Division of Mines and Mineral Resources — Report 1990/12

Preliminary report on the occurrence of Au-Ag-Te mineralisation in the Henty Prospect, Tasmania

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INTRODUCTION

The Henty Prospect is located by the Henty River in a valley between Gooseneck Hill and Mt Read, about 30 km north of Queenstown.

The mineralisation and the geology of the area have been recently described by Newnham and Roberts (1988), Arnold (1988), and Roberts and Fleming (1989).

The Henty Fault, a major NNE-trending fault system, dominates the geology of the area and separates the Central Volcanic Complex in the west from the younger Tyndall Group to the east. The mineralisation at which the Henty Prospect occurs lies immediately east of the Henty Fault, and is hosted by the lower Tyndall Group volcanics.

The purpose of this report is to briefly describe the occurrence of gold, silver and Te-bearing minerals in the Henty Prospect.

In general, an understanding of habit and association of gold with other minerals in a hydrothermal gold deposit is essential, because they can improve the recovery rate of gold from host minerals by applying more appropriate extraction methods and can constrain the physicochemical conditions or behaviour of hydrothermal fluids under which gold is deposited or remobilised.

To date 73 polished thin sections from different hydrothermally altered / mineralised rocks have been prepared for this study. The polished thin sections prepared from the samples with gold values greater than 2 g/t (RGC Exploration geochemical results) were examined systematically at $\times 100$, $\times 250$, and $\times 600$ (oil immersion) magnifications. The samples are listed in Appendix 1.

A progress report, including the results from petrography, mineragraphy, geochemistry, mineral chemistry, stable isotope ($\delta^{18}O$, $\delta^{34}S$, $\delta^{13}C$) and fluid inclusion studies will be submitted by the end of September 1990.

HYDROTHERMAL ALTERATION AND THE ASSOCIATED Au-Ag-Te MINERALISATION

The hydrothermally altered rocks may be divided into four broad mineral assemblages:

(1) Sericite $\pm$ quartz $\pm$ carbonate $\pm$ sulphides

(2) Quartz $\pm$ Au $\pm$ Ag $\pm$ Te-bearing minerals + sulphides

(3) Massive pyrite + carbonate $\pm$ quartz

(4) Chlorite + carbonate $\pm$ quartz $\pm$ sericite $\pm$ sulphides

The mineral assemblages represent the general rock types and are based on field and petrographical observations without considering the paragenetic stages of the minerals in each mineral assemblage.

Only mineral assemblages 2 (quartz-sulphides) and 3 (massive pyrite-carbonate) carry significant gold (RGC Exploration geochemical results), and these are briefly described in this report.

QUARTZ-SULPHIDES-Au-Ag-Te MINERALISATION

Based on the nature of the mineralisation and cross-cutting relationships, this style of mineralisation can be subdivided into three different types:

(1) Massive Quartz-Chalcopyrite-Au-Ag-Te Mineralisation

This style of mineralisation is characterised by lenses of massive, recrystallised quartz with minor muscovite and carbonate ranging from a few metres to 50 m in length and up to 1.3 m wide (M. Fleming, pers. comm). It may also occur as sheared veins varying in thickness from 1 to about 30 cm and showing lateral and vertical pinch-and-swell structure (fig. 2). The massive quartz lenses and the sheared veins are parallel to the general N-trending foliation and are hosted by sericite-quartz-sulphide rocks. They may therefore represent large-scale boudins.

The quartz has been affected by extensive recrystallisation at different stages. The earliest stage of recrystallisation is

characterised by fine-grained recrystallised quartz and minor fine-grained muscovite. The recrystallised quartz, which has been affected by another, later stage of recrystallisation or polygonisation, is commonly free from muscovite. The boundaries between the two stages of recrystallisation or the early recrystallisation and the later polygonisation are characterised by stylolitic contacts in which muscovite and, in places, sulphides have been deposited (fig. 3). It appears that the muscovite and some of the earlier-formed sulphides have been remobilised and redeposited along the contact during deformation. The massive quartz has commonly been cut by barren clear quartz veinlets of about 1 to 2 mm wide. The vein quartz is totally recrystallised and often indistinguishable from the massive quartz under the microscope. The main sulphide minerals in the massive quartz include chalcopyrite, pyrite and galena with minor sphalerite. The concentration and proportion of different minerals may vary locally. Chalcopyrite is the main sulphide and may occur in different ways:

(a) along irregular and discontinuous microfractures,

(b) infillings along with galena in fractured / brecciated pyrite, and

(c) along grain boundaries (figs. 4, 5, 6 and 7).

Quartz adjacent to the chalcopyrite is mildly strained without exhibiting pressure shadows. The etching tecnique of Kelly and Clark (1975) on chalcopyrite from samples 103758 and 103766 did not show any deformation microstructures such as recrystallisation, deformation twining etc. The undeformed nature of the chalcopyrite in the Henty Prospect may either indicate a late stage of formation for chalcopyrite or the remobilisation of the chalcopyrite at different stages during deformation. Chalcopyrite and galena are commonly associated with

dark grey-blue quartz, which may also be observed in close association with sulphides in late-formed quartz veins (fig. 8 and 9). The dark blue colour of the quartz is probably due to the occurrence of fine sulphides. Minor fine-grained (2 to 20 μm) disseminated pyrite and chalcopyrite also occur in the massive quartz, which appears to have been deposited prior to the formation of the sulphides in the microfractures (fig. 12).

Electrum is mainly associated with chalcopyrite, galena and Te-bearing minerals, either as inclusions or in contact with them in the microfractures (fig. 4, 5, 6 and 7). It may also occur as inclusions in quartz or carbonate, however the gold appears to have been remobilised along the grain boundaries or into the microfractures which were subsequently annealed during later stages of recrystallisation (fig. 10). The occurrence of gold in the massive quartz is characteristically similar to those of galena and chalcopyrite, as they all appear to have gone through the same stage(s) of deformation and commonly exhibit ductile behaviour during deformation (fig. 11).

The electrum grain size mostly ranges between 6 and 25 μm, however one electrum grain up to 130 μm was also observed (e.g. sample 103934). Electrum grains in the mineralised massive quartz may rarely be large enough to be observable under the hand lenses. The frequency distribution of the average dimension of electrum grain is shown in Figure 1. Due to the erratic distribution in electrum grain size, more grains must be measured to obtain a statistically reliable histogram.

Preliminary microprobe analyses of gold from sample 103773 gave an average atomic Au/Ag ratio of 6.7 (i.e. ~92 wt% Au, ~8 wt% Ag) with Hg contents up to 0.2 wt%. Based on petrographic observation, gold appears to be rare in barren to weakly mineralised (i.e. minor fine-grained disseminated pyrite + chalcopyrite), massive quartz (e.g.
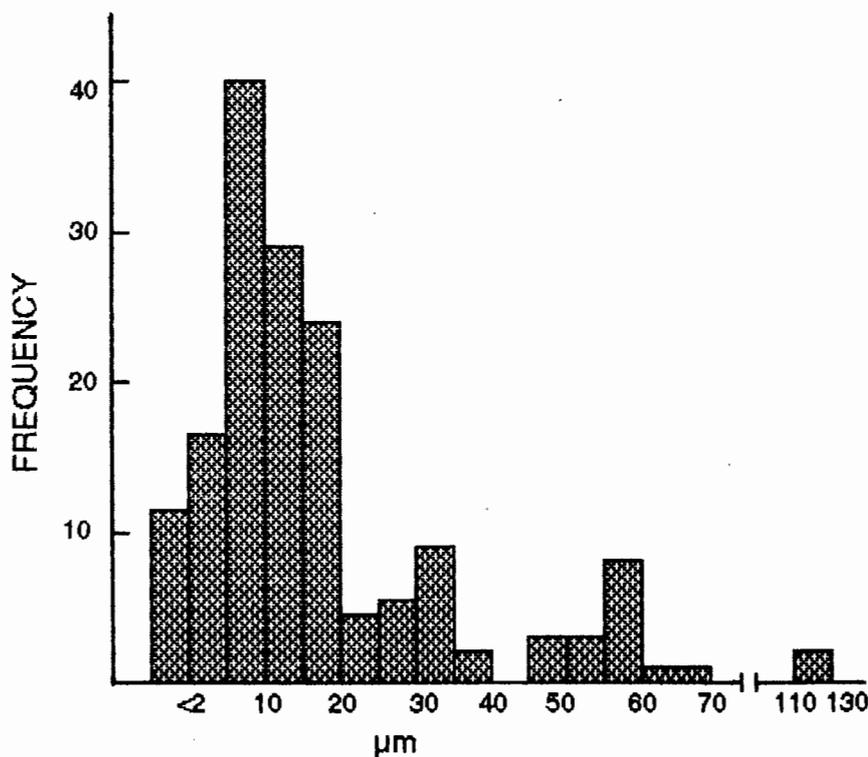

Figure 1. *Frequency distribution of average dimension of electrum grain size from the massive quartz-sulphide-gold mineralisation.*

Figure 2. *Sheared massive quartz mineralisation (mq) in quartz-sericite-sulphide rock. Northern side of the sill, NF 30–31E. Looking south.*
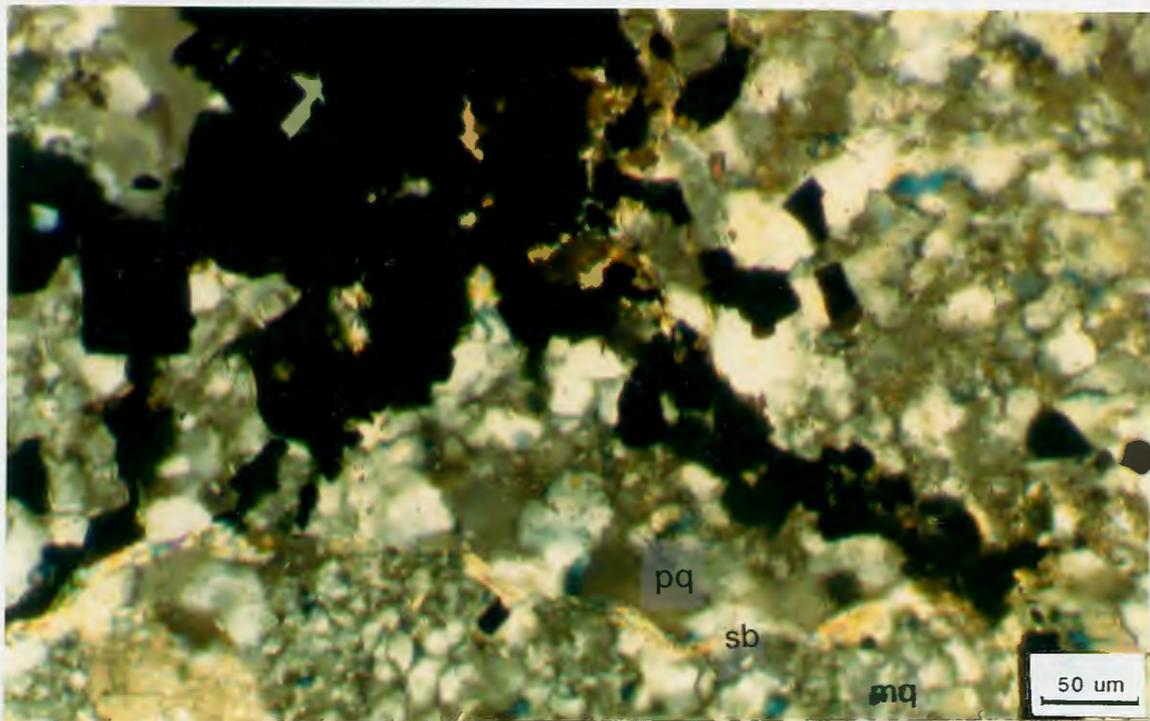
Figure 3. *Recrystallised pyrite in recrystallised massive quartz. Note the stylolitic boundary (sb) between muscovite-bearing recrystallised quartz (mq) and later polygonised quartz (pq) free from muscovite. See text for explanation. Sample 103934.*
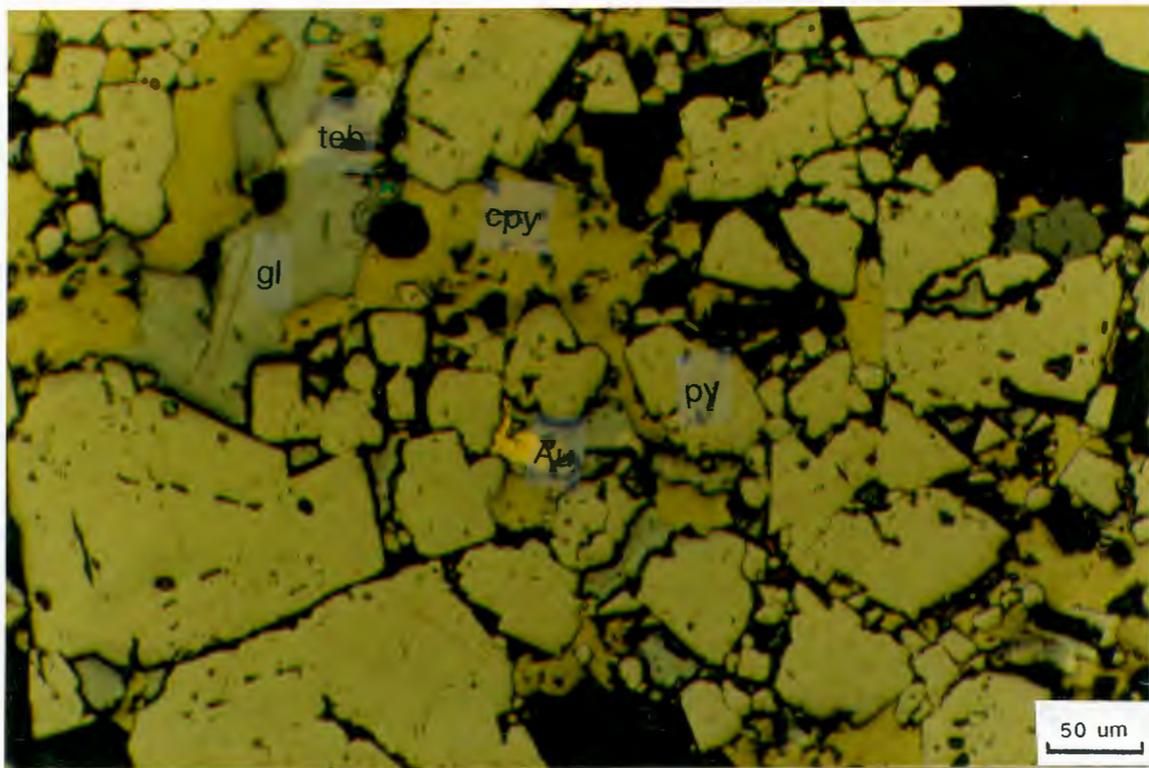
Figure 4. *Occurrence of chalcopyrite (cpy) and galena(gl) as infillings between recrystallised pyrite (py) grains. Note the close association of gold (Au) with galena, chalcopyrite and tellurbismuth [Bi2Te3? (teb)]. Sample 103934.*
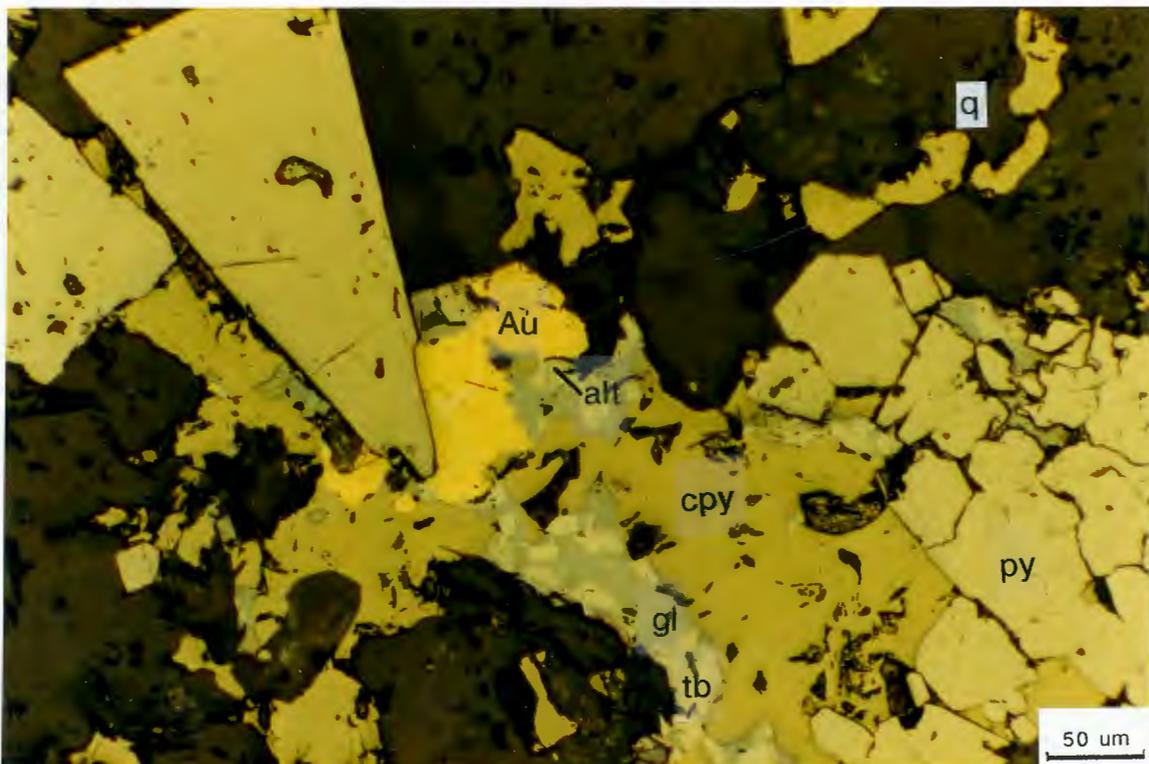
Figure 5. *Gold (Au), chalcopyrite (cpy), galena (gl), altaite, [PbTe(alt)] and tellurbismuth [Bi2Te3?(teb)] assemblage in massive recrystallised quartz. Note the nature of the assemblage as being formed in microfractures in quartz (q) and pyrite (py). Sample 103934.*
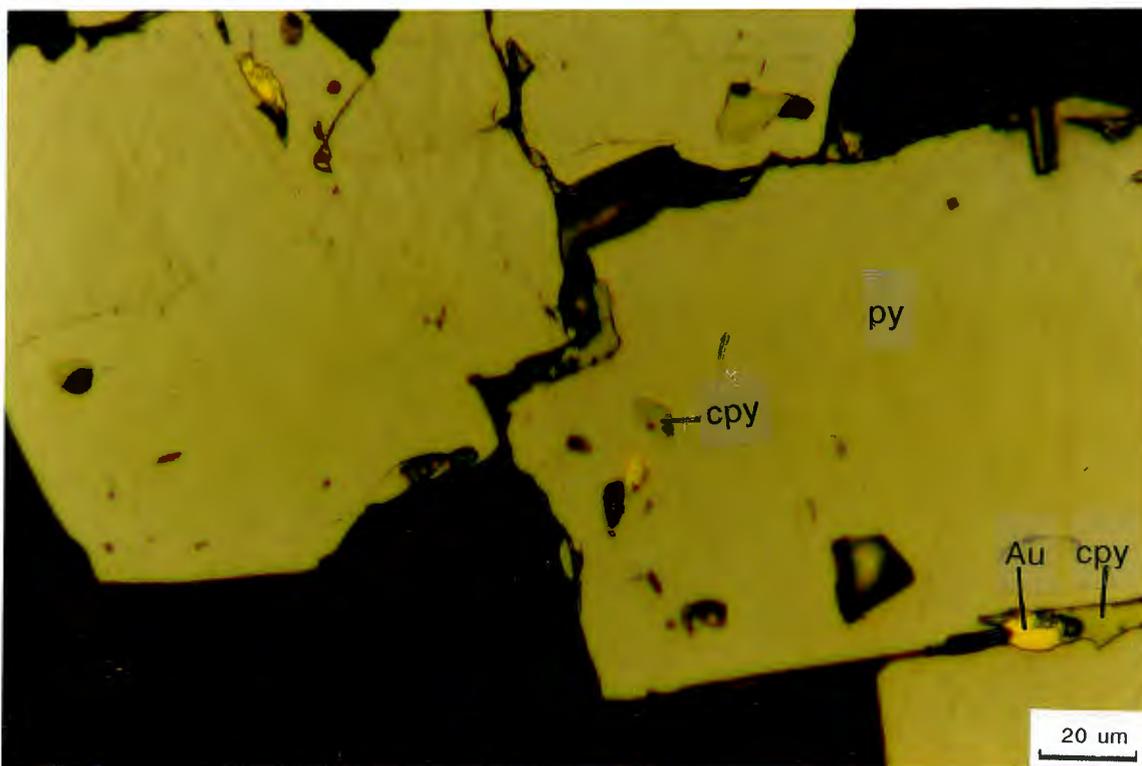
Figure 6. *Occurrence of gold (Au) and chalcopyrite (cpy) at grain boundary and as inclusions in recrystallised pyrite (py). Sample 103927.*
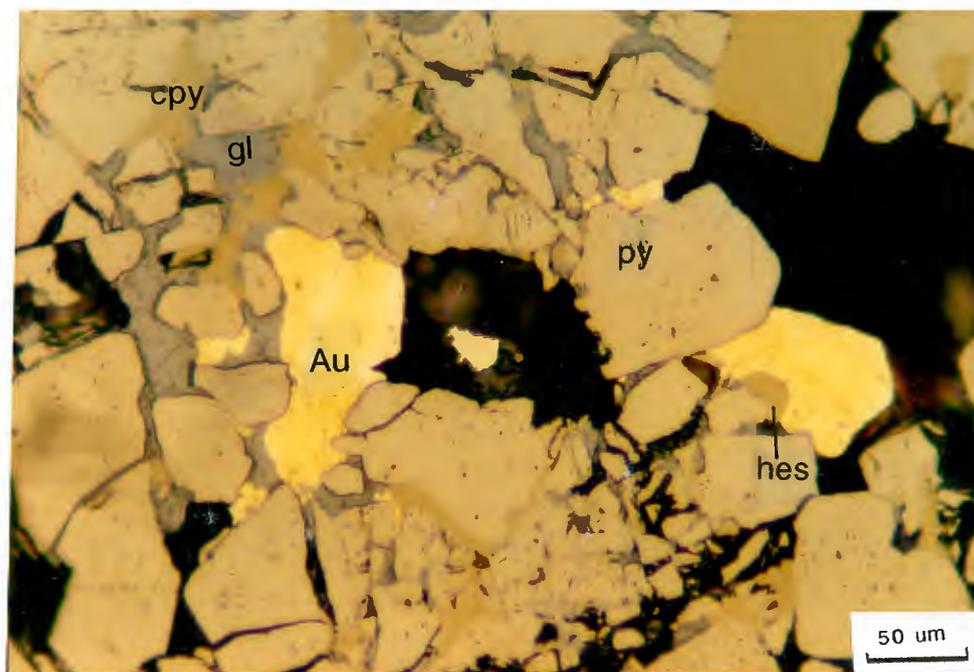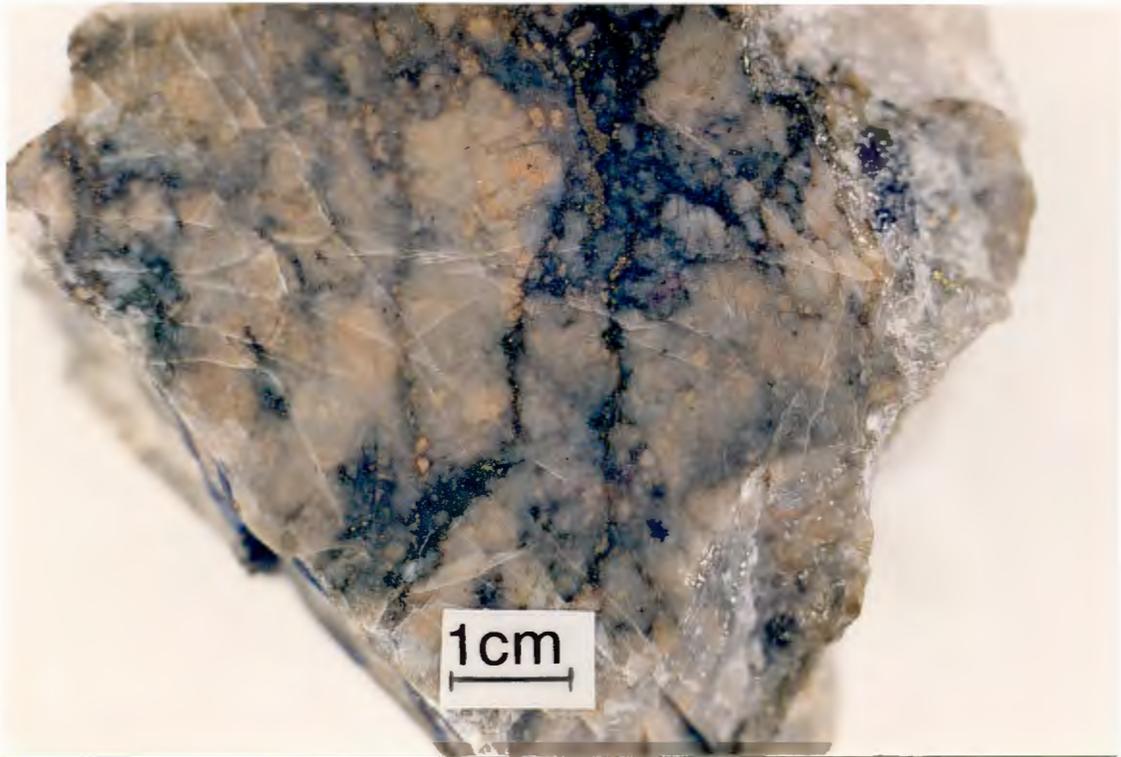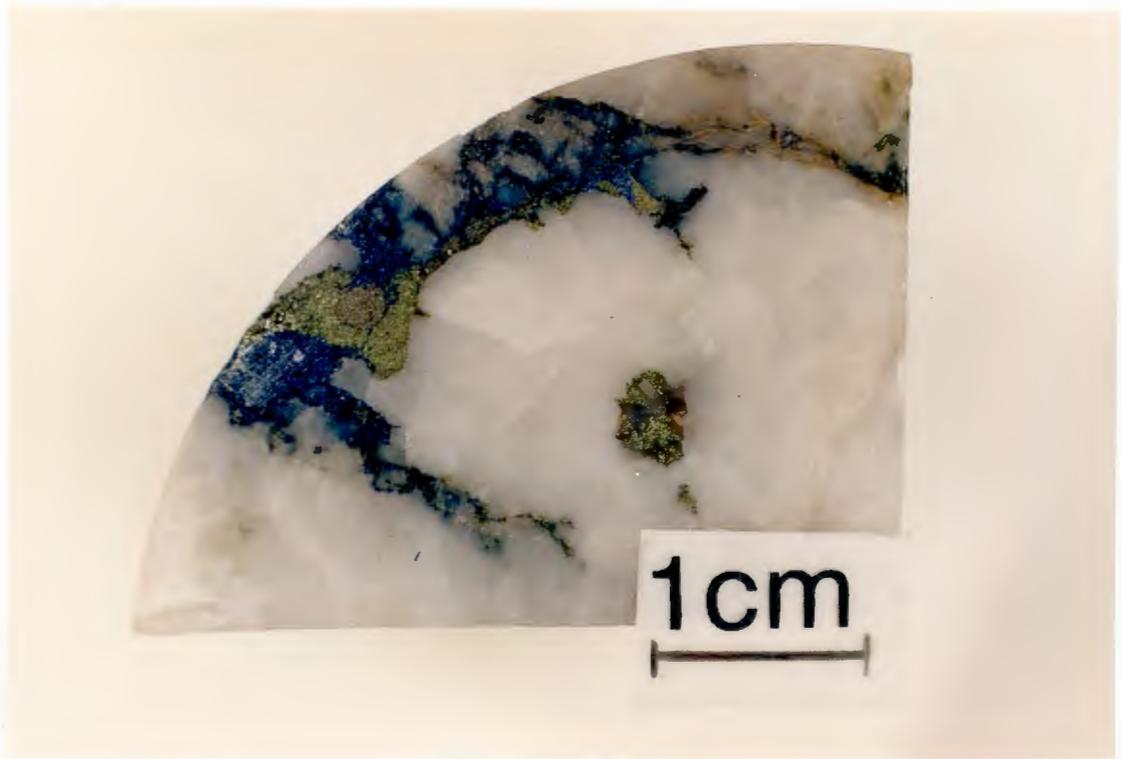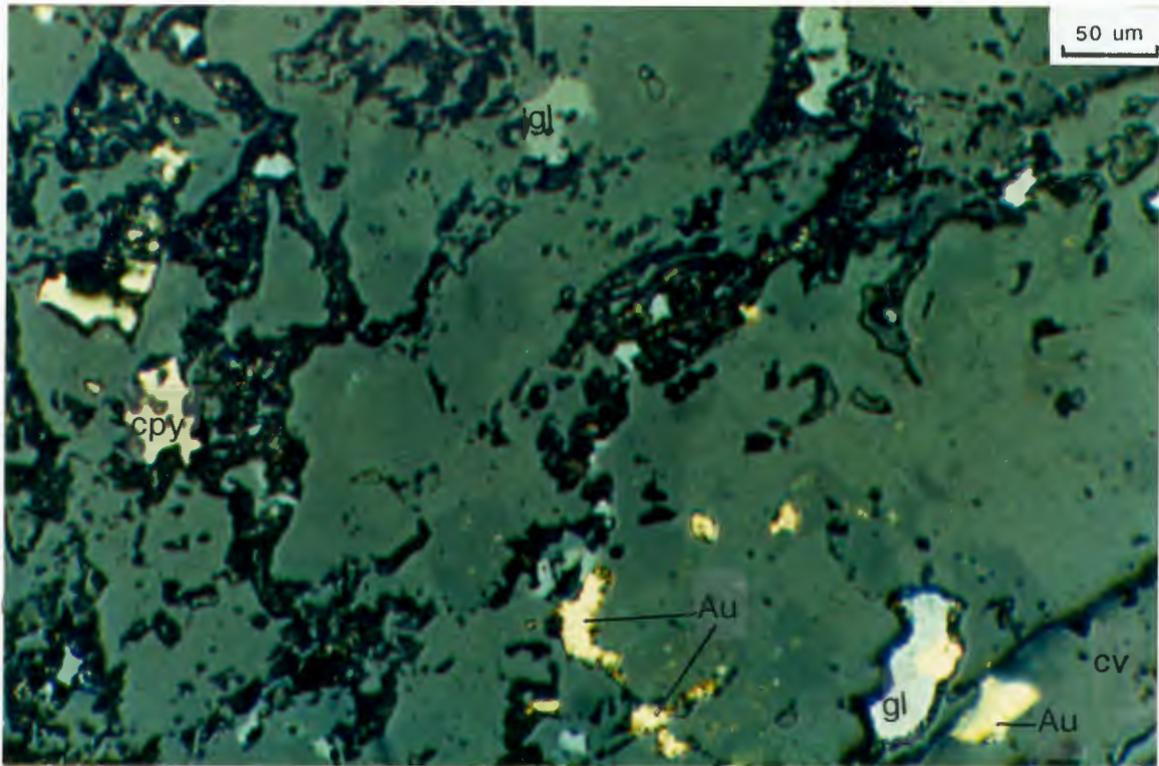

Figure 7. *Gold (Au), chalcopyrite (cpy), galena (gl) and hessite? [Ag₂Te (hes)] as infillings in fractured, recrystallised pyrite (py). Sample 103773.*

Figure 8. *Sample from massive quartz-sulphide mineralisation showing the occurrence of sulphides and the associated dark blue-grey quartz in fractures. Sample 103934.*

Figure 9. *Drill core sample from a late-formed quartz vein with the associated sulphide mineralisation. Note the similarity of the colour of the quartz associated with the sulphides to that in the massive quartz-sulphide mineralisation in Figure 7. Sample 103784.*

Figure 10. *Gold (Au), chalcopyrite(cpy) and galena (gl) along microfractures and as inclusions in recrystallised quartz. Note the occurrence of gold in a late-formed carbonate veinlet (cv). Sample 103773.*
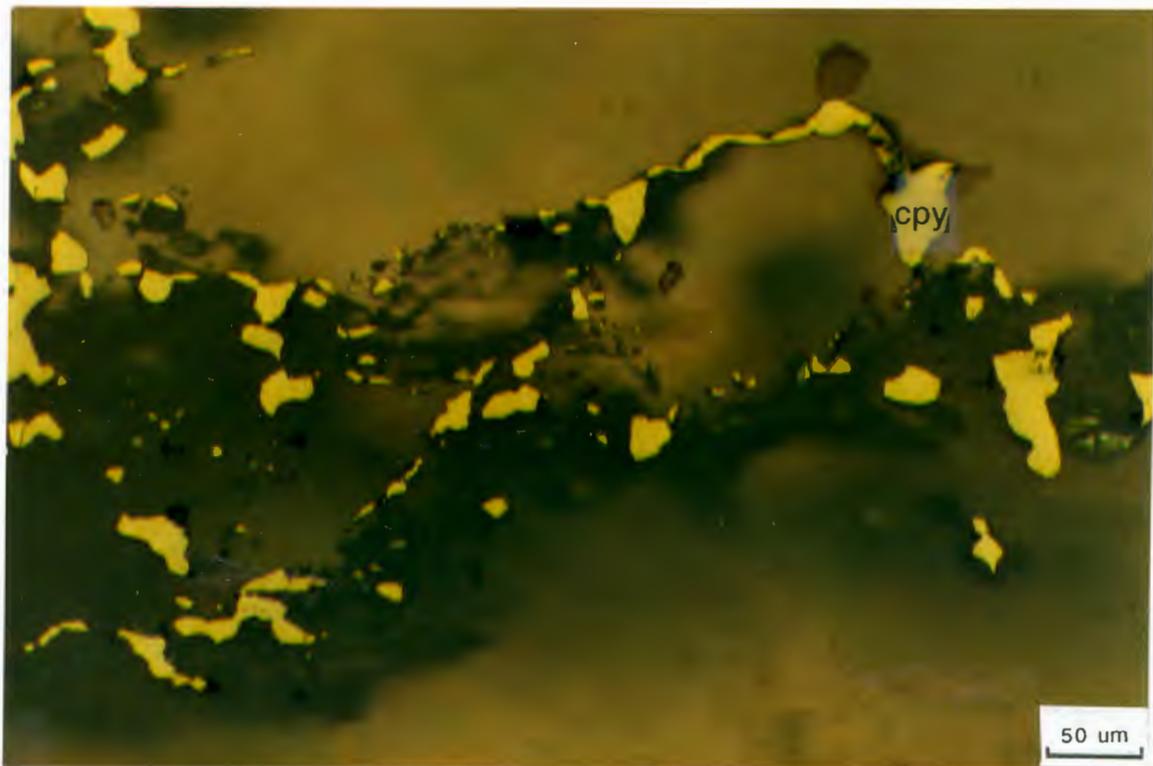
Figure 11. *Occurrence of chalcopyrite (cpy) along the grain boundaries and microfractures in massive quartz. Combined reflected and transmitted light. Sample 103927.*

sample 103741). The gold (unknown composition) in these samples occurs as isolated small grains (~2 to 3 µm) within the massive recrystallised quartz (fig. 12). These gold grains may represent the original (pretectonic) nature of the gold in the Henty Prospect.

Te-bearing minerals identified by microprobe analyses include Ag-telluride (hessite?, Ag_2Te), Pb-telluride (altaite, $PbTe$), and Bi telluride (tellurbismuth?, Bi_2Te_3). These minerals are mainly asssociated with gold, chalcopyrite and galena, and occur as infillings in microfractures, at grain boundaries, or as inclusions in galena (fig. 4 and 5). The occurrence of Te-bearing minerals is not limited to the massive quartz and they may be observed as late-forming minerals in the other types of mineralisation (fig. 13).

Ag-bearing minerals identified to date include electrum and the Ag-bearing telluride. However other minerals such as chalcopyrite, sphalerite, and specifically galena may contain significant proportions of Ag in the Henty Prospect. Chemistry of the gold and the Te-bearing minerals will be studied in detail by electron microprobe analyses.

(2) Quartz–Base Metal Mineralisation.

This style of mineralisation has only been observed as thin intervals in the drill core and its extent, distribution and relationship to other types of mineralisation is not known to the authors and requires further inspection of the drill core. The main minerals include sphalerite, galena, pyrite, quartz and muscovite, with minor chalcopyrite. Sphalerite occurs in dissemination to semi-massive forms in close association with galena and pyrite. It consistently exhibits extensive chalcopyrite disease on the margins of the grains or alongside microfractures in the semi-massive sphalerite (fig. 14 and 15). Optically, the areas affected by chalcopyrite disease are opaque, whereas the original sphalerite is transparent and is light brown in colour. Preliminary microprobe analyses indicate a higher Cu content for the sphalerite showing chalcopyrite disease than that for the original sphalerite. Galena mainly occurs as irregular patches of different sizes enclosing sphalerite and pyrite, or may occur as infillings in fractured pyrite and less commonly in sphalerite. The relationship between galena, sphalerite and pyrite may indicate that galena is a later-formed mineral than pyrite or sphalerite. However the observed relationship may also be explained by the ductile behaviour of galena during deformation. Pyrite occurs as recrystallised grains enclosed by sphalerite and galena, or as disseminations in the recrystallised quartz. Pyrite and sphalerite appear to be pretectonic to syntectonic, as the quartz and muscovite adjacent to some of the pyrite and sphalerite grains occur as pressure shadows. Muscovite is closely associated with sphalerite and pyrite, and in places is mildly deformed. Electrum, together with chalcopyrite, occurs as inclusions in the margins of and in contact with sphalerite (fig. 14 and 15). No gold was observed in association with the light brown (original) sphalerite or pyrite.

(3) Mineralisation Associated With Late Quartz Veins

This style of mineralisation is economically less significant than the massive quartz mineralisation, as it volumetrically occupies a very small portion of the mineralised system (underground observations) and electrum grains are less common than in the massive quartz. The quartz veins are mainly of tensional type and commonly occur adjacent to faults. They are extensively fractured and are cut by yet later-formed barren veinlets. Sulphide minerals include chalcopyrite, galena and pyrite. The occurence of the associated Au-Ag-Te mineralisation is similar to that in the massive quartz. However, the sulphides occur as irregularly distributed patches, with chalcopyrite and galena being the common minerals (fig. 16). A few microprobe analyses from sample 103784 indicate high mercury contents of up to about 9 wt% in the electrum grains. More microprobe analyses are needed to establish the chemical composition of the electrum in this style of mineralisation.

MASSIVE PYRITE + Au + CARBONATE + QUARTZ

This style of mineralisation occurs as restricted thin lenses a few metres long and about 20 cm wide which are parallel to the NS-trending foliation (fig. 17). The etching method of Fleet et al. (1988) on massive pyrite (e.g. sample 103738) showed that pyrite is zoned in As content, and is finely brecciated and healed by later-formed pyrite. Some pyrite exhibits framboidal centres grading into anhedral to euhedral margins. Recrystallised pyrite is common and appears to be compositionally uniform (i.e. unzoned). Carbonate and quartz have also been recrystalised to different degrees. Polished thin sections prepared from the massive pyrite-carbonate mineralisation (Appendix 1) were studied in great detail with high magnifications to identify gold grains and to study gold occurrence. Only sample 103926 showed fine disseminated grains (<1 to 6 µm) with high reflectivity and pale yellow colour. The grains occured in massive pyrite, carbonate and in quartz, and exhibited erratic distributions. In places up to 29 grains were observed in the same field of view at × 600 magnification. The section was etched to study the relationship between the grains and the original (i.e. framboidal) pyrite. However the grains were lost after etching and repolishing of the same section, and preparation of a second section from the same sample did not reveal similar grains. Hence the gold-like grains may be an artifact (tin?) introduced during polishing. However unequivocal gold and Te-bearing minerals occur rarely along microfractures and/or at the grain boundaries of recrystallised pyrite postdating the massive pyrite mineralisation (sample 103752). No Te-bearing minerals were observed within the massive pyrite.

It is planned to analyse the samples from which polished thin sections were made in order to verify the existence of gold, and then to study the nature and occurrence of gold in these samples using more advanced techniques (e.g. SEM, electron microprobe) as gold may occur as solid solution or sub-micron grains (<0.1 µm) in massive pyrite in the Henty prospect.

The possibility of pyrite being the original gold-bearing mineral in VMS deposits has been commonly noted in the literature (e.g. Knuckey and Watkins, 1982; Large et al., 1989; Huston and Large, 1988). Fine sub-micron sized gold (<0.1 µm) in pyrite and quartz has also been identified in epithermal systems (e.g. Bakken et al., 1989).

Figure 12. *Occurrence of isolated gold grain in recrystallised quartz. Note the small disseminated sulphides (out of focus) in the quartz. Sample 103741.*
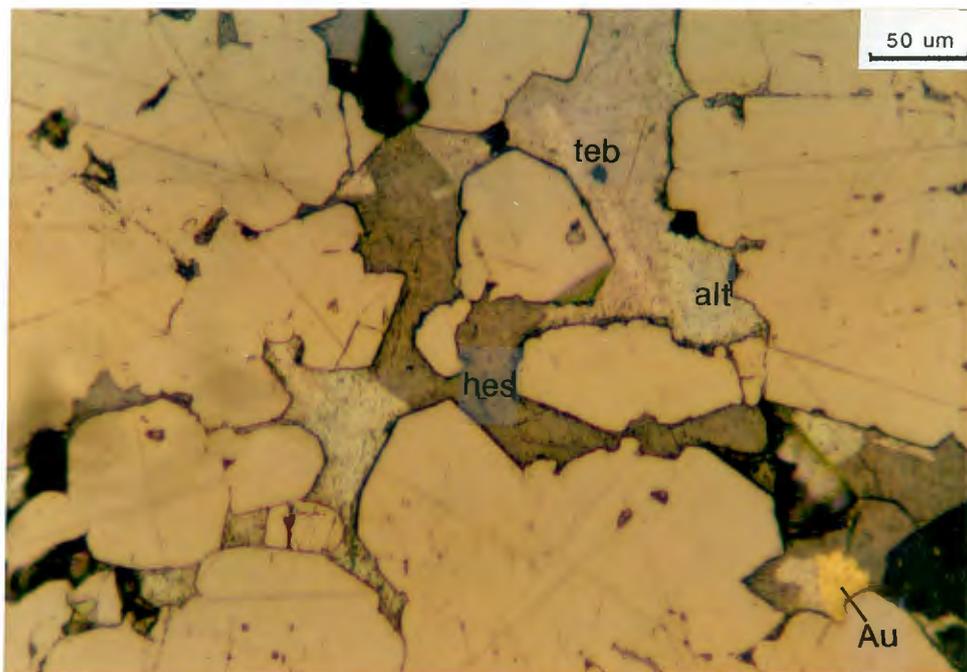

Figure 13. *Ag, Pb and Bi tellurides [hessite?(hes), altaite (alt) and tellurbismuth (teb)] and gold (Au) as infillings in pyrite. Sample 103752 (quartz + sericite + carbonate + sulphides assemblage).*
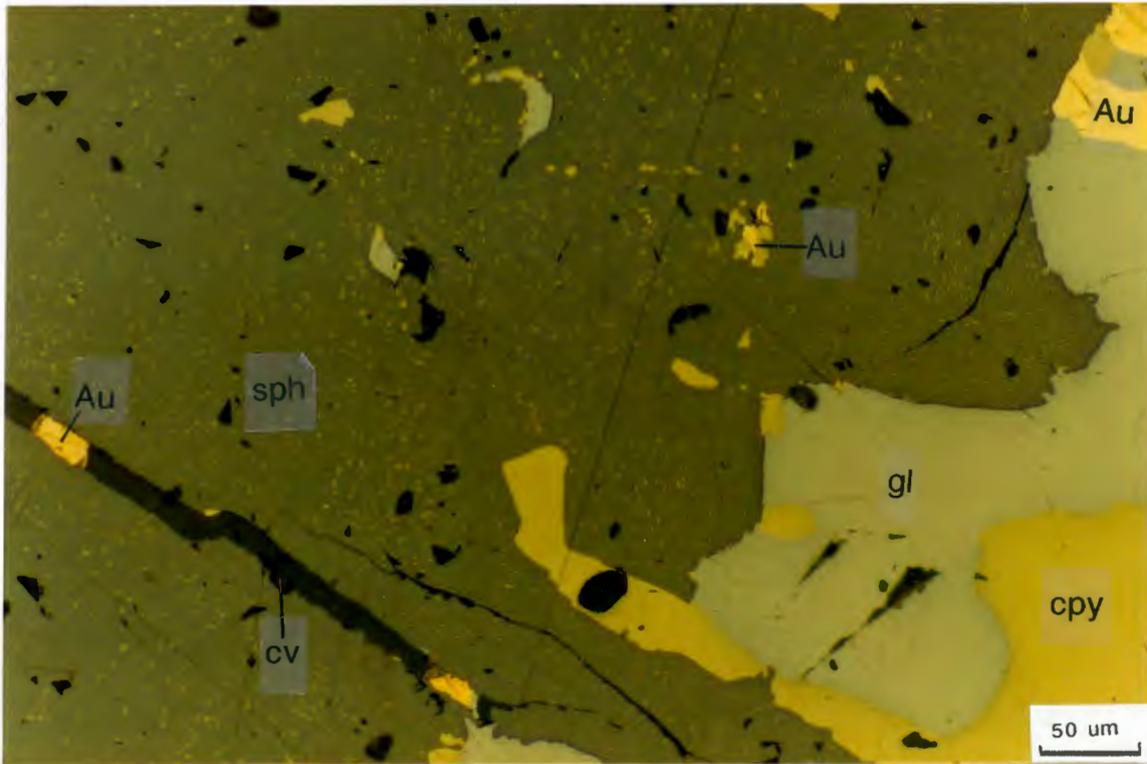
Figure 14. *Chalcopyrite disease on the margins and along the microfracture and veinlet in sphalerite (sph). Note the occurrence of gold (Au) in close association with chalcopyrite and galena on the margins and in the late carbonate veinlet (cv). Sample 103775.*
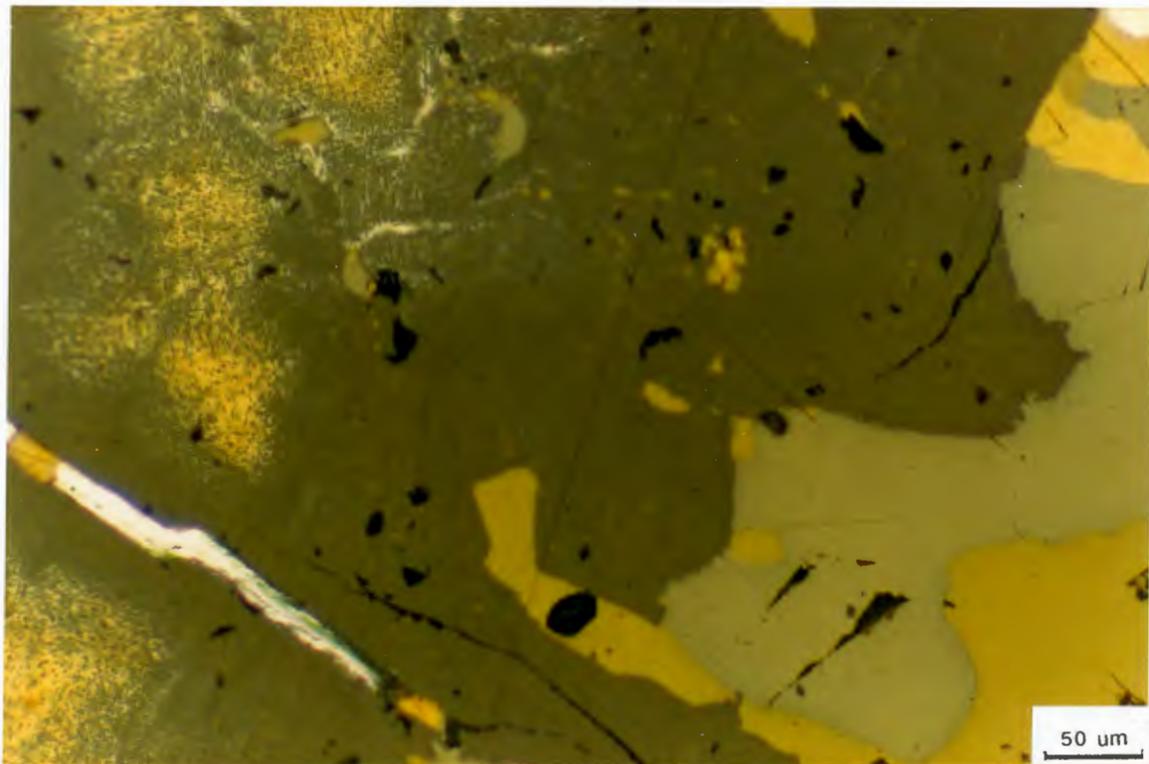
Figure 15. *As for Figure 10 under combined reflected and transmitted light. Note the abundance of chalcopyrite inclusions in opaque (diseased) areas relative to the light brown (original) sphalerite. The dark brown dots in sphalerite are secondary fluid inclusions.*
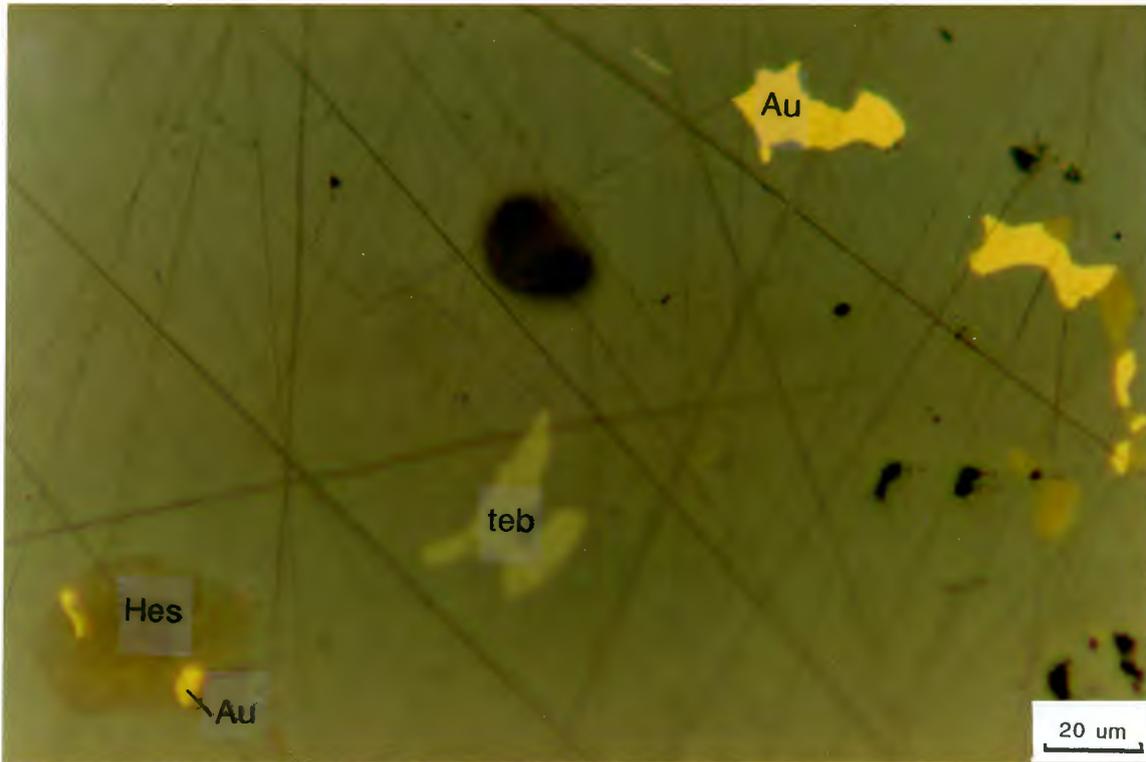
Figure 16. *Occurrence of gold (Au), hessite? (hes), and tellurbismuth? (teb) in galena in a late-formed quartz vein. Sample 103734A.*

Figure 17. *Massive pyrite lense (mp) in quartz-sericite-sulphide rock. Southern side of sill, SF 19E. Looking south.*

At the Henty Prospect, fine (2 to 3 µm) disseminated gold grains in the massive quartz possibly represent the original (pretectonic) nature of the gold. Most gold, however, has been remobilised and redeposited in low pressure zones during deformation. The occurrence of gold mineralisation in late (Devonian) veins, and particularly the similarity of this mineralisation with that in the massive quartz, may suggest that the regional Middle Devonian deformation was possibly a significant factor for the remobilisation and the redeposition of some of the metals, including gold, in the Henty Prospect. The possible origin(s) of the mineralisation will be discussed in the next progress report by considering the geology of the area and by interpreting the petrochemical, stable isotope, and the fluid inclusion results.

CONCLUSIONS

- The alteration facies, including the massive quartz, were formed prior to (or early in) the regional deformation.

- Au-Ag-Te mineralisation in massive quartz postdates the original silicification event.

- The small gold-bearing grains (<2 to 3 µm) in the massive quartz mineralisation may represent the original (predeformation) nature of the gold in the Henty Prospect.

- The regional Devonian deformation may have played a significant role in remobilising the gold together with chalcopyrite, galena and Te-bearing minerals from the massive quartz lenses and possibly from the surrounding rocks, and redepositing it in the microfractures in the massive quartz lenses and the late (Devonian) quartz veins.

- No gold grains were positively identified in the massive pyrite-carbonate mineralisation. This indicates that

gold may occur as solid solution or as sub-micron (<0.1 µm) grains in the massive pyrite.

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[8 May 1990]

APPENDIX 1

Sample locations for massive quartz-sulphide
and massive pyrite-carbonate rocks

Massive Quartz-Sulphide-Au-Te-Ag Mineralisation

Field No. (Location)	Catalogue No.
HP 42, 605.6	103773
HP 6, 112.2	103764
HP 19, 284.8	103753
HP 51, 129.6	103785
HP 19, 280.4	103751
HP 41, 258.7	103737
HP 17, 160.0	103750
HP 16, 314.6	103743
HP 6, 310.6	103741
HP 42, 606.1	103774
HP 6, 310.8	103742
HP 41, 256.7	103904
HP 42, 606.1	103774
*NF 13 E	103934
*NF 30-31E	103743
*SF 32-33 W	103928
*NF 12-13E	103934
*SF32-33W	103927
*NF 19-20E	103930

Quartz-Base Metal Mineralisation

Field No. (Location)	Catalogue No.
HP 24, 120.8	103758
HP 28,326.2	103765
HP 28, 328.7	103766

HP53, 165.6	103787
HP 42, 611.3	103777
HP 42, 603.8	103772
HP 9, 131.8	103746

Late Quartz Vein

Field No. (Location)	Catalogue No.
HP 51, 129.8	103786
HP 51, 128.4	103784
HP 24, 117.8	103755
HP 24, 118.5	103757
HP 24, 117.8	103761
HP 24, 118.5	103757
NF 23-24W	103945
NF 12-13E	103946
*SF 33	103926
*NF 13	103934A

Massive Pyrite-Carbonate Mineralisation

Field No. (Location)	Catalogue No.
HP 20, 144.4	103754
HP 24, 125.4	103762
HP 31, 334.5	103768
HP 4, 260. 7	103738
*SF19-20E	103950
*SF 33	103926

* Underground (sill) samples.