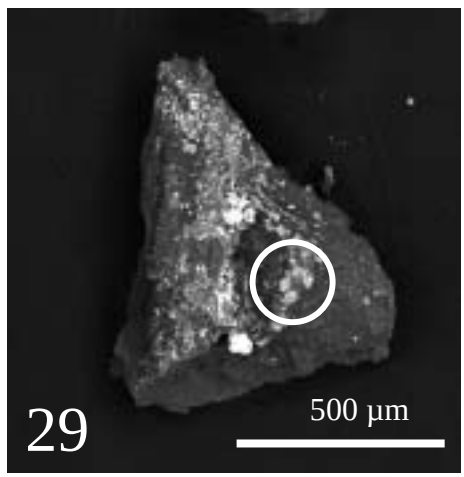
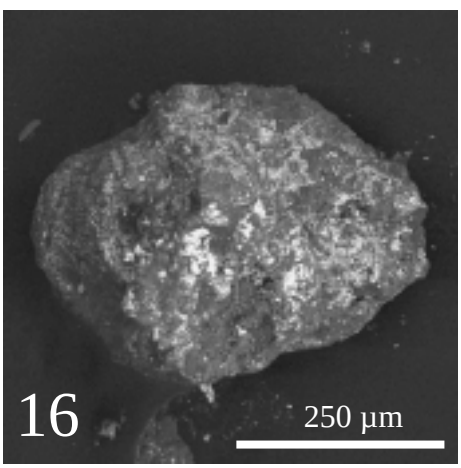


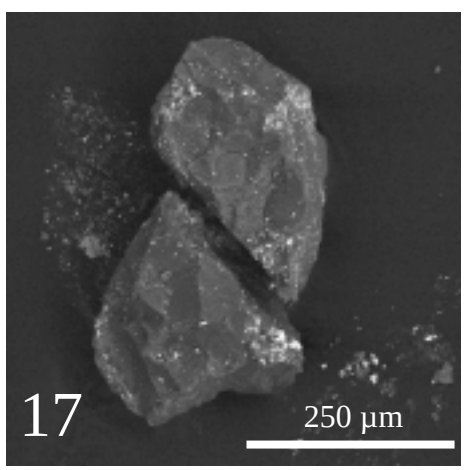
Plate 2-Grains 10 to 29

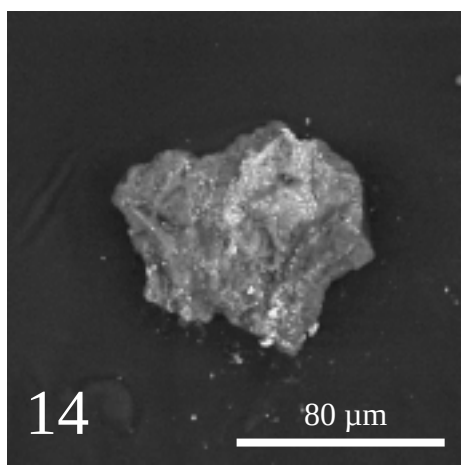


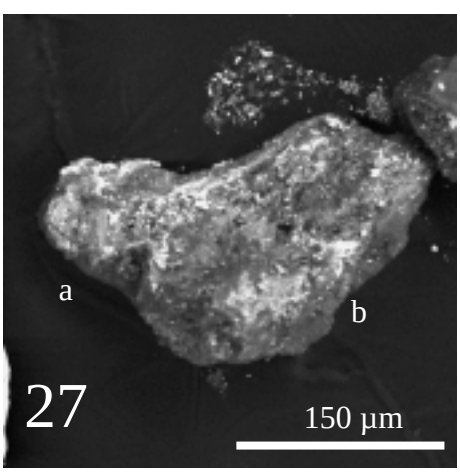


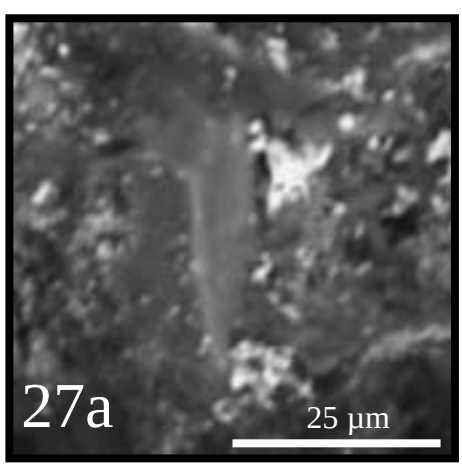












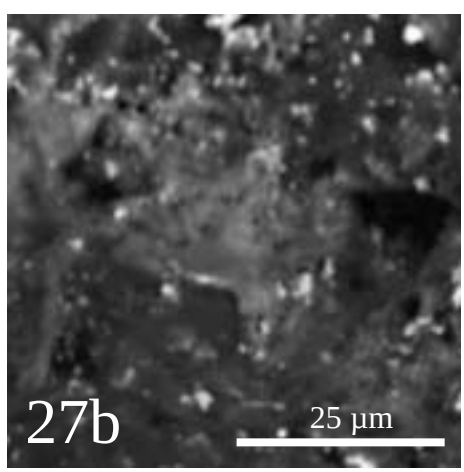


Plate 3-Grains 1481 and 1484

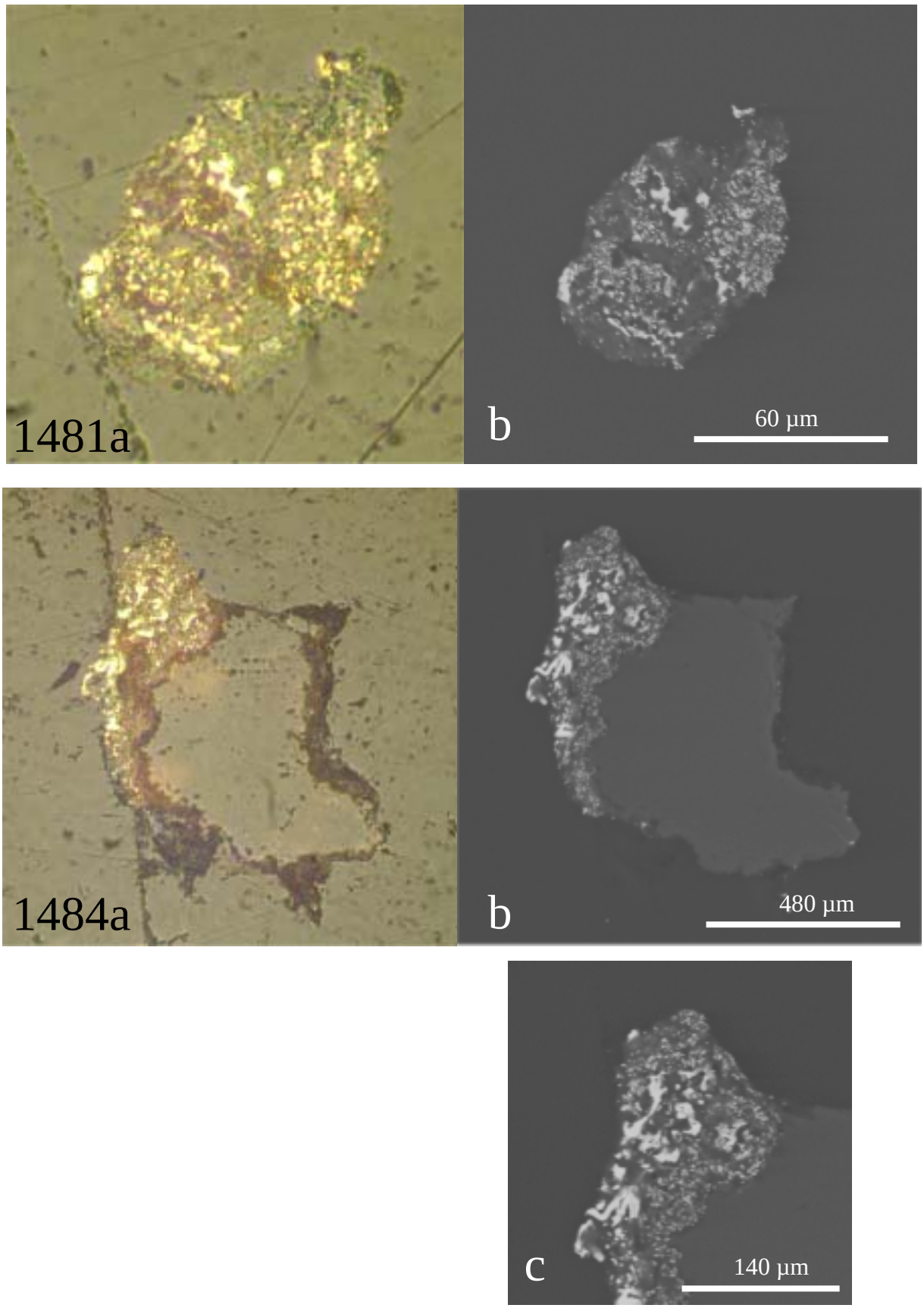
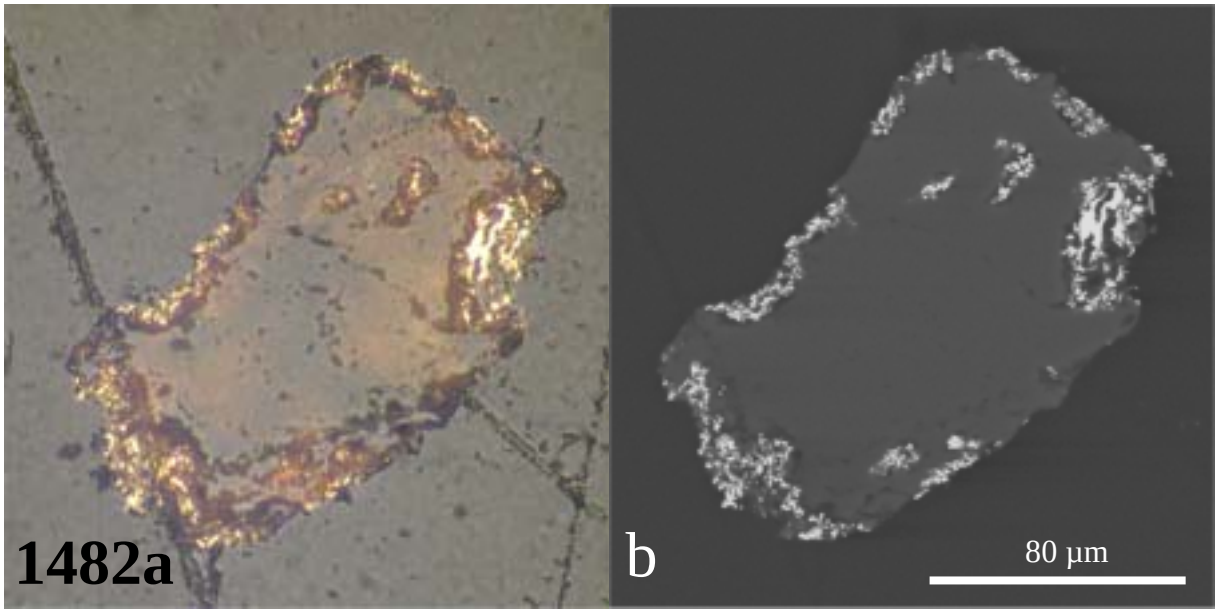
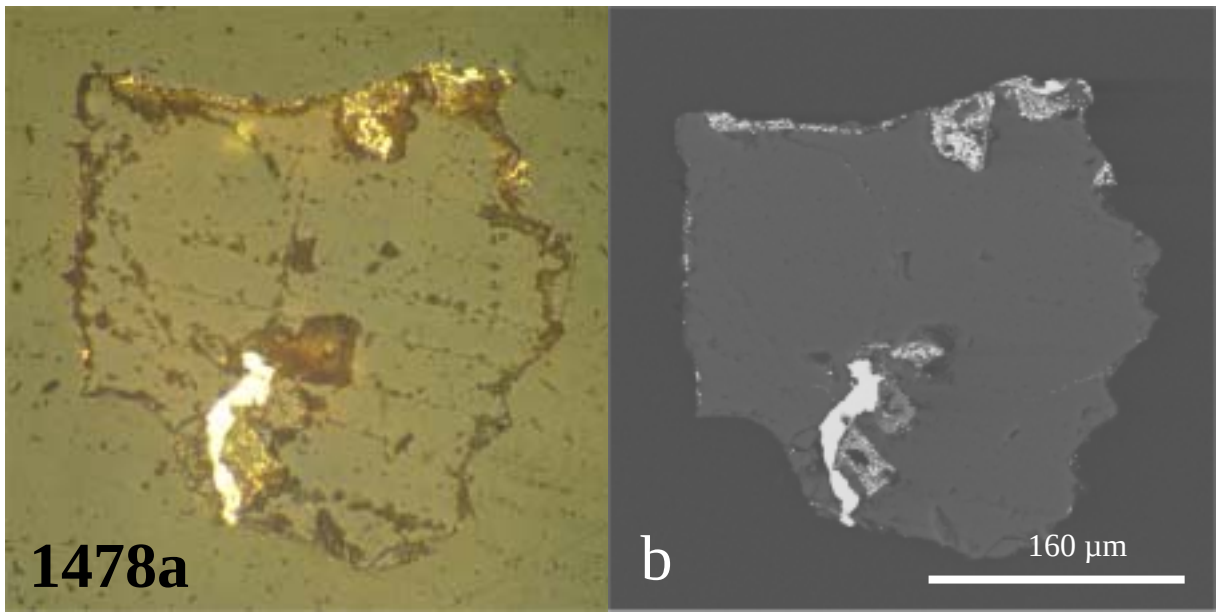


Plate 4-Grains 1478-1482-1486





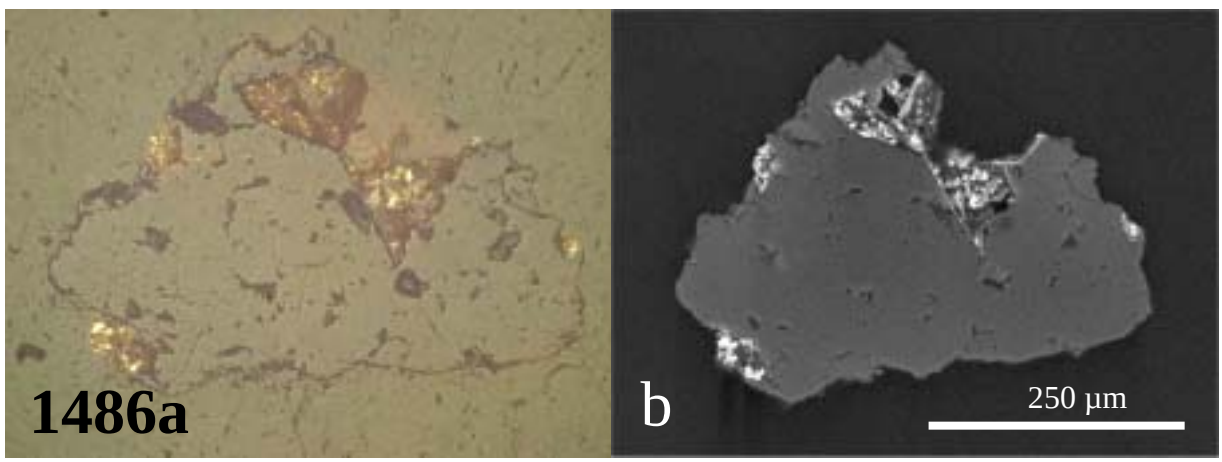
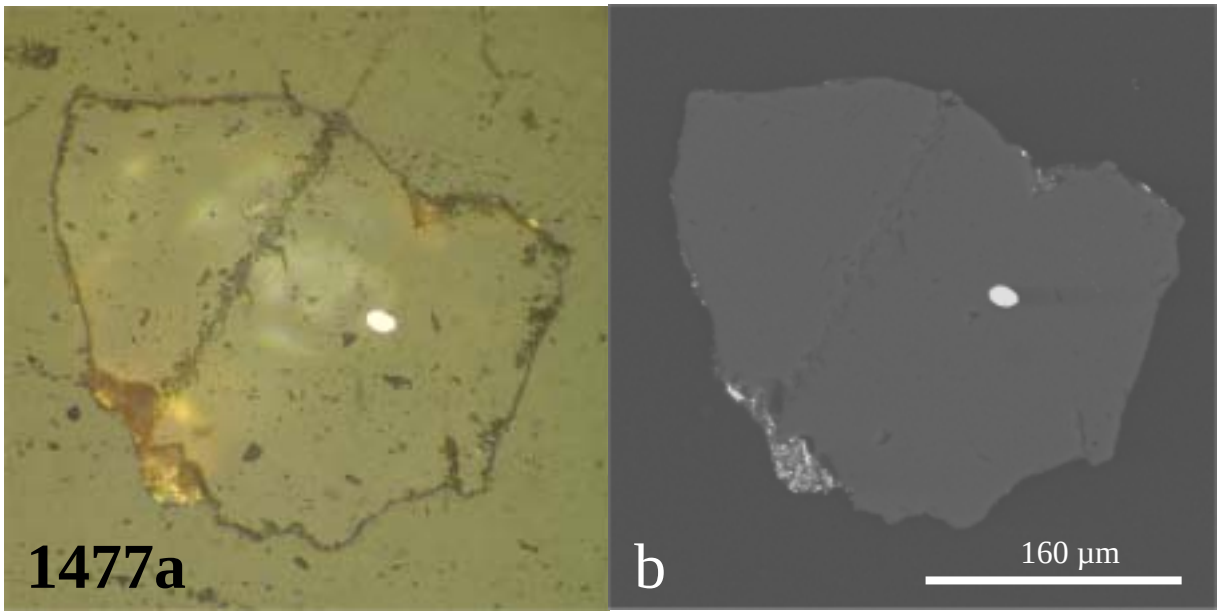
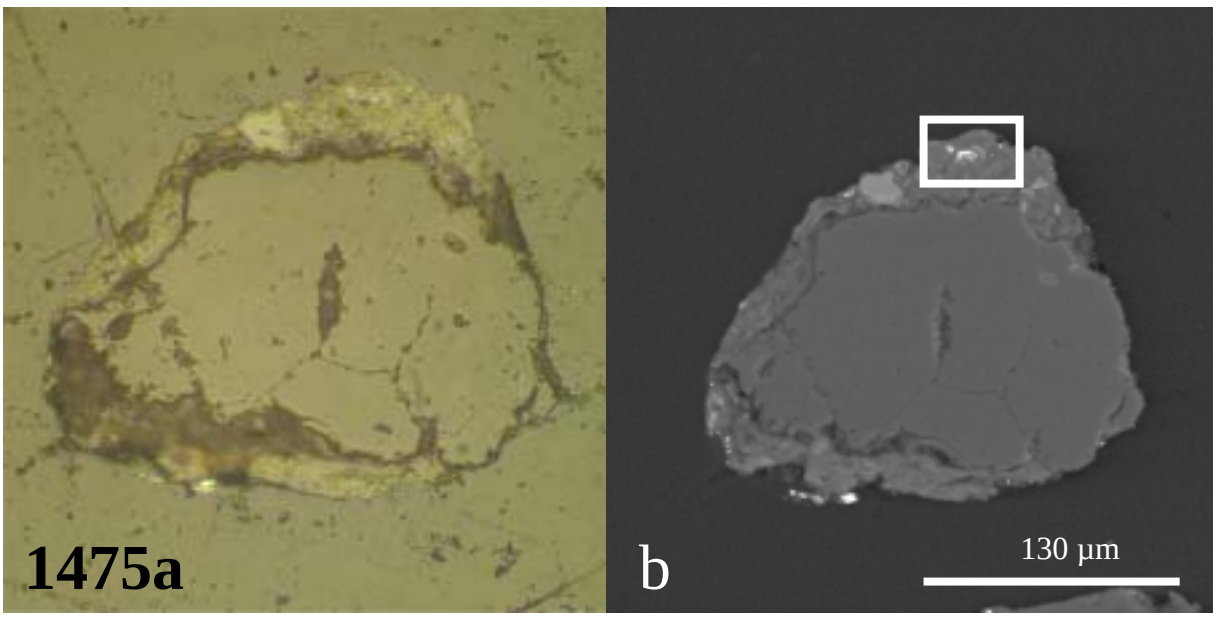


Plate 5-Grains 1475 and 1477





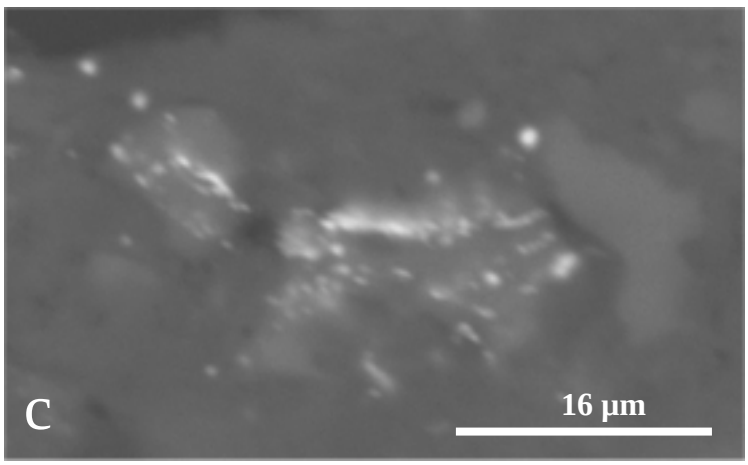
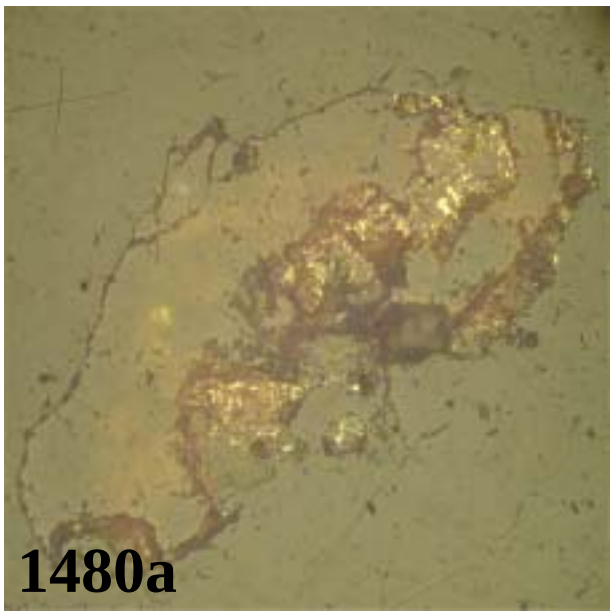
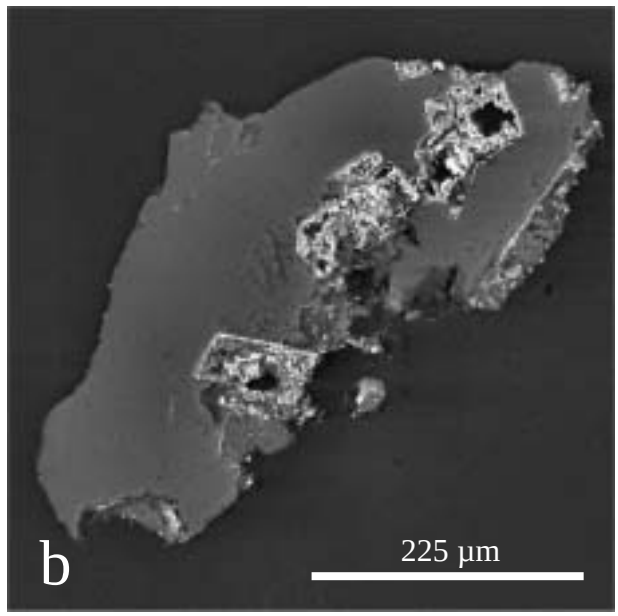
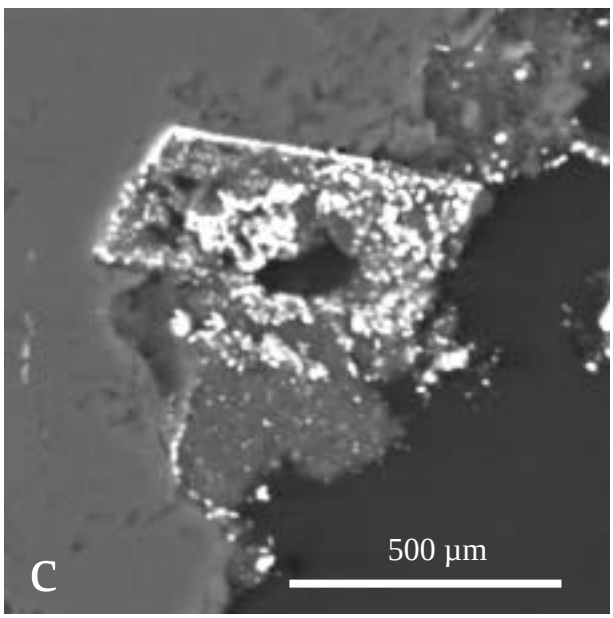


Plate 6-Grain 1480







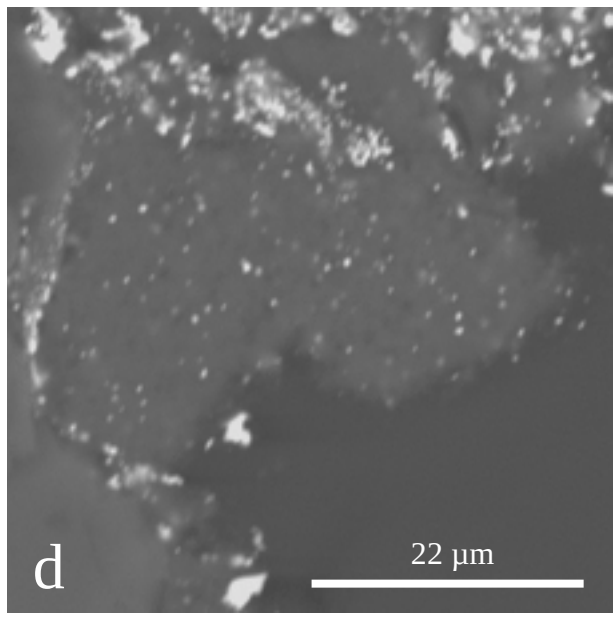
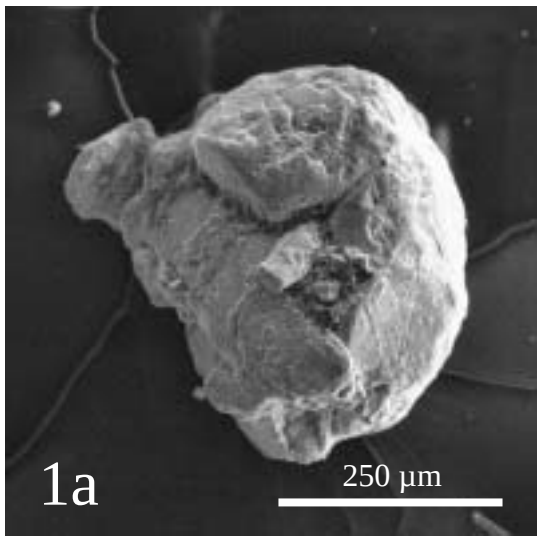
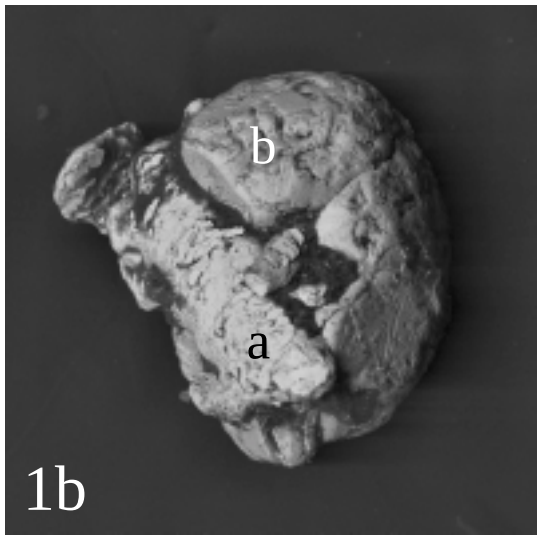
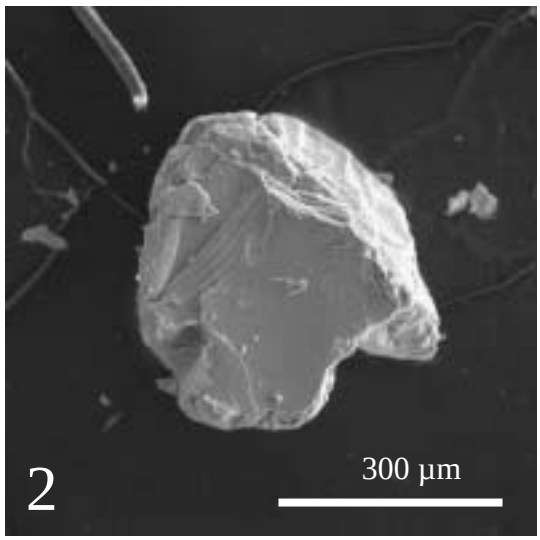
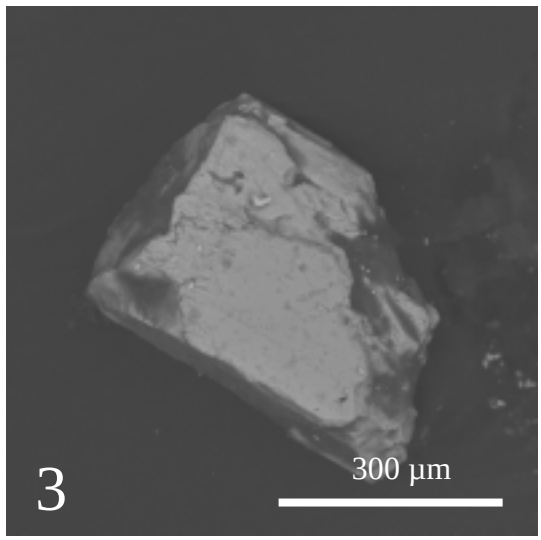


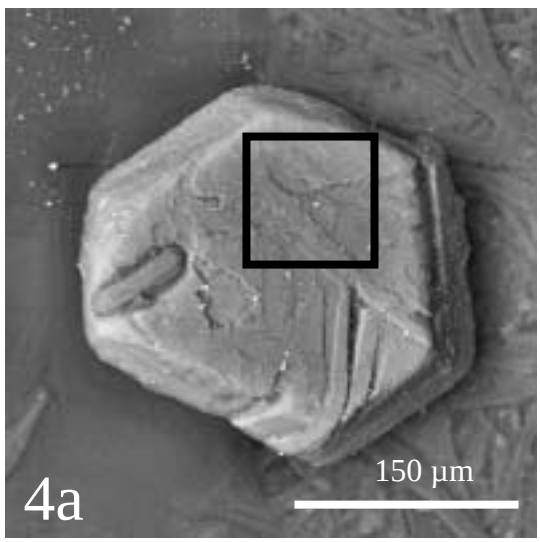
PLATE 7











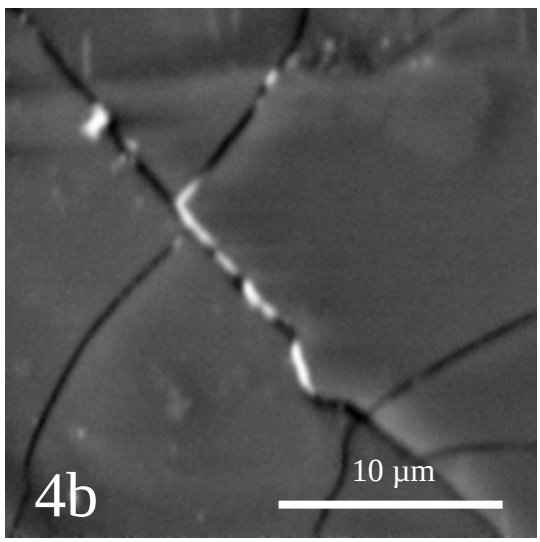


PLATE 8