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Investigation of opaque mineralogy, Lega Dembi gold deposit, Ethiopia

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The mineralogical distribution of gold in quartz-sulphide ores has been addressed by detailed reflected light microscopy, scanning electron microscopy and EDS semi-quantitative microanalysis to investigate why gold recoveries are lower than expected. The majority of gold in these samples is present as gold-rich electrum disseminated within quartz. Typical grain size is 10-75 µm, only rarely exceeding 100 µm or more. Gold is also observed locked with sulphides – approximately equally split between chalcopyrite and galena. Grain size is comparable with gold in quartz and should be recovered. However, gold, electrum and tellurides (hessite, stützite and petzite) are also observed as < 10 µm size inclusions in coarse pyrite, closely associated with a suite of Pb-As sulphosalts, not previously reported from the Lega Dembi Mine. This gold may not be recovered using present practices. It is also noted that arsenopyrite is a common accessory/minor mineral of the ores and it may reasonably be suspected that this mineral is host to invisible gold. Gold not recovered (either as small inclusions in the pyrite, intergrown with Pb-As-sulphosalts, as Au-Ag-tellurides and as invisible gold) probably does not account for more than 5-10% of the total, yet is nevertheless significant. The presence of bornite, suspected during the field visit, has not been confirmed in microscopic studies. Chalcopyrite-pyrrhotite-pentlandite Ni-Cu ores from the hanging wall contact also carry a characteristic trace mineral assemblage. Electrum is rare, but where observed, is closely associated with a suite of Se- and Te-bearing minerals, of which hessite, laitakarite and pilsenite are most abundant. Several Ag-minerals are present and Ag-concentrations may be significantly greater than previously appreciated. Argentopentlandite and hessite are the most abundant Ag-bearing phases. Although not identical, the trace mineral signature resembles that in the main part of the deposit. The presence of a persistent Ag-Te-Se-(Bi) trace mineral assemblage may provide information on the character and origin of fluids responsible for mineralisation.

Emneord: Ethiopia	Lega Dembi	Shear zone
Ore Mineralogy	Gold	Silver
Electrum	Telluride minerals	

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1. INTRODUCTION

Following a field visit to the Lega Dembi gold mine by the authors of this report in November-December 1999 and discussions with relevant personnel at the mine (Peter Pitts, senior geologist and others), it was decided to undertake a mineralogical investigation of gold ores being exploited in the mine at that time.

Several studies had been carried out in the early stages of mining at Lega Dembi, before the involvement of Midroc Gold. This previous work is reviewed in more detail below. These studies were able to distinguish several types of gold-bearing assemblages. Gold was recognised as being associated with a complex suite of minerals, including Pb-Sb sulphosalt minerals, Ni-bearing minerals, antimonides and especially with tellurides and galena (see below). However, these studies were based on the ore being worked at that time (mid-1980's) and it was unclear whether they are representative of the entire orebody. Persistently good gold recoveries in the intervening years led to no further work being carried out.

In late 1999, however, an increasing content of sulphide minerals was noted in ore. This was certainly the case in ores seen by the report authors. These ores, while generally of higher than average grade, present certain processing problems and generally reduced gold recoveries. The field visit identified the presence of pyrrhotite in the ore and the presence of bornite was also suspected. It was considered that this was evidence that the ore was changing in composition and mineralogical distribution of gold as the mine was extended. The apparent differences in ore mineralogy between these ores and those previously worked underlined the necessity of an updated investigation of mineral assemblages and the liberation properties of gold in run-of-mill ore, including sulphide rich ore types. Such an investigation was considered reasonable in the context of better characterising shear zone-hosted gold mineralisation in the Lega Dembi area (Ghebreab *et al.*, 1992; Billay *et al.*, 1997; Tolessa and Pohl, 1999). Additionally, the work set out to assist future interpretation of deposit genesis in the context of the regional geodynamic environment of the Adola Greenstone Belt (Kazmin *et al.*, 1978; Bogliotti, 1989; Ghebreab, 1992; Worku and Yifa, 1992; Gichile and Fyson, 1993; Worku, 1993a; b; Worku and Schandelmeier, 1996).

1.1 Goals of the investigation

The investigation has the following goals:

- To provide an updated account of the major, minor and trace mineralogy of gold ores.
- To establish with which minerals gold is associated in the different ore types and the locking characteristics of gold grains within these minerals.
- Characterise the gold-bearing assemblages in sulphide-rich ore in detail, to assess the potential role of tellurides as gold carriers (if any), and establish if pyrrhotite and/or bornite are hosts for gold minerals.
- Provide data on grain size of gold grains in the samples and establish differences in size, locking habit and association of gold in different ore types.

1.2 Summary of previous work

Two comprehensive studies had been carried out in the mid-1980's. The first, a detailed study of 100 samples (Nikulin *et al.*, 1986) stressed that 74-82 % of gold is free gold, the remainder is intergrown with sulphides. Apart from native gold/electrum, two other gold minerals, aurostibite, $AuSb_2$ and petzite, Ag_3AuTe_2, were noted in minor amounts. Neither was considered to contribute significantly to the total mineralogical balance for gold. A second study (Fiori *et al.*, 1987, 1988) reported a comparable Au-Ag-Cu-Zn-Pb-Sb-Ni-Te paragenesis in the Lega Dembi ores. The strong association between gold and galena was confirmed in run-of-mill samples. The gold telluride petzite (and other tellurides hessite and altaite) is reported as more abundant in ores from lens 2 than lens 1.

A later study (Billay et al., 1997) gave considerable attention to the mineralogy of the gold ores, but just how representative this sample set was is unclear. These authors recognised 4 distinct types of veins. Sulphide-bearing mineralisation within type-1 veins was found to consist of chalcopyrite, galena, pyrrhotite, pyrite, sphalerite, gersdorffite, arsenopyrite, bournonite, molybdenite, tellurides, Ag-tetrahedrite and gold. Gold was again identified as closely associated with galena, commonly with chalcopyrite, pyrrhotite and the tellurides, hessite and stützite. However, within the biotite-actinolite alteration bordering type-1 veins, a pyrrhotite-gersdorffite (± pyrite, chlalcopyrite, arsenopyrite, pentlandite, niccolite) assemblage is dominant. Assemblages in type-2 and –3 veins are less complex, characterised by a pyrite-pyrrhotite-chalcopyrite assemblage with minor galena and rare microscopic gold. Type-4 veins were found not to carry gold or sulphides.

Table 1 Opaque mineralogy at Lega Dembi as recorded in previous studies.

Major sulphides	Other sulphides	Gold minerals	Other tellurides
Hex. pyrrhotite ($Fe_{1-x}S$)	Arsenopyrite (FeAsS)	Native Gold (Au)	Hessite ($AgTe_2$)
Mon pyrrhotite ($Fe_{1-x}S$)	Gersdorffite (NiAsS)	Electrum (Au,Ag)	Altaite (PbTe)
Pyrite (FeS_2)	Sphalerite (ZnS)	Aurostibite ($AuSb_2$)	Stützite ($Ag_{5-x}Te_3$)
Galena (PbS)	Ullmannite (NiSbS)	Petzite (Ag_3AuTe_2)	
Chalcopyrite ($CuFeS_2$)	Pentlandite ($(Fe,Ni)_9S_8$)		
	Violarite ($FeNi_2S_4$)	**Sulphosalts**	**Antimonides**
	Cubanite ($CuFe_2S_3$)	Bournonite ($CuPbSbS_3$)	Breithauptite (NiSb)
	Argentopentlandite ($Ag(Fe,Ni)_8S_8$)	Boulangerite ($Pb_5Sb_4S_{11}$)	Nisbite ($NiSb_2$)
			Dyscrasite (Ag_3Sb)
	Mackinawite ($(Fe,Ni)_9S_8$)	Meneghinite ($CuPb_{13}Sb_7S_{24}$)	Native Antimony (Sb)
	Molybdenite (MoS_2)		Nickeline (NiAs)
	Troilite (FeS)	Ag-tetrahedrite ($(Ag,Cu)_{10}(Fe,Zn)_2Sb_4S_{13}$)	
	Marcasite (FeS_2)		

Most recently, Polessea and Pohl (1999) carried out a geochemical study, noting element correlations and associations, and using geostatistical analysis (correlation coefficients and factor analysis). They propose that a polyphase genesis for the deposit best fits their observations. An early phase of mineralisation is represented by chalcopyrite, pyrite, pyrrhotite and sphalerite, while a later phase includes gold and galena. In their conclusions, Tolessa and Pohl state that "the Au-Cu-Ni-Pb and Au-Cd-Co-Cu-Ni-Pb-Zn associations they observed in Lega Dembi ores are due to the overlap of Pb-Ag-Au mineralisation with pre-existing Fe-Cu-Zn mineralisation in mafic-ultramafic rocks". They do not, however, rule out the possibility of "remobilisation and reconcentration of pre-existing Fe-Cu-Zn mineralisation during deformation". Ore minerals previously reported from Lega Dembi are listed in Table 1.

2. SAMPLE LOCATION AND INVESTIGATIVE METHODS

A suite of 40 samples was collected at the Lega Dembi Mine in November/December 1999. The samples are derived from 7 locations in the mine, representative of the different ore types and the different ore lenses, including:

- Lens 1 (North & Upper; several locations)
- Lens 2 (Upper)
- Lenses 3 and 5 (central)
- Pyrrhotite-rich 'ores' at hanging wall contact (Upper).
- Sulphide rich ores, loc. N2040 G-28 (Upper).

It was decided, in the laboratory investigation, to concentrate on the quartz-sulphide rich ores (type-1 vein types; Billay *et al.*, 1997) and ores from the hanging wall. Other sections underwent only cursory investigation.

- Quartz-sulphide rich ores from waste dump: 11 samples (LD-1J, -2J, -3J, -4J, -5J, -6J, -11J, -11J2, -12J, -14J, -14J2). 3 samples of similar material (LD-1F, -2F, -2F2) were collected *in situ* (loc. N2040 G-28). 3 further samples (LD-1E, -1G, -1G2) are from similar material collected earlier by P. Pitts.
- Hanging-wall ores: 7 samples (LD-2H, -3H, -5H, -6H, -10H, -13H, -14H).
- Other samples are: Lens 1(Upper pit): 1 sample (LD-4B); Lens 2 (North pit): 1 sample (LD-I1) and low-grade ore (lens 5, central pit): 1 sample (LD-1D).

A one-inch polished section was prepared from each of the above 27 samples. Each was investigated using a reflected light microscope at 10x, 40x and 100x magnifications. Data on mineral association, grain size and locking characteristics have been gathered and photomicrographs made. The chemical composition of selected mineral phases has been investigated using scanning electron microscopy and semi-quantitative energy-dispersive microanalysis at the IKU/SINTEF facility, Trondheim.

3. SULPHIDE-RICH ORES

Summary: The majority of gold in these samples is present as gold-rich electrum disseminated within quartz. Typical grain size is 10-75 μm, only rarely exceeding 100 μm or more. Gold is also observed locked with sulphides – approximately equally split between chalcopyrite and galena. Grain size is comparable with gold in quartz and should be recovered. Gold, electrum and tellurides (hessite, stützite and petzite) are observed as <10 μm inclusions in pyrite, closely associated with Pb-As sulphosalts. This gold may not be recovered. Arsenopyrite is a common accessory/minor mineral of the ores and it may reasonably be suspected that this mineral is host to invisible gold. Gold not recovered (either as small inclusions, intergrown with Pb-As-sulphosalts, as Au-Ag-tellurides and as invisible gold probably does not account for > 5-10% of the total, yet is nevertheless significant. The presence of bornite has not been confirmed.

The galena-chalcopyrite-pyrite-rich sulphide ores contain gold minerals in several distinct habits and associations – markedly different from the other ore types.

Firstly and most importantly, gold occurs as electrum (averaging $Au_{85}Ag_{15}$) disseminated within quartz (Fig. 1). Free gold within quartz accounts for about 60% of total visible gold in the studied samples. Most electrum grains are rounded and typical grain diameters are in the range 10-75 μm (Fig. 6a). A single grain, 315 μm in diameter, was however observed (Fig.1 lower right).

Gold is also observed locked and at the grain margins of both galena and chalcopyrite (Figs. 2-4). Observed grains are roughly equally split between the two minerals (about 15% of total gold located within, or combined with each mineral). Grain size is directly comparable with free gold within quartz (typically in the 10-100 μm size range; Fig. 6b). Grain shapes are, however, rather more varied and range from rounded to elongate. Good recovery of such gold should be achievable, since only a very small proportion of them are smaller than 10 μm in diameter. Monoclinic pyrrhotite is an abundant accessory in assemblages dominated by galena. Other accessory minerals include arsenopyrite, marcasite and native bismuth. Analyses of pyrite, chalcopyrite and arsenopyrite are given In Table 1, and galena in Table 2.

A single grain of native silver has been observed (Fig. 5). Numerous grains of electrum have a characteristic Ag-enriched rim (seen on upper photographs on Fig. 3).

Arsenopyrite is a common minor mineral of the sulphide ores, especially where pyrite is abundant. We note that no grains of gold were observed as inclusions within arsenopyrite. However, based on past experience, we would propose that this mineral may be host to invisible gold, i.e. gold at concentrations of tens to thousands of ppm within the mineral lattice or as sub-microscopic inclusions not visible with the microscope (Cook and Chryssoulis, 1990). Such gold is refractory and is generally not recovered if the arsenopyrite is not floated and subsequently treated by roasting or leaching. In the case of the Lega Dembi ores, the distribution of arsenopyrite tends to be extremely localised and the amount of the mineral generally rather small, such that any attempt to recover arsenonopyrite-bound gold, if present, would not be economic. However, the distribution of arsenopyrite deserves to be studied and correlated with gold recoveries.

Gold is also enclosed within pyrite, as native gold, electrum and rarer Au-bearing tellurides. This gold in this association is typically much finer; 50% of grains are smaller than 10 μm in diameter (Fig. 6c). The association of gold in pyrite is very specific and would appear to be the reason for poor recoveries. The small gold minerals occur together with a suite of Pb-As minerals, identified in Lega Dembi ores for the first time. These minerals, gold and tellurides, cluster close to grain boundaries of the pyrite and comprise an association specific to the pyrite-bearing ores. Arsenopyrite, pyrrhotite, galena and tennantite are commonly associated together within the pyrite, forming 'composite' inclusions in As-rich assemblages, all apparently exsolved from the pyrite. The timing of the exsolution may be before the latest deformation, as there is abundant evidence for late remobilisation of sulphosalts along late crosscutting fractures, which are only partially resealed. Not all the inclusion clusters contain Au-minerals – they are preferentially found in composite inclusions also containing jordanite and dufrenoysite. We note that many of the composite inclusions also contain various gangue minerals of unknown composition, but conceivably volatile-rich phases, tied to the exsolution process under conditions of pressure release along the borders of the pyrite or adjacent to fractures attributable to micro-shearing within that mineral. It is also possible that the fractures, representing enhanced fluid pathways may represent zones with enrichment in locked gold. 'Chemical mapping' of individual, micro-structurally documented parageneses would be necessary to show if this is indeed the case..

Three As-sulphosalt minerals are identified as persistent associate minerals of native gold, electrum and associated telluride phases. We have documented, in detail, a number of inclusions within pyrite from representative polished sections (Figs. 7-17), illustrating the profound association of gold minerals with the Pb-As sulphosalts in these ores. **Jordanite,** $Pb_{14}As_6S_{23}$, a relatively common Pb-As-sulphosalt is the most abundant of these. The mineral occurs as abundant, small (sub-100 μm) inclusions in pyrite. Subordinate is another Pb-As sulphosalt, **dufrenoysite** ($Pb_2As_2S_5$), which commonly appears together with jordanite ± galena, in equilibrium, indicating co-crystallisation during cooling from a high temperature phase at 487 °C, supporting known phase relationships in the PbS-As_2S_3 system (Walia and Chang, 1973). Although the composition of both minerals may extend into the ternary PbS-As_2S_3-Sb_2S_3 system, only jordanite shows any Sb substitution at Lega Dembi, with variable (1-26% of the geocronite molecule, $Pb_{14}As_6S_{23}$, present; Table 3); dufrenoysite contains only minimal amounts of Sb (Table 4; Fig. 18).

Closely associated with jordanite and dufrenoysite as inclusions in galena are members of the tetrahedrite-tennantite ("fahlore") family (Tables 5 and 6). Consistent with the As-dominant character of the other sulphosalts, **tennantite,** $Cu_{10}Fe_2As_4S_{13}$ is dominant. Tennantite contains up to 4 mol. % of the tetrahedrite molecule and up to 4 wt. % Ag (Table 5). Lesser amounts of intermediate members in the **tetrahedrite-tennantite series** $(Cu,Ag)_{10}(Fe,Zn)_2As_4S_{13}$ - $(Cu,Ag)_{10}(Fe,Zn)_2Sb_4S_{13}$ (4.9 to 6.3 wt. % Ag) are also recognised, generally together with Sb-richer jordanite, reflecting local variations in bulk As/Sb ratios. Two grains of **argentian tennantite** (12 and 17 wt. % Ag) were also identified (Table 6, Figs. 18 and 19). The economic significance of the sulphosalt phases is their close association with Au- and Ag-bearing minerals.

Orpiment, As_2S_3, is a common accessory of these assemblages (Table 7) and displays characteristic orange-brown internal reflections. This appears to be a primary mineral in the assemblage.

Our analytical work also revealed the presence of several very small phases apparently containing the element thallium (Tl). Although we have included some analyses (Table 8), we remain unsure if the Tl we have detected is genuine, or rather an analytical artefact, possibly related to overlapping spectroscopic peaks (?). None of the analyses (all 'phases' appear to be sulphides of Pb-Tl-Fe) correspond to known mineral phases. However, Tl is a relatively common trace element within Au-ores (notably in Carlin-type ores) and its presence in Lega Dembi ores, while a curiosity, would not be entirely unexpected. The mineralogy of Tl in precious metal and sulphide deposits is poorly understood, and new Tl minerals of complex composition are reported with some regularity.

The compositions of gold grains in pyrite vary somewhat (Table 9), the majority having compositions of native gold ($Au_{<85}$). Compositions of gold and silver minerals are plotted in Au-Ag-Te space in Fig. 20. Gold is also present within the Au-Ag telluride, **petzite**, Ag_3AuTe_2. Both this mineral and the Ag-telluride **hessite**, Ag_2Te, are relatively common accessory minerals in the pyritic ores. Typical grain size is less than 10 μm. Like gold/electrum, Ag- and Ag-Au tellurides are characteristically associated with the Pb-As sulphosalt phases, as small inclusions. Lesser amounts of a third telluride phases, **stützite**, Ag_5Te_3 are also noted. Compositions of the three telluride phases are given in Table 10 and plotted on Fig. 20.

We believe that it is primarily the gold within the pyrite associations which is not being recovered, explaining the lower recoveries reported for the sulphide-rich ore. Although significant, however, gold not recovered (either as small inclusions, intergrown with Pb-As-sulphosalts, as Au-Ag-tellurides and as invisible gold probably does not account for more than 5-10% of the total, although this would need to be quantified before firm conclusions could be drawn .

It had been suggested, during the mine visit that bornite could be present in small quantities within the sulphide-rich ores. Bornite does not readily float and it was thought that the presence of this mineral could explain reduced gold recoveries. The presence of bornite has not been confirmed during microscopic investigation; none of the sections contained this mineral. The reddish phase seen in hand specimen was probably monoclinic pyrrhotite.

4 PYRRHOTITE-RICH 'ORES' AT THE HANGING WALL CONTACT

Summary: Ni-Cu ores at the hanging wall contact carry a characteristic trace mineral assemblage. Electrum is rare, but where observed, is closely associated with a suite of Se- and Te-bearing minerals, of which hessite, laitakarite and pilsenite are most abundant. Several Ag-minerals are present and Ag-concentrations may be significantly greater than previously appreciated. Argentopentlandite and hessite are the most abundant Ag-bearing phases. Although not identical, the trace mineral signature resembles that in the main part of the deposit.

Samples from the sulphide-rich hanging wall are dominated by **chalcopyrite** and **pyrrhotite**. **Pentlandite**, as flame-like exsolution lamellae in pyrrhotite and more massive crystals within both pyrrhotite and chalcopyrite is a major phase (Figs. 21 and 22). Microscopic investigation of representative ores has, however, revealed a more complex ore mineralogy than previously recognised. Although there are gross differences in mineralogy between the main ore types and those in the hanging wall (a function of chemical reaction with wallrock?), the trace mineralogy (e.g. abundance of tellurides) has direct parallels with that of the gold ore. The parallels have implications for deposit genesis, a topic beyond the scope of the present report.

Microanalyses of pyrrhotite and chalcopyrite are given in Table 11 and those of pentlandite in Table 12. Pentlandite, $(Fe,Ni,Co)_9S_8$ has comparable compositions in all associations and paragenetic positions. It is generally Ni-rich, with Ni exceeding Fe in the calculated formulae. All analysed pentlandite grains contain 6-8 wt. % Co, giving a mean formula of $(Fe_{4.02}Ni_{4.12}Co_{0.86})_9S_8$. Compositions are plotted in Fe_9S_8-Ni_9S_8-Co_9S_8 space in Fig. 23 and show a tight cluster.

Other accessory minerals include **sphalerite**, as often spectacular 'stars' within chalcopyrite (Fig. 21) and **violarite**, $FeNi_2S_4$, observed as an alteration product of pentlandite.

The hanging wall ores reveal a silver-rich mineralogy, with several silver minerals present in abundance. **Argentopentlandite**, $Ag(Fe,Ni)_8S_8$ is the most abundant Ag-bearing phase (Figs. 21 and 22), where it occurs as 20-200 μm size inclusions within chalcopyrite and along grain boundaries between chalcopyrite and gangue. Argentopentlandite is a relatively rare mineral, only recognised as a discrete phase in 1971. To date, the mineral has only been reported from a handful of ore deposits worldwide. The reasons for this may be sought in the general rarity of silver (or gold) in significant concentrations within Ni-Cu deposits and also in its appearance, which so closely resembles pyrrhotite that it may readily be overlooked. Argentopentlandite from Lega Dembi has a composition closely following anticipated stoichiometry. Numerous microanalyses of argentopendlandite are included here (Table 13). In comparison with pentlandite, argentopentlandite is appreciably poorer in Ni and contains almost no Co. Compositions are projected onto Fig. 23, assuming Ag=1. Minor amounts of a Fe-Co-Ni phase, tentatively assigned to a Ni-Co enriched griegite, a member of the thiospinel series (Fe_3S_4-Ni_3S_4-Co_3S_4) are observed as thin lamellae within the argentopentlandite. The low Ni and Co of content of argentopentlandite may be explained by exsolution into this discrete phase.

A suite of Se- and Te- minerals appear characteristic of the hanging wall sulphides. **Hessite**, Ag_2Te, the most common silver telluride, occurs as 5-25 μm diameter, rounded, octagonal or elongate inclusions within both chalcopyrite and pyrrhotite (Figs. 24-26). Analyses are given in Table 14. Closely associated with hessite is the mineral **laitakarite**, $Bi_4(Se,Te,S)_3$. Laitakarite, a relatively rare mineral, occupies a range of compositions within Bi_4Se_3-Bi_4Te_3-Bi_4S_3 space (Fig. 27). Compositions of this mineral from Lega Dembi support the presence of extensive solid solution. **Pilsenite**, ideally Bi_4Te_3 is also observed, intimately associated with hessite, in which it has exsolved as lamellae and lath-like grains (Figs 24-26). Compositions, including Se-rich varieties close to the pilsenite-laitakarite boundary are also observed (Table 16, Fig. 27). A further Bi-telluride, **tsumoite** (ideally BiTe, but commonly displaying non-stoichiometry between Bi and Te as well as extensive Te-Se-S substitution) is also found in the hanging wall ores, associated with hessite (Fig. 26). A further silver telluride is noted. This has been tentatively assigned to **stützite** (Table 17, Fig. 26), ideally Ag_5Te_3 on the basis of appearance. However, significant concentrations of sulphur are noted in the mineral, beyond the normal minor amounts. Calculation of the formula based on 7 atoms gives a formula close to **Ag_4Te_2S**. There are no known phases in the Ag-Te-S system with such a composition. Minor amounts of native gold or **electrum** are observed in association with laitakarite and hessite (Figs. 24 and 25, top).

5. CONCLUSIONS

1. The study has indicated that the ore mineralogy of the Lega Dembi deposit is more complex than previously recognised.
2. Fine-grained gold (native gold, electrum, tellurides) locked within pyrite would appear to be the main reason for lower-than-typical gold recoveries in the quartz-sulphide ore. Invisible gold within arsenopyrite may also play a role.
3. The fine-grained gold is intimately associated with a characteristic mineral suite, comprising jordanite, dufenoysite, galena, orpiment and tennantite. This As-dominated association is previously unreported from Lega Dembi. Pb-Sb sulphosalts have been previously reported and it may be that deeper mining levels are marked by a switch from an 'antimony' to an 'arsenic' association, reflecting zonation or evolution of the hydrothermal system during shear-zone development and fluid pumping.
4. We have confirmed earlier studies that tellurides are locally abundant and that petzite probably accounts for a minor amount of Au in the ores.
5. The hanging wall ores are found to carry very significant (and hitherto unrecognised?) amounts of silver, primarily as abundant argentopentlandite inclusions, but also as hessite.
6. The following minerals are reported from Lega Dembi for the first time: jordanite, dufrenoysite, tennantite, argentian tennantite, orpiment, laitakarite, pilsenite, tsumoite and a Fe-rich thiospinel. Other phases require further investigation, including Tl-minerals.
7. We do not see evidence among the investigated assemblages for two distinct generations of ore minerals. Observed assemblages and textures can be efficiently explained by sequential processes of syn-deformational ore remobilisation.

6. FURTHER WORK

Although firm conclusions have been drawn, description of observed mineral assemblages remains incomplete. The complexity of several assemblages necessitates further work, including quantitative electron probe microanalysis. This will be carried out at a later date using facilities outside Norway. Investigation of the role played of invisible gold and the distribution of arsenopyrite in the ore and correlation with Au recoveries could form the basis of a potential follow-up project. We would also recommend an investigation of gold-bearing parageneses filling fractures in pyrite by SEM & cathode luminescence (CL) methods to identify possible micro-structural controls. The NGU team working on the project will carry this out during 2001 in the context of increasing knowledge about mineralisation in the Adola Belt and also ongoing paragenetic studies of Ag-Au-(Bi) telluride minerals. We reserve the right to publish scientific results of the study. Any manuscripts resulting from the work would, however, be submitted to Midroc Gold for their agreement before submission.

7 REFERENCES

Billay, A.Y., Kisters, A.F.M., Meyer, F.M., Schneider, J. (1997): The geology of the Lega Dembi gold deposit, southern Ethiopia: implications for Pan-African gold exploration. Mineralium Deposita 32: 491-504.

Bogliotti, C. (1989): A reinterpretation of the large-scale structure of Precambrian rocks in the Adola Goldfield (Ethiopia) based on two generations of interference pattern. Precambrian Research 44: 289-304.

Cook, N.J., Chryssoulis, S.L. (1990): Concentrations of "invisible gold" in the common sulphides. Canadian Mineralogist 28: 1-16.

Fiori, M., Gabarino, C., Grillo, S., Solomon, T., Valera, R.G. (1987): The primary gold deposit of Lega Dembi (Sidamo): Ore mineral association and genetic significance. Unpubl. Report, University of Cagliari, Italy.

Fiori, M., Gabarino, C., Grillo, S., Solomon, T., Valera, R.G. (1988): Mineral parageneses in the Au-Ag-Cu-Zn-Pb-Te deposit of Lega Dembi (Ethiopia). In: Bicentennial Gold 88, extended abstract volume, Geological Society of Australia, 184-186.

Ghebreab, W. (1992): The geological evolution of the Adola Precambrian greenstone belt, Southern Ethiopia. Journal of African Earth Sciences 14: 457-469.

Ghebreab, W., Yohannes, E. and Giorgis, L.W. (1992): The Lega Dembi gold mine: an example of shear zone-hosted mineralisation in the Adola greenstone belt, Southern Ethiopia. Journal of African Earth Sciences 14: 489-500.

Gichile, S. and Fyson, W.K. (1993): An inference of the tectonic setting of the Adola Belt of Southern Ethiopia from the geochemistry of magmatic rocks. Journal of African Earth Sciences 16: 367-380.

Kazmin, V., Schifferaw, A. and Balcha, T. (1978): The Ethiopian Basement: Startigraphy and possible manner of evolution. Geologische Rundschau 67: 531-546.

Nikulin, A.I., Filimonov, N.V., Demina, N.N. (1986): Results of laboratory-technological studies of gold-bearing ores from Lega Dembi deposit in the Socialist Ethiopia. Unpubl. Report, V/O “Technoexport”, USSR Ministry of Geology, Moscow.

Tolessa, D. and Pohl, W. (1999): Constraints on interpretation of geochemical data for gold exploration in multiply deformed and metamorphosed areas: an example from Legadembi gold deposit, Southern Ethiopia. Journal of African Earth Sciences 14: 37-55.

Walia, D.S. and Chang, L.L.Y. (1973): Investigations in the systems $PbS-Sb_2S_3-As_2S_3$ and $PbS-Bi_2S_3-As_2S_3$. Canadian Mineralogist 12: 113-119.

Worku, H. (1993a): Structural geology and tectonic setting of the Adola Belt (Southern Ethiopia). In: Geoscientific Research in Northeast Africa (U. Thorweihe and H. Schandelmeier eds.). Balkema, Rotterdam: 139-144.

Worku, H. (1993b): Implication of the structural evolution of the Adola Belt on shear zone-hosted gold mineralisation. In: Geoscientific Research in Northeast Africa (Thorweihe and H. Schandelmeier eds.). Balkema, Rotterdam: 541-547.

Worku, H. and Schandelmeier, H. (1996): Tectonic evolution of the Neoproterozoic Adola Belt of southern Ethiopia: evidence for a Wilson Cycle process and implications for oblique plate collision. Precambrian Research 77: 179-210.

Worku, H. and Yifa, K. (1992): The tectonic evolution of the Precambrian metamorphic rocks of the Adola Belt (Southern Ethiopia). Journal of African Earth Sciences 14: 37-55.

Table 1 Microanalysis of pyrite, chalcopyrite and arsenopyrite (Samples LD-14J and LD-14J2)

	Pyrite						Chalcopyrite	Arsenopyrite
	LD 14J2			LD-14J			LD 14J2	
	a10.gen	p1	p2	a3.gr5.p18	p19	3.gr4.p20	a10.p2	gr3.p2
Analysis (wt. %)								
Cu	0.00	0.00	0.00	0.68	0.00	0.00	34.36	0.30
Pb	0.38	0.61	0.63	0.00	0.85	0.01	0.34	0.00
Fe	48.06	48.06	48.75	47.73	47.85	48.46	30.69	39.39
Ni								
Co								
As	0.20	0.94	0.23	0.45	0.06	0.00	0.23	33.84
Sb	0.37	0.20	0.09	0.00	0.00	0.00	0.00	0.41
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58
S	50.61	50.04	49.56	50.30	50.78	51.25	31.71	18.85
Te	0.15	0.00	0.11	0.00	0.32	0.03	0.20	0.44
Se	0.11	0.14	0.13	0.32	0.13	0.00	0.33	0.39
Total	**99.88**	**99.99**	**99.50**	**99.48**	**99.99**	**99.75**	**97.86**	**94.20**
Atomic Proportions								
Cu	0.00	0.00	0.27	0.44	0.00	0.00	25.74	0.26
Pb	0.08	0.12	0.12	0.00	0.17	0.00	0.08	0.00
Fe	35.12	35.26	35.84	34.90	34.97	35.12	26.16	39.33
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Co	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As	0.11	0.52	0.13	0.25	0.04	0.00	0.14	1.54
Sb	0.12	0.07	0.03	0.00	0.00	0.00	0.00	0.19
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
S	64.42	63.96	63.47	64.07	64.65	64.71	47.10	32.79
Te	0.05	0.00	0.04	0.00	0.10	0.01	0.07	0.19
Se	0.06	0.00	0.07	0.16	0.07	0.00	0.20	0.27
Formula ignoring Ag								
(based on S = 2)							**(based on S = 2)**	**(based on S = 1)**
Cu	0.00	0.00	0.01	0.00	0.00	0.00	1.09	0.01
Pb	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Fe	1.09	1.10	1.13	1.09	1.08	1.09	1.10	1.18
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Co	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total M	**1.09**	**1.11**	**1.14**	**1.09**	**1.08**	**1.09**	**2.19**	**1.19**
As	0.00	0.02	0.00	0.01	0.00	0.00	0.01	0.05
Sb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	2.00	2.00	2.00	2.00	1.99	2.00	1.99	0.99
Te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Se	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Total (S,Te)	**2.01**	**2.02**	**2.01**	**2.01**	**2.00**	**2.00**	**2.01**	**1.06**

Table 2 Microanalysis of galena (sample LD-14J and LD-14J2)

	LD 14J2		LD-14J	zonation: Ag, Tl, free							
	a10.gr2.p1	a12.gr2.p2	a3.gr5.p8	p13	p9	p12	p20	p10	p11	a3.gr1.p2	a4.gr3.p2
Analysis (wt. %)											
Pb	84.07	85.52	82.63	82.66	82.16	83.10	79.44	84.66	83.74	84.78	83.11
Tl	3.29	0.00	0.00	0.00	3.76	2.55	2.84	0.00	0.00	0.00	0.00
Cu	0.00	0.41	0.76	0.50	0.37	0.28	0.10	0.00	0.00	0.00	0.60
Fe	0.57	0.27	0.95	1.65	0.78	1.30	4.65	1.32	1.53	0.71	1.43
Ag	0.23	0.00	2.15	1.85	0.30	0.19	0.24	0.00	0.00	0.48	0.00
As	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bi	0.13	0.00	0.13	1.01	0.00	0.00	0.31	0.00	0.67	0.00	0.09
Sb	0.00	0.00	0.37	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.32
S	11.03	13.36	11.73	11.41	11.31	12.00	11.15	12.68	12.39	12.90	12.49
Te	0.00	0.19	0.46	0.22	0.39	0.00	0.41	0.00	0.00	0.28	0.39
Se	0.44	0.24	0.30	0.29	0.29	0.35	0.00	0.20	0.40	0.26	0.39
Total	**99.76**	**99.99**	**99.48**	**99.89**	**99.36**	**99.77**	**99.14**	**98.86**	**98.73**	**99.41**	**98.82**
Atomic Proportions											
Pb	51.60	48.82	48.14	48.47	49.39	48.67	45.54	48.67	47.85	48.60	47.17
Tl	2.05	0.00	0.00	0.00	2.29	1.51	1.65	0.00	0.00	0.00	0.00
Cu	0.00	0.77	1.44	0.95	0.72	0.54	0.18	0.00	0.00	0.00	1.18
Ag	0.28	0.00	2.40	2.09	0.34	0.22	0.27	0.00	0.00	0.53	0.00
Fe	1.30	0.58	2.06	3.60	1.73	2.84	9.90	2.82	3.25	1.51	3.00
As	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bi	0.08	0.00	0.07	0.59	0.00	0.00	0.18	0.00	0.38	0.00	0.05
Sb	0.00	0.00	0.37	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.31
S	43.74	49.29	44.16	43.24	43.92	45.41	41.32	47.10	45.77	47.81	45.83
Te	0.00	0.18	0.44	0.21	0.38	0.00	0.39	0.00	0.00	0.26	0.36
Se	0.72	0.36	0.46	0.44	0.46	0.54	0.00	0.30	0.59	0.38	0.57
Formulae (ignoring Fe)											
(based on 2 atoms in formula: PbS											
Pb	1.05	0.98	0.99	1.01	1.01	1.00	1.02	1.01	1.01	1.00	0.99
Tl	0.04	0.00	0.00	0.00	0.05	0.03	0.04	0.00	0.00	0.00	0.00
Cu	0.00	0.02	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.02
Ag	0.01	0.00	0.05	0.04	0.01	0.00	0.01	0.00	0.00	0.01	0.00
As	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bi	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Sb	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total M	**1.10**	**1.00**	**1.07**	**1.07**	**1.08**	**1.05**	**1.06**	**1.01**	**1.01**	**1.01**	**1.01**
S	0.89	0.99	0.91	0.90	0.90	0.94	0.92	0.98	0.97	0.98	0.96
Te	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01
Se	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
Total S,Se,Te	**0.90**	**1.00**	**0.92**	**0.91**	**0.92**	**0.95**	**0.93**	**0.99**	**0.98**	**0.99**	**0.98**

Table 3 Microanalysis of jordanite (sample LD-14J and LD-14J2)

	LD-14 J2												
	a1&2.gr1.p1	p3	gr2.p1	gr3.p5	gr4.p1	gr5.p1	p2	gr6.p1	gr7.p4	a10.gr1.p1	p3	12.gr1.p1	a9.gr2.p1
Analysis (wt. %)													
Pb	70.90	70.16	71.04	70.87	71.54	70.77	70.89	71.62	70.18	70.16	67.53	72.05	68.70
Tl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cu	0.81	0.93	0.00	0.87	0.00	0.55	0.00	0.37	0.19	0.57	0.27	0.00	0.45
Fe	2.03	2.33	2.60	1.97	1.75	2.44	2.31	2.15	2.22	2.38	4.21	0.92	1.77
Ag	0.39	0.35	0.00	0.07	0.00	0.03	0.00	0.01	0.00	0.00	0.56	0.24	0.66
Sn	0.09	0.12	0.44	0.20	0.27	0.00	0.34	0.00	0.09	0.00	0.35	0.00	0.27
As	7.04	7.23	7.54	7.17	7.77	7.12	7.26	7.29	6.81	7.13	7.39	6.44	7.03
Bi	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.74	0.00	0.00	0.00	0.00	0.00
Sb	0.88	1.45	0.62	1.07	1.59	0.61	1.51	0.00	1.82	1.17	1.30	3.05	3.62
S	17.13	17.16	17.12	17.20	16.70	17.65	16.81	17.47	17.55	17.80	17.99	16.91	16.13
Te	0.19	0.00	0.41	0.00	0.28	0.00	0.23	0.00	0.66	0.00	0.10	0.16	0.57
Se	0.41	0.28	0.23	0.28	0.10	0.53	0.24	0.37	0.30	0.31	0.25	0.24	0.39
Total	**99.87**	**100.01**	**100.00**	**99.70**	**100.00**	**100.00**	**99.59**	**100.02**	**99.82**	**99.52**	**99.95**	**100.01**	**99.59**
Atomic Proportions													
Pb	32.95	32.37	33.00	32.90	33.85	32.44	33.32	33.23	32.36	32.06	29.94	34.46	32.55
Tl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cu	1.23	1.40	0.00	1.32	0.00	0.83	0.00	0.55	0.29	0.84	0.39	0.00	0.69
Fe	3.49	3.98	4.49	3.40	3.07	4.15	4.03	3.69	3.81	4.03	6.92	1.63	3.12
Ag	0.30	0.31	0.00	0.06	0.00	0.02	0.00	0.01	0.00	0.00	0.48	0.22	0.60
Sn	0.07	0.10	0.36	0.16	0.22	0.00	0.28	0.00	0.08	0.00	0.27	0.00	0.23
As	9.05	9.22	9.69	9.21	10.17	9.03	9.43	9.35	8.69	9.01	9.06	8.52	9.21
Bi	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.34	0.00	0.00	0.00	0.00	0.00
Sb	0.69	1.14	0.49	0.85	1.28	0.00	1.21	0.00	1.43	0.91	0.98	2.48	2.92
S	51.46	51.15	51.39	51.62	51.06	52.28	51.06	52.38	52.31	52.56	51.57	52.26	49.40
Te	0.14	0.00	0.31	0.00	0.22	0.00	0.17	0.00	0.50	0.00	0.07	0.13	0.44
Se	0.50	0.33	0.28	0.34	0.13	0.64	0.29	0.44	0.52	0.37	0.29	0.30	0.49
	96.39	96.02	95.52	96.46	96.93	95.38	95.76	96.30	96.18	95.75	93.05	98.37	96.53
Formula ignoring Fe													
(based on 43 atoms in formula: $Pb_{14}As_6S_{23}$													
Pb	14.70	14.50	14.86	14.67	15.02	14.62	14.96	14.84	14.47	14.40	13.84	15.06	14.50
Tl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cu	0.55	0.63	0.00	0.59	0.00	0.37	0.00	0.25	0.13	0.38	0.18	0.00	0.31
Ag	0.13	0.14	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.22	0.10	0.27
Total M	**15.38**	**15.26**	**14.86**	**15.28**	**15.02**	**15.01**	**14.96**	**15.09**	**14.60**	**14.77**	**14.24**	**15.16**	**15.07**
As	4.04	4.13	4.36	4.11	4.51	4.07	4.23	4.17	3.89	4.05	4.19	3.72	4.10
Bi	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Sb	0.31	0.51	0.22	0.38	0.57	0.00	0.54	0.00	0.64	0.41	0.45	1.08	1.30
Sn	0.03	0.04	0.16	0.07	0.10	0.00	0.13	0.00	0.04	0.00	0.12	0.00	0.10
Total Me	**4.38**	**4.69**	**4.74**	**4.56**	**5.18**	**4.13**	**4.90**	**4.33**	**4.56**	**4.45**	**4.76**	**4.81**	**5.51**
S	22.96	22.91	23.13	23.01	22.65	23.57	22.93	23.39	23.39	23.60	23.83	22.84	22.01
Te	0.06	0.00	0.14	0.00	0.10	0.00	0.08	0.00	0.22	0.00	0.03	0.06	0.20
Se	0.22	0.15	0.13	0.15	0.06	0.29	0.13	0.20	0.23	0.17	0.13	0.13	0.22
Total S,Se,Te	**23.24**	**23.05**	**23.40**	**23.16**	**22.81**	**23.86**	**23.13**	**23.59**	**23.84**	**23.77**	**24.00**	**23.03**	**22.42**
% jordanite	92.3	88.1	91.9	90.1	87.1	98.5	86.4	96.5	85.2	90.8	87.9	77.5	74.5
% geocronite	7.7	11.9	8.1	9.9	12.9	1.5	13.6	3.5	14.8	9.2	12.1	22.5	25.5

Table 3 continued Microanalysis of jordanite (sample LD-14J and LD-14J2)

				LD-14J										
	p2	gr1.p1	p2	a1.p2	a3.gr4.p1	p2	4.gr10.p3	a3.gr1.p1	p3	a4.gr7.p2	p3	gr2.p1	a4.gr1.p3	a3.gr7.p1
Analysis (wt. %)														
Pb	69.27	68.19	69.56	70.76	71.60	69.31	68.69	70.68	71.10	70.44	71.08	70.31	71.86	72.58
Tl	0.00	5.38	0.00	0.00	0.00	0.00	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00
Cu	0.00	0.00	0.72	0.00	0.00	0.00	0.52	0.61	0.72	1.09	0.61	0.00	0.00	0.00
Fe	3.26	1.28	2.45	1.06	2.23	2.81	2.92	0.84	1.29	1.75	1.39	2.59	1.43	1.34
Ag	0.21	0.20	0.72	0.41	0.39	0.00	0.39	0.42	0.10	0.12	0.13	0.04	0.00	0.40
Sn	0.15	0.06	0.10	0.47	0.00	0.29	0.41	0.00	0.00	0.06	0.25	0.20	0.22	0.18
As	6.55	7.06	6.94	6.89	8.06	8.47	7.60	7.76	8.32	7.95	7.63	8.08	7.95	8.04
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb	2.34	1.28	1.52	2.61	0.38	0.10	1.18	0.49	0.32	0.94	1.07	0.50	0.73	0.00
S	17.57	14.25	17.06	17.30	16.71	17.55	16.41	16.03	17.78	16.80	17.40	17.32	17.06	16.84
Te	0.01	0.06	0.61	0.00	0.00	0.31	0.12	0.00	0.00	0.24	0.00	0.22	0.20	0.00
Se	0.17	0.00	0.19	0.21	0.51	0.30	0.45	0.27	0.09	0.15	0.18	0.45	0.31	0.15
Total	**99.53**	**97.76**	**99.87**	**99.71**	**99.88**	**99.14**	**98.69**	**97.92**	**99.72**	**99.54**	**99.74**	**99.71**	**99.76**	**99.53**
Atomic Proportions														
Pb	31.60	33.98	32.17	33.26	33.62	31.48	31.91	33.75	32.66	32.85	33.04	32.32	33.81	34.40
Tl	0.00	2.72	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
Cu	0.00	0.00	1.09	0.00	0.00	0.00	0.78	0.95	1.07	1.65	0.92	0.00	0.00	0.00
Fe	5.51	5.11	4.21	1.85	3.88	4.74	5.04	1.49	2.20	3.03	2.40	4.41	2.50	2.36
Ag	0.19	0.19	0.00	0.37	0.35	0.00	0.35	0.39	0.09	0.11	0.12	0.03	0.00	0.36
Sn	0.12	0.05	0.33	0.39	0.00	0.23	0.33	0.00	0.00	0.05	0.21	0.16	0.18	0.15
As	8.26	9.73	8.88	8.96	10.46	10.64	9.77	10.25	10.57	10.25	9.81	10.27	10.34	10.53
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb	1.82	1.09	1.20	2.09	0.30	0.08	0.93	0.40	0.25	0.75	0.85	0.39	0.58	0.00
S	51.79	45.90	50.99	52.57	50.71	51.53	49.29	49.47	52.80	50.64	52.28	51.46	51.87	51.60
Te	0.00	0.05	0.46	0.00	0.00	0.23	0.09	0.00	0.00	0.18	0.00	0.16	0.16	0.00
Se	0.21	0.00	0.23	0.26	0.51	0.36	0.45	0.34	0.11	0.19	0.18	0.54	0.38	0.18
	93.99	93.71	95.35	97.90	95.95	94.55	93.90	95.95	97.55	96.67	97.41	95.33	97.32	97.22
Formula ignoring Fe														
(based on 43 atoms in formula: $Pb_{14}As_6S_{23}$														
Pb	14.46	15.59	14.51	14.61	15.07	14.32	14.61	15.13	14.40	14.61	14.58	14.58	14.94	15.21
Tl	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00
Cu	0.00	0.00	0.49	0.00	0.00	0.00	0.36	0.43	0.47	0.73	0.41	0.00	0.00	0.00
Ag	0.09	0.09	0.00	0.16	0.16	0.00	0.16	0.17	0.04	0.05	0.05	0.01	0.00	0.16
Total M	**14.54**	**16.93**	**15.00**	**14.77**	**15.22**	**14.32**	**15.13**	**15.90**	**14.91**	**15.39**	**15.04**	**14.59**	**14.94**	**15.37**
As	3.78	4.46	4.00	3.94	4.69	4.84	4.47	4.59	4.66	4.56	4.33	4.63	4.57	4.66
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb	0.83	0.50	0.54	0.92	0.13	0.04	0.43	0.18	0.11	0.33	0.38	0.18	0.26	0.00
Sn	0.05	0.02	0.15	0.17	0.00	0.10	0.15	0.00	0.00	0.02	0.09	0.07	0.08	0.07
Total Me	**4.67**	**4.99**	**4.69**	**5.02**	**4.82**	**4.98**	**5.05**	**4.77**	**4.77**	**4.92**	**4.80**	**4.88**	**4.90**	**4.72**
S	23.69	21.06	22.99	23.09	22.73	23.44	22.57	22.17	23.27	22.53	23.08	23.21	22.92	22.82
Te	0.00	0.02	0.21	0.00	0.00	0.10	0.04	0.00	0.00	0.08	0.00	0.07	0.07	0.00
Se	0.10	0.00	0.10	0.11	0.23	0.16	0.21	0.15	0.05	0.08	0.08	0.24	0.17	0.08
Total S,Se,Te	**23.79**	**21.08**	**23.31**	**23.20**	**22.95**	**23.70**	**22.82**	**22.32**	**23.32**	**22.69**	**23.16**	**23.53**	**23.16**	**22.90**
% jordanite	81.0	89.5	85.3	78.3	97.2	97.2	88.6	96.2	97.7	92.8	90.2	94.9	93.2	98.6
% geocronite	19.0	10.5	14.7	21.7	2.8	2.8	11.4	3.8	2.3	7.2	9.8	5.1	6.8	1.4

Table 4 Microanalysis of dufrenoysite (sample LD-14J and LD-14J2; 8 grains)

	LD-14 J2			LD-14J									
	a10.gr3.p1	p3	p4	a1.p1	a3.gr4.p4	p5	p6	4.gr10.p4	gr7.p3	gr2.p3	a4.gr1.p2	a3.gr7.p2	p7
Analysis (wt. %)													
Pb	58.63	58.18	59.21	59.78	59.56	57.84	59.76	53.15	59.74	58.10	59.19	58.07	58.87
Tl	0.00	0.00	0.00	0.00	0.00	0.00	0.49	6.53	0.00	0.00	0.00	1.06	0.00
Cu	0.30	0.18	0.00	0.30	0.00	0.00	0.24	0.23	0.00	0.61	0.00	0.55	0.35
Fe	1.50	2.29	1.52	1.63	2.49	2.49	1.91	3.89	1.79	1.61	1.79	1.28	1.46
Ag	0.03	0.41	0.18	0.73	0.39	0.38	0.16	0.27	0.00	0.27	0.20	0.47	0.00
Sn	0.00	0.00	0.00	0.16	0.07	0.25	0.00	0.00	0.00	0.31	0.12	0.00	0.00
As	15.09	14.78	14.70	14.52	15.77	15.38	15.89	15.65	16.12	15.87	15.83	16.29	16.62
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb	1.39	1.43	1.52	1.63	0.43	0.08	0.19	0.80	0.00	0.87	0.44	0.00	0.00
S	22.26	22.68	21.50	21.01	20.49	21.98	20.65	19.33	21.64	21.10	21.21	21.25	21.85
Te	0.00	0.00	0.73	0.10	0.17	0.14	0.23	0.00	0.00	0.30	0.20	0.00	0.53
Se	0.41	0.06	0.48	0.40	0.58	0.62	0.45	0.00	0.30	0.35	0.57	0.21	0.33
Total	**99.61**	**100.01**	**99.84**	**100.26**	**99.95**	**99.16**	**99.97**	**99.85**	**99.59**	**99.39**	**99.55**	**99.18**	**100.01**
Atomic Proportions													
Pb	23.02	22.55	23.66	24.24	23.99	22.49	24.11	21.67	23.66	23.08	23.61	23.08	23.15
Tl	0.00	0.00	0.00	0.00	0.00	0.00	0.20	2.70	0.00	0.00	0.00	0.43	0.00
Cu	0.38	0.23	0.00	0.39	0.00	0.00	0.32	0.30	0.00	0.78	0.00	0.71	0.44
Fe	2.19	3.29	2.43	1.39	3.72	3.59	2.86	5.88	2.63	2.37	2.65	1.88	2.13
Ag	0.02	0.31	0.13	0.57	0.30	0.28	0.12	0.21	0.00	0.21	0.15	0.36	0.00
Sn	0.00	0.00	0.00	0.11	0.05	0.17	0.00	0.00	0.00	0.21	0.09	0.00	0.00
As	16.38	15.84	16.25	16.28	17.56	16.53	15.89	17.64	17.65	17.43	17.47	17.90	18.07
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb	0.93	0.94	1.03	1.12	0.30	0.05	0.13	0.56	0.00	0.59	0.30	0.00	0.00
S	56.49	56.79	55.50	55.05	53.33	55.23	53.86	50.92	55.39	54.16	54.69	54.57	55.52
Te	0.00	0.00	0.47	0.07	0.11	0.09	0.15	0.00	0.00	0.20	0.13	0.00	0.34
Se	0.42	0.06	0.51	0.43	0.61	0.63	0.48	0.00	0.31	0.36	0.59	0.21	0.34
Formula ignoring Fe (and correcting for S in pyrite) (based on 9 atoms in formula: $Pb_2As_2S_5$													
Pb	2.22	2.10	2.18	2.22	2.24	2.12	2.28	2.07	2.20	2.14	2.19	2.14	2.13
Tl	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.26	0.00	0.00	0.00	0.04	0.00
Cu	0.04	0.02	0.00	0.04	0.00	0.00	0.03	0.03	0.00	0.07	0.00	0.07	0.04
Ag	0.00	0.03	0.01	0.05	0.03	0.03	0.01	0.02	0.00	0.02	0.01	0.03	0.00
Total M	**2.26**	**2.15**	**2.19**	**2.31**	**2.27**	**2.15**	**2.34**	**2.38**	**2.20**	**2.23**	**2.20**	**2.27**	**2.17**
As	1.58	1.47	1.50	1.49	1.64	1.56	1.50	1.69	1.64	1.62	1.62	1.66	1.66
Bi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb	0.09	0.09	0.10	0.10	0.03	0.00	0.01	0.05	0.00	0.05	0.03	0.00	0.00
Sn	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
Total Me	**1.67**	**1.56**	**1.59**	**1.60**	**1.67**	**1.58**	**1.51**	**1.74**	**1.64**	**1.69**	**1.66**	**1.66**	**1.66**
S	5.03	4.67	4.67	4.79	4.29	4.53	4.55	3.75	4.65	4.58	4.58	4.70	4.71
Te	0.00	0.00	0.04	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.00	0.03
Se	0.04	0.01	0.05	0.04	0.06	0.06	0.05	0.00	0.03	0.03	0.05	0.02	0.03
Total S,Se,Te	**5.07**	**4.68**	**4.76**	**4.83**	**4.36**	**4.60**	**4.61**	**3.75**	**4.68**	**4.64**	**4.65**	**4.72**	**4.78**

Table 5 Microanalysis of tennantite (sample LD-14J and LD-14J2)

	LD-14J2						LD-14J				
	a1&2/gr1.p4	.p2 (re)	.p3 (re)	p5	gr7.p2	p3	a4.gr10.p2	a4.gr7.p1	a3.gr7.p4	a3.gr7.p6	a3.gr5.p15
Analysis (wt. %)											
Cu	44.91	42.61	41.19	43.23	43.80	45.09	41.18	42.34	42.69	42.29	40.24
Pb	0.95	0.00	0.00	0.00	0.00	1.60	0.85	0.81	0.51	0.53	1.41
Tl	0.00	3.14	1.05	4.99	3.68	0.35	0.60	1.65	0.00	0.00	0.31
Ag	0.52	1.06	0.62	0.61	0.00	0.07	2.08	1.20	1.71	1.67	4.16
Fe	9.12	9.07	8.54	9.41	7.90	8.46	9.44	8.86	8.58	9.33	8.04
As	16.90	16.93	17.32	16.36	17.57	17.03	17.95	17.99	17.76	18.14	16.88
Bi	0.36	1.10	1.77	0.36	0.00	0.00	0.28	0.00	0.16	0.00	0.00
Sb	0.24	0.00	0.02	0.68	1.13	0.14	0.00	0.00	0.63	0.19	0.15
S	26.53	25.03	27.93	23.93	25.58	26.48	26.37	26.15	27.19	27.09	26.16
Te	0.00	0.16	0.08	0.00	0.26	0.09	0.47	0.00	0.05	0.00	0.52
Se	0.00	0.00	0.00	0.13	0.08	0.37	0.30	0.00	0.13	0.36	0.44
Total	**99.53**	**99.10**	**98.52**	**99.70**	**100.00**	**99.68**	**99.52**	**99.00**	**99.41**	**99.60**	**98.31**
Atomic Proportions											
Cu	36.38	35.61	33.33	36.70	36.48	36.71	33.73	34.72	34.60	34.19	33.37
Pb	0.24	0.00	0.00	0.00	0.00	0.40	0.21	0.20	0.13	0.13	0.36
Tl	0.00	0.82	0.26	1.32	0.95	0.09	0.15	0.42	0.00	0.00	0.08
Ag	0.25	0.52	0.29	0.30	0.00	0.04	1.01	0.58	0.82	0.79	2.03
Fe	8.41	8.62	7.87	9.09	7.49	7.84	8.80	8.27	7.91	8.58	7.59
As	11.61	12.00	11.89	11.78	12.41	11.75	12.47	12.51	12.21	12.44	11.87
Bi	0.15	0.28	0.44	0.16	0.00	0.00	0.12	0.00	0.07	0.00	0.00
Sb	0.06	0.00	0.01	0.17	0.29	0.03	0.00	0.00	0.16	0.05	0.04
S	42.60	41.47	44.79	40.25	42.23	42.72	42.80	42.51	43.67	43.42	43.00
Te	0.00	0.06	0.03	0.00	0.11	0.04	0.19	0.00	0.02	0.00	0.21
Se	0.00	0.00	0.00	0.09	0.05	0.24	0.20	0.00	0.08	0.24	0.29
Formulae											
(based on 29 atoms in formula: $(Cu,Ag)_{10}Fe_2As_4S_{13}$											
Cu	10.58	10.39	9.77	10.66	10.58	10.66	9.81	10.15	10.07	9.93	9.79
Pb	0.07	0.00	0.00	0.00	0.00	0.12	0.06	0.06	0.04	0.04	0.11
Tl	0.00	0.24	0.08	0.38	0.28	0.03	0.04	0.12	0.00	0.00	0.02
Ag	0.07	0.15	0.09	0.09	0.00	0.01	0.29	0.17	0.24	0.23	0.60
Fe	2.45	2.52	2.31	2.64	2.17	2.28	2.56	2.42	2.30	2.49	2.23
Total M	**13.17**	**13.30**	**12.24**	**13.77**	**13.03**	**13.09**	**12.77**	**12.92**	**12.65**	**12.69**	**12.74**
As	3.38	3.50	3.49	3.42	3.60	3.41	3.63	3.66	3.55	3.61	3.48
Bi	0.04	0.08	0.13	0.05	0.00	0.00	0.03	0.00	0.02	0.00	0.00
Sb	0.02	0.00	0.00	0.05	0.08	0.01	0.00	0.00	0.05	0.01	0.01
Total Me	**3.44**	**3.58**	**3.62**	**3.52**	**3.68**	**3.42**	**3.66**	**3.66**	**3.62**	**3.63**	**3.49**
S	12.39	12.10	13.13	11.69	12.25	12.41	12.45	12.43	12.71	12.61	12.62
Te	0.00	0.02	0.01	0.00	0.03	0.01	0.06	0.00	0.01	0.00	0.06
Se	0.00	0.00	0.00	0.03	0.01	0.07	0.06	0.00	0.02	0.07	0.09
Total S,Se,Te	**12.39**	**12.12**	**13.14**	**11.72**	**12.29**	**12.49**	**12.57**	**12.43**	**12.74**	**12.68**	**12.76**
% tennantite	98.2	97.7	96.4	97.3	97.7	99.7	99.0	100.0	98.2	99.6	99.7
% tetrahedrite	1.8	2.3	3.6	2.7	2.3	0.3	1.0	0.0	1.8	0.4	0.3

Table 6 Microanalysis of tetrahedtite-tennantite and Ag-tennantite (sample LD-14J)

	Tetrahedrite-tennatite ss series LD-14J			Argentian tennantite LD-14J	
	a12.gr1.p1	p2	p5	a3.gr5.p14	p17
Analysis (wt. %)					
Cu	35.67	35.29	36.13	28.78	30.41
Pb	0.00	0.00	0.98	0.30	0.00
Tl	0.00	0.00	1.61	0.00	2.64
Ag	6.26	4.86	5.87	16.71	11.90
Fe	6.93	6.87	7.28	5.59	6.82
As	9.13	9.08	9.64	13.47	13.85
Sb	16.23	16.21	12.63	0.00	0.00
Bi	0.38	0.29	0.36	0.69	0.78
S	25.16	24.94	23.82	19.21	19.85
Te	0.00	0.00	0.95	10.03	8.06
Se	0.22	0.22	0.57	0.28	0.13
Total	**99.98**	**97.76**	**99.84**	**95.06**	**94.44**
Atomic Proportions					
Cu	31.39	31.38	32.32	28.22	29.23
Pb	0.00	0.00	0.27	0.09	0.00
Tl	0.00	0.00	0.45	0.00	0.79
Ag	3.25	2.55	3.09	9.65	6.74
Fe	6.94	7.52	7.41	6.24	7.46
As	6.82	6.85	7.31	11.21	11.29
Sb	7.46	7.52	5.90	0.00	0.00
Bi	0.10	0.08	0.10	0.21	0.23
S	43.89	43.96	42.24	37.36	37.81
Te	0.00	0.00	0.42	4.90	3.86
Se	0.16	0.16	0.41	0.22	0.10
Formulae					
(based on 29 atoms in formula: $(Cu,Ag)_{10}Fe_2(As,Sb)_4S_{13}$					
Cu	9.10	9.10	9.38	8.34	8.69
Pb	0.00	0.00	0.08	0.03	0.00
Tl	0.00	0.00	0.13	0.00	0.23
Ag	0.94	0.74	0.90	2.85	2.00
Fe	2.01	2.18	2.15	1.84	2.22
Total M	**12.06**	**12.02**	**12.64**	**13.07**	**13.15**
As	1.98	1.99	2.12	3.31	3.36
Sb	2.16	2.18	1.71	0.00	0.00
Bi	0.03	0.02	0.03	0.06	0.07
Total Me	**4.17**	**4.19**	**3.86**	**3.38**	**3.43**
S	12.73	12.75	12.26	11.04	11.24
Te	0.00	0.00	0.12	1.45	1.15
Se	0.05	0.05	0.12	0.07	0.03
Total S,Se,Te	**12.77**	**12.79**	**12.50**	**12.56**	**12.42**
% tennantite	47.4	47.4	54.9	98.2	98.0
% tetrahedrite	52.6	52.6	45.1	1.8	2.0

Table 7 Microanalysis of orpiment (sample LD-14J)

	LD-14J a3.gr4.p13	p14	p15	a4.gr2.p2	a4.gr1.p4	a3.gr7.p3	p5
Analysis (wt. %)							
Cu	0.21	0.00	0.52	0.00	0.00	0.80	0.00
Pb	1.50	0.00	0.00	0.97	4.95	0.40	0.42
Tl	0.00	0.00	1.86	1.94	2.33	4.00	5.53
Ag	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Au	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Fe	2.42	2.61	2.66	2.18	3.58	2.12	2.55
As	57.59	59.78	60.45	60.91	54.96	60.58	59.64
Bi	0.00	0.35	0.00	0.00	0.00	0.40	0.70
Sb	1.08	0.87	0.17	0.00	0.37	0.40	0.40
S	35.64	34.31	32.52	33.61	33.64	30.65	29.82
Te	0.13	0.49	0.00	0.00	0.00	0.00	0.77
Se	0.82	0.58	0.87	0.00	0.17	0.00	0.16
Total	**99.48**	**98.99**	**99.11**	**99.61**	**100.00**	**99.35**	**99.99**
Atomic Proportions							
Cu	0.17	0.00	0.43	0.00	0.00	0.68	0.00
Pb	0.37	0.00	0.00	0.24	1.27	0.10	0.11
Tl	0.00	0.00	0.48	0.32	0.61	1.06	1.49
Ag	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Au	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Fe	2.21	2.40	2.49	2.03	3.40	2.05	2.51
As	39.27	41.02	42.24	42.33	38.89	43.76	43.82
Bi	0.00	0.15	0.00	0.00	0.00	0.18	0.31
Sb	0.26	0.21	0.04	0.00	0.09	0.10	0.11
S	56.80	55.02	53.09	54.58	55.63	51.73	51.20
Te	0.05	0.20	0.00	0.00	0.00	0.00	0.33
Se	0.53	0.38	0.58	0.00	0.11	0.00	0.11
Formula ignoring Fe (and correcting for S in pyrite) (based on 5 atoms in formula: As_2S_3							
Cu	0.01	0.00	0.02	0.00	0.00	0.03	0.00
Pb	0.02	0.00	0.00	0.01	0.06	0.01	0.01
Tl	0.00	0.00	0.02	0.02	0.03	0.05	0.07
Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Au	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.11	0.12	0.13	0.10	0.17	0.10	0.13
Total M	**0.14**	**0.12**	**0.17**	**0.13**	**0.26**	**0.20**	**0.21**
As	1.97	2.06	2.13	2.13	1.94	2.20	2.19
Bi	0.00	0.01	0.00	0.00	0.00	0.01	0.02
Sb	0.01	0.01	0.00	0.00	0.00	0.01	0.01
Total Me	**1.98**	**2.08**	**2.13**	**2.13**	**1.95**	**2.21**	**2.21**
S	2.85	2.77	2.67	2.74	2.78	2.60	2.56
Te	0.00	0.01	0.00	0.00	0.00	0.00	0.02
Se	0.03	0.02	0.03	0.00	0.01	0.00	0.01
Total S,Se,Te	**2.88**	**2.80**	**2.70**	**2.74**	**2.79**	**2.60**	**2.58**

Table 8 Microanalysis of Tl-bearing phases (sample LD-14J and LD-14J2)

	LD-14 J2			LD-14J		LD-14 J2	
	a1&2.gr2.p2	**p5**	**p6**	**p17**	**p18**	**a1&2gr3.p1**	**p3**
Analysis (wt. %)							
Pb	25.65	18.71	38.07	4.96	0.18	59.43	56.66
Tl	**38.86**	**35.44**	**24.51**	**20.10**	**34.52**	**17.55**	**22.89**
Cu	0.00	0.88	0.31	0.18	0.05	0.14	0.31
Fe	22.12	26.92	18.68	49.98	42.86	5.21	4.72
As	0.13	0.04	0.17	0.87	1.73	5.65	5.50
Bi	1.14	1.96	1.79	0.00	0.00	0.00	0.00
Sb	0.00	0.00	0.00	0.18	0.29	0.77	0.60
S	12.02	15.65	15.90	23.27	19.35	10.60	8.39
Te	0.00	0.24	0.35	0.33	0.30	0.00	0.23
Se	0.08	0.15	0.22	0.09	0.19	0.32	0.23
Total	**100.00**	**99.99**	**100.00**	**99.96**	**99.47**	**99.67**	**99.53**
Atomic proportions							
Pb	11.33	7.16	15.91	1.36	0.05	32.32	33.21
Tl	17.39	13.75	10.38	5.58	10.69	9.67	13.60
Cu	0.00	1.10	0.42	0.16	0.05	0.26	0.59
Fe	36.20	38.21	28.96	50.75	48.57	10.51	10.26
As	0.16	0.05	0.20	0.66	1.46	8.50	8.91
Bi	0.50	0.74	0.74	0.00	0.00	0.00	0.00
Sb	0.00	0.00	0.00	0.08	0.15	0.71	0.60
S	34.29	38.69	42.92	41.17	38.20	37.24	31.78
Te	0.00	0.15	0.24	0.15	0.15	0.00	0.22
Se	0.09	0.15	0.24	0.07	0.15	0.45	0.35
Formula (to 12 atoms)							
Pb	1.36	0.86	1.91	0.16	0.01	3.89	4.00
Tl	2.09	1.65	1.25	0.67	1.29	1.16	1.64
Cu	0.00	0.13	0.05	0.02	0.01	0.03	0.07
Fe	4.35	4.59	3.47	6.09	5.86	1.27	1.24
As	0.02	0.01	0.02	0.08	0.18	1.02	1.07
Bi	0.06	0.09	0.09	0.00	0.00	0.00	0.00
Sb	0.00	0.00	0.00	0.01	0.02	0.09	0.07
S	4.12	4.64	5.15	4.94	4.61	4.48	3.83
Te	0.00	0.02	0.03	0.02	0.02	0.00	0.03
Se	0.01	0.02	0.03	0.01	0.02	0.05	0.04

Table 9 Microanalysis of native gold and electrum (sample LD-14J and LD-14J2)

	LD-14J2											LD-14J	
	a1/2.gr1.p2	p2(re)	gr8.p1	p2	p3	p4	a12.gr3.p1	p2	p3	gr4.p1	p2	a3.gr5.p3	a2.gn.p2
Analysis (wt. %)													
Au	91.89	90.95	96.96	94.40	87.56	87.12	71.25	62.93	60.41	68.83	84.39	82.07	44.74
Ag	4.33	3.63	1.66	1.56	1.66	1.52	27.04	33.17	33.60	27.21	11.17	13.41	52.99
Cu	0.82	0.00	0.00	0.00	0.00	0.37	0.34	0.50	0.00	0.50	0.28	0.61	0.00
Pb	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92
Bi	0.17	0.00	0.26	0.00	0.00	0.00	0.51	0.20	0.62	0.54	0.50	0.00	0.45
As	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Sb	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
S	0.14	0.00	0.16	0.43	3.20	3.88	0.23	0.00	0.39	0.00	0.71	0.09	0.00
Te	0.00	0.36	0.00	0.80	0.48	0.08	0.00	0.57	0.00	0.47	0.00	0.76	0.00
Total	**97.35**	**97.00**	**99.04**	**97.19**	**92.90**	**92.97**	**99.37**	**97.37**	**95.02**	**97.55**	**97.05**	**96.94**	**99.73**
Atomic Proportions													
Au	82.29	83.69	94.30	87.61	68.76	65.71	56.98	47.72	44.45	54.51	69.90	68.86	44.74
Ag	7.08	6.09	2.95	2.64	2.38	2.09	39.49	45.93	45.14	39.35	16.90	20.54	52.99
Cu	2.27	0.00	0.00	0.00	0.00	0.86	0.85	1.17	0.00	1.22	0.71	1.60	0.00
Pb	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60
Bi	0.14	0.00	0.24	0.00	0.00	0.00	0.39	0.14	0.43	0.54	0.39	0.00	0.29
As	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
Sb	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47
S	0.78	0.00	0.98	2.45	15.43	17.97	1.15	0.00	1.76	0.00	3.64	0.48	0.00
Te	0.00	0.52	0.00	1.15	0.58	0.09	0.00	0.20	0.00	0.58	0.00	0.98	0.00
Formulae													
Au	0.889	0.901	0.958	0.934	0.789	0.758	0.576	0.501	0.484	0.567	0.764	0.745	0.450
Ag	0.076	0.066	0.030	0.028	0.027	0.024	0.399	0.483	0.492	0.409	0.185	0.222	0.533
Cu	0.025	0.000	0.000	0.000	0.000	0.010	0.009	0.012	0.000	0.013	0.008	0.017	0.000
Pb	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
Bi	0.002	0.000	0.002	0.000	0.000	0.000	0.004	0.001	0.005	0.006	0.004	0.000	0.003
As	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Sb	0.000	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
S	0.008	0.000	0.010	0.026	0.177	0.207	0.012	0.000	0.019	0.000	0.040	0.005	0.000
Te	0.000	0.006	0.000	0.012	0.007	0.001	0.000	0.002	0.000	0.006	0.000	0.011	0.000
% gold	**92.08**	**93.22**	**96.97**	**97.07**	**96.65**	**96.92**	**59.06**	**50.96**	**49.61**	**58.08**	**80.53**	**77.02**	**45.78**
% silver	**7.92**	**6.78**	**3.03**	**2.93**	**3.35**	**3.08**	**40.94**	**49.04**	**50.39**	**41.92**	**19.47**	**22.98**	**54.22**

Table 10 Microanalysis of hessite, petzite and stuetzite (sample LD-14J)

	hessite		petzite				stuetzite			
	LD-14J		LD-14J				LD-14J			
	a2.gn.p1	p4	a2.gn.p3	a3.gr5.p4	p5	p6	p1filter5	a3.gr5.p1	p2	p7
Analysis (wt. %)										
Ag	60.49	60.58	40.82	42.65	43.89	40.83	54.65	55.79	55.60	58.02
Au	0.13	0.16	22.27	20.05	17.23	19.33	2.41	2.98	4.87	2.95
Cu	0.36	0.51	0.52	0.22	0.28	0.33	0.18	0.34	0.00	0.17
Pb	0.35	0.08	0.00	0.00	0.00	0.00	0.00	0.11	0.42	0.25
Fe	0.01	0.26	0.00	1.37	1.57	1.60	1.44	0.80	1.14	0.93
Tl	0.00	0.37	1.22	0.00	1.28	1.69	0.90	0.96	0.00	0.00
As	0.00	0.32	1.04	0.40	0.80	0.00	0.03	0.00	0.36	0.00
Sb	0.60	0.00	0.04	0.26	0.00	0.97	0.76	0.80	0.00	0.00
Bi	0.26	0.23	0.25	0.16	0.15	0.39	0.05	0.07	0.26	0.00
Te	37.54	36.69	33.54	34.46	33.52	33.92	38.93	37.23	36.99	37.32
Se	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.12	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.26	0.37
Total	**99.86**	**99.20**	**99.70**	**99.89**	**98.72**	**99.06**	**99.35**	**99.08**	**99.90**	**100.01**
Atomic Proportions										
Ag	63.98	63.69	48.54	48.67	50.06	47.07	58.65	59.50	59.44	61.31
Au	0.08	0.09	14.50	12.53	10.77	12.20	1.40	1.74	2.85	1.70
Cu	0.65	0.91	1.04	0.43	0.55	0.64	0.32	0.62	0.00	0.30
Pb	0.19	0.04	0.00	0.00	0.00	0.29	0.00	0.06	0.23	0.14
Fe	0.01	0.53	0.00	3.02	3.46	3.56	2.96	2.70	2.35	1.91
Tl	0.00	0.20	0.76	0.00	0.77	1.03	0.50	0.54	0.00	0.00
Bi	0.00	0.17	0.64	0.23	0.47	0.00	0.02	0.00	0.20	0.00
Sb	0.57	0.00	0.04	0.27	0.00	0.99	0.71	0.75	0.00	0.00
As	0.40	0.34	0.43	0.26	0.24	0.65	0.07	0.10	0.40	0.00
Te	33.57	32.61	33.71	33.24	32.33	33.05	34.94	33.57	33.43	33.34
Se	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.44	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.92	1.31
Formulae (ignoring Fe and Cu)										
(based on 3 atoms in formula: Ag_2Te)			**(based on 6 atoms in formula: Ag_3AuTe_2)**				**(based on 8 atoms in formula: Ag_5Te_3)**			
Ag	1.93	1.97	2.95	3.03	3.17	2.96	4.87	4.94	4.88	5.02
Au	0.00	0.00	0.88	0.78	0.68	0.77	0.12	0.14	0.23	0.14
Pb	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.01
Tl	0.00	0.01	0.05	0.00	0.05	0.06	0.04	0.04	0.00	0.00
Bi	0.00	0.01	0.04	0.01	0.03	0.00	0.00	0.00	0.02	0.00
Sb	0.02	0.00	0.00	0.02	0.00	0.06	0.06	0.06	0.00	0.00
As	0.01	0.01	0.03	0.02	0.02	0.04	0.01	0.01	0.03	0.00
Total M	**1.97**	**1.99**	**3.95**	**3.85**	**3.95**	**3.92**	**5.10**	**5.21**	**5.18**	**5.17**
Te	1.01	1.01	2.05	2.07	2.05	2.08	2.90	2.79	2.74	2.73
Se	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.08	0.11
Total S,Se,Te	**1.03**	**1.01**	**2.05**	**2.15**	**2.05**	**2.08**	**2.90**	**2.79**	**2.82**	**2.83**

Table 11 Microanalysis of pyrrhotite, chalcopyrite & Ni-Co-pyrrhotite phase (Sample LD-2H)

	pyrrhotite		chalcopyrite			thiopspinel phase				
	p5	p4	gr2.p3	p11	a4.gr1.p6	gr1.p9	gr2.p2	p4	p5	p6
Analysis (wt. %)										
Ag	0.00	0.14	0.00	0.00	0.00	0.88	0.33	0.00	0.07	0.00
Cu	0.00	0.17	35.41	34.67	33.99	0.32	0.00	0.13	0.42	0.26
Tl	3.66	0.00	0.85	1.00	0.00	1.20	0.04	0.00	0.00	0.07
Fe	60.40	62.32	30.26	30.33	31.48	48.56	43.33	48.26	41.58	46.52
Ni	0.43	0.28	0.23	0.51	0.00	5.32	12.08	8.76	15.30	9.37
Co	0.06	0.17	0.07	0.00	0.04	5.37	6.03	4.34	5.50	4.01
Pt	0.37	0.20	0.00	0.09	0.34	0.06	0.19	0.20	0.28	0.37
As	0.00	0.00	0.68	0.80	0.00	0.00	0.00	0.02	0.01	0.00
Sb	0.26	0.18	0.00	0.00	0.00	0.23	0.00	0.19	0.00	0.07
Bi	0.96	0.00	0.54	0.70	0.65	0.08	0.68	0.31	0.44	0.24
S	33.56	36.39	30.85	31.35	33.21	37.90	37.11	37.38	35.76	37.31
Te	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.12	0.00	0.10
Total	99.70	99.85	98.89	99.45	99.78	99.92	99.79	99.71	99.36	98.32
Atomic Proportions										
Ag	0.00	0.06	0.00	0.00	0.00	0.36	0.14	0.00	0.03	0.00
Cu	0.00	0.12	26.60	25.95	24.96	0.22	0.00	0.09	0.30	0.18
Tl	0.83	0.00	0.20	0.23	0.00	0.26	0.01	0.00	0.00	0.02
Fe	49.90	49.22	25.87	25.83	26.30	38.54	34.47	38.17	33.33	36.91
Ni	0.55	0.21	0.19	0.42	0.00	4.02	9.14	6.59	11.66	7.07
Co	0.04	0.13	0.06	0.00	0.03	4.04	4.55	3.26	4.18	3.01
Pt	0.09	0.04	0.00	0.02	0.08	0.01	0.04	0.05	0.06	0.08
As	0.00	0.00	0.43	0.51	0.00	0.00	0.00	0.01	0.00	0.00
Sb	0.10	0.06	0.00	0.00	0.00	0.08	0.00	0.07	0.00	0.02
Bi	0.21	0.00	0.12	0.16	0.15	0.02	0.14	0.07	0.09	0.05
S	48.28	50.06	45.93	46.52	48.35	52.39	51.44	51.49	49.92	51.55
Te	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.04
Formula ignoring Ag, Cu, Fe and Ni										
(based on S = 1)			**(based on S = 2)**			**(based on S = 4)**				
Ag	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00
Cu	0.00	0.00	1.16	1.12	1.03	0.02	0.00	0.01	0.02	0.01
Tl	0.02	0.00	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00
Fe	1.03	0.98	1.13	1.11	1.09	2.94	2.68	2.96	2.67	2.86
Ni	0.01	0.00	0.01	0.02	0.00	0.31	0.71	0.51	0.93	0.55
Co	0.00	0.00	0.00	0.00	0.00	0.31	0.35	0.25	0.33	0.23
Pt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total M	**1.06**	**0.99**	**2.30**	**2.25**	**2.12**	**3.62**	**3.76**	**3.74**	**3.97**	**3.67**
As	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Sb	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
Bi	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00
S	1.00	1.00	2.00	2.00	2.00	4.00	4.00	4.00	4.00	4.00
Te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total (S,Te)	**1.00**	**1.00**	**2.01**	**2.01**	**2.01**	**4.00**	**4.01**	**4.01**	**4.01**	**4.00**

Table 12 Microanalysis of pentlandite (Sample LD-2H)

	a4.gr1.p1	p2	p3	p4	p7	p8	p9	gr2.p1	p2	p3
Analysis (wt. %)										
Ag	0.00	1.57	0.00	0.00	0.22	0.02	0.09	0.00	0.00	0.29
Cu	0.00	0.00	0.40	0.00	0.00	0.13	0.36	0.39	0.00	0.19
Tl	0.00	0.00	1.06	0.86	0.00	1.18	2.31	3.69	0.90	0.40
Fe	28.30	28.75	30.90	28.61	28.26	28.34	29.37	28.17	28.98	30.94
Ni	32.22	31.32	28.75	32.93	32.28	32.11	31.11	30.43	32.44	30.11
Co	8.38	6.66	6.89	5.49	6.90	5.90	6.21	6.96	5.98	6.03
Pt	0.00	0.00	0.33	0.00	0.15	0.00	0.20	0.41	0.21	0.10
Cd	0.00	0.00	0.00	0.24	0.00	0.29	0.03	0.00	0.00	0.10
As	0.00	0.05	0.00	0.00	0.00	0.08	0.00	0.04	0.00	0.01
Sb	0.02	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
Bi	0.00	0.00	0.40	0.00	0.00	0.67	0.71	0.78	0.38	0.63
S	30.78	31.18	30.66	30.69	30.65	29.28	29.51	28.32	30.46	30.24
Te	0.29	0.11	0.00	0.00	0.00	0.00	0.00	0.21	0.28	0.00
Total	**99.99**	**99.87**	**99.39**	**98.82**	**98.46**	**98.00**	**99.90**	**99.40**	**99.85**	**99.04**
Atomic Proportions										
Ag	0.00	0.67	0.00	0.00	0.09	0.01	0.04	0.29	0.00	0.13
Cu	0.00	0.00	0.75	0.00	0.00	0.10	0.27	0.29	0.00	0.14
Tl	0.00	0.00	0.24	0.20	0.00	0.27	0.54	0.87	0.21	0.09
Fe	23.46	23.89	25.84	23.87	23.51	24.04	24.97	24.42	24.28	25.96
Ni	25.40	24.76	22.87	26.14	25.54	25.90	25.16	25.10	25.85	24.03
Co	6.58	5.24	5.46	4.34	5.44	4.74	5.00	5.72	4.75	4.79
Pt	0.00	0.00	0.08	0.00	0.03	0.00	0.05	0.10	0.05	0.02
Cd	0.00	0.00	0.00	0.10	0.00	0.12	0.01	0.00	0.00	0.04
As	0.00	0.03	0.00	0.00	0.00	0.05	0.00	0.03	0.00	0.01
Sb	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
Bi	0.00	0.00	0.09	0.00	0.00	0.15	0.16	0.18	0.09	0.14
S	44.44	45.14	44.66	44.60	44.40	43.25	43.70	42.77	44.46	44.19
Te	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.08	0.10	0.00
Formula (based on argentopentlandite formula $Ag(Fe,Ni,Co)_8S_9$)										
Ag	0.00	0.11	0.00	0.00	0.01	0.00	0.01	0.05	0.00	0.02
Cu	0.00	0.00	0.12	0.00	0.00	0.02	0.04	0.05	0.00	0.02
Tl	0.00	0.00	0.04	0.03	0.00	0.04	0.09	0.14	0.03	0.01
Fe	3.81	3.94	4.21	3.93	3.87	3.92	4.01	3.87	3.96	4.23
Ni	4.12	4.08	3.73	4.30	4.21	4.22	4.04	3.98	4.22	3.92
Co	1.07	0.86	0.89	0.71	0.90	0.77	0.80	0.91	0.78	0.78
Pt	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.00
Cd	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.01
Total M	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**
As	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Sb	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Bi	0.00	0.00	0.01	0.00	0.00	0.02	0.03	0.03	0.01	0.02
S	7.21	7.45	7.28	7.34	7.32	7.05	7.02	6.78	7.26	7.20
Te	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00
Total (S,Te)	**7.21**	**7.45**	**7.28**	**7.34**	**7.32**	**7.05**	**7.02**	**6.78**	**7.26**	**7.20**

Table 13 Microanalysis of argentian pentlandite (Sample LD-2H)

	area 2.gr1.p	p2	p3	p4	p5	p6	p7	p8	p10	gr2.p1	p7	p8
Analysis (wt. %)												
Ag	11.92	13.40	11.92	12.36	13.28	12.88	12.75	12.71	13.17	12.52	13.40	13.19
Cu	0.21	0.27	0.06	0.16	0.28	0.48	0.91	0.00	0.00	0.34	0.57	0.89
Tl	7.09	2.72	7.09	2.57	0.00	0.00	2.83	0.00	0.00	1.08	0.00	1.81
Fe	35.79	38.00	35.79	37.39	38.05	37.07	35.88	37.49	37.56	36.70	36.63	36.51
Ni	18.43	17.87	18.43	17.88	18.18	17.45	18.97	19.21	15.83	19.72	15.88	18.24
Co	0.20	0.00	0.20	0.00	0.16	0.58	0.03	0.00	0.00	0.00	0.34	0.00
Pt	0.00	0.06	0.00	0.28	0.26	0.40	0.46	0.31	0.00	0.24	0.00	0.18
Cd	0.00	0.00	0.00	0.00	0.15	0.01	0.41	0.00	0.26	0.00	0.13	0.00
As	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.20	0.00	0.00	0.00	0.09
Sb	0.08	0.00	0.08	0.44	0.23	0.20	0.00	0.15	0.04	0.19	0.16	0.00
Bi	0.21	0.28	0.21	0.79	0.21	0.43	0.20	0.12	0.00	0.70	0.48	0.55
S	25.36	27.40	25.36	27.89	29.18	29.21	27.47	28.99	28.98	28.04	29.10	27.33
Te	0.47	0.00	0.47	0.23	0.00	0.03	0.00	0.35	0.15	0.05	0.17	0.00
Total	**99.76**	**100.00**	**99.61**	**99.99**	**99.98**	**98.76**	**99.91**	**99.53**	**95.99**	**99.58**	**96.86**	**98.79**
Atomic Proportions												
Ag	5.81	6.26	5.81	5.78	6.04	5.87	5.97	5.79	5.99	5.78	6.11	6.17
Cu	0.05	0.21	0.05	0.12	0.22	0.37	0.72	0.00	0.00	0.27	0.44	0.71
Tl	1.82	0.67	1.82	0.63	0	0.00	0.70	0.00	0.00	0.26	0.00	0.45
Fe	33.68	34.31	33.68	33.74	33.44	32.64	32.48	32.96	33.00	32.75	32.27	33.00
Ni	16.49	15.35	16.49	15.35	15.2	14.62	16.34	16.07	15.83	16.73	15.88	15.68
Co	0.18	0	0.18	0	0.13	0.49	0.03	0.00	0.00	0.00	0.28	0.00
Pt	0	0.02	0	0.07	0.07	0.10	0.12	0.08	0.00	0.06	0.00	0.05
Cd	0	0	0	0	0.06	0.01	0.19	0.00	0.26	0.00	0.06	0.00
As	0	0	0	0	0	0.01	0.00	0.13	0.00	0.00	0.00	0.06
Sb	0.03	0	0.03	0.18	0.09	0.08	0.00	0.06	0.04	0.08	0.07	0.00
Bi	0.05	0.07	0.05	0.19	0.05	0.10	0.05	0.03	0.00	0.17	0.11	0.13
S	41.58	43.11	41.58	43.84	44.68	44.81	43.31	44.41	44.35	43.58	44.65	43.03
Te	0.19	0	0.19	0.09	0	0.01	0.00	0.13	0.06	0.02	0.06	0.00
Formula (based on argentopentlandite formula $Ag(Fe,Ni)_9S_8$)												
Ag	0.90	0.99	0.90	0.93	0.99	0.98	0.95	0.95	0.98	0.93	1.00	0.99
Cu	0.01	0.03	0.01	0.02	0.04	0.06	0.11	0.00	0.00	0.04	0.07	0.11
Tl	0.28	0.11	0.28	0.10	0.00	0.00	0.11	0.00	0.00	0.04	0.00	0.07
Fe	5.22	5.43	5.22	5.45	5.46	5.43	5.17	5.40	5.39	5.28	5.28	5.30
Ni	2.56	2.43	2.56	2.48	2.48	2.43	2.60	2.63	2.59	2.70	2.60	2.52
Co	0.03	0.00	0.03	0.00	0.02	0.08	0.00	0.00	0.00	0.00	0.05	0.00
Pt	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.01	0.00	0.01
Cd	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.04	0.00	0.01	0.00
Total M	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**
As	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01
Sb	0.00	0.00	0.00	0.03	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
Bi	0.01	0.01	0.01	0.03	0.01	0.02	0.01	0.00	0.00	0.03	0.02	0.02
S	6.45	6.83	6.45	7.08	7.29	7.45	6.89	7.28	7.25	7.02	7.30	6.91
Te	0.03	0.00	0.03	0.01	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.00
Total S,Te	**6.45**	**6.83**	**6.45**	**7.08**	**7.29**	**7.45**	**6.89**	**7.28**	**7.25**	**7.02**	**7.30**	**6.91**

Table 13 continued Microanalysis of argentian pentlandite (Sample LD-2H)

	gr2.p9	p10	gr3.p1	p2	gr4.p1	p2	area x.p1	p2	gr10.p5
Analysis (wt. %)									
Ag	13.31	12.80	12.74	12.34	12.24	13.48	13.60	13.46	12.05
Cu	0.00	0.00	0.42	1.04	0.65	0.46	0.28	0.47	0.72
Tl	0.74	0.00	0.00	0.00	0.04	0.29	0.00	0.17	0.00
Fe	37.94	37.04	36.81	37.66	37.45	37.34	35.46	34.99	38.39
Ni	18.08	19.22	19.51	18.45	18.45	18.68	19.45	19.89	17.75
Co	0.04	0.00	0.00	0.46	0.00	0.00	0.00	0.30	0.00
Pt	0.00	0.09	0.03	0.16	0.29	0.08	0.06	0.06	0.00
Cd	0.00	0.00	0.00	0.00	0.00	0.22	0.24	0.00	0.00
As	0.00	0.06	0.06	0.01	0.00	0.00	0.00	0.02	0.00
Sb	0.07	0.00	0.04	0.19	0.05	0.16	0.00	0.00	0.08
Bi	0.00	0.13	0.33	0.00	0.50	0.38	0.28	0.59	0.43
S	29.00	28.97	29.10	29.59	28.82	28.48	29.62	28.85	29.48
Te	0.24	0.37	0.21	0.00	0.03	0.00	0.00	0.41	0.00
Total	**99.42**	**98.68**	**99.25**	**99.90**	**98.52**	**99.57**	**98.99**	**99.21**	**98.90**
Atomic Proportions									
Ag	6.08	5.83	5.79	5.57	5.58	6.18	6.18	6.17	5.46
Cu	0.00	0.00	0.32	0.80	0.50	0.36	0.22	0.37	0.55
Tl	0.09	0.00	0.00	0.00	0.01	0.07	0.00	0.04	0.00
Fe	33.46	32.58	32.32	32.82	32.98	33.06	31.14	30.98	33.59
Ni	15.17	16.08	16.30	15.29	15.45	15.73	16.25	16.75	14.77
Co	0.03	0.00	0.00	0.38	0.00	0.00	0.00	0.26	0.00
Pt	0.00	0.02	0.01	0.04	0.07	0.02	0.01	0.02	0.00
Cd	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00
As	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.01	0.00
Sb	0.03	0.00	0.02	0.08	0.02	0.07	0.00	0.00	0.03
Bi	0.00	0.03	0.08	0.00	0.12	0.09	0.07	0.14	0.10
S	44.55	44.38	44.51	44.91	44.21	43.93	45.32	44.51	44.93
Te	0.09	0.14	0.08	0.00	0.01	0.00	0.00	0.16	0.00
Formula (based on argentopentlandite formula $Ag(Fe,Ni)_9S_8$)									
Ag	1.00	0.96	0.95	0.91	0.92	1.00	1.03	1.02	0.90
Cu	0.00	0.00	0.05	0.13	0.08	0.06	0.04	0.06	0.09
Tl	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
Fe	5.49	5.38	5.31	5.38	5.44	5.36	5.20	5.11	5.56
Ni	2.49	2.65	2.68	2.51	2.55	2.55	2.71	2.76	2.44
Co	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.04	0.00
Pt	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Cd	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00
Total M	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**
As	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Sb	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00
Bi	0.00	0.00	0.01	0.00	0.02	0.01	0.01	0.02	0.02
S	7.31	7.33	7.32	7.36	7.29	7.12	7.57	7.34	7.44
Te	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.00
Total S,Te	**7.31**	**7.33**	**7.32**	**7.36**	**7.29**	**7.12**	**7.57**	**7.34**	**7.44**

Table 14 Microanalysis of hessite (Sample LD-2H)

	T1 xxx.re.p2	xxx.p1	p8	T6 tell2.p1	p2	p3	T2 ll.gr2.p2	T3 gr1.p2	p5	p6	T4 xx.gr1.p1	T5 gr2.p2	T7 gr7.p1	T8 gr8.p3	T9 gr9.p1
Analysis (wt. %)															
Ag	59.41	59.99	59.82	60.40	59.81	58.40	59.26	61.53	59.79	60.40	58.72	59.14	59.81	57.00	55.32
Au	0.09	0.00	0.00	0.44	0.00	0.00	0.10	0.13	0.21	0.44	0.02	0.16	0.00	0.00	0.19
Cu	0.00	0.74	0.34	0.00	1.76	1.41	0.00	0.00	0.00	0.00	0.00	0.00	1.71	1.65	1.99
Pb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.01	0.73
Fe	1.04	1.57	1.02	1.17	0.58	0.83	1.19	1.03	1.06	1.17	2.23	2.62	0.73	2.73	2.32
Tl	0.00	0.50	0.62	0.26	0.12	0.48	0.00	0.02	0.15	0.26	0.86	0.30	0.04	0.33	0.85
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.24	0.00	0.35	0.18	0.00
Pt	0.18	0.05	0.47	0.03	0.25	0.50	0.12	0.02	0.31	0.03	0.38	0.17	0.08	0.16	0.15
Bi	0.36	0.31	0.00	0.00	0.00	0.15	2.14	0.18	0.10	0.00	0.62	0.15	0.00	1.20	0.00
Sb	0.57	1.07	0.49	0.37	0.21	0.06	0.00	0.00	0.46	0.37	0.16	0.44	0.00	0.00	0.79
As	0.10	0.00	0.00	0.10	0.00	0.10	0.17	0.03	0.08	0.10	0.00	0.07	0.07	0.09	0.24
Te	37.43	34.63	36.81	35.55	37.01	36.09	36.30	36.74	36.66	35.55	36.25	36.56	36.05	35.04	34.99
Se	0.06		0.08	0.16	0.00	0.21	0.17	0.00	0.17	0.16	0.00	0.00	0.00	0.00	0.12
S	0.35	0.00	0.07	0.36	0.13	0.10	0.24	0.32	0.27	0.36	0.00	0.23	0.00	0.74	1.83
Total	99.59	98.86	99.72	98.84	99.87	98.33	99.69	100.00	99.46	98.84	99.48	99.84	99.09	99.13	99.52
Atomic Proportions															
Ag	61.84	62.00	62.76	62.48	62.10	60.52	62.18	64.15	62.27	62.48	61.24	60.89	61.75	57.01	54.44
Au	0.05	0.00	0.00	0.25	0.00	0.00	0.00	0.07	0.12	0.25	0.01	0.09	0.00	0.00	0.10
Cu	0.00	1.30	0.60	0.00	3.10	2.48	0.00	0.00	0.00	0.00	0.00	0.00	3.00	2.81	3.32
Pb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.14	0.00	0.00	0.00	0.14	0.01	0.38
Fe	2.10	3.13	2.06	2.34	1.16	1.66	2.42	2.08	2.14	2.38	4.48	5.20	1.46	5.27	4.40
Tl	0.00	0.27	0.34	0.14	0.07	0.26	0.00	0.01	0.08	0.14	0.47	0.16	0.02	0.18	0.44
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.46	0.00	0.66	0.33	0.00
Pt	0.10	0.03	0.27	0.02	0.14	0.29	0.07	0.01	0.18	0.02	0.22	0.10	0.05	0.09	0.08
Bi	0.19	0.16	0.00	0.00	0.00	0.08	1.16	0.10	0.05	0.00	0.34	0.08	0.00	0.62	0.00
Sb	0.53	0.98	0.45	0.34	0.20	0.05	0.00	0.00	0.43	0.34	0.15	0.40	0.00	0.00	0.69
As	0.14	0.00	0.00	0.14	0.00	0.16	0.25	0.04	0.12	0.14	0.00	0.10	0.10	0.13	0.35
Te	32.93	30.26	32.65	31.09	32.48	31.61	32.20	32.38	32.28	31.09	31.96	31.82	31.47	29.63	29.11
Se	0.09	0.00	0.12	0.23	0.00	0.29	0.25	0.00	0.24	0.23	0.00	0.00	0.00	0.00	0.16
S	1.23	0.00	0.24	1.24	0.46	0.36	0.84	1.14	0.94	1.24	0.00	0.80	0.00	2.50	6.07
Formula (based on 3 atoms in Ag2Te formula, ignoring Cu, Fe and Ni)															
Ag	1.91	1.99	1.94	1.95	1.95	1.94	1.92	1.97	1.89	1.95	1.95	1.93	1.98	1.90	1.78
Au	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Pb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.01
Tl	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
Pt	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Bi	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00
Sb	0.02	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.02
As	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total M	**1.94**	**2.03**	**1.98**	**1.98**	**1.96**	**1.97**	**1.97**	**1.97**	**1.98**	**1.98**	**1.98**	**1.96**	**1.99**	**1.93**	**1.85**
Te	1.02	0.97	1.01	0.97	1.02	1.01	1.00	0.99	0.98	0.97	1.02	1.01	1.01	0.99	0.95
Se	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01
S	0.04	0.00	0.01	0.04	0.01	0.01	0.03	0.03	0.03	0.04	0.00	0.03	0.00	0.08	0.20
Total S,Se,Te	**1.06**	**0.97**	**1.02**	**1.02**	**1.04**	**1.03**	**1.03**	**1.03**	**1.02**	**1.02**	**1.02**	**1.04**	**1.01**	**1.07**	**1.15**

Table 15 Microanalysis of laitakarite (Sample LD-2H)

	T1 xxx.re.p1	p3	p4	p5	xxx.p2	p3	p4	p5	p6	p7	p9
Analysis (wt. %)											
Ag	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Au	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cu	0.11	0.48	0.73	0.48	0.02	0.52	0.25	0.00	0.33	0.00	0.21
Pb	1.59	0.61	2.05	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	1.77	1.57	2.28	1.57	1.86	1.13	1.40	1.56	1.76	1.27	3.32
Tl	0.00	0.00	1.48	0.00	0.00	0.00	0.81	0.00	0.00	0.94	0.00
Ni	0.00	0.10	0.32	0.10	0.35	0.11	0.76	0.00	0.19	0.18	0.00
Pt	0.03	0.33	0.48	0.33	0.08	0.00	0.31	0.19	0.15	0.28	0.20
Bi	72.25	75.91	73.04	75.91	77.19	78.62	75.87	77.56	76.79	76.20	74.96
Sb	0.08	0.14	0.00	0.14	0.17	0.00	0.27	0.38	0.12	0.44	0.00
As	0.00	0.00	0.00	0.00	0.03	0.00	0.11	0.00	0.00	0.00	0.00
Te	9.38	9.03	8.40	9.03	8.85	8.00	8.83	8.90	8.76	9.26	9.76
Se	9.32	9.10	8.79	9.10	9.18	9.33	8.80	9.19	9.68	9.18	9.52
S	2.07	2.40	1.43	2.40	2.12	2.30	2.16	2.18	1.92	2.05	1.74
Total	96.92	99.67	99.00	99.67	99.85	100.01	99.57	99.96	99.70	99.80	99.71
Atomic Proportions											
Ag	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Au	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cu	0.27	1.12	1.74	1.12	0.05	1.23	0.58	0.00	0.79	0.00	0.49
Pb	1.16	0.43	1.49	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	4.78	4.18	6.17	4.18	5.02	3.07	3.76	4.24	4.74	3.47	8.75
Tl	0.00	0.00	1.10	0.00	0.00	0.00	0.59	0.00	0.00	0.70	0.00
Ni	0.00	0.26	0.82	0.26	0.91	0.28	0.76	0.00	0.48	0.47	0.00
Pt	0.03	0.25	0.37	0.25	0.06	0.00	0.24	0.15	0.11	0.22	0.15
Bi	54.40	53.89	52.72	53.89	55.50	57.10	54.43	56.40	55.16	55.51	52.78
Sb	0.10	0.17	0.00	0.17	0.21	0.00	0.34	0.48	0.15	0.54	0.00
As	0.00	0.00	0.00	0.00	0.06	0.00	0.22	0.00	0.00	0.00	0.00
Te	11.11	10.49	9.94	10.49	10.42	9.52	10.38	10.60	10.30	11.04	11.25
Se	17.83	17.10	16.80	17.10	17.46	17.93	16.71	17.68	18.41	17.70	17.75
S	9.77	11.10	6.72	11.10	9.95	10.87	10.10	10.32	9.00	9.72	8.01
Formula (based on 7 atoms in general formula $Bi_4(S,Se,Te)_3$) ignoring Cu, Fe and Ni											
Ag	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Au	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pb	0.09	0.03	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tl	0.00	0.00	0.09	0.00	0.00	0.00	0.04	0.00	0.00	0.05	0.00
Pt	0.00	0.02	0.03	0.02	0.00	0.00	0.02	0.01	0.01	0.02	0.01
Bi	4.01	4.04	4.14	4.04	4.15	4.19	4.10	4.13	4.15	4.07	4.11
Sb	0.01	0.01	0.00	0.01	0.02	0.00	0.03	0.04	0.01	0.04	0.00
As	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Total M	**4.14**	**4.10**	**4.37**	**4.10**	**4.17**	**4.19**	**4.20**	**4.17**	**4.17**	**4.18**	**4.12**
Te	0.82	0.79	0.78	0.79	0.78	0.70	0.78	0.78	0.77	0.81	0.88
Se	1.32	1.28	1.32	1.28	1.30	1.32	1.26	1.29	1.38	1.30	1.38
S	0.72	0.83	0.53	0.83	0.74	0.80	0.76	0.76	0.68	0.71	0.62
Total (S,Se,Te)	**2.86**	**2.90**	**2.63**	**2.90**	**2.83**	**2.81**	**2.80**	**2.83**	**2.83**	**2.82**	**2.88**

Table 16 Microanalysis of pilsenite, selenian pilsenite and tsumoite (Sample LD-2H)

	Pilsenite			Selenian pilsenite			Tsumoite (?)		
	T8		T11	T2			T7		
	gr8.p1	p2	gr11.p1	tell.re.gr2.p	p2	p3	gr7.p2	p3	p4
Analysis (wt. %)									
Ag	0.17	0.35	0.00	0.63	0.00	0.89	1.07	5.04	2.08
Cu	2.02	3.07	5.55	0.00	0.00	0.00	4.03	2.46	2.28
Pb	0.00	0.00	1.57	2.95	3.30	2.59	0.00	0.05	0.71
Fe	1.37	1.82	5.05	1.28	1.62	1.78	3.86	1.82	2.26
Tl	0.00	0.00	0.00	2.13	0.68	0.18	0.00	0.00	1.85
Ni	0.28	0.19	0.06	0.43	0.22	0.11	0.06	0.00	0.00
Pt	0.08	0.10	0.10	0.43	0.14	0.00	0.15	0.35	0.44
Bi	67.51	67.88	68.41	69.89	69.63	69.04	60.58	62.16	55.95
Sb	0.21	0.26	0.00	0.00	0.00	0.28	0.49	0.00	0.00
As	0.13	0.09	0.04	0.11	0.04	0.12	0.18	0.15	0.00
Te	24.20	23.03	14.72	14.34	15.04	14.89	23.81	24.15	31.33
Se	3.20	2.75	0.49	7.35	8.02	7.72	2.90	2.43	2.09
S	0.49	0.50	2.78	0.24	0.70	0.84	2.65	0.84	0.92
Total	99.66	100.04	98.77	99.78	99.39	98.44	99.78	99.45	99.91
Atomic Proportions									
Ag	0.24	0.50	0.00	0.94	0.00	1.27	1.32	6.94	2.84
Cu	4.96	7.46	11.86	0.00	0.00	0.00	8.44	5.77	5.28
Pb	0.00	0.00	1.03	2.31	2.49	1.92	0.00	0.03	0.50
Fe	3.83	5.05	12.26	3.72	4.53	4.89	9.21	4.84	5.94
Tl	0.00	0.00	0.00	1.69	0.52	0.14	0.00	0.00	1.33
Ni	0.74	0.51	0.13	1.20	0.58	0.28	0.14	0.00	0.00
Pt	0.07	0.08	0.07	0.35	0.12	0.00	0.10	0.27	0.33
Bi	50.50	50.21	44.40	54.29	52.13	50.73	38.60	44.23	39.34
Sb	0.27	0.26	0.00	0.00	0.00	0.35	0.53	0.00	0.00
As	0.27	0.18	0.08	0.25	0.07	0.24	0.32	0.31	0.00
Te	29.65	27.90	15.65	18.24	18.44	17.92	24.85	28.14	36.08
Se	6.34	5.38	0.85	15.11	15.89	15.02	4.90	4.57	3.90
S	2.37	2.43	11.77	1.20	3.41	4.02	11.02	3.91	4.22
Formula ignoring Ag, Cu, Fe and Ni									
(based on 7 atom formulae $Bi_4(S,Se,Te)_3$)							**to 6 atom formulae $Bi_3(S,Se,Te)_3$)**		
Pb	0.00	0.00	0.10	0.17	0.19	0.15	0.00	0.00	0.04
Tl	0.00	0.00	0.00	0.13	0.04	0.01	0.00	0.00	0.09
Pt	0.01	0.01	0.01	0.03	0.01	0.00	0.01	0.02	0.02
Bi	3.95	4.07	4.21	4.07	3.92	3.93	2.88	3.26	2.75
Sb	0.02	0.02	0.00	0.00	0.00	0.03	0.04	0.00	0.00
As	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.00
Total M	**4.00**	**4.11**	**4.32**	**4.41**	**4.16**	**4.14**	**2.95**	**3.30**	**2.91**
Te	2.32	2.26	1.48	1.37	1.39	1.39	1.86	2.07	2.53
Se	0.50	0.44	0.08	1.13	1.20	1.16	0.37	0.34	0.27
S	0.18	0.19	0.96	0.09	0.24	0.30	0.74	0.27	0.28
Total (S,Se,Te)	**2.99**	**2.88**	**2.52**	**2.59**	**2.83**	**2.85**	**2.96**	**2.68**	**3.08**

Table 17 Microanalysis of stuetzite or unknown Ag_4Te_2S (Sample LD-2H)

	T9 gr9.p2	T10 gr10.p1	p4
Analysis (wt. %)			
Ag	53.55	46.03	49.43
Cu	1.20	5.21	2.02
Pb	1.63	1.56	1.42
Fe	1.63	5.69	3.82
Tl	1.63	0.65	1.34
Ni	0.00	0.05	1.03
Pt	0.59	0.23	0.37
Bi	0.00	0.00	0.00
Sb	0.09	0.06	0.05
As	1.55	0.51	1.41
Te	32.27	29.77	28.64
Se	0.56	0.10	0.37
S	3.92	5.27	4.08
Total	98.62	95.13	93.98
Atomic Proportions			
Ag	50.21	38.78	43.47
Cu	1.90	7.44	3.01
Pb	0.79	0.68	0.65
Fe	4.50	9.27	6.49
Tl	0.62	0.29	0.62
Ni	0.00	0.08	1.66
Pt	0.30	0.11	0.18
Bi	0.00	0.00	0.00
Sb	0.08	0.04	0.04
As	2.09	0.62	1.79
Te	25.58	21.20	21.29
Se	0.72	0.12	0.45
S	12.36	14.93	12.07
Formula ignoringFormula ignoring Cu, Fe and Ni (based on 7 atom formulae Ag_4Te_2S			
Ag	3.79	3.54	3.78
Pb	0.06	0.06	0.06
Tl	0.05	0.03	0.05
Pt	0.02	0.01	0.02
Bi	0.00	0.00	0.00
Sb	0.01	0.00	0.00
As	0.15	0.05	0.14
Total M	**4.08**	**3.69**	**4.05**
Te	1.93	1.93	1.85
Se	0.05	0.01	0.04
S	0.90	1.22	0.96
Total (S,Se,Te)	**2.88**	**3.16**	**2.85**

Fig. 1 Free native gold / electrum within quartz in sulphide-rich ores.

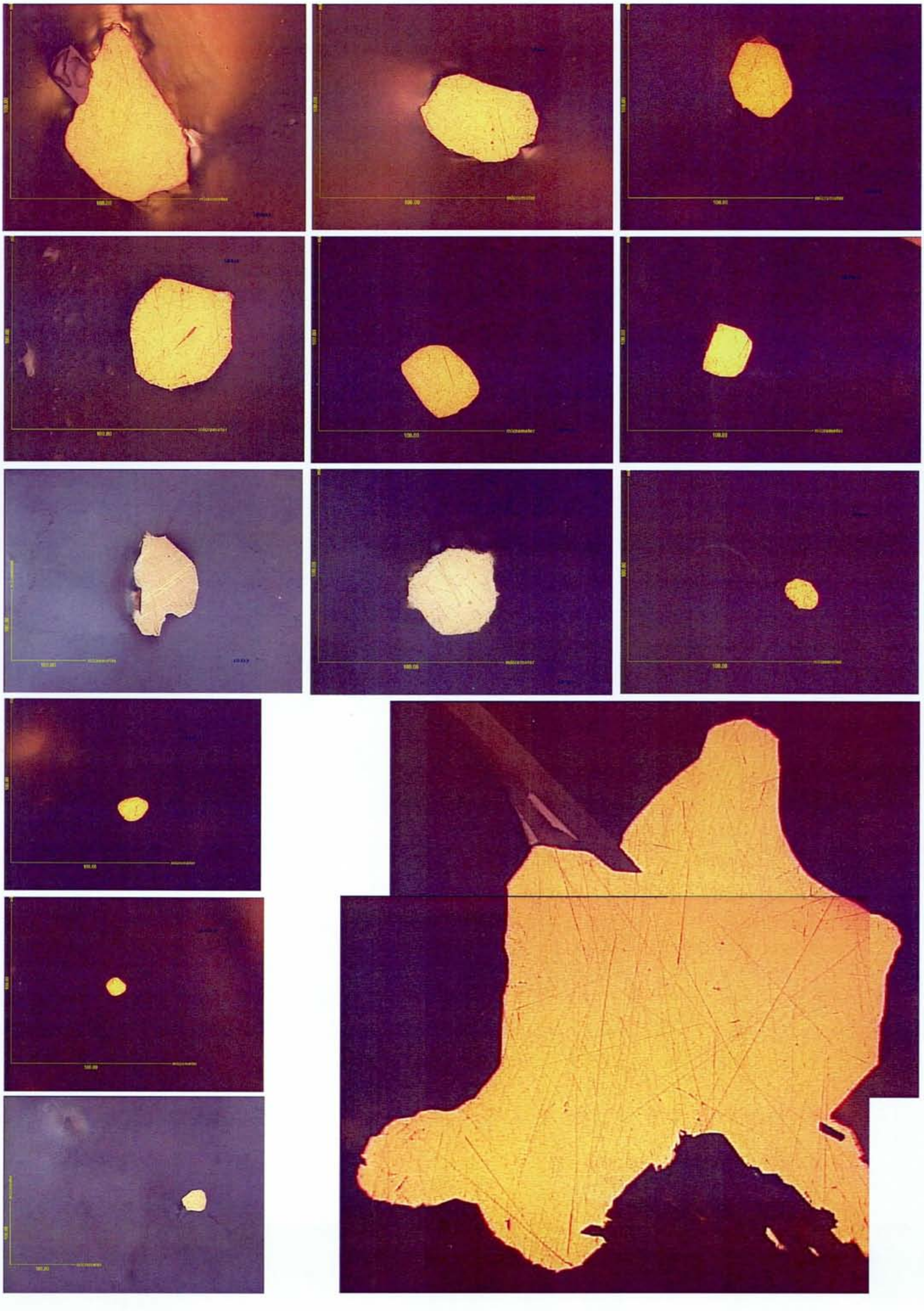


Fig. 2 Free native gold / electrum enclosed or combined with chalcopyrite (cp) or galena (gn). mpo: monoclinic pyrrhotite. Dark matrix is quartz.

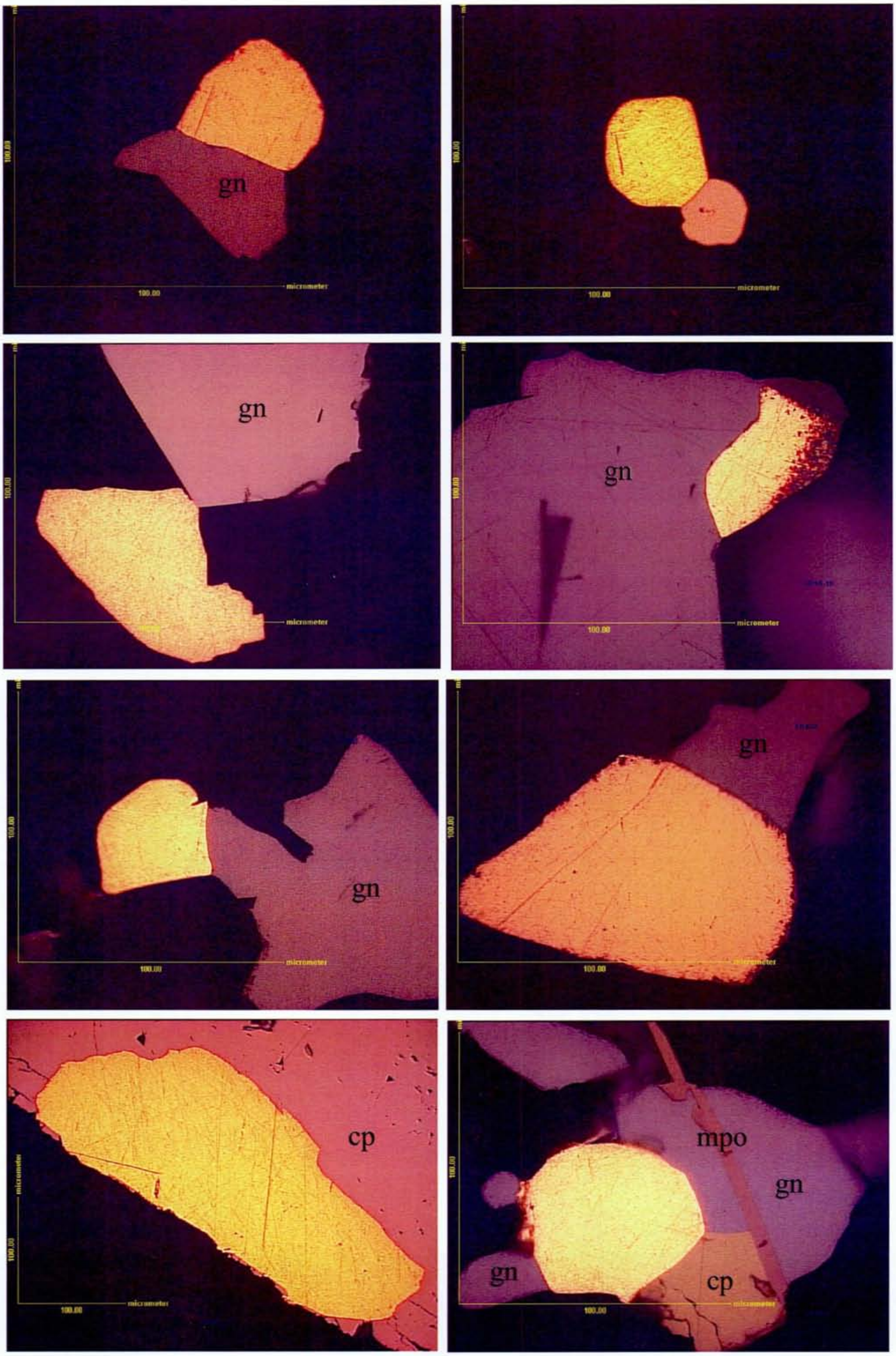


Fig. 3 Free native gold / electrum enclosed or combined with chalcopyrite (cp) or galena (gn). Note silver-rich rims to several of the grains. sph: sphalerite. Dark matrix is quartz.

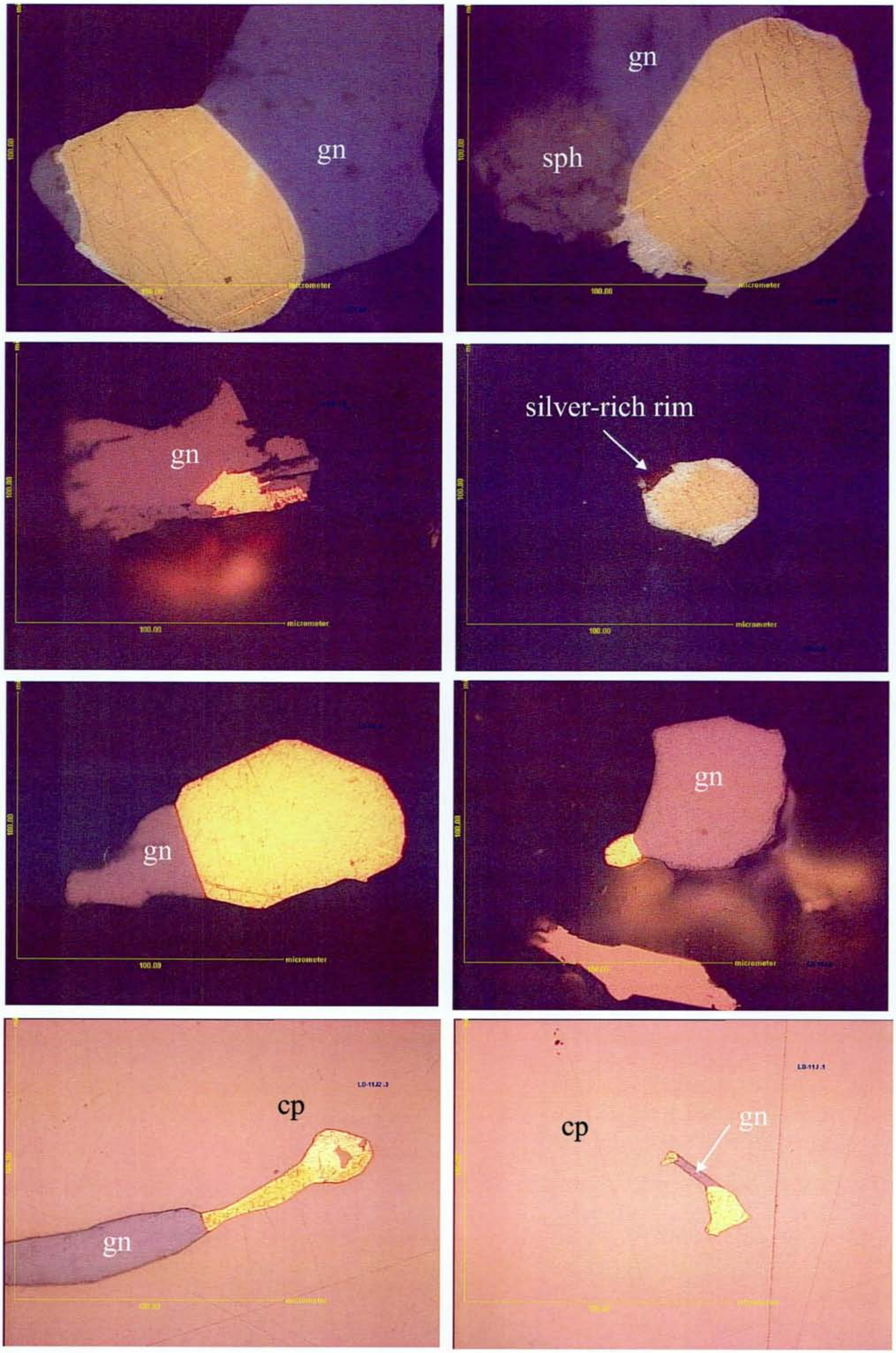


Fig. 4 Free native gold / electrum associated with chalcopyrite (cp), galena (gn) or pyrrhotite (po). Dark matrix is quartz.

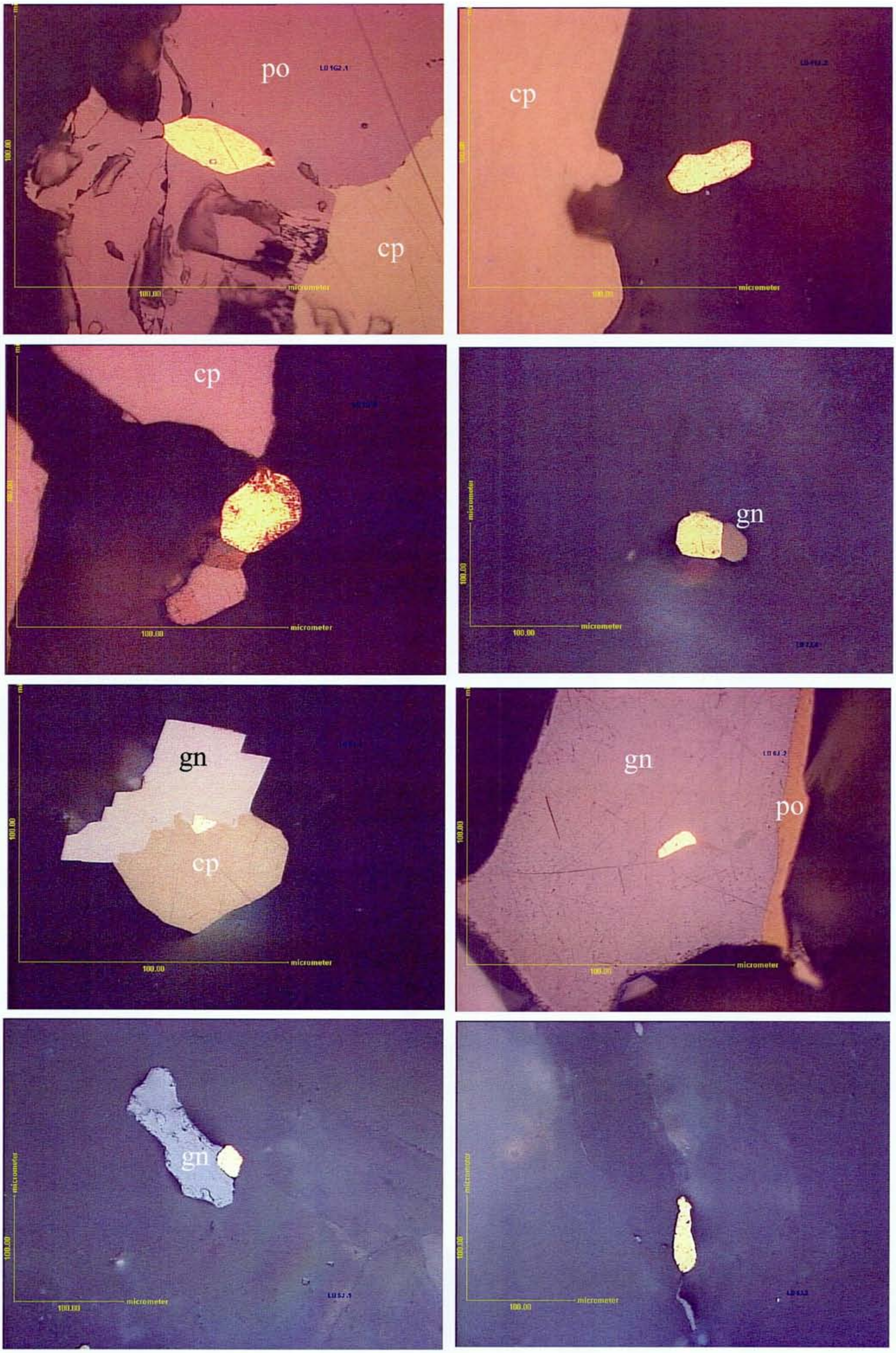


Fig. 5 Other assemblages in Lega Dembi ores. mrs: marcasite, py: pyrite, po: pyrrhotite, apy: arsenopyrite, gn: galena, tnn: tennantite, duf: dufrenoysite, jo: jordanite, cp: cvhalcopyrite, sph: sphalerite.

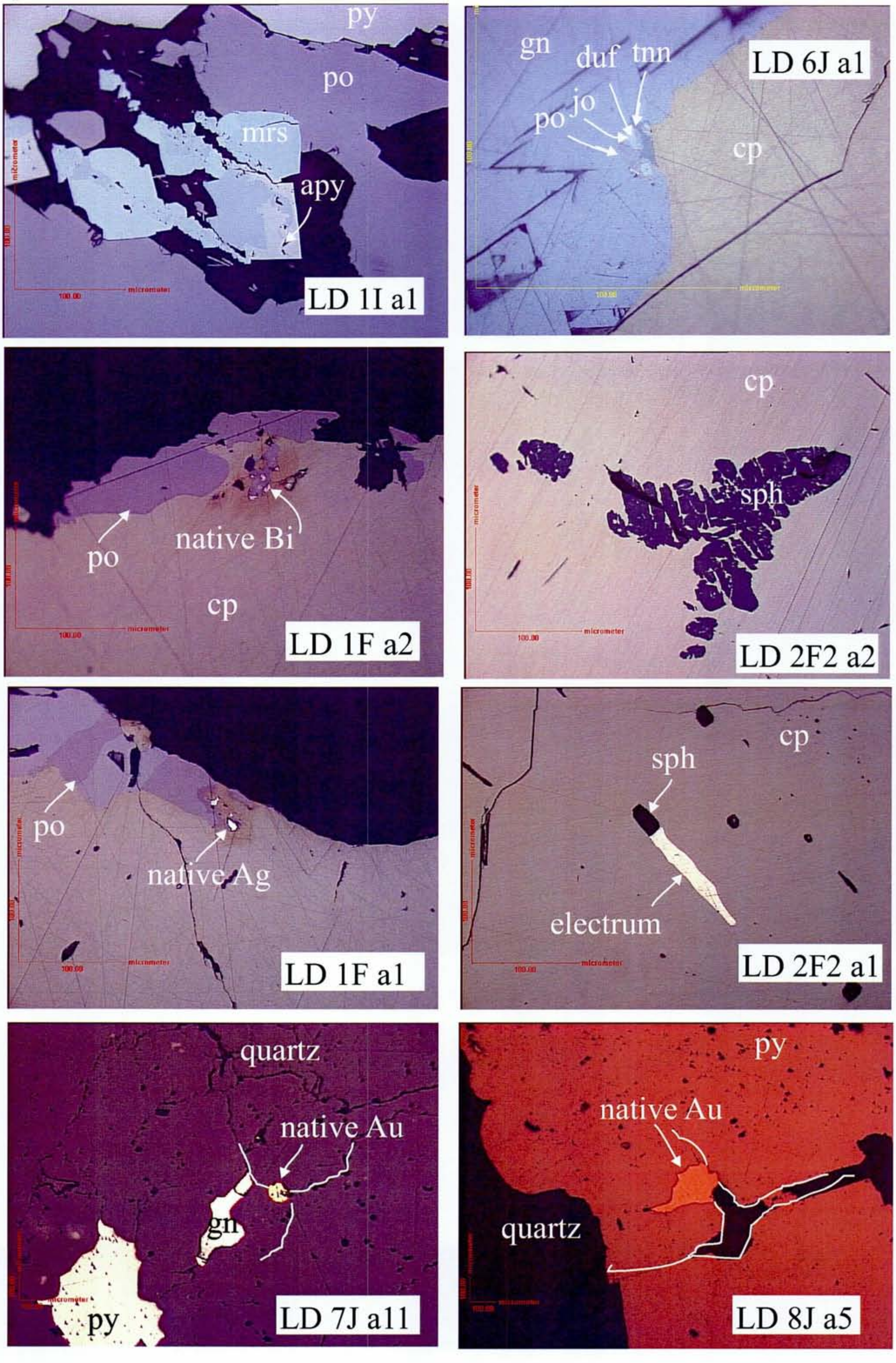


Fig. 6

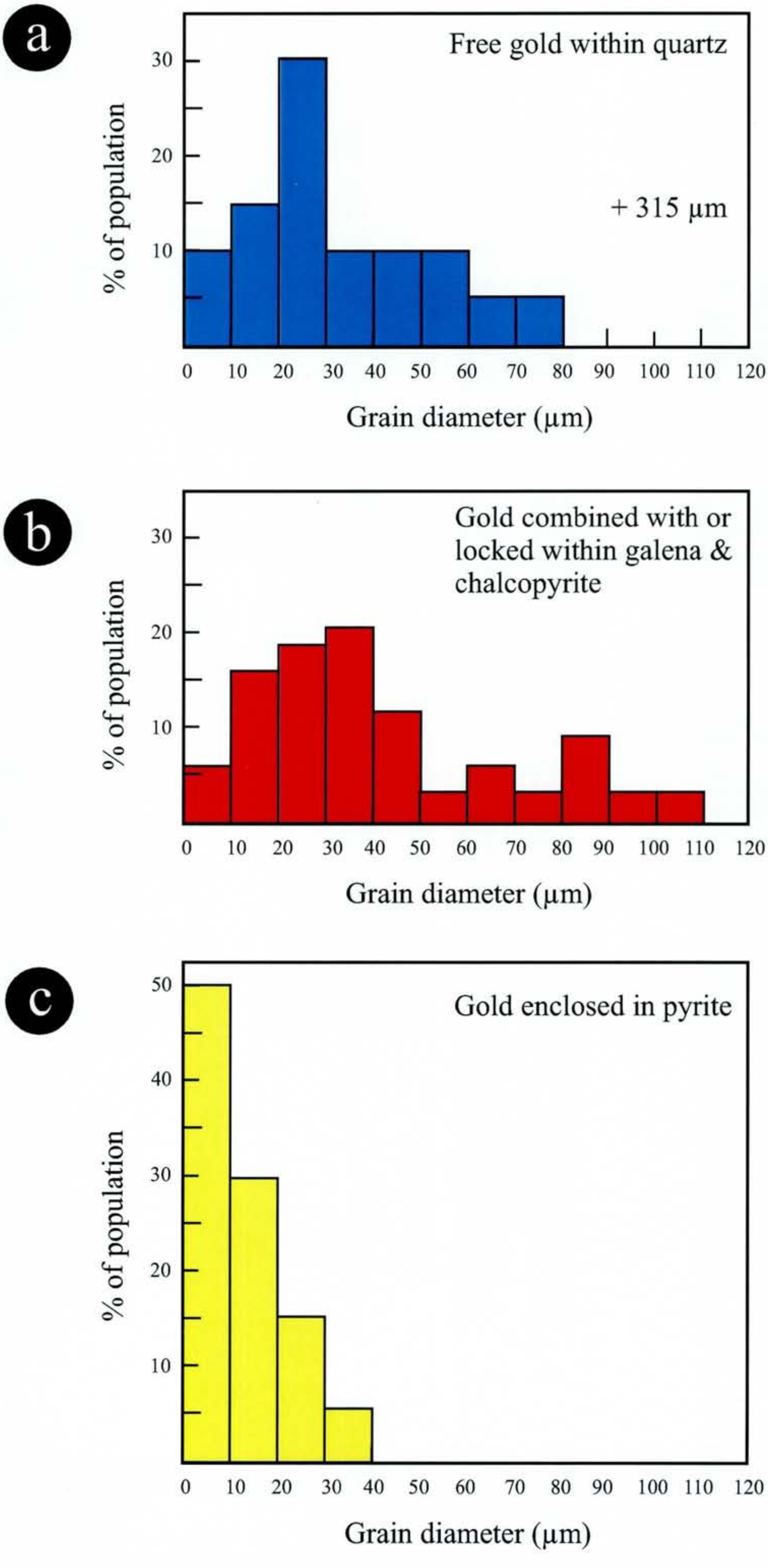

a
Free gold within quartz
+ 315 µm
% of population
30
20
10
0 10 20 30 40 50 60 70 80 90 100 110 120
Grain diameter (µm)
b
Gold combined with or locked within galena & chalcopyrite
% of population
30
20
10
0 10 20 30 40 50 60 70 80 90 100 110 120
Grain diameter (µm)
c
Gold enclosed in pyrite
% of population
50
40
30
20
10
0 10 20 30 40 50 60 70 80 90 100 110 120
Grain diameter (µm)

Fig. 7 Pb-As sulphosalts and associated minerals, including electrum and petzite within inclusions in pyrite. po: pyrrhotite, co: chalcopyrite, apy: arsenopyrite, gn: galena, py: pyrite, tnn: tennantite, duf: dufrenoysite, jo: jordanite.

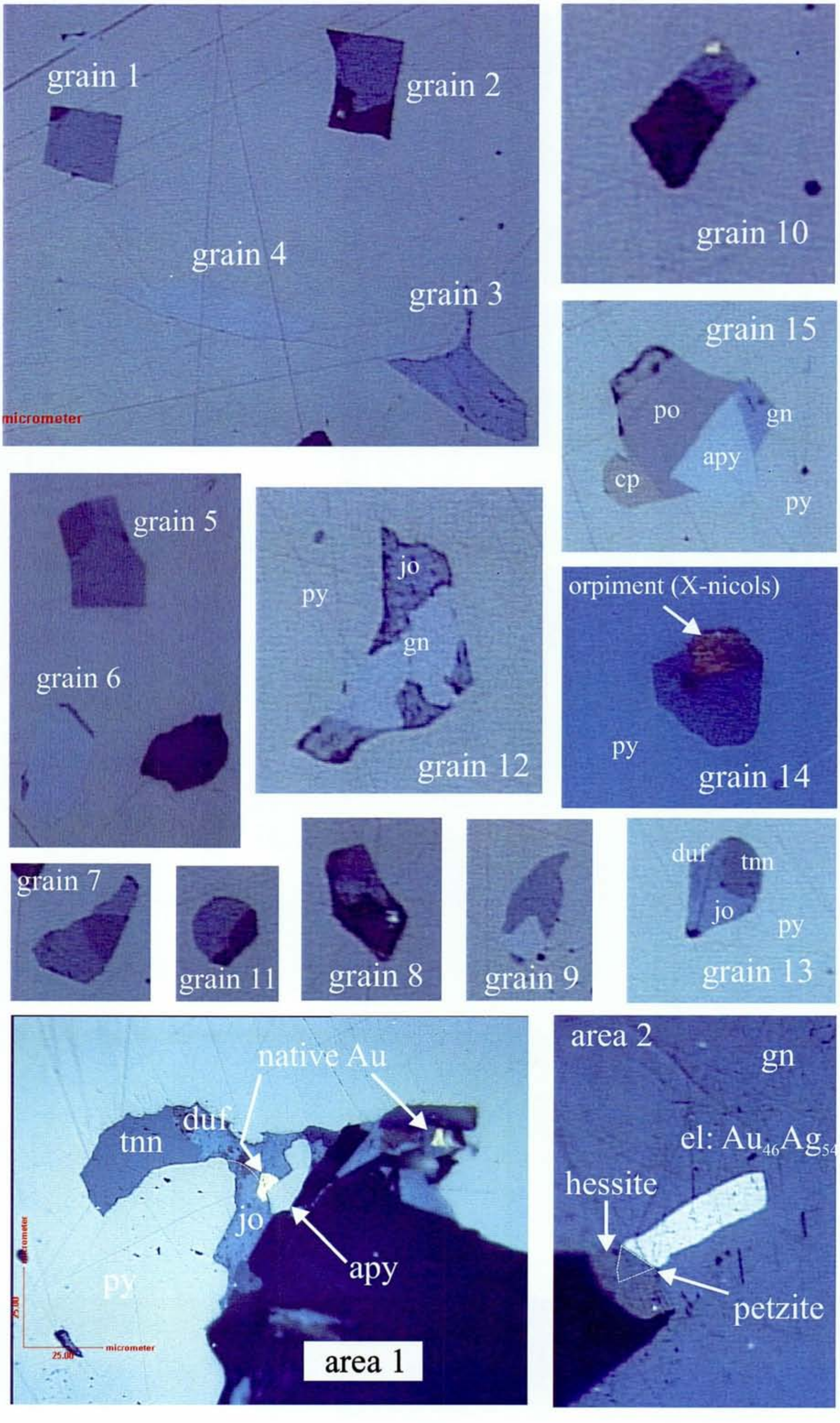


Fig. 8 Assemblages within sulphide-quartz ores containing gold minerals(electrum and petzite). apy: arsenopyrite, tnn: tennantite, duf: dufrenoysite, py: pyrite, jo: jordanite, gn: galena, qz: quartz.

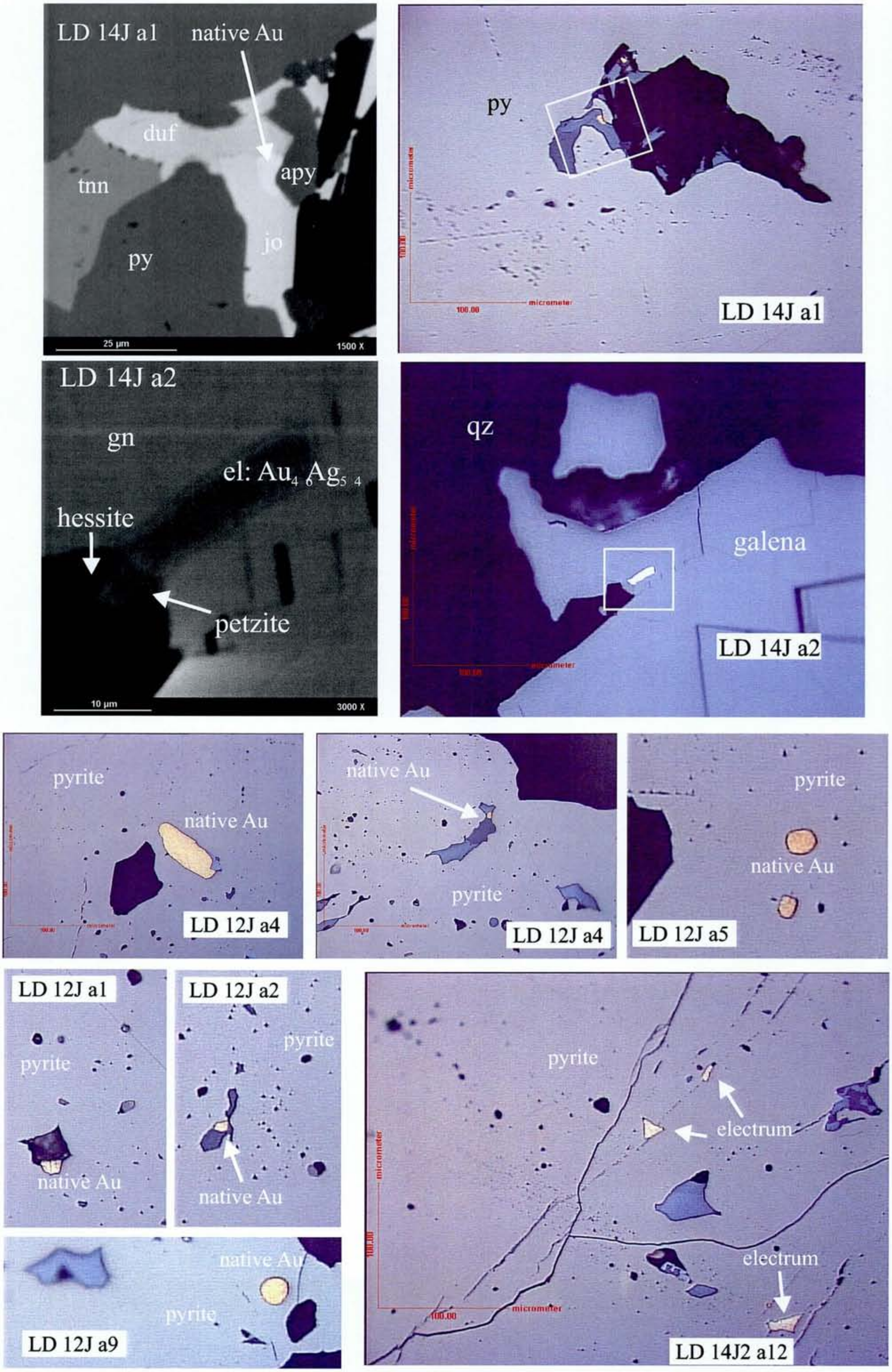


Fig. 9 Assemblages enclosed in pyrite within sulphide-quartz ores. po: pyrrhotite, apy: arsenopyrite, tnn: tennantite, py: pyrite, jo: jordanite, gn: galena.

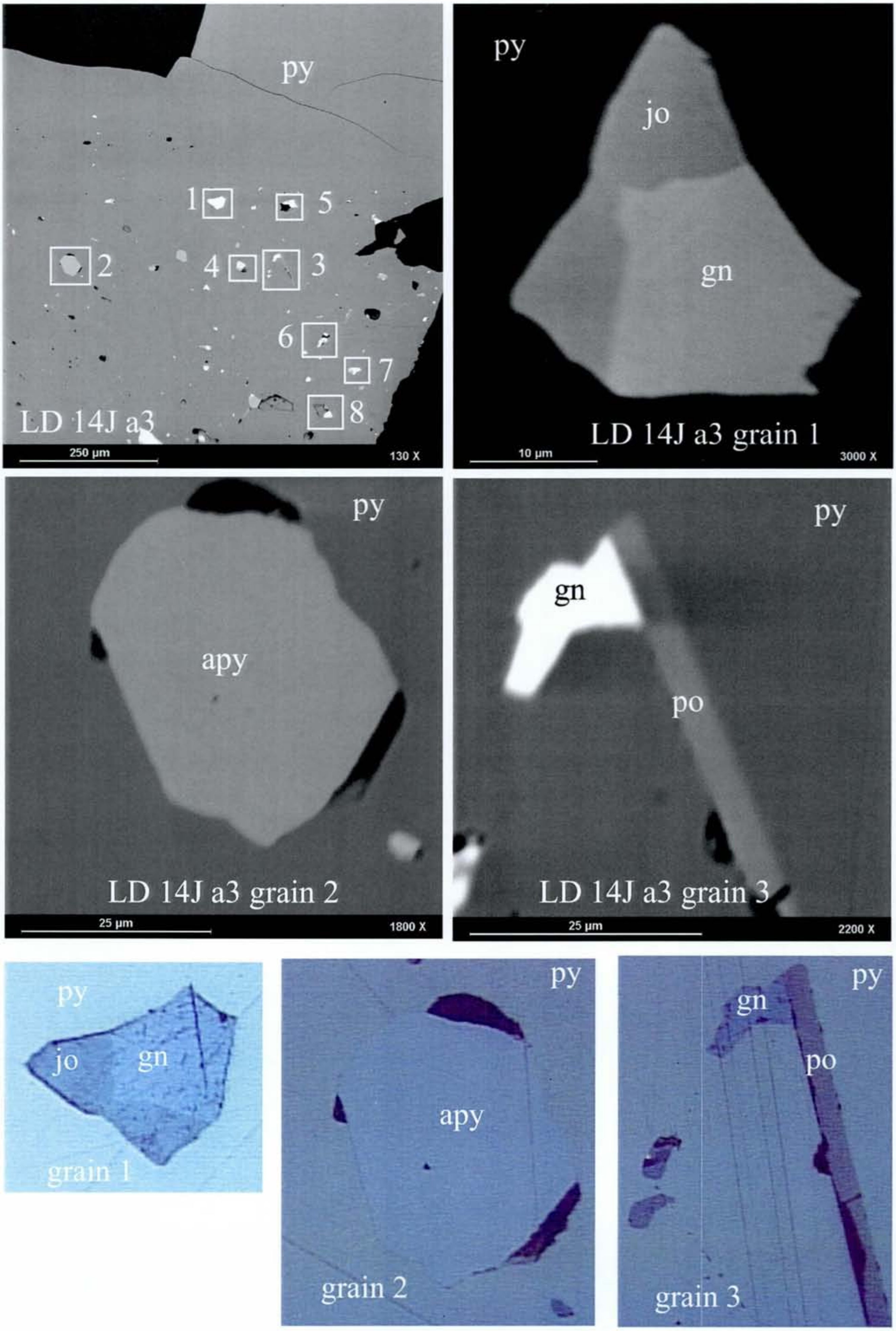


Fig. 10 Assemblages enclosed in pyrite within sulphide-quartz ores. orp: orpiment, jo: jordanite, duf: dufrenoysite, py: pyrite, gn: galena, Au: native gold, tnn: tennantite, apy: arsenopyrite.

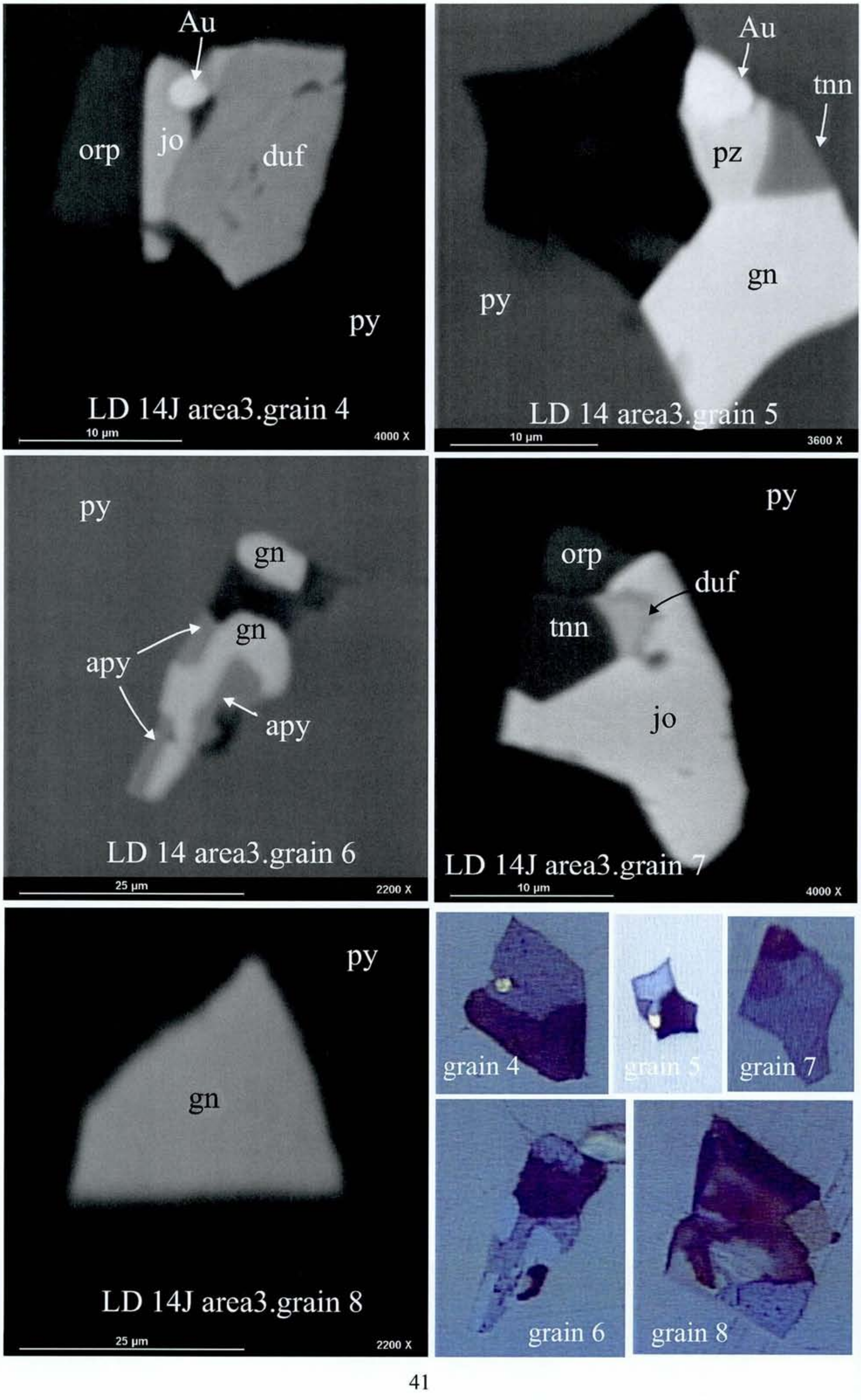


Fig. 11 Assemblages enclosed in pyrite within sulphide-quartz ores. jo: jordanite, apy: arsenopyrite, tnn: tennantite, py: pyrite, duf: dufrenoysite, Pz: petzite, Au: native gold.

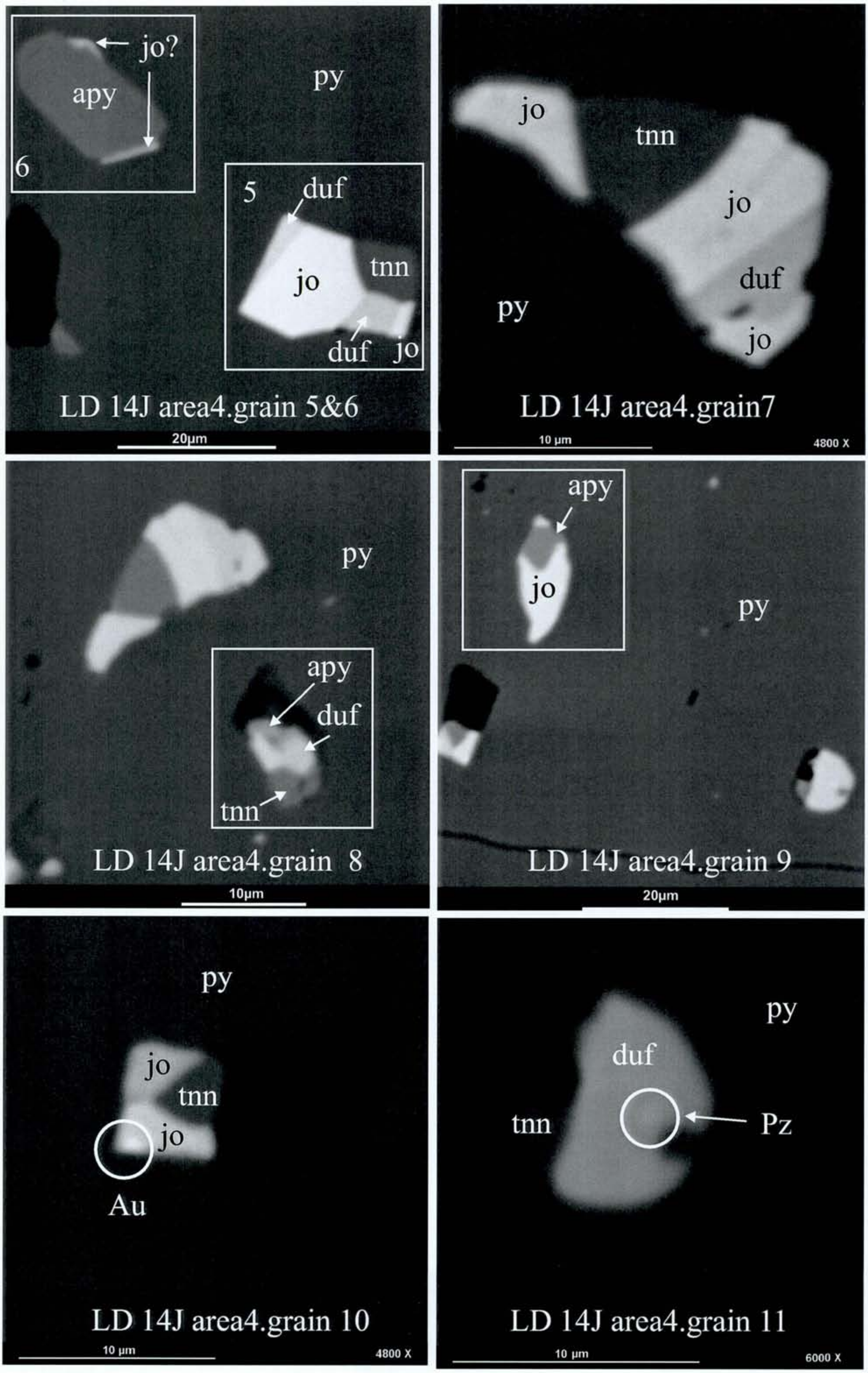


Fig. 12 Assemblages enclosed in pyrite within sulphide-quartz ores. jo: jordanite, apy: arsenopyrite, tnn: tennantite, gn: galena, py: pyrite, duf: dufrenoysite, orp: orpiment, hs: hessite, pz: petzite.

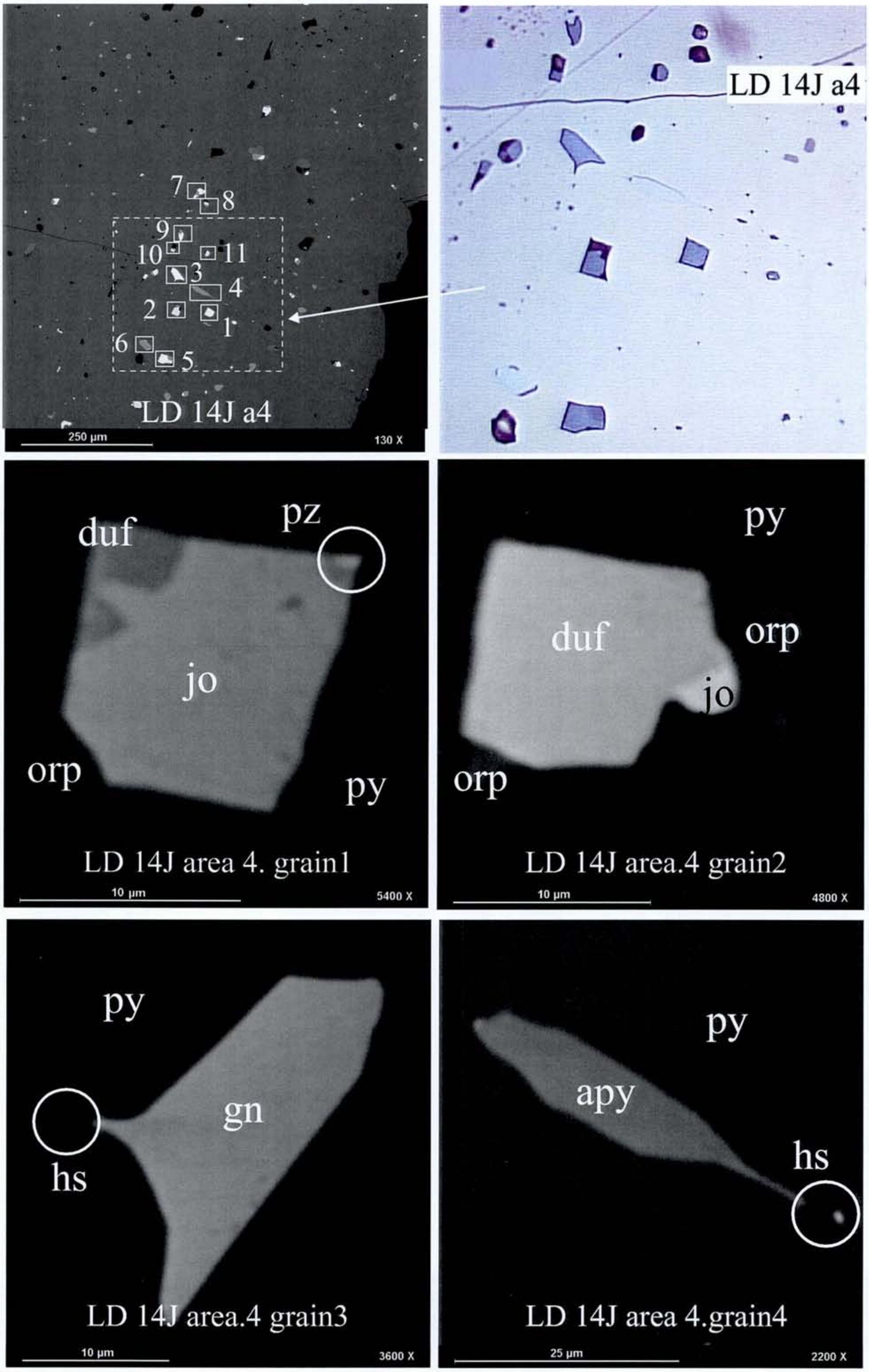


Fig. 13 Assemblages enclosed in pyrite within sulphide-quartz ores. jo: jordanite, apy: arsenopyrite, tnn: tennantite, py: pyrite, el: electrum.

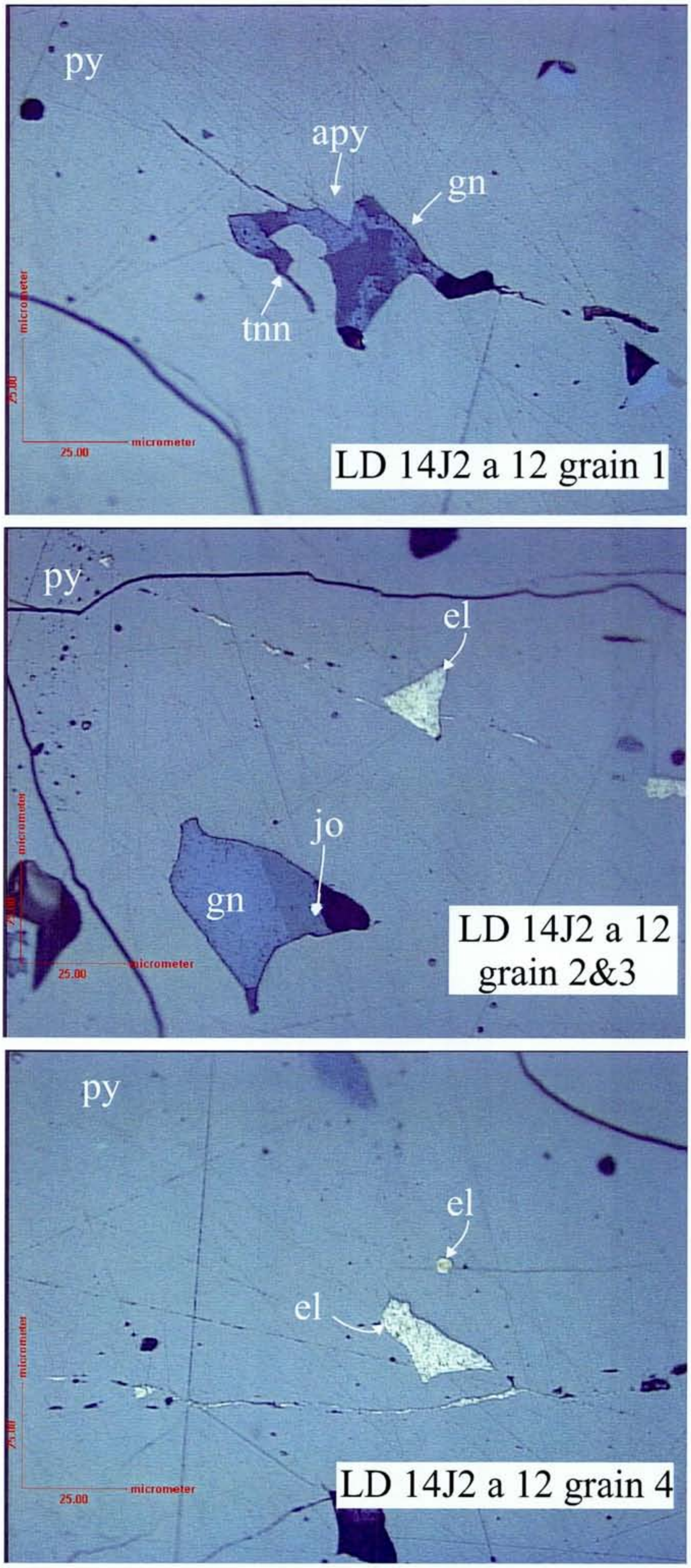


Fig. 14 Assemblages enclosed in pyrite within sulphide-quartz ores, including those hosting native gold. jo: jordanite, tnn: tennantite, py: pyrite, apy: arsenopyrite.

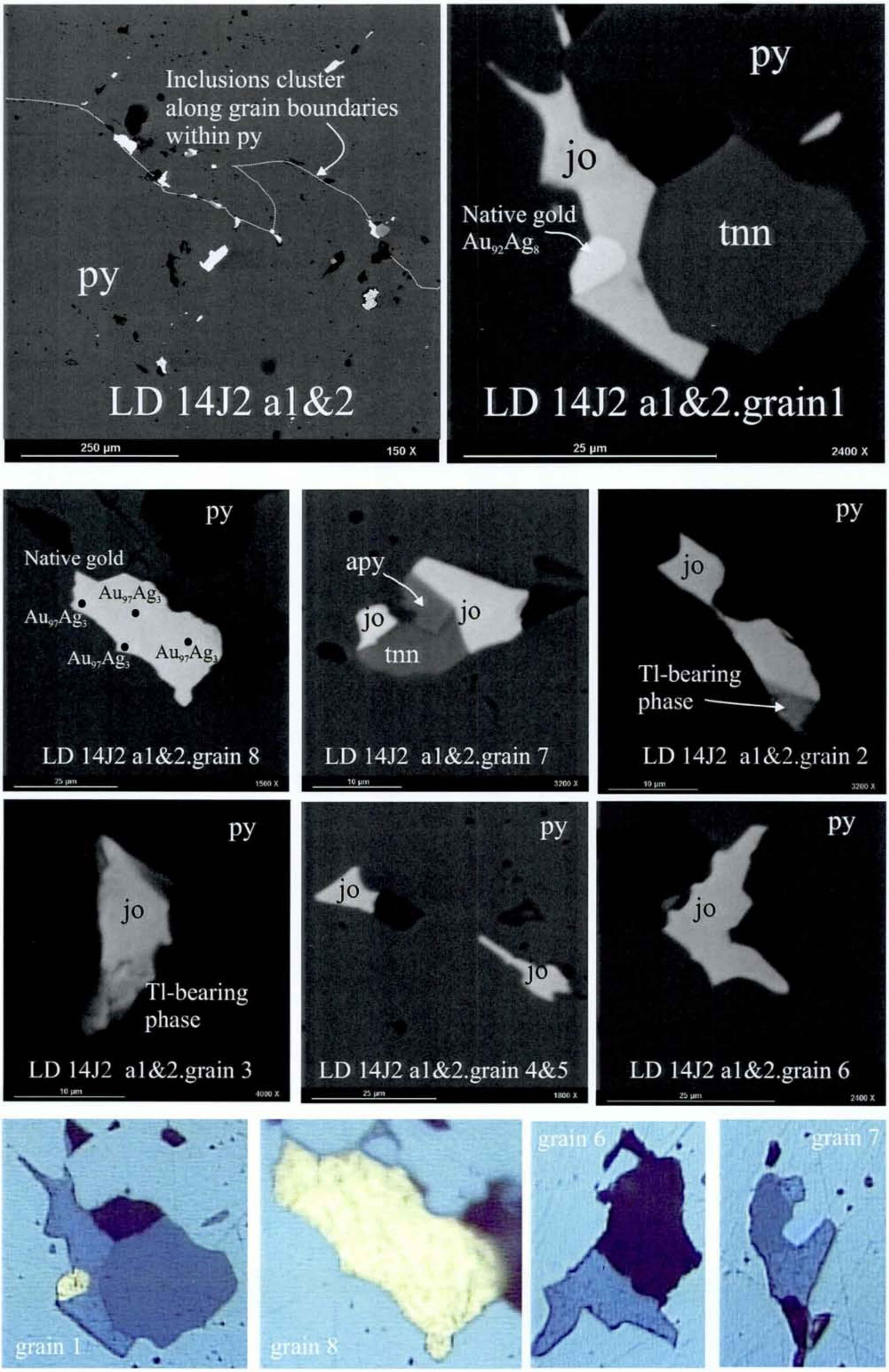


Fig. 15 Assemblages enclosed in pyrite within sulphide-quartz ores, including those hosting native gold. py: pyrite, gn: galena, apy: arsenopyrite, cp: chalcopyrite, sph: sphalerite, jo: jordanite.

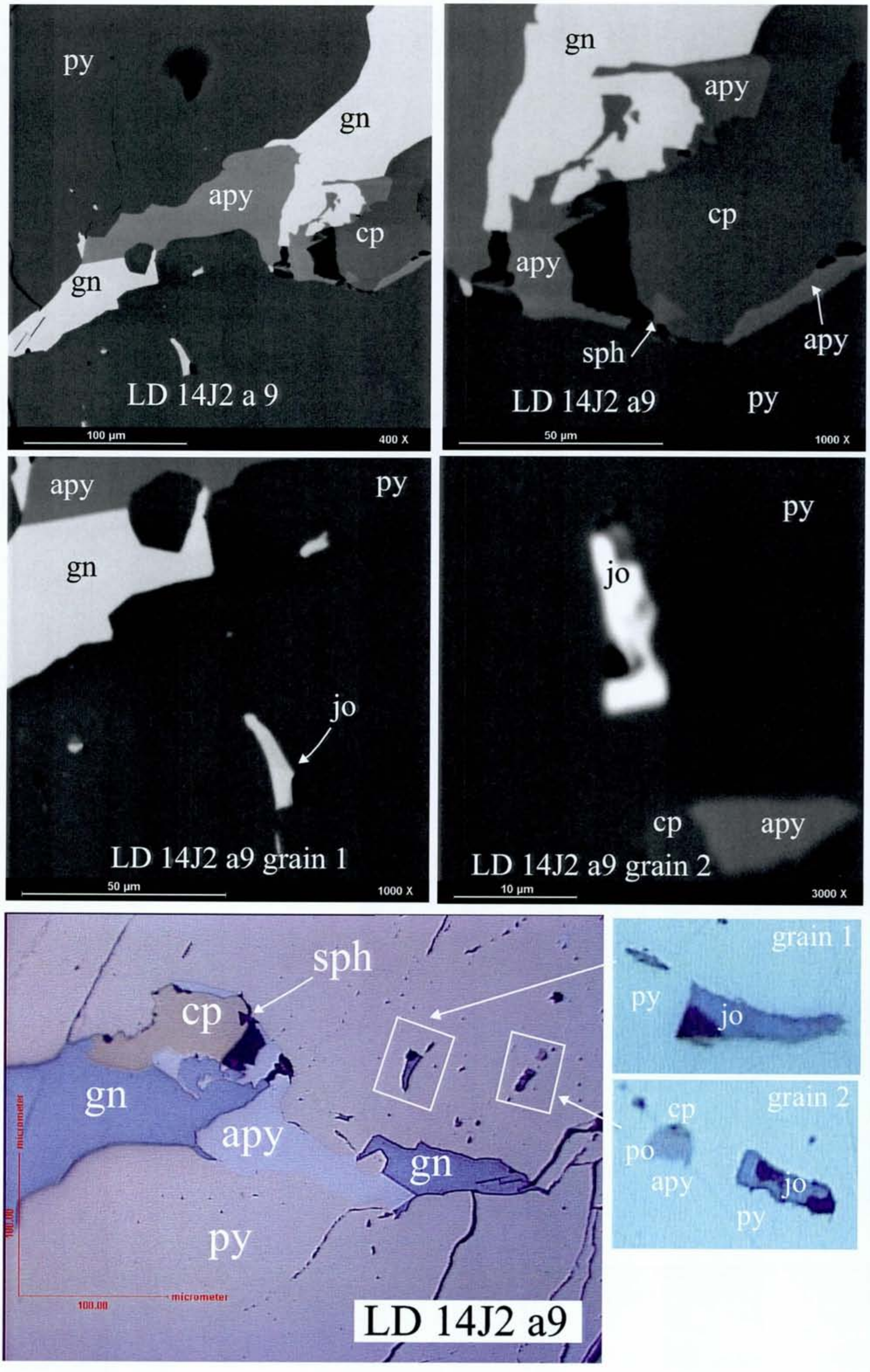


Fig. 16 Assemblages enclosed in pyrite within sulphide-quartz ores. py: pyrite, gn: galena, apy: arsenopyrite, cp: chalcopyrite, jo: jordanite, duf: dufrenoysite. Note appreance of inclusions close to the margin of the pyrite grains and close to fractures..

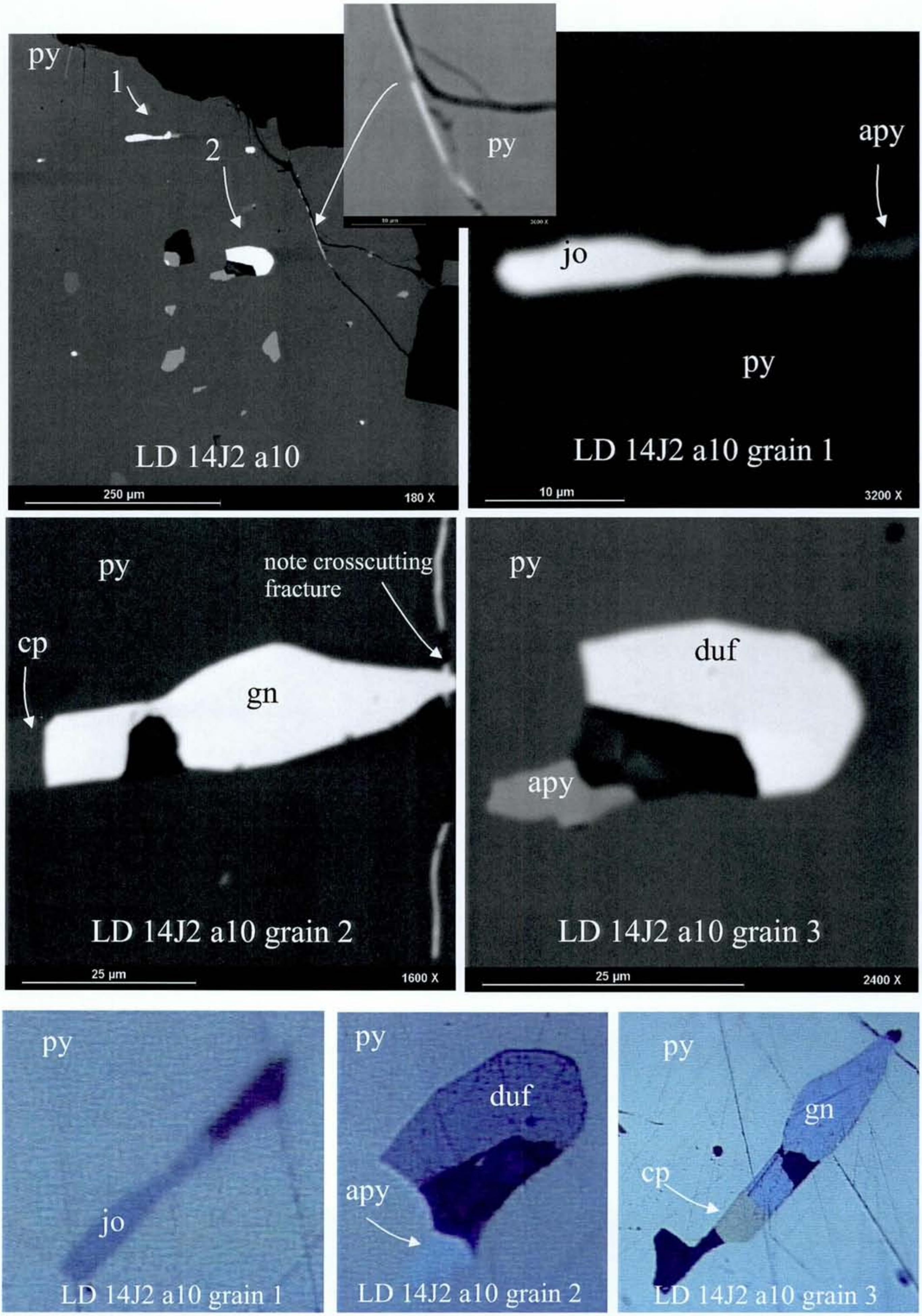


Fig. 17 Assemblages enclosed in pyrite within sulphide-quartz ores, including those hosting native gold. py: pyrite, gn: galena, el: electrum, tnn: tennantite, apy: arsenopyrite, cp: chalcopyrite, jo: jordanite.

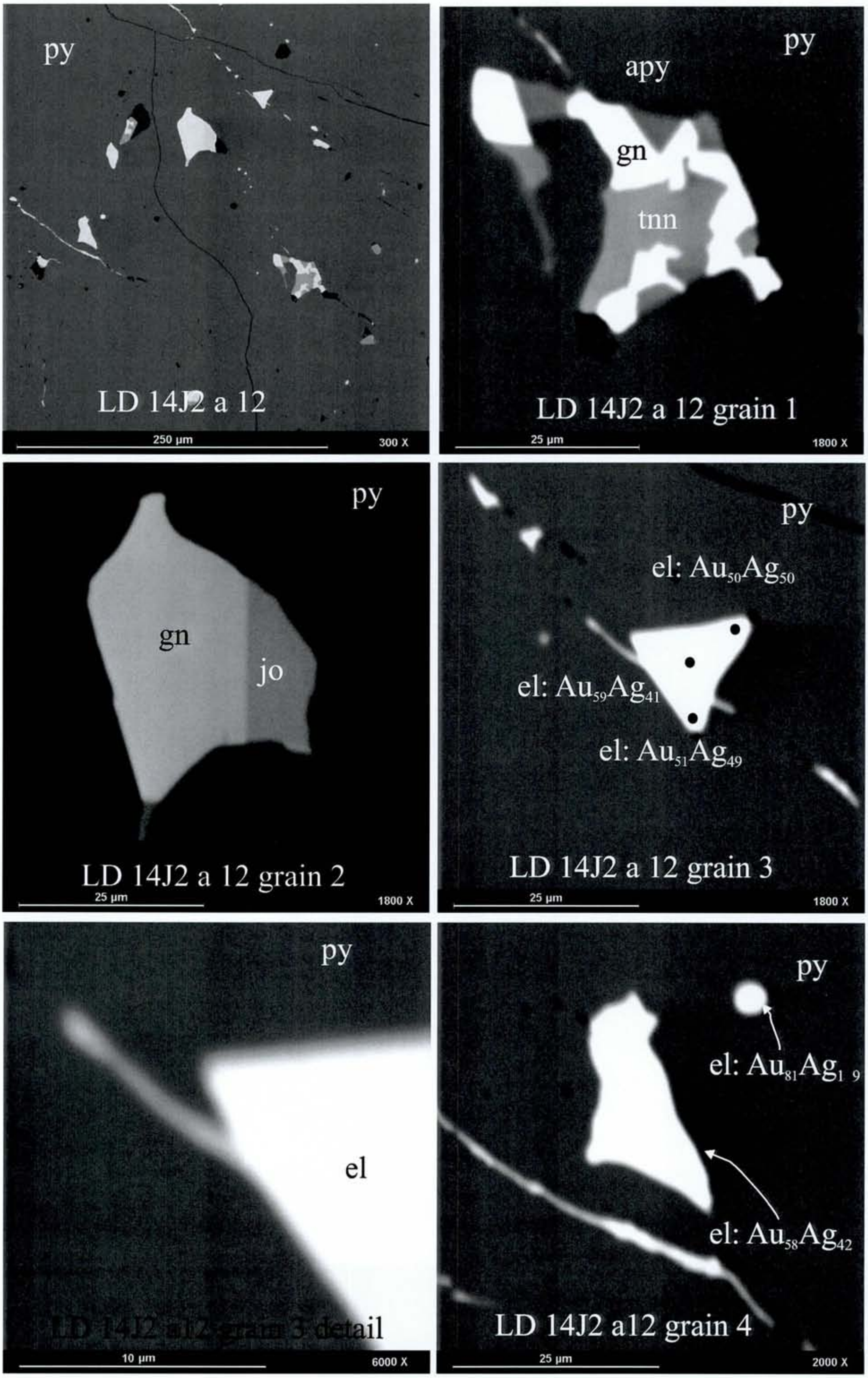


Fig. 18 Compositions of Pb-As sulphosalts and associated phases.

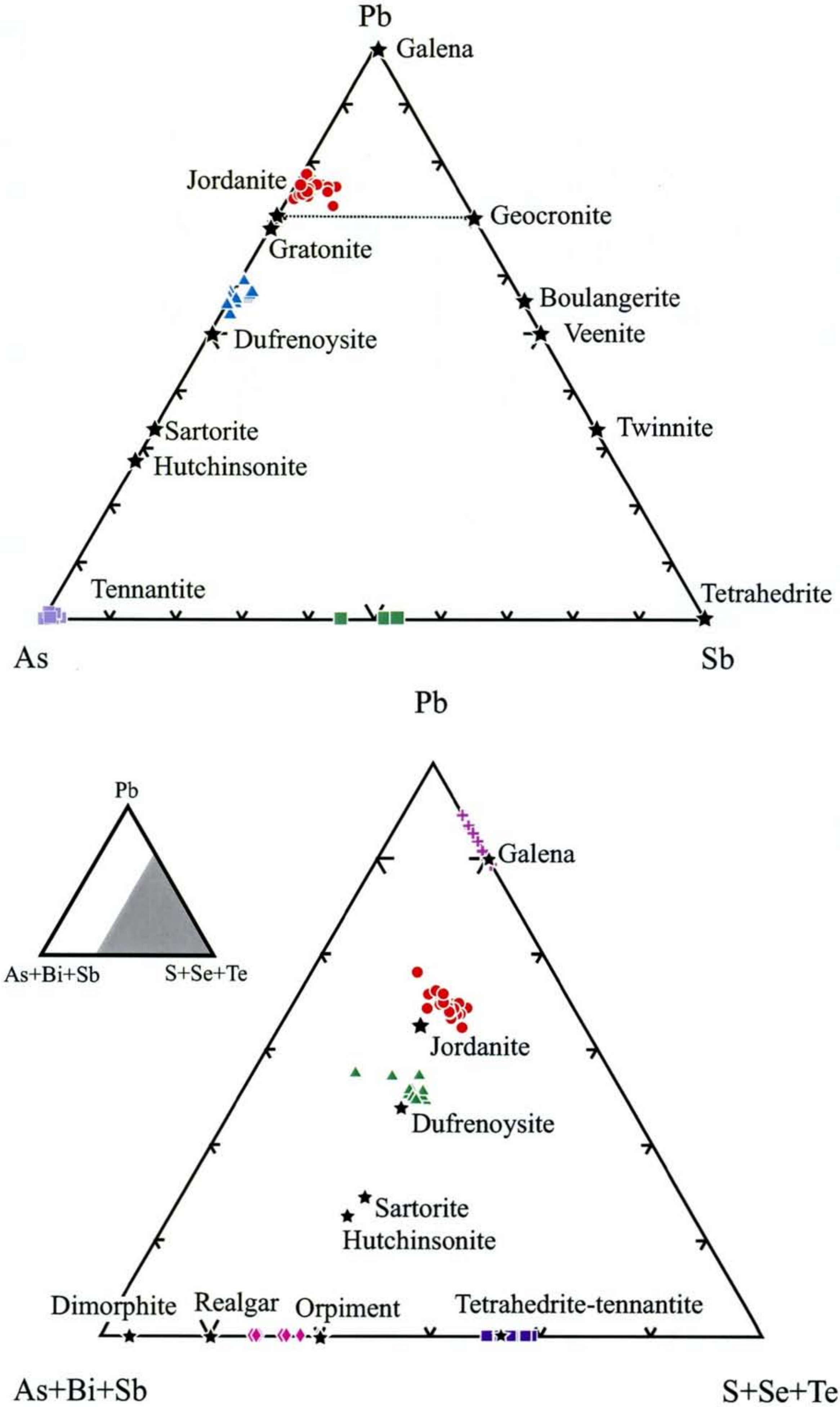


Fig. 19 Compositions of phases in the tetrahedrite-tennanntite group.

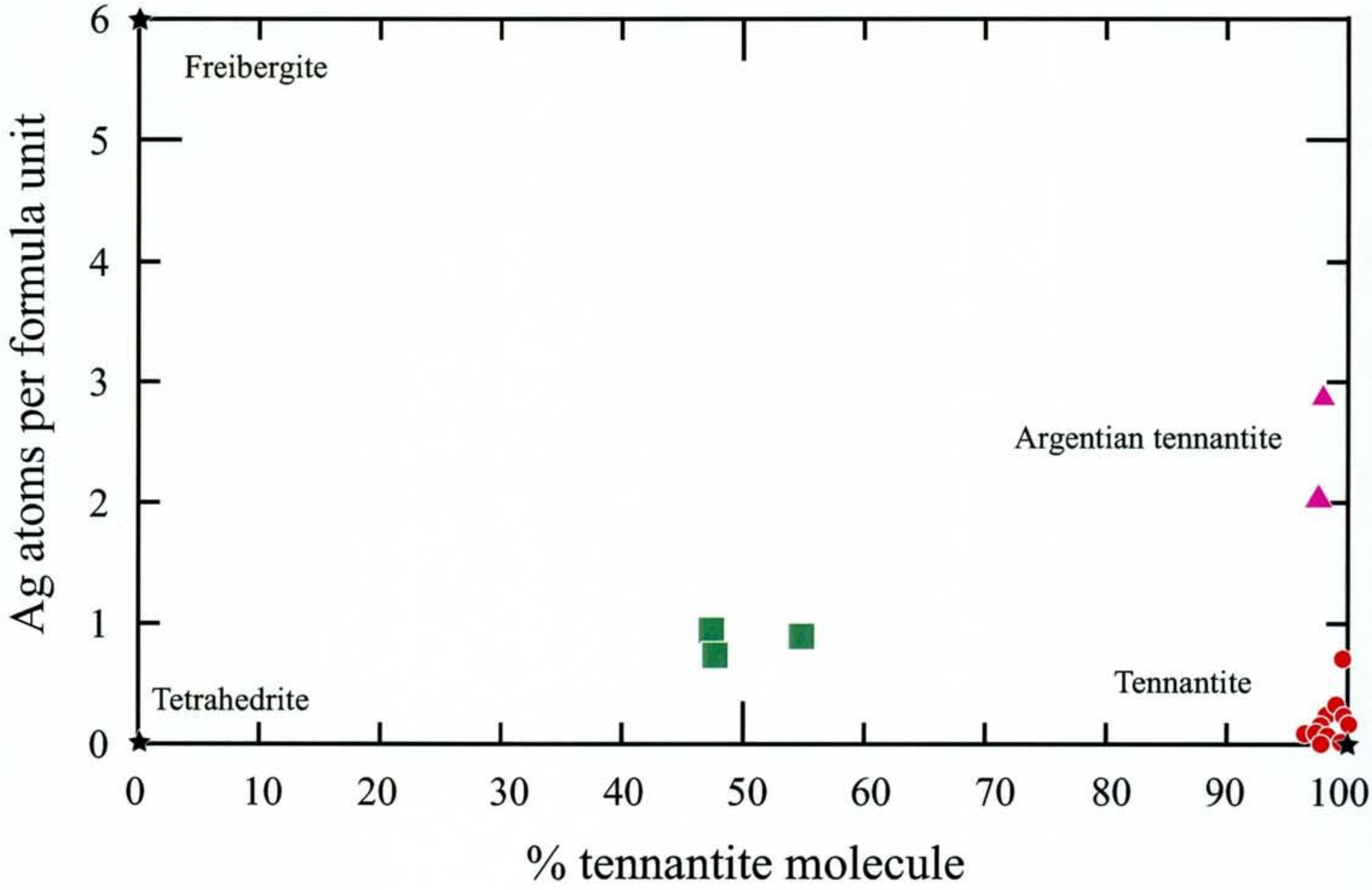


Fig. 20 Compositions of native gold/electrum and Ag- and Ag-Au tellurides plotted in Ag-Au-Te space.

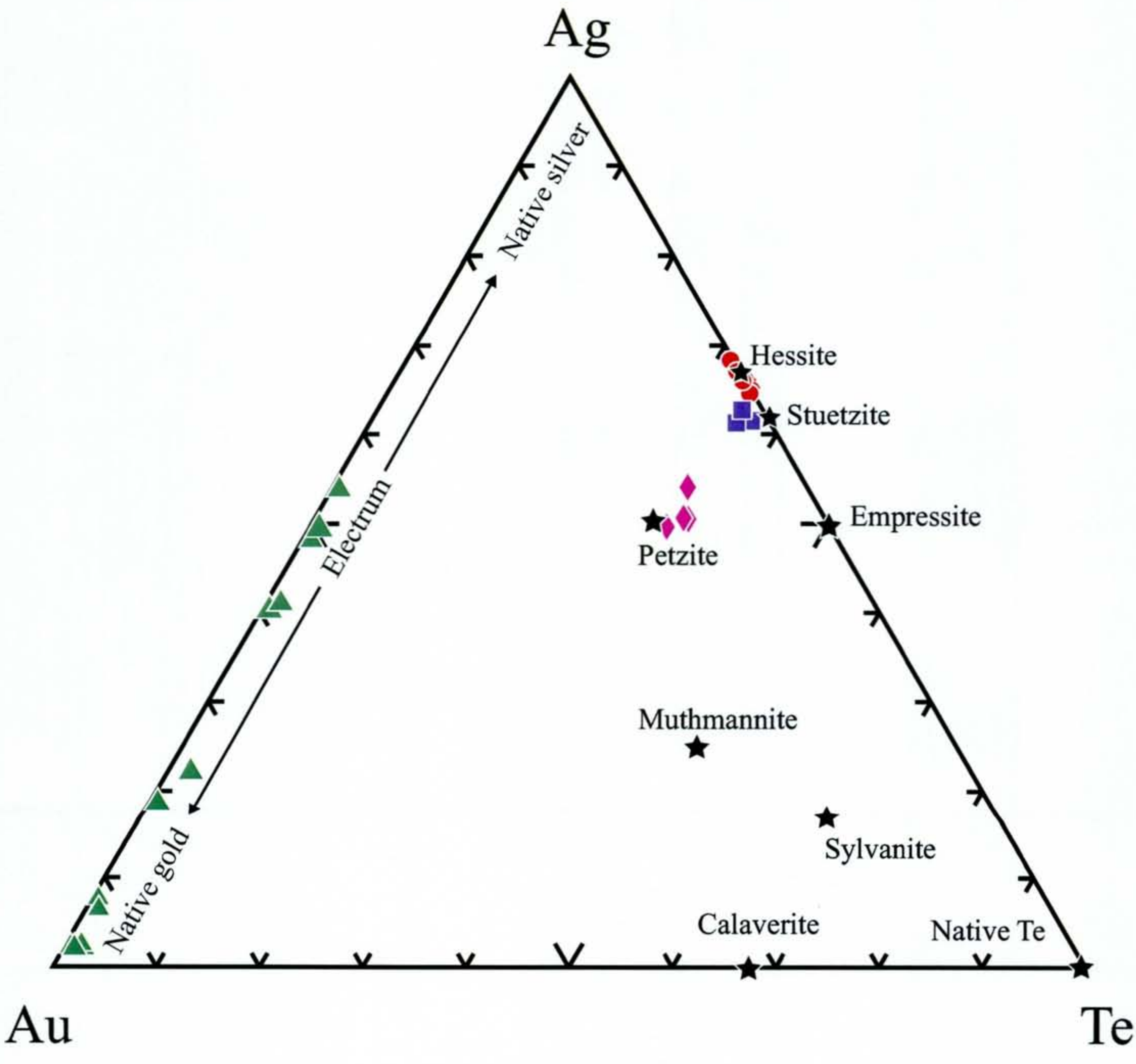


Fig. 21 Sulphide assemblages in ores from the hanging-wall contact.

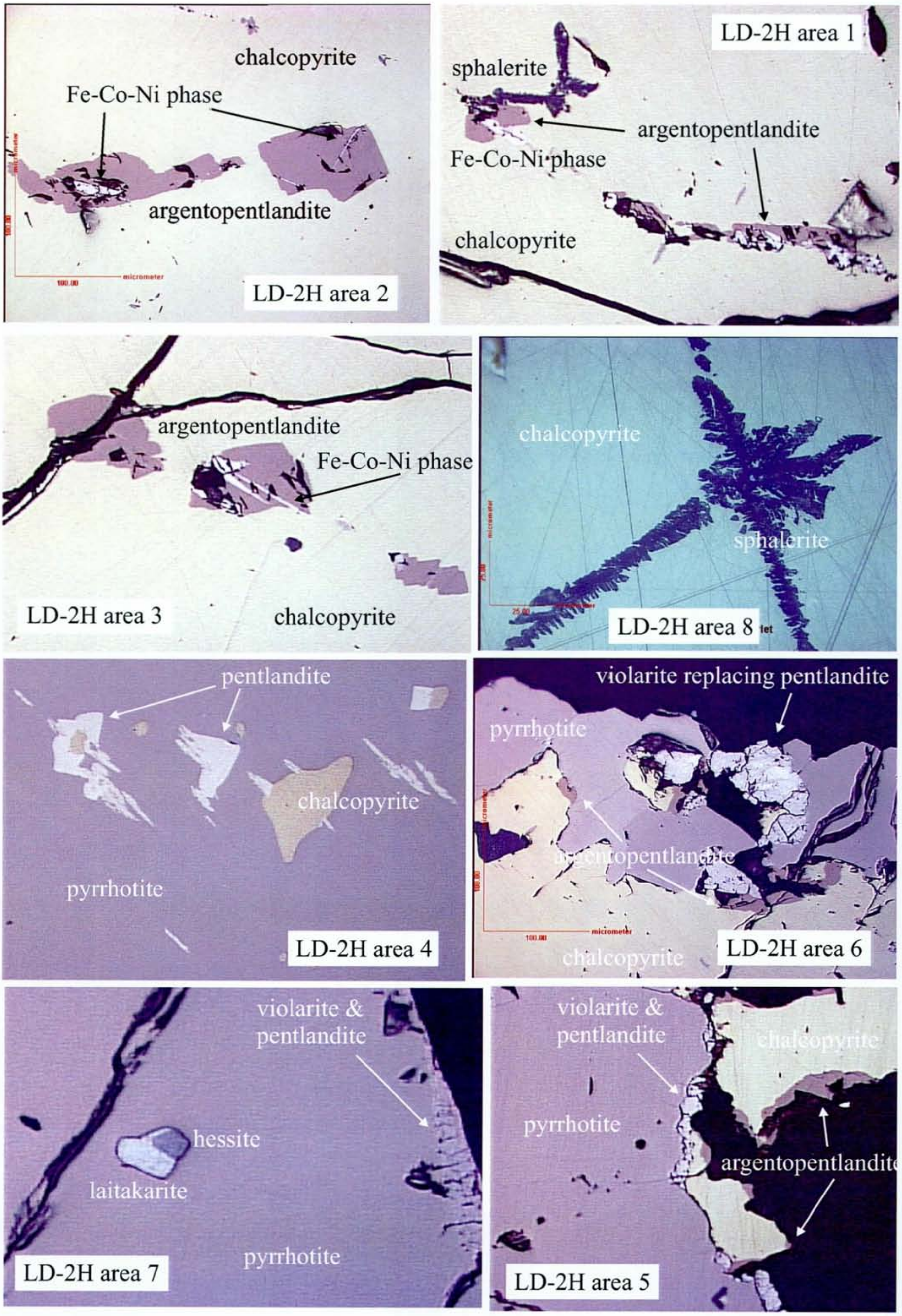


Fig. 22 Sulphide assemblages in ores from the hanging-wall contact (back-scattered images). Ag-Pn: argentopentlandite, Cp: chalcopyrite, Pn: pentlandite, Po: pyrrhotite.

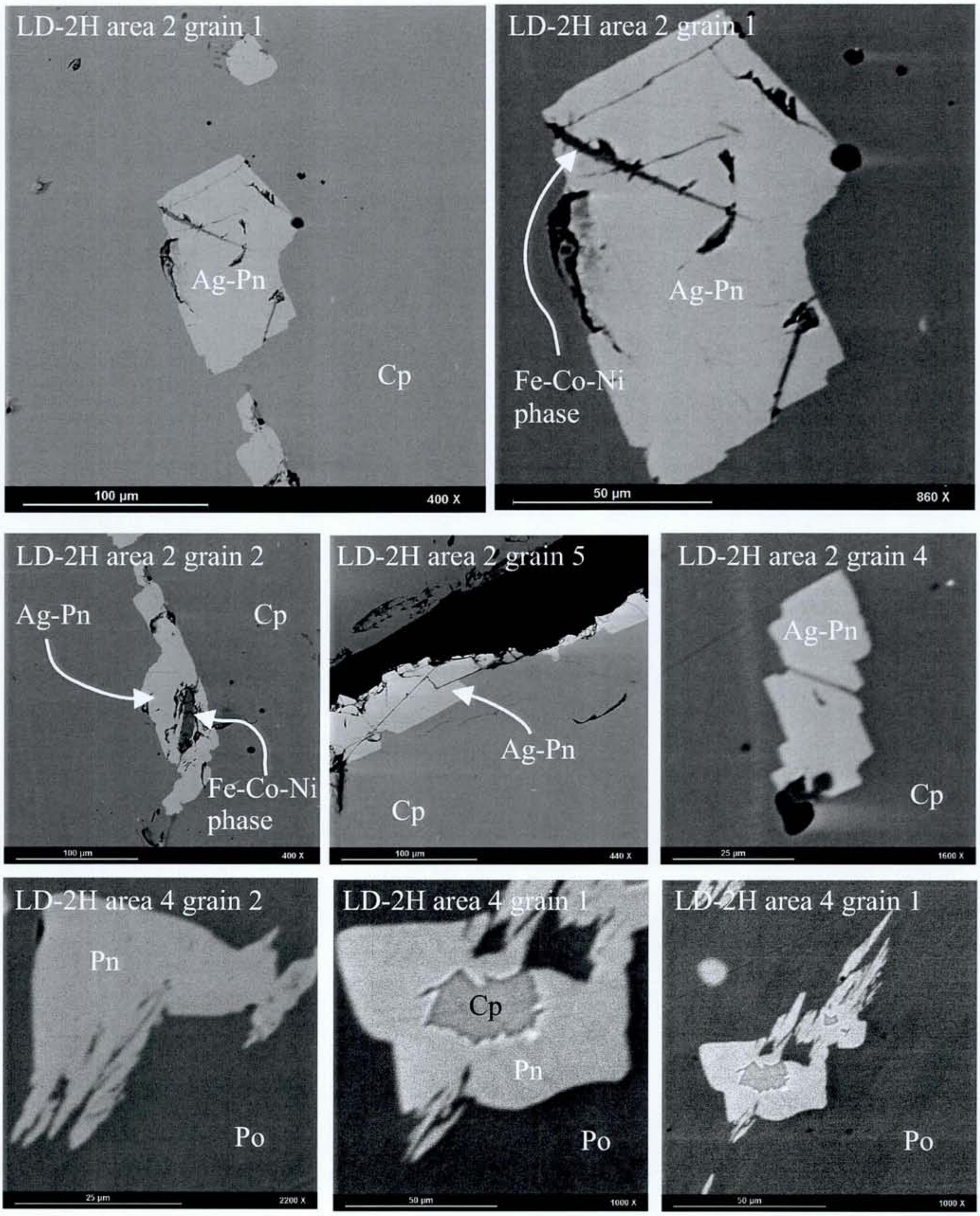


Fig. 23 Compositions of pendlandite and argentopentlandite plotted in terms of Fe-, Ni, and Co-end members. Argentopentlandite is assumed to contain one atom of Ag per formula unit.

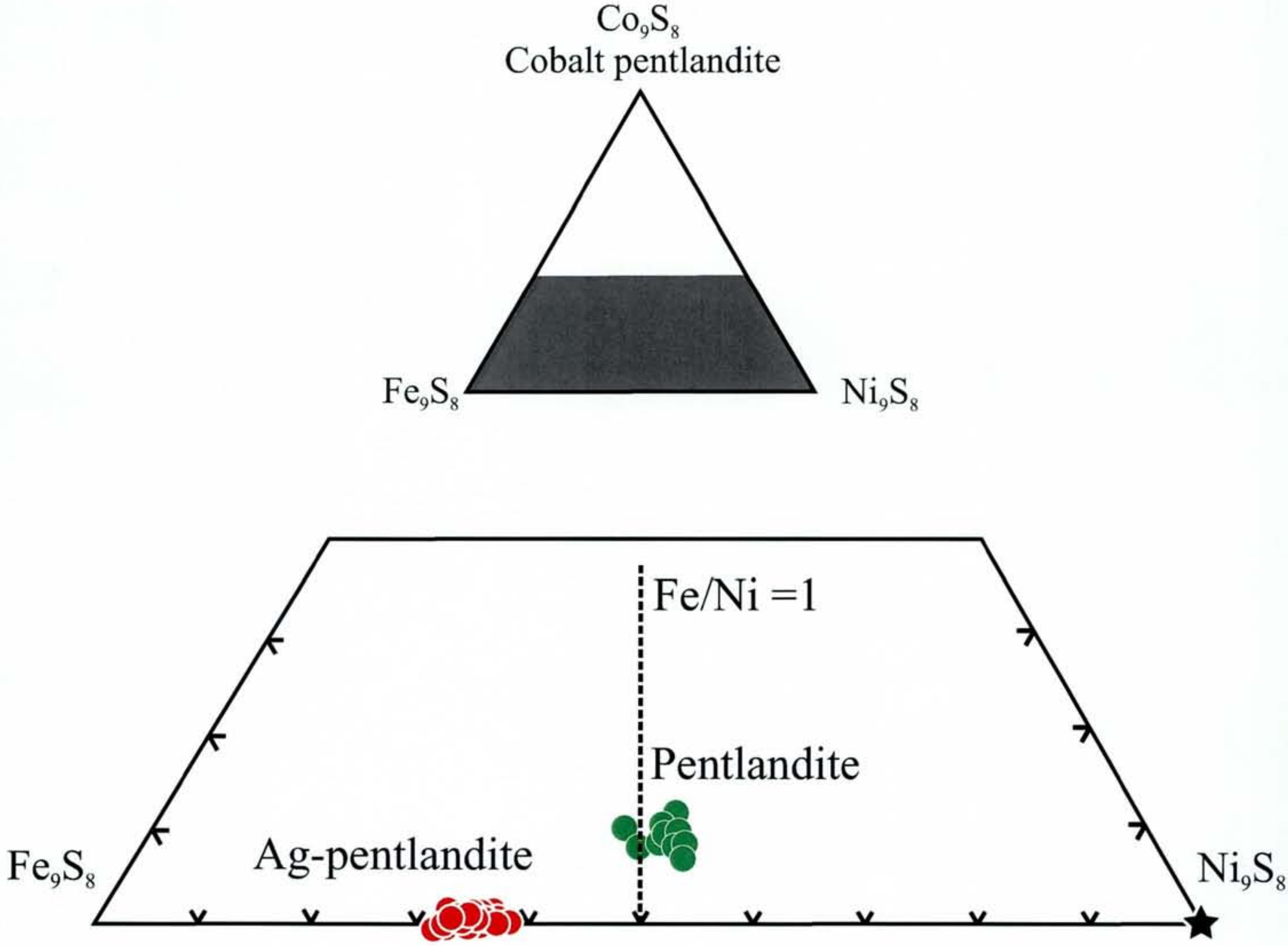
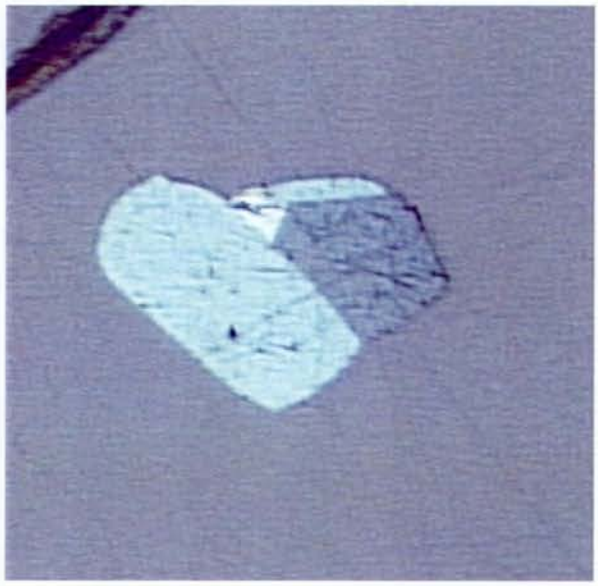


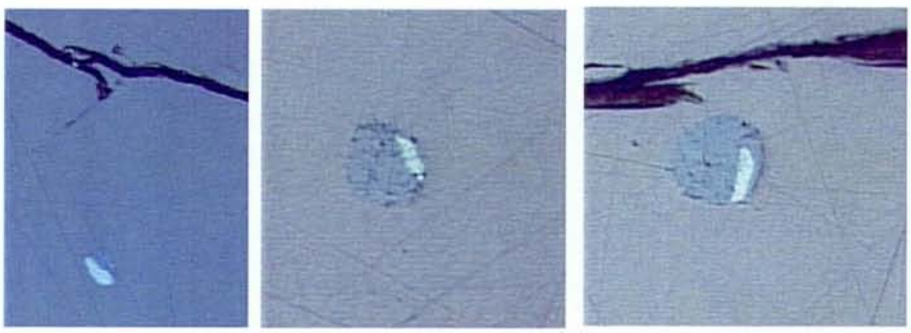
Fig. 24 inclusions of tellurides in chalcopyrite and pyrrhotite from ores at the hanging-wall contact.

Composite inclusion consisting of laitakarite (light bluish grey), hessite (bluish grey)and electrum (white) in pyrrhotite. Note equilibrium grain contacts, suggesting simultaneous exsolution.



Hessite (bluish grey) with exsolved lamellae of pilsenite (white). Telluride inclusions are typically 5-25 µm in diameter.

Rounded octagonal sections of hessite (bluish grey) containing exsolved lamellae of pilsenite (white). Note proximity of inclusions to fractures.



Hessite in chalcopyrite. Grain on right contains a lath-like sphalerite grain.

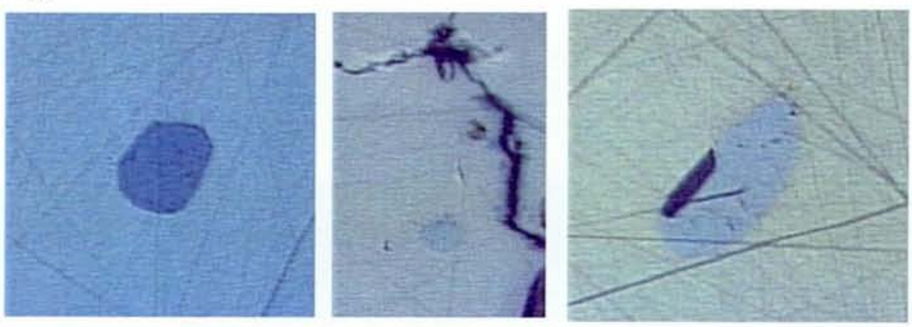


Fig. 25 inclusions of tellurides in chalcopyrite and pyrrhotite from ores at the hanging-wall contact (back-scattered electron images).

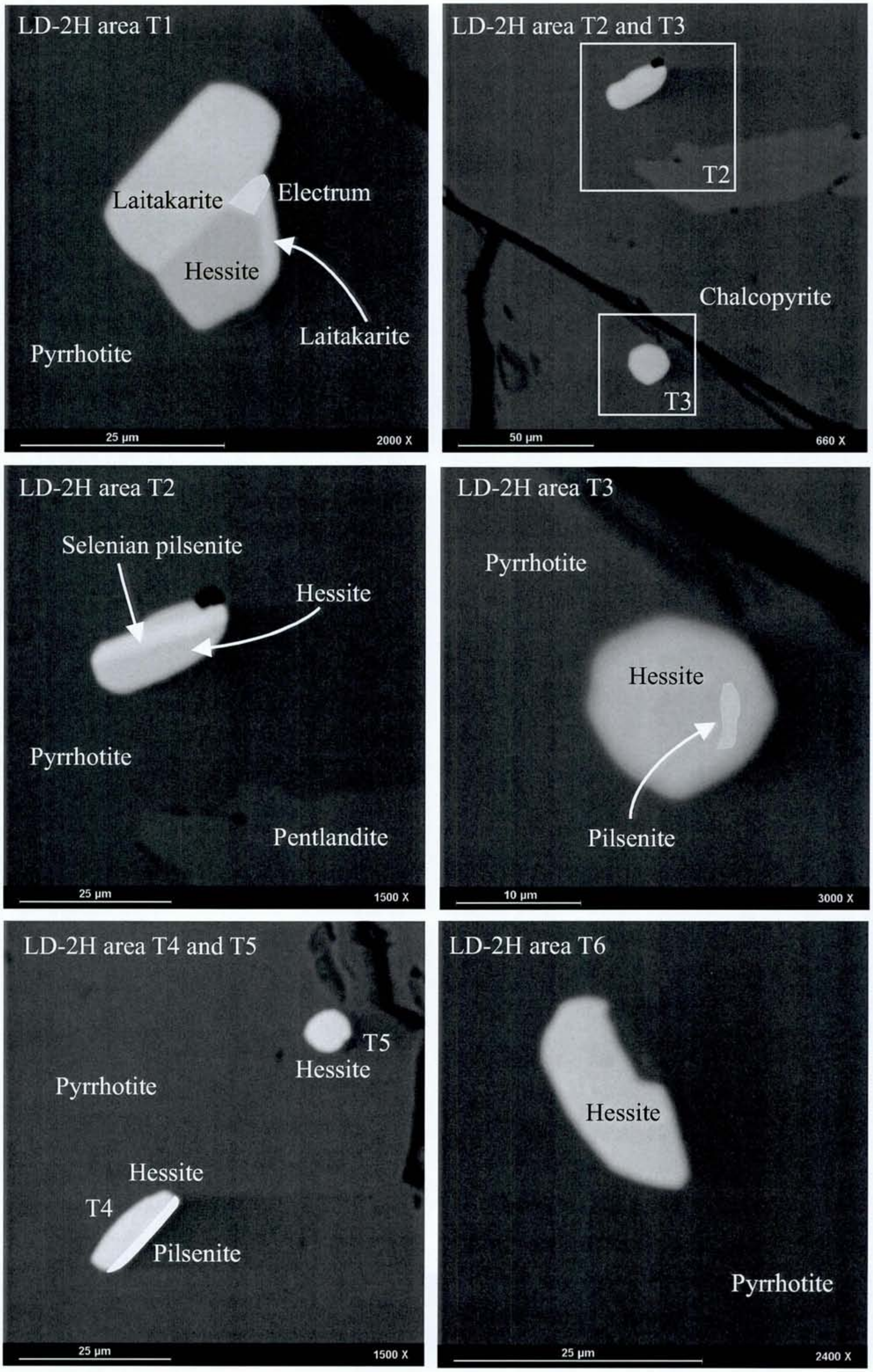


Fig. 26 inclusions of tellurides in chalcopyrite and pyrrhotite from ores at the hanging-wall contact (back-scattered electron images).

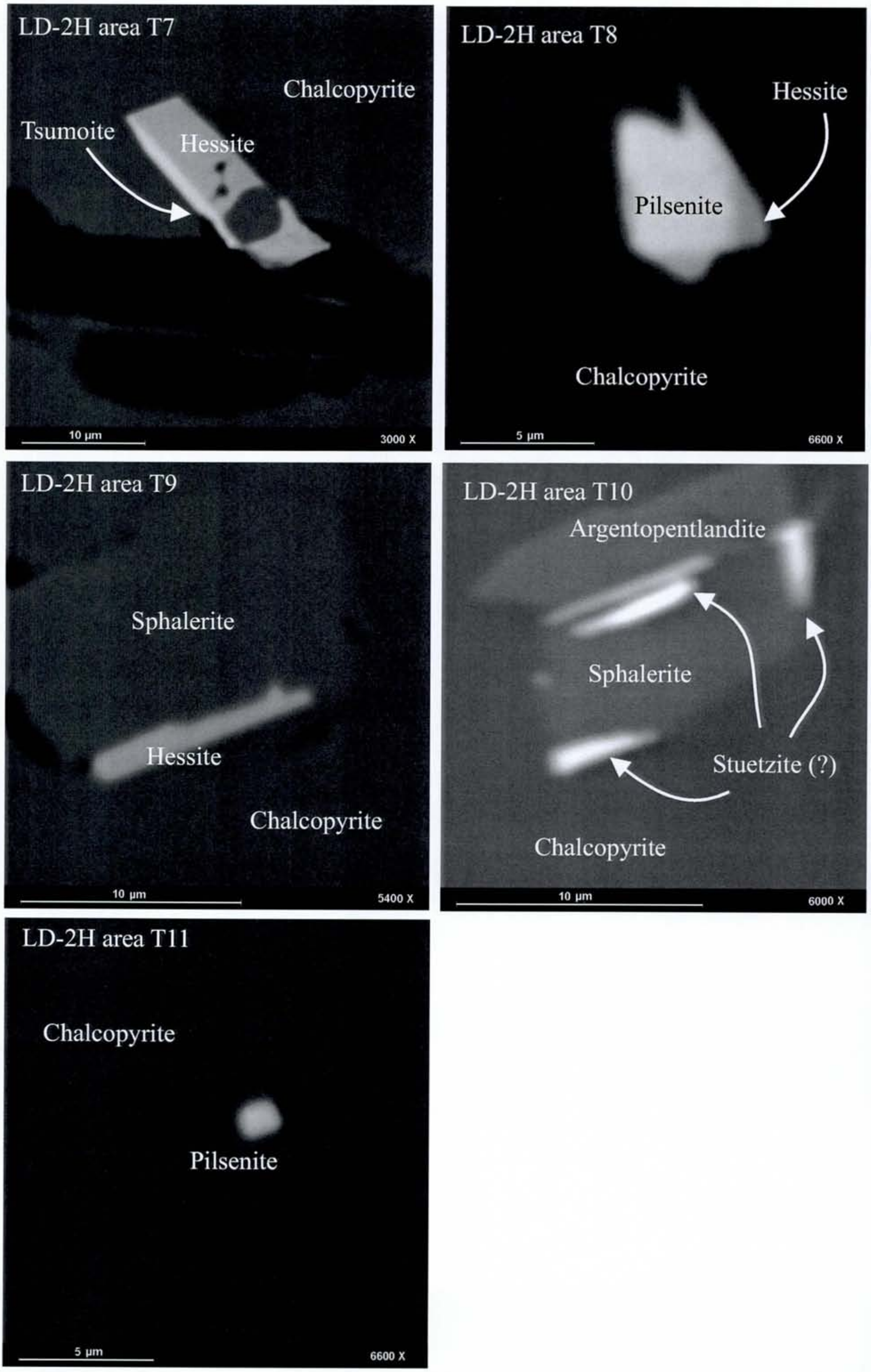


Fig. 27 Compositions of minerals in the Bi-S-Se-Te system with 4:3 stoichiometry plotted in Bi_4S_3-Bi_4Se_3-Bi_4Te_3 space.