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REPORT CMS 88/6/32

YOUR REFERENCE: Purchase Order
No. 11087

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SAMPLE NOS.: 18 Drill Cores
5 Size Fractions

SUBMITTED BY: P. Appleby

WORK REQUESTED: Mineralogy

H.W. Fander, M. Sc.

OPEN FILE
FACSIMILE MESSAGE

TO: Mr. Tim McCristal
FROM: H.W. Fander
DATE SENT: 17.0.1900
LOCAL TIME: 11.45 a.m.

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Herewith descriptions of DH 24. Completed report will follow shortly.

Regards,

Transmission will be in two lots again.
Eighteen drill core intersections, and five size fractions of ground material from DH 23, were received for mineralogical examination. Polished sections were prepared which, as far as possible, were representative of the metre-intersections, and were described in detail on the attached sheets. The grindability products were also examined in polished section and are described in a separate section.

A few photomicrographs were prepared, to illustrate some of the problematical features of the ore.

**Summary of Drill Cores**

The mineralogy of DH 23 and DH 24 is very similar; clearly, this material differs substantially from previous orebodies. Textures are much more complex and on a fine scale, and the mineralogical composition is more diverse; the two factors taken together result in material which would be very difficult to upgrade satisfactorily.

The occurrence of significant amounts of marcasite throughout, an unstable sulphide which is actively oxidising in these cores, further complicates the situation. Additionally, the bulk of the arsenopyrite (the principal source of As here) is exceedingly fine-grained.

The dominant source of silver is believed to be tetrahedrite, which is widespread, but almost certainly some is contained in galena and possibly in other sulphides; this would need to be verified by an electron-probe microanalysis investigation.

Pale argentiferous gold (or electrum) was detected in DH 23 (sample 5) as minute inclusions in a variety of sulphides; it undoubtedly occurs elsewhere in a similar manner, but is not easy to detect.

**Sample DH 23/A-3/1**

Five size fractions (+106 um, +75 um, +53 um, +38 um, -38 um) from an ore grindability test (10 min. grind) were received for mineralogical examination. Polished sections were prepared and examined. The results are in keeping with the ore characteristics as seen in DH 23 and DH 24 and described above.

**General Comments**

The sulphide mineralogy is as follows: pyrite, marcasite, sphalerite, galena, arsenopyrite, tetrahedrite, chalcopyrite, and geocronite. The assay figures indicate a fairly even distribution of metal values, i.e. the mineralogical composition is relatively constant, with a slight concentration of softer minerals (containing Pb, Sb, Ag) in the finer sizes. There is a
good correlation between Ag and Pb values in particular. This correlation is not surprising, since much of the Ag-bearing tetrahedrite is closely associated with the Pb minerals. It also suggests that Ag may well be present in the galena and possibly in the geocronite.

Liberation. Individual minerals are well liberated in the -38 um fraction, though a few sulphide/sulphide composites still occur, mainly sphalerite with minor inclusions of chalcopyrite, galena, marcasite or pyrite. In the +38 um fraction, 10-15 % of the sulphides are composite, and some gangue grains (mainly carbonate) contain small sulphide inclusions; the composites are between two or more sulphides and are in line with expectations based on the mineralogy of the cores. There is a progressive increase in the number and textural complexity of the composites with coarser size fractions; most composites involve sphalerite, since this is the commonest sulphide, but composites between pyrite, or marcasite, and other sulphides are also common; many composites are sphalerite with very fine (< 20 um) inclusions of at least one other sulphide.

H.W. Fander, M. Sc.
CALCULATION OF MAGNIFICATION
OF PROJECTED IMAGES

The total magnification of the projected image can easily be calculated by measuring the shorter dimension of that image, in inches, and using that figure as a magnification factor. Thus, if the indicated magnification is, say, 33x, and the shorter dimension of the projected image is 40 inches, then the final magnification is $33 \times 40 = 1320x$. 
The photomicrographs were prepared to illustrate some of the more complex textural relationships between minerals. All were from DH 23, sample 5.

Photo 1  
(Magnification = 33x on slide, 135x on print)
Shows sphalerite (dark grey with intergranular films of chalcopyrite (< 5 um wide). A complex intergrowth (centre) of yellow chalcopyrite, brown pyrrhotite, green/grey tetrahedrite/galena/jordanite-geocronite. Arsenopyrite (white) as minute inclusions in sphalerite.

Photo 2  
(Magnification = 33x on slide, 135x on print)
Very fine intergrowth of pale creamy-yellow marcasite with pale grey galena and dark sphalerite. White arsenopyrite crystals and galena in sphalerite.

Photo 3  
(Magnification = 67x on slide, 270x on print)
Minute (1-10 um) blebs of pale gold or electrum in sphalerite (dark grey), galena (pale grey) and geocronite (greenish). Surrounded by marcasite (with parallel microfractures).

Photo 4  
(Magnification = 67x on slide, 270x on print)
Complex, fine intergrowth of sphalerite (dark grey host), pyrrhotite (brown), chalcopyrite (yellow), arsenopyrite (white crystals, mostly < 5 um), and rare tetrahedrite (darker brown).

Photo 5  
(Magnification = 67x on slide, 270x on print)
Chalcopyrite (yellow) rimmed with tetrahedrite (greenish-brown), with galena (pale grey), geocronite-jordanite (greenish-grey) and sphalerite (dark grey).

H.W. Fander, M. Sc.
DRILL HOLE NO.: 23 / 56 m
SAMPLE NO.: 1 (P.S. 60225)

GENERAL DESCRIPTION: Massive banded/streaky sulphides, with only minor gangue. Mainly sphalerite, with pyrite, chalcopyrite, marcasite, arsenopyrite, galena; minor trace of tetrahedrite (possibly Ag-rich freibergite). Rare pyrrhotite.

DETAILS OF SULPHIDES:

a) Sphalerite: Large semi-continuous masses, forming matrix for other sulphides; thus, although abundant and widespread, inclusion-free areas seldom exceed 100 um and are often smaller.

b) Galena: Mostly as finely intergrown composites with marcasite (10-50 um scale), forming patches up to 0.5 mm across.

c) Pyrite/Marcasite: Pyrite as good single crystals each 30-500 um, and as compact larger masses of 5-50 um crystals. Marcasite is microgranular, forming lattice-like aggregates finely intergrown with galena or sphalerite. Pyrrhotite as scattered 10-100 um grains in sphalerite host.

d) Chalcopyrite: Minute grains and rods throughout sphalerite, and as larger patches up to 200 um in sphalerite and pyrite. Occasional semi-continuous lenses and bands up to 1 mm wide.

e) Others: Arsenopyrite as small (< 100 um) clusters of minute (< 2 um) crystals in sphalerite; sometimes coarser single crystals up to 100 um, clusters up to 500 um. Tetrahedrite (probably the Ag-rich variety freibergite) as 5-30 um inclusions in sphalerite, generally near, or rimming, chalcopyrite.

f) Gangue: Thin streaks, a few coarser patches, of quartz and carbonate. Occasional mica flakes.
DRILL HOLE NO.: 23 / 57 m
SAMPLE NO.: 2 (P.S. 60224)

GENERAL DESCRIPTION: Massive granular sulphides, with sphalerite as the matrix and host to the others and to gangue; very minor gangue. Material is prone to oxidation, and polished surface is partly tarnished, with Fe sulphates formed in small patches. Conspicuous marcasite.

DETAILS OF SULPHIDES:

a) **Sphalerite:** As masses up to several millimetres (up to 1-2 cm), but containing many small inclusions of other sulphides and gangue; inclusion-free patches are < 200 um, most are < 100 um. Granular aggregates, in which individual grains are outlined by minute chalcopyrite grains.

b) **Galena:** Occasional patches up to 100 um, but mostly intergrown on 5-30 um scale with granular marcasite, with intricate interlocking textures.

c) **Pyrite/Marcasite:** Pyrite as small clusters of fine crystals, and as granular intergrowths with fine marcasite, forming angular large patches believed to represent original pyrrhotite crystals. The marcasite is often tarnished due to oxidation (after polishing).

d) **Chalcopyrite:** As 1-20 um granular and elongate inclusions in sphalerite, and occasional larger, irregular patches up to 200 um in pyrite and sphalerite.

e) **Others:** Arsenopyrite as loose and compact clusters up to 100-150 um across, composed of ultrafine individual crystals often < 2 um in size. Tetrahedrite(-freibergite?) as 10-50 um grains scattered through sphalerite, probably carry most of the Ag values, though some Ag is likely to be in the galena also. Traces of < 20 um pyrrhotite occur as inclusions in sphalerite.

f) **Gangue:** Small crystals, patches, of quartz and carbonate, with occasional mica flakes. The carbonate is a likely source of Mn (as is sphalerite).
DRILL HOLE NO.: 23 / 58 m
SAMPLE NO.: 3 (P.S. 60225)

GENERAL DESCRIPTION: A texturally and mineralogically complex ore consisting mainly of a variety of fine-grained sulphides and patchy gangue. There is evidence of incipient oxidation on freshly polished surfaces, and development of Fe-sulphate encrustations.

DETAILS OF SULPHIDES:

a) Sphalerite: Common, as large patches but full of other sulphides on all scales from coarse to very fine, and thus seldom free of inclusions even < 100 um. It appears to have a moderate Fe content (perhaps 6-8 %).

b) Galena: Occurs in two modes - as very fine intergrowths with marcasite (as in 1 and 2), also as larger patches up to 500-1000 um, with tetrahedrite and pyrite inclusions. There are occasional fine galena-chalcopyrite intergrowths.

c) Pyrite/Marcasite: Pyrite is abundant as small and large, well-formed crystals and as compact aggregates. Marcasite very common throughout, as granular aggregates (after ?pyrrhotite) with finely intergrown galena, sphalerite.

d) Chalcopyrite: Scarce, as small inconspicuous patches intergrown with pyrite, sometimes with galena as intricate composite patches - liberation would be difficult.

e) Others: Tetrahedrite is conspicuous, mainly as < 50 um inclusions/intergrowths with galena and jordanite. Pyrrhotite occurs throughout, as minute needles and larger patches. Arsenopyrite in clusters of minute crystals, generally in sphalerite. A few jordanite (Pb arsenide-sulphide) patches, with tetrahedrite inclusions. Textures generally complex and on a very small scale.

f) Gangue: Patchy quartz, carbonate and micas.
DRILL HOLE NO.: 23 / 59 m
SAMPLE NO.: 4 (P.S. 60226)

GENERAL DESCRIPTION: Fairly massive sulphides, but patchily distributed; both gangue and sphalerite act as hosts to small inclusions of other sulphides. There are many pseudomorphous aggregates of pyrite-marcasite after original ?pyrrhotite crystals, and the ore is evidently recrystallised.

DETAILS OF SULPHIDES:

a) Sphalerite: Continuous patches/lenses up to 20 mm, but always with small (down to 1-2 um) inclusions of other sulphides; these often outline single crystals of sphalerite (100-200 um) and form fine networks in granular aggregates of sphalerite.

b) Galena: Very sparse, mainly as fine intergrowths with marcasite-pyrite aggregates, on a < 50 um scale.

c) Pyrite/Marcasite: Pyrite as well-formed single crystals, generally forming compact masses up to 20-30 um across, largely free of other sulphides; also as finely granular intergrowths with marcasite. These aggregates have definite outlines inherited from previous ?pyrrhotite, and are intergrown with gangue, or sphalerite, or galena.

d) Chalcopyrite: Sparse, as minute (1-20 um) inclusions in sphalerite; also as 20-100 um grains, distributed in other sulphides and in gangue.

e) Others: Tetrahedrite as 10-50 um very sporadic inclusions in sphalerite, sometimes finely intergrown with chalcopyrite. Traces of fine pyrrhotite. Arsenopyrite as ultrafine (1-2 um) crystals dusting sphalerite, singly and as small clusters, irregularly distributed, in swarms in places, absent elsewhere; sometimes as ultrafine intergrowths with small chalcopyrite patches.

f) Gangue: Patchy carbonate and quartz throughout, from 10 um to several millimetres. Scattered mica flakes.
A massive sulphide intersection with very little gangue. Complex mineral assemblage, and extensive development of complex, fine-grained intergrowths of sulphides with very difficult liberation characteristics. The bulk of the Ag is very probably in the "tetrahedrite" (probably as Ag end-member tennantite). "Tetrahedrite" is used as a group name for the tetrahedrite-tennantite series.

DETAILS OF SULPHIDES:

a) Sphalerite: Forms a semi-continuous matrix for all other sulphides and is thus full of large to very small inclusions. Inclusion-free areas exceptionally up to 300 um, usually < 100 um.

b) Galena: Complex. Occurs as clear patches up to 200-300 um, but more commonly finely intergrown with marcasite and eutectoid patches with geocronite or jordanite. Also patches full of ultrafine arsenopyrite.

c) Pyrite/Marcasite: Pyrite as scattered small crystals up to 50 um, but mainly as fine granular intergrowths with marcasite (and galena) pseudomorphous after pyrrhotite. Much pyrite and marcasite < 20 um. Pyrrhotite conspicuous as ultrafine needles, small platy crystals, throughout other sulphides.

d) Chalcopyrite: Occasional clear patches up to 600 um, but the bulk is intergrown, on a 5-50 um scale, with galena, pyrrhotite, tetrahedrite, pyrite, marcasite, and as ultrafine bodies in sphalerite outlining grains and forming networks.

e) Others: Jordanite - eutectoid intergrowths (5-30 um scale) with galena. Tetrahedrite - irregular, interlocking and eutectoid textures, in galena, also with marcasite-pyrite. Arsenopyrite - generally minute (< 2 um) crystals (occasionally up to 50 um) dusting other sulphides. Cubanite (CuFe2S3) - rare patches up to 100 um flanking some chalcopyrite. Geocronite - occasional eutectoid intergrowths with galena. Pale Au as 1-10 um blebs in sphalerite, galena, jordanite-geocronite.

f) Gangue Rare, as small inclusions.
DRILL HOLE NO.: 23 / 61 m
SAMPLE NO.: 6 (P.S. 60228)

GENERAL DESCRIPTION: A crudely banded ore, with alternating sphaleritic and pyritic/marcasitic bands and lenses, and conspicuous gangue. Very abundant fine marcasite, which shows signs of oxidation and is unstable.

DETAILS OF SULPHIDES:

a) Sphalerite: Forms irregular patches and more substantial bands and lenses, composed of mosaics of grains defined by networks of ultrafine chalcopyrite. Areas totally free of inclusions seldom exceed 100 um.

b) Galena: Sparse, as irregular < 50 um grains scattered through the other sulphides and gangue.

c) Pyrite/Marcasite: Very abundant intergrowths of finely granular (5-20 um) pyrite/marcasite, in which marcasite is generally tarnished; these aggregates represent masses and single crystals of ?pyrrhotite, and often contain minor fine galena, sphalerite, chalcopyrite.

d) Chalcopyrite: Occasional large patches, up to 5 mm, probably account for the bulk of this mineral; they contain minute (< 5 um) sphalerite inclusions throughout, and are sometimes partly rimmed with cubanite. Much finer material occurs in sphalerite.

e) Others: Minor traces of fine cubanite, tetrahedrite and jordanite as < 50 um inclusions in sphalerite. Minute (mostly < 5 um), but well-formed single crystals, clusters and stringers of arsenopyrite sporadically scattered through the sphalerite.

f) Gangue: Common. Large and small granular masses of carbonate, quartz. Relatively coarse mica flakes.
DRILL HOLE NO.: 23 | 62 m
SAMPLE NO.: 7 (P.S. 60229-

GENERAL DESCRIPTION: A well-foliated sulphide ore with strong preferred orientation, but not banded on the scale of the polished section. Lensoid development of individual sulphides, with interspersed minor gangue. Abundant marcasite, therefore prone to oxidation.

DETAILS OF SULPHIDES:

a) Sphalerite: As large expanses of granular aggregates, with many fine inclusions of other sulphides. Inclusion-free areas up to 400 um, but generally smaller.

b) Galena: Very minor, as irregular patches and grains < 200 um with very small pyrite inclusions, in gangue and in sphalerite, and as veinlets in pyrite-marcasite.

c) Pyrite/Marcasite: Almost all pyrite is closely associated with marcasite as microgranular intergrowths forming angular, platy aggregates pseudomorphous after coarse pyrrhotite. The marcasite tends to tarnish. Other sulphides are finely intergrown with these aggregates. Abundant.

d) Chalcopyrite: Mostly as 1-20 um inclusions in sphalerite, along grain-boundaries, rarely up to 50 um.

e) Others: Fine, well-formed arsenopyrite crystals, up to 50 um, but mostly < 10 um, scattered through sphalerite. Tetrahedrite grains up to 50 um, throughout sphalerite. Traces of fine pyrrhotite, also in sphalerite. The tetrahedrite is almost certainly the major source of Ag.

f) Gangue: Subparallel mica flakes; lenses of carbonate and minor quartz.
GENERAL DESCRIPTION: Disseminated sulphides, as small patches scattered through major gangue. The polished section is not representative of the assays for this interval, and is a Pb-poor, As-rich portion of the ore. This suggests that the ore is crudely compositionally banded.

DETAILS OF SULPHIDES:

a) Sphalerite: Patches of granular sphalerite, up to several millimetres across, but many are 100 um to 1 mm. Always contains small inclusions of other sulphides, and clear areas are seldom more than 100 um across.

b) Galena: Sporadic small irregular patches, < 100 um, in sphalerite.

c) Pyrite/Marcasite: Pyrite as well-formed crystals up to 1 mm or more, but mostly 100-200 um. Also as fine intergrowths with marcasite as in previous samples.

d) Chalcopyrite: All as very small grains and thin films outlining sphalerite grains. Individual grainsizes seldom > 20 um.

e) Others: Arsenopyrite is abundant throughout, as single crystals 5 um to 100 um (but mostly < 50 um), and as clusters, embedded in sphalerite and gangue. There are minor traces of fine pyrrhotite.

f) Gangue: Abundant carbonate patches, with micas and quartz.
DRILL HOLE NO.: 23 / 64 m
SAMPLE NO.: 9 (P.S. 60231)

GENERAL DESCRIPTION: A disseminated sulphide intersection with a strong preferred fabric, generally fairly fine-grained. Sulphides intergrown with, and replacing, abundant micaceous material.

DETAILS OF SULPHIDES:

a) Sphalerite: As small platy crystals, possibly replacing mica flakes, and as grains < 5 um to 100 um in gangue. Also larger lenses. Smaller masses often free of inclusions, but patches > 300 um have other sulphides.

b) Galena: Mostly as 5-50 um (but mainly < 20 um) inclusions in pyrite; rarely up to 100 um in sphalerite.

c) Pyrite/Marcasite: Pyrite mainly occurs as well-formed single crystals and as granular aggregates which contain very small inclusions of other sulphides (sphalerite, galena, marcasite). A few small, microgranular pyrite/marcasite intergrowths.

d) Chalcopyrite: As < 20 um inclusions in the large sphalerite patches; rarely up to 50 um.

e) Others: Arsenopyrite occurs as well-formed crystals 5 um to 100 um and as small clusters in gangue and in sphalerite.

f) Gangue: Mainly carbonate, minor quartz, mica flakes.
DRILL HOLE NO.: 24/ 45.8 m

SAMPLE NO.: 1 (P.S. 60232)

GENERAL DESCRIPTION: This is a fine-grained, cherty, graphitic schist which is weakly mineralised with sporadic small spots of sulphides. Thus it is mineralised wall-rock.

DETAILS OF SULPHIDES:

a) Sphalerite: Small sporadic grains, 5-100 μm in size, generally with a few small chalcopyrite inclusions. Rare patches up to 200 μm.

b) Galena: Isolated < 20 μm inclusions in sphalerite.

c) Pyrite/Marcasite: Irregular pyrite patches are scattered through the rock and contain small gangue inclusions. No marcasite was detected.

d) Chalcopyrite: As 1-10 μm blebs in gangue and in sphalerite; rarely up to 50 μm.

e) Others: None detected.

f) Gangue: Dominantly microcrystalline, cherty quartz; very small mica and graphite flakes. A few small carbonate patches.
DRILL HOLE NO.: 24 / 47.6 m
SAMPLE NO.: 2 (P.S. 60233)

GENERAL DESCRIPTION: A very weakly mineralised banded slate or schist, markedly folded on a small scale, with folded quartz veins containing sulphides, chiefly pyrite.

DETAILS OF SULPHIDES:

a) Sphalerite: Small isolated grains, up to 250 um in size, but mostly < 50 um. Sometimes with intergrown or included fine galena, chalcopyrite.

b) Galena: Rare fine intergrowths with marcasite, and also in sphalerite as small patches.

c) Pyrite/Marcasite: Pyrite is common, semi-massive, but with many gangue inclusions; it is believed to be recrystallised marcasite. Rare small granular marcasite aggregates, with galena.

d) Chalcopyrite: Isolated grains up to 200x400 um in quartz; incipiently oxidised/tarnished.

e) Others: None detected.

f) Gangue: A fine-grained quartz-rich rock with minor fine micas and graphite.
DRILL HOLE NO.: 24 / 49.7 m
SAMPLE NO.: 3 (P.S. 60234)

GENERAL DESCRIPTION: A loose, porous aggregate of small dolomite crystals, with many cavities; dispersed fine sulphides, quite inconspicuous in hand specimen.

DETAILS OF SULPHIDES:

a) Sphalerite: Small, fairly evenly scattered grains ranging from 5 um to 300 um, but mostly around 50 um in size, throughout the rock, generally free of inclusions. Single crystals and small clusters.

b) Galena: Very rare, as < 20 um grains generally associated with sphalerite.

c) Pyrite/Marcasite: Small elongate aggregates of microgranular marcasite are common, and are thought to represent platy pyrrhotite crystals. Very minor pyrite is associated with some of these.

d) Chalcopyrite: Rare minute (< 5 um) inclusions in sphalerite.

e) Others: Isolated small grains of a Pb-As-sulphide similar to jordanite, which probably account for most of the Pb and As in the assay. Very fine-grained covellite.

f) Gangue: Dominantly dolomite (very probably containing Fe, i.e. verging on ankerite); minor quartz. Occasional pockets of pale chlorite.
DRILL HOLE NO.: 24 / 50.5 m
SAMPLE NO.: 4 (P.S. 60235)

GENERAL DESCRIPTION: A disseminated sulphide ore; the polished section is anomalous in containing far more sulphides than the assay indicates, scattered through a predominantly siliceous, micaceous, fine-grained rock.

DETAILS OF SULPHIDES:

a) Sphalerite: As scattered patches up to 1 mm across, composed of granular aggregates with ultrafine intergranular galena and fine chalcopyrite inclusions. Also coarser intergrowths with larger galena patches, and ultrafine intergrowths with gangue (< 20 um scale).

b) Galena: As patches up to 800 um in size, sometimes intergrown with geocronite. Rims appear corroded. Networks of fine (< 10 um wide) veinlets in sphalerite.

c) Pyrite/Marcasite: Pyrite as somewhat porous crystals with sharp outlines and with fine galena inclusions. A few small marcasite aggregates with fine galena inclusions.

d) Chalcopyrite: Only as < 10 um (mostly < 5 um) inclusions in sphalerite.

e) Others: A few isolated < 20 um arsenopyrite crystals in sphalerite. Geocronite intergrown with galena.

f) Gangue: Mainly quartz and micas, with minor fine carbonate.
DRILL HOLE NO.: 24 / 51.65 m
SAMPLE NO.: 5
P.S. 60236)

GENERAL DESCRIPTION: A finely banded, massive sulphide ore with very little gangue. Textures are complex and fine-grained; marcasite is abundant and thus oxidation problems are likely to arise.

DETAILS OF SULPHIDES:

a) Sphalerite: This mineral forms the matrix for the other sulphides, and thus is full of inclusions on all scales, with free areas seldom exceeding 100 um across. The finest sulphides are arsenopyrite, pyrrhotite, chalcopyrite, all mostly < 10 um and often < 5 um in size.

b) Galena: Almost all galena is very finely (< 20 um scale) intergrown with marcasite, as composite aggregates replacing ?pyrrhotite. Occasional free patches up to 50 um across.

c) Pyrite/Marcasite: Pyrite as well-formed crystals 10 um to 1.5 mm and as granular aggregates with small inclusions of other sulphides. Marcasite is abundant as microgranular aggregates with sphalerite or galena or geocronite.

d) Chalcopyrite: Mostly as < 20 um inclusions in sphalerite, occasionally up to 30 um across.

e) Others: Swarms of minute (mostly < 5 um) arsenopyrite crystals dispersed through sphalerite, also minute pyrrhotite rods. Brown, Ag-rich tetrahedrite (="freibergite") in sphalerite and in geocronite patches, as well as in galena, up to 100 um across.

f) Gangue: Very sparse quartz and carbonate.
Massive sulphide ore with very little gangue. Complex textures and fine grain sizes, with significant marcasite. Abundant tetrahedrite is responsible for the high Ag content of this intersection.

**DETAILS OF SULPHIDES:**

a) **Sphalerite:**
This forms the matrix for the other sulphides and is thus full of small and large inclusions; areas free of other minerals seldom exceed 200 um and are mostly much smaller.

b) **Galena:**
Extensive areas, but almost always intergrown on a fine scale with marcasite or with boulangerite and/or geocronite. Occasional free areas up to 400 um. May contain Ag in solid solution.

c) **Pyrite/Marcasite:**
Coarse pyrite crystals and many clusters of fine, well-formed crystals. Marcasite aggregates are very common, intricately intergrown with other sulphides, and are very fine-grained.

d) **Chalcopyrite:**
Mainly as ultrafine inclusions in sphalerite, but also as occasional larger, irregular patches up to 300 um, intergrown with galena, in sphalerite.

e) **Others:**
Ultrafine (mainly < 10 um) arsenopyrite crystals in swarms in sphalerite. Patches of boulangerite and geocronite, often intimately intergrown with galena; these composite patches also contain conspicuous brown argentiferous tetrahedrite-freibergite. Occasional fresh pyrrhotite crystals up to 200 um. Tetrahedrite also occurs in sphalerite; grain sizes are 5-50 um.

f) **Gangue:**
Sparse carbonate and quartz patches.
DRILL HOLE NO.: 24 / 53.5 m  
SAMPLE NO.: 7 (P.S. 60238)  
GENERAL DESCRIPTION: Semi-massive, granular sulphide ore; it differs from the other intersections in that the major source of Pb is geocronite rather than galena.

DETAILS OF SULPHIDES:

a) Sphalerite: Although there are expanses of sphalerite up to several millimetres across, they contain numerous large and small inclusions of other sulphides; inclusion-free areas up to 300 um exist, but most are < 200 um.

b) Galena: Mainly as small (< 50 um) inclusions in geocronite, and as fine intergrowths with marcasite/pyrite. Also as isolated inclusions in coarse pyrite.

c) Pyrite/Marcasite: Pyrite occurs as well-formed large crystals up to 1-2 mm, generally containing small inclusions of other sulphides, and as clusters of 10-50 um crystals. Marcasite scarce, largely recrystallised to pyrite.

d) Chalcopyrite: As inclusions up to 100 um in pyrite, up to 50 um in geocronite, and < 10 um in sphalerite.

e) Others: Arsenopyrite as spongy clusters/swarms of < 10 um crystals in sphalerite. Geocronite forms expanses up to 1-2 mm, always full of fine pyrite, and with galena, chalcopyrite inclusions. Tetrahedrite as 10-100 um inclusions in sphalerite. Trace fine pyrrhotite.

f) Gangue: Irregular quartz and carbonate patches throughout.
DRILL HOLE NO.: 24 / 54.3 m 8
SAMPLE NO.: 8 (P.S. 60239)

GENERAL DESCRIPTION: This is a fairly weakly mineralised, fine-grained cherty slate or schist and is hard and compact. Sulphides are scattered through the rock as small individual grains as well as sulphide composites.

DETAILS OF SULPHIDES:

a) Sphalerite: As 10-100 um grains, and a few larger lenses (to 300 um) which are generally composite with other sulphides. Occasional patches up to 500 um to 1 mm, with fine chalcopyrite inclusions.

b) Galena: Sporadic patches up to 200 um, mostly intergrown with sphalerite. Also as 5-50 um inclusions in massive, granular marcasite.

c) Pyrite/Marcasite: Massive granular marcasite, marginally recrystallised to pyrite; marcasite is easily tarnished (i.e. oxidised) containing fine inclusions of other sulphides.

d) Chalcopyrite: Traces only, as < 20 um inclusions in sphalerite, and up to 50 um in geocronite.

e) Others: Sporadic patches of geocronite up to 300 um, in folded quartz veins, and containing occasional < 50 um tetrahedrite grains. The geocronite contributes Pb, Sb and As to the sample. Tetrahedrite also occurs in galena.

f) Gangue: The host rock is dominantly finely siliceous (cherty) with many small mica flakes (?sericite).
A weakly mineralised, fine-grained schist, in which the sulphides are largely confined to quartzose lenses which probably represent disrupted veins.

DETAILS OF SULPHIDES:

a) Sphalerite: As scattered small grains, seldom more than 100 µm; some are intergrown with other sulphides.

b) Galena: Irregular small scattered grains, and isolated larger patches (up to 500 µm) in pyrite, but full of pyrite/marcasite inclusions. Also as partial rims to quartz veins.

c) Pyrite/Marcasite: Large masses of granular, very easily oxidised marcasite, generally with pyrite rims. Ultrafine pyrite edging quartz veins, and large well-formed pyrite crystals with inclusions of other sulphides.

d) Chalcopyrite: Isolated grains, 5 µm to 300 µm, in quartz.

e) Others: Geoctonite patches up to 200 µm, with tetrahedrite inclusions up to 100 µm.

f) Gangue: Quartzose and micaceous schist.
Central Mineralogical Services

Nicron Resources Ltd.
P.M.B. 60
WINNELLIE / N.T. 5789
Attn. C. Georgees/P. Appleby

20th November, 1987

REPORT CMS 87/9/17

YOUR REFERENCE: Purchase Order
No. 007682

DATE RECEIVED: 15th September, 1987

SAMPLE NOS.: 15 Samples

SUBMITTED BY: C. Georgees

WORK REQUESTED: Mineralogy/Petrology

H.W. Fander, M. Sc.
11th September, 1987

Central Mineralogical Services
39 Beulah Road
NORWOOD SA 5067

ATTENTION: H.W. Fander

Dear Sir,

A total of 15 drill core samples of the Woodcutters S5 mineralization are enclosed for detailed mineralogical examination. Please use whatever techniques you consider necessary. Perhaps polished thin sections (and some probe work?) would be appropriate. Assays of the relevant intervals with hand specimen descriptions of the samples are appended.

Your previous examinations of Woodcutters mineralization have been mostly of near surface, partly oxidized open cut ore from the S36 orebody, which was hosted dominantly by black carbonaceous calcareous slates. The present S5 samples are from a slightly different geological setting some 50 - 100 metres across strike from the S36 mineralization at a deeper stratigraphic level than S36, and with no evidence anywhere of supergene oxidation. The S5 ore appears to have formed partly by replacement of the so-called (lamprophyric) dolomite dyke, and partly by replacement of dololutite and slate interbeds. Its chemistry is very high in the penalty elements (As, Sb, Fe), and concern is expressed regarding the S5 mineralogy, and whether or not the present milling circuit at Woodcutters is adequate for its treatment.

Would you please make particular comments on the mineralogy and chemistry of S5 ore in this regard, and the existence of exotic sulphosalts from which Pb and Ag may be non-recoverable.

Also, please comment on -

(1) An apparent tendency for high As, Sb and Fe ore to be spatially associated with lamprophyric dykes, and ore low in these elements to be associated with dololutite.
(2) Paragenetic sequence of the ore minerals. Mesoscopically this appears to be massive or banded pyrite, sphalerite ± galena, then galena and sulphosalt veining.

(3) Interpretation of "banded" textures in the ore.

(4) The possible use of fluid inclusions in quartz or calcite in roughly determining temperature of mineralization.

(5) Any other recommendations for further work (eg. lead isotopes) that may be useful in elucidating the origin of Woodcutters mineralization.

(6) Your interpretation of cleavage patterns, grain size and the likely effect on the liberation of metal components.

Should you require any further samples or clarification of field relationships to make the above assessments, please contact me in Townsville (077) 794956. Would you please return offcuts.

Regards,

[Signature]

CHARLIE GEORGEES
CONSULTING GEOLOGIST

Enc:

P.S. Please provide estimate cost for work to P. Appleby, Mill Superintendent
<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>FROM</th>
<th>TO</th>
<th>Pb%</th>
<th>Zn%</th>
<th>Ag g/t</th>
<th>Fe%</th>
<th>Sb%</th>
<th>As%</th>
<th>Cu%</th>
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<td>186.0</td>
<td>187.0</td>
<td>6.94</td>
<td>48.0</td>
<td>205</td>
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<td>0.82</td>
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<td>(186.7m)</td>
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<td>0.09</td>
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<tr>
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<td>0.58</td>
<td>38.0</td>
<td>10</td>
<td>6.94</td>
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<td>Zn%</td>
<td>Ag g/t</td>
<td>Fe%</td>
<td>Sb%</td>
<td>As%</td>
<td>Cu%</td>
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<td>141.6</td>
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<td>470</td>
<td>1.13</td>
<td>5.71</td>
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<td>High grade S5 ore - replaced dolomite dyke</td>
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<tr>
<td>5115-3</td>
<td>118.0</td>
<td>119.0</td>
<td>5.63</td>
<td>7.04</td>
<td>30</td>
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<td>2.71</td>
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<td>1.10</td>
<td>S5 sulphides with unusual high arsenic and copper</td>
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<td>112.0</td>
<td>113.0</td>
<td>0.34</td>
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<td>65</td>
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<td>0.46</td>
<td>0.11</td>
<td>Minor replacement S5 sulphides within dololutite</td>
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<td>S1060</td>
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<td></td>
<td>Dolomite dyke adjacent to S5 ore body. Cleavage and bedding labelled. Contact rock grey carbonaceous calcareous slate</td>
</tr>
</tbody>
</table>
Fifteen drill core intersections were received for mineralographic-petrographic examination; fourteen polished sections and three thin-sections were prepared and described in the attached tables; since most intersections consist of massive sulphides, thin sections were inappropriate.

It was not considered necessary at this stage to carry out electron-probe microanalyses; the mineralogy gives a fairly clear picture of the distribution of the main elements.

Since there was virtually no representation of the host rocks in this suite, and no details of geology, core logs or other data were supplied, it was not possible to give any interpretation of host rock/orebody relationships, orebody genesis, or to make meaningful comments such as were sought in your letter under 1), 3), 4) and 5).

Summary

1. Sulphides

The sulphide minerals identified were sphalerite, pyrite, boulangerite, galena, arsenopyrite, geocronite, tetrahedrite, chalcopyrite and ?stannite; of these, the first five are the most consistent and quantitatively important. The sphalerite is a very pale, low-Fe variety.

Sphalerite is generally coarse-grained and/or present as large masses with large areas (i.e. volumes) relatively free of inclusions, and with simple textural relationships towards other sulphides and gangue. Thus, liberation should be good, and it should be possible to produce very high-grade concentrates with low penalty-element levels.

Pyrite is always well-crystallized, often distributed as lenses or in thin bands; however, most crystals, especially larger ones, contain small inclusions of other sulphides, notably boulangerite, and are microfractured and veined by other sulphides. Its textural relationships show that it was essentially contemporaneous with the other sulphides, though appearing earlier because of its strong tendency to form good crystals.

Boulangerite and galena are often associated, occurring as intergrowths which generally consist of boulangerite blebs in a galena host, though the two minerals are associated in all proportions; liberation of the two components from each other would be difficult because they would not separate cleanly on grinding. Geocronite occurs in similar fashion.
Arsenopyrite is common, occurring in most intersections, as well-defined crystals; however, it is often quite fine-grained and may be difficult to liberate. This may be partly offset by its well-defined, clean outlines which are conducive to good liberation. The larger crystals are often microfractured and veined by other sulphides, and arsenopyrite is analogous to pyrite in this respect, being early-formed though essentially contemporaneous.

Tetrahedrite occurs sporadically, and is the main source of Ag; there is a good correlation between tetrahedrite occurrences and high Ag values. The actual Ag content would need to be checked by electron-probe microanalysis.

Chalcopyrite is also very sporadic in its occurrence, and is not necessarily the main source of Cu in a given sample (see below).

Stannite was tentatively identified as small (2-100 μ, but mostly < 20 μ) inclusions in sphalerite in two intersections, and needs verification by assay or electron-probe microanalysis.

2. Element Distribution

a) Pb. This occurs mainly in galena and boulangerite, and in minor amounts, sporadically, in geocronite.

b) Zn. The only identified source is as sphalerite, which appears to have a very high Zn content, but may also contain significant Cd.

c) Sb. The main source is boulangerite, with patchy contributions from geocronite and with tetrahedrite as a very minor source.

d) As. Arsenopyrite is the principal source, followed by geocronite. It is strongly suspected that pyrite might contain significant As (it has optically anomalous properties often associated with As in the pyrite lattice). The tetrahedrite may well contain minor As, but this would be insignificant.

e) Cu. Sporadic minor to trace amounts of chalcopyrite are present, and tetrahedrite is a further source of Cu. Also, analyses of geocronite show Cu to be present in some samples (ref. Dana's System of Mineralogy). Stannite also contains Cu.

f) Ag. There is a good correlation between high Ag values and the occurrence of tetrahedrite. No doubt the galena also contains some Ag, and there are other possible loci; it would require detailed electron-probe microanalysis to study the distribution of Ag, but tetrahedrite is bound to be the major source.

g) Fe. The main source is pyrite, with a subordinate contribution from arsenopyrite, a very minor amount in sphalerite (however, although the Fe content is probably < 3 %, the abundance of sphalerite causes a significant Fe contribution).

H.W. Fander, M. Sc.
Sample No. Sulphide Mineralogy

S 1055 186.7 m
Major coarse sphalerite with few small inclusions of other sulphides; simple interlocking textures with lobate masses of granular geocronite with subordinate boulangerite, containing tetrahedrite 20-500 μ grains, arsenopyrite euhedral 5-200 μ, and associated pyrite crystals 20 μ to 2 mm, generally with < 50 μ inclusions and veinlets of geocronite. Rare fine galena. Geocronite-boulangerite masses up to 15-20 mm, grains 30-500 μ.

S 1061 224.75 m
Clear areas of sphalerite up to 3-4 mm virtually free of other sulphides; large masses of very coarse arsenopyrite crystals (individuals up to 1-2 mm long), but all microfractured and veined by sphalerite, boulangerite. Conspicuous pyrite, with numerous < 50 μ boulangerite inclusions. Larger masses of granular boulangerite, up to 1-2 mm. Generally a good coarse ore except for inclusions in pyrite and arsenopyrite.

Sphalerite is the matrix for the other sulphides which have a thinly banded distribution; there are clear areas in sphalerite up to 500-700 μ, but it contains scattered interlocking galena and small pyrite crystals. Galena bands, lenses up to 1.5 mm wide, generally with 50-400 μ boulangerite inclusions. Pyrite forms thin bands of euhedral crystals full of < 50 μ galena inclusions, veinlets; larger pyrite crystals are microfractured. Scattered 20-50 μ euhedral arsenopyrite crystals, mainly included in boulangerite. Textures more complex than in above cores.

5300-1 75.67 m
Crude bands and wedges of boulangerite, as granular aggregates with or without granular galena; euhedral pyrite is generally embedded in these masses, and is microfractured and full of small inclusions, veinlets of boulangerite. Sphalerite is finer-grained, often as shapeless masses swarming with minute tourmaline needles. Boulangerite/tourmaline masses also occur. Arsenopyrite as patches up to 1 mm in tourmaline swarms. Boulangerite/galena textures difficult.

5300-1 103.04 m
Banded ore, with clean sphalerite bands up to 7 mm wide flanked by tourmaline/sphalerite masses; pyrite-rich bands, lenses with associated granular boulangerite surrounding pyrite and as inclusions (< 50 μ) and veinlets. Scattered arsenopyrite, 20 μ to 800 μ crystals and larger masses. Minor galena, mostly as < 100 μ inclusions in boulangerite. Trace geocronite. Incipient oxidation in microfractures.

5300-2 111.02 m
Mainly coarse euhedral pyrite and arsenopyrite, but both extensively microfractured and finely veined by galena and tetrahedrite. Also larger masses of tetrahedrite, up to 1.3 mm, relatively conspicuous - main source of Cu and Ag. Traces of chalcoprite up to 100 μ in gangue and tetrahedrite (which is also the main source of Sb). Abundant coarse carbonate gangue.
Sample No. | Sulphide Mineralogy
---|---
5300-2 | 130.3 m  
Semi-continuous massive sphalerite forming matrix for thin bands of pyrite with scattered arsenopyrite crystals 20 μ to 1 mm; small (1-50 μ) grains of ?stannite throughout sphalerite, and < 200 μ boulangerite patches. A Zn-rich intersection. Pyrite appears corroded. Small trace ultrafine chalcopyrite in sphalerite.

5190-5 | 119.85 m  
Massive coarse sphalerite with minute inclusions of ?stannite, small boulangerite grains, and bands, lenses, aggregates of pyrite crystals full of small boulangerite needles; associated complexly intergrown granular masses of galena/geocronite/boulangerite. Scattered arsenopyrite crystals, 30-200 μ. Cu probably contained in geocronite.

5190-5 | 123.18 m  
Well-banded ore, with massive bands (up to 7 mm thick) of granular boulangerite and boulangerite/galena intergrowths, alternating with sphalerite bands; pyrite as large and small crystals, full of small boulangerite inclusions, throughout, but mainly in boulangerite. Sporadic arsenopyrite as grains (1-50 μ) and corroded crystals up to 300 μ.

5190-5 | 141.3 m  
Large (up to 30 mm or more) masses of granular boulangerite, intergrown with galena on a fine to coarse scale and in varying proportions; containing lines of (mostly < 20 μ) arsenopyrite crystals; larger arsenopyrite crystals, clusters, up to 300 μ. Sphalerite as masses up to 10 mm, with < 20 μ inclusions of pyrite, arsenopyrite, trace chalcopyrite; cut by boulangerite veinlets. Tetrahedrite patches up to 5 mm, with fine inclusions of boulangerite, arsenopyrite, galena, sphalerite.

5115-3 | 118.7 m  
Matrix of massive, coarse sphalerite with inclusions-free areas up to several millimetres square, with thin bands/ stringers of pyrite, with associated and included boulangerite. Also large lenses of compact pyrite/arsenopyrite with intergrown sphalerite, boulangerite. Wisps, streaks of fine tourmaline needles.

5115-3 | 122.08 m  
Not representative. Large masses (up to 30 mm) of coarse galena with boulangerite as inclusions and intergrowths on coarse to fine scale. Minor sphalerite, scattered pyrite, trace arsenopyrite and fine chalcopyrite.

5300-2 | 110.04 m  
Disseminated sulphides in carbonate host. Individual euhedral crystals of pyrite, arsenopyrite (up to 1 mm); chalcopyrite as patches up to 2-3 mm (and smaller grains). Occasional tetrahedrite up to 500 μ with chalcopyrite. Galena and chalcopyrite as networks of minute veinlets in gangue. Minor sphalerite, mostly 10-100 μ grains in gangue.

5190-5 | 112.0 m  
Disseminated sulphides in carbonate (+ quartz) gangue; mainly coarsely crystalline pyrite and interstitial coarse, clean sphalerite. Pyrite has small inclusions and veinlets of galena, sphalerite, boulangerite. Also a few larger boulangerite patches. Not very representative.
Sample No. | Petrography
--- | ---
5300-1 | Dominantly sulphides, as crustiform-banded masses, impregnating matted needles of pale tourmaline. Relict patches of mosaic quartz impregnated with random tourmaline needles. The sulphides appear to have almost completely replaced a quartz-tourmaline rock of unknown origin. The sphalerite is a pale amber to white, very low-Fe variety.
103.04 m | Dolostone, originally fine-grained, uniform, microcrystalline and faintly bedded, cut by diagenetic dolomite veinlets; weakly carbonaceous. Extensively veined by younger, coarse dolomite veins (i.e. post-diagenetic), representing recrystallization. Irregular patches of fine replacive quartz, ovoid, lensoid and vein-like. Scattered euhedral pyrite, and replacive veins and networks of pale sphalerite, which appear to be younger than all other components. Low Fe content suggests low-temperature formation and is supported by vague relict colloform textures.
5190-5 | Thus, the inferred paragenesis is: 1) chemical sedimentation of carbonaceous fine dolostone, 2) formation of thin veins of clear dolomite during diagenesis, 3) deposition of pyrite, 4) partial replacement by quartz masses, 5) formation of coarse dolomite veins, and 6) replacive veining by sphalerite.
112.0 m | Carbonaceous dolostone with a superimposed slaty cleavage which makes an angle of 70° with the original bedding, as correctly indicated on the core. Bedding is defined by more carbonaceous laminations alternating with less carbonaceous dolomite, passing fairly abruptly (in the core) into a pale grey, weakly carbonaceous dolostone. The rock is recrystallized from originally very fine (silt-sized) dolomite grains, to larger interlocking patches. The slaty cleavage is accentuated by wisps of semi-graphitic material derived from the original rock. Veins of clear dolomite, with quartz and minor pyrite, traverse the rock and are more or less concordant with the cleavage; the quartz within them is quite strongly stressed, suggesting a further (i.e. younger) weak dynamic episode.
S 1060 | N.B. Most intersections contain tourmaline, generally as clusters and swarms of fine needles pervaded by sulphides.
213.5 m |
Central Mineralogical Services

Mr. P. Appleby
Metallurgy Manager
Micron Resources Ltd.
Woodcutters Mine
P.M.B. 60
WINNELIE / N.T. 5789

6th November, 1987

REPORT CMS 87/10/36

YOUR REFERENCE: Order No. 008188
DATE RECEIVED: 30th October, 1987
SAMPLE NOS.: 3 Samples
SUBMITTED BY: P. Appleby
WORK REQUESTED: Mineralogy

H.W. Fander, M. Sc.
28th October, 1987

Central Mineralogical Services
39 Beulah Road
NORWOOD SA 5067

ATTENTION: Wally Fander

Dear Sir,

Pursuant to our telecon of October 28th 1987, please find enclosed three composite samples of concentrator products identified as "final tail" and "Zn Clnr Tail" Zn RO 1 and 2 dated 27.10.87.

Problems encountered with Zn metallurgy on this particular day were -

(a) High zinc losses to final tail;
(b) Extremely slow flotation rate of Zn minerals during 1st, 2nd and 3rd stages of cleaning.

From a performance survey of zinc operations on this date it is almost certain that the bulk of the Zn losses resulted from high Zn values in the first Zn cleaner tail. This material had already floated out during Zn Roughing/Scavenging operations but proved difficult to refloat during cleaning stages despite lowering pH values, staging collector additions and increasing reagent addition rates.

It was interesting to note that the concentrate from the first two roughing cells which are currently reporting to final con. assumed a pale creamy grey colour while the cleaner concentrates displayed an orange-red colour.

The majority of the zinc losses appear to be in the -106 μm range. Major losses in this size range do not usually occur.

Please carry out mineralogical determinations on all samples and make any pertinent comments.

Regards,

PAUL APPLEBY
METALLURGY MANAGER

Enc:
Three samples of mill products, comprising the Final Tail, Zn Cleaner Tail, and Rougher Con. 1 and 2, were received for mineralogical examination, with special reference to high Zn losses. Polished sections were prepared and are described below.

1. **Final Tail**  
   (P.S. 59130)

   The sphalerite is virtually all free, with occasional composites with pyrite or with < 15 μ inclusions of geocronite; the grains appear to have a narrow size range, the bulk being in the 50-100 μ range, with a few up to 150 μ and only a small proportion < 50 μ. The sphalerite appears normal, i.e. comparable with sphalerite in concentrates.

   Geocronite is dominantly free. The major sulphide is free pyrite; it is believed to be arsenical. It sometimes contains small (< 20 μ) inclusions of galena, and there are a few composites with sphalerite.

2. **Zn Cleaner Tail**  
   (P.S. 59131)

   Sphalerite is the dominant sulphide, principally as free grains; most grains are in the 25-75 μ range, with a substantial proportion in the 75-125 μ range, but much less < 25 μ material. A few composites with pyrite occur.

   Pb is mainly present as free, ultrafine galena (< 15 μ). Pyrite is common; assays and optical properties suggest that it contains significant As.

3. **Zn Rougher 1 & 2**  
   (P.S. 59132)

   Sphalerite is all free, except for isolated < 20 μ inclusions of galena and pyrite; the size range is very wide, from 1 μ to 150 μ, with a substantial proportion in the < 10 μ range, which accounts for the pale, creamy colour of the product.

   Free and composite pyrite is a minor constituent, and there are grains of free galena and rare boulangerite/geocronite; some of the As occurs in pyrite.

**Comments**

There is no mineralogically detectable reason for the abundance of free sphalerite in the final tail; the sphalerite appears the same as the material in the concentrate.

However, there is an interesting trend in the sphalerite grain size ranges between the three samples. Sphalerite sizes are in a very narrow range in the final tail, a wider range in the Zn Cleaner Tail, and with abundant very fine sphalerite in the Rougher Concentrate.

**H.W. Fander, M. Sc.**
Central Mineralogical Services

Mr. S. Cross
Mill Superintendent
Woodcutters J.V.
P.M.B. 60
WINNELLIE / N.T. 5789

21st February, 1986

REPORT CMS 86/2/10

YOUR REFERENCE:       Letter dated 13.2.1986
DATE RECEIVED:         14th February, 1986
SAMPLE NOS.:           14 Samples
SUBMITTED BY:          L. McCrabb
WORK REQUESTED:        Mineralogy

Copy to:
The Manager
Woodcutters J.V.
Suite 304
203, South Head Road
EDGECLIFF / N.S.W. 2027

H.W. Fander, M. Sc.
REPORT CMS 86/2/10

S 1006 Flotation Products - Tests F 13, F 13B

Two sets of flotation products, each of seven samples, were received for mineralogical examination. On the basis of Pb assays (received verbally from S. Cross), key samples were selected from each set and were examined; in addition, the -2 mm head sample (M034) was re-examined by different methods.

Head Sample (M 034)

In de-sliming a portion of the sample it was noticed that a graphite-like film formed on the aqueous surface; evidently, the finer sulphide grains (especially boulangerite) are strongly hydrophobic, and would cause some losses. The coarser boulangerite particles appear to be etched and corroded, and some are very thinly coated with a black substance of unknown composition, which would not be detectable in a polished section.

Test F 13 Samples 203, 204, 205, 208

203 The components are very fine-grained, with few grains > 50 μ and most < 25 μ. Samples 204 and 205 are also very fine grained, and thus there are very few composites.

Boulangerite is the Pb mineral in this sample. The main diluent is free pyrite, with subordinate gangue, minor sphalerite, a trace of arsenopyrite; there are rare grains of covellite and composites of boulangerite/sphalerite.

204 The dominant Pb mineral is free boulangerite, with minor galena. Diluents are mainly free gangue, pyrite, minor sphalerite; there are rare covellite grains and composites.

205 This consists, in approximate order of abundance, of free pyrite, gangue, sphalerite, boulangerite, traces of galena and arsenopyrite. Composites are rare, and the sulphide grains appear fresh.

208 This is a much coarser product, but liberation is nevertheless excellent, with a few binary composites of pyrite/sphalerite, sphalerite/boulangerite, sphalerite/arsenopyrite. The major minerals are gangue and pyrite, with subordinate boulangerite and sphalerite, minor galena and a trace of arsenopyrite. Boulangerite and sphalerite are up to 150 μ in size. The sulphides appear fresh in polished section, but could have submicroscopic coatings/films.
Test F 13B        Samples 423, 424, 425

423       This is a much coarser product than sample 203, but liberation is very
good. It consists mainly of free pyrite, subordinate boulangerite,
minor sphalerite, traces of gangue, galena and arsenopyrite. Many grains
are incipiently to extensively corroded and some are quite porous; the
accompanying photomicrograph (200x magnification) shows very porous
boulangerite (B), etched pyrite (P) and galena (G); the pores and
etch-cavities contain corrosion/oxidation-products which were not
identified.

424       This sample consists of major pyrite, subordinate sphalerite, minor
gangue and boulangerite, traces of arsenopyrite and galena. A few grains
are etched, but the great majority are free and appear fresh. Some of
the galena and boulangerite is free, but the bulk occurs as composites/
inclusions with sphalerite or pyrite.

425       This sample is composed dominantly of free pyrite and sphalerite, with
subordinate gangue, minor arsenopyrite, traces of boulangerite and galena;
these mainly occur as small (mostly < 25 μ) inclusions in pyrite or
sphalerite.

Comments

Since liberation in all samples is very good, the main problem seems to be
related to flotation response, no doubt due to the partial oxidation which is
evident in this ore intersection.

Some evidence of microfracturing, leaching, incipient oxidation, black powdery
coatings and other features would have been expected to show up in the drillcore,
and these and other small-scale features could be more important, in giving
early warning of possible poor metallurgical performance, than has hitherto
been appreciated.

H.W. Fander, M. Sc.
Central Mineralogical Services

Mr. S. Cross
Mill Superintendent
Woodcutters J.V.
P.M.B. 60
WINNELIE / N.T. 5789

20th February, 1986

REPORT CMS 86/2/7

YOUR REFERENCE: Note dated 10.2.1986
DATE RECEIVED: 11th February, 1986
SAMPLE NOS.: 20 Samples
SUBMITTED BY: L. McCrabb
WORK REQUESTED: Mineralogy

Copy to:
The Manager
Woodcutters J.V.
Suite 304
203, South Head Road
EDGECLIFF / N.S.W. 2027

[Signature]
H.W. Fander, M. Sc.
Two sets of size fractions, comprising twenty samples, were received for mineralogical examination; the head samples were mineralogically described in report CMS 86/2/1. Where possible, the samples are described in summary form, to avoid repetition and unnecessary cost.

**Sample 667 (10 size fractions) AFS 1**

The mineralogy differs slightly from that of the head sample, not in species but in mineral proportions, no doubt because the size fractions are more representative than the ~2 mm crushed material.

The minerals, in approximate order of abundance, are pyrite, sphalerite, boulogerite, arsenopyrite, minor galena and gangue; the pyrite is characterised by small boulogerite inclusions < 5 μ to 50 μ. Traces of goethite and oxidation-products (pyromorphite, bindheimite) are present in all the fractions.

Composites decrease from the coarsest fractions as follows:

- +150 μ / 15-20 %, +106 μ / 8-10 %, +75 μ / 5-7 %, +53 μ / 2-3 %,
- +45 μ / 1-2 %, cyclone 1 and below, < 1 %. Whilst the +150 μ fraction contains complex sulphide composites, especially in the +300 μ grains, which may consist of three or four intergrown phases, most composites are "inclusion textures", i.e. inclusions of one sulphide in another, where the inclusions are generally small (< 30 μ). The commonest of these are boulogerite in pyrite, and pyrite in sphalerite. Simple, binary composites are also present, but are minor.

The gangue content of the fractions is low and is fairly constant, but with a very marked and progressive increase from cyclone 3 to cyclone 5; cyclone 3 also seems to contain a higher proportion of sphalerite.

The presence of oxidation-products is a warning of possible flotation problems.

**Sample 669 (10 size fractions) CS 2**

This material is severely oxidised, as already described in relation to the head sample. The oxidation was selective and also has a liberating effect on the residual sulphides, so that very few composites are present even in the +150 μ fraction. Liberation is partly due to oxidation and disintegration along fractures in sulphides, and partly to solution and removal of sulphides.

All the sulphides have been affected by oxidation; many of the surviving sulphide grains, especially in the coarse size fractions, are etched and corroded.

Pyrite is the main sulphide; there are minor to trace amounts of sphalerite, arsenopyrite and boulogerite, and galena was detected only in finer fractions (probably liberated, by grinding, from coarser composites where it was protected from oxidation).
There appear to be very few composites between sulphides and their oxidation-products, suggesting that the oxidation-products were removed as solutions and were deposited elsewhere.

The proportions of both gangue (mainly quartz) and oxidation-products increase in finer fractions; the proportion of pyrite also seems to increase, with a decrease in the other sulphides.

Liberation is very good, even in the coarsest fractions, and is virtually complete at 75 μ.

H.W. Fander, M. Sc.
Mr. S. Cross  
Mill Superintendent  
Woodcutters J.V.  
P.M.B. 60  
WINNELLIE / N.T. 5789  

12th February, 1986

REPORT CMS 86/2/1

YOUR REFERENCE: Letter  
DATE RECEIVED: 4th February, 1986  
SAMPLE NOS.: 10 Samples  
SUBMITTED BY: L. McCrabb  
WORK REQUESTED: Mineralogy

Copy to:  
The Manager  
Woodcutters J.V.  
Suite 304  
203, South Head Road  
EDGECLIFF / N.S.W. 2027

H.W. Fander, M. Sc.
Woodcutters Drillhole and Pit Samples

Ten samples were received for mineralogical examination; they included six size fractions from S 1013, and four other samples (mine bench sample, autogenous feed sample, two clay samples). Polished sections were prepared, and the clay samples were also examined by other methods. The results are presented in the tables 1 and 2.

Comments

There is evidence of oxidation in all samples except M 643 (MBS 1), with advanced oxidation in M 645 (CS 1) and particularly in M 646 (CS 2).

The oxidation-products represent metal losses; although some could be recovered by gravity methods, efficiency would not be good. However, the oxidation-products may contain enhanced Ag values; experimental recovery of a gravity concentrate from a flotation tail may be worth investigating.

Sample S 1013 shows better liberation characteristics than might have been anticipated from the textures.

H.W. Fander, M. Sc.
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Brief Mineralogical Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 267 -2 mm</td>
<td>Major pyrite, gangue, sphalerite; minor arsenopyrite, boulangerite, galena. Some fragments are microfractured and partly oxidised pyrite + arsenopyrite. Pyrite contains &lt; 20 μ veinlets and inclusions of boulangerite, galena. Fine intergrowths of gangue/sphalerite fairly common, also gangue/boulangerite. Arsenopyrite generally well-crystallized. Some sphalerite is coarse, with few sulphide inclusions. Textural relationships more complex, and finer, than in other drillholes. More gangue.</td>
</tr>
<tr>
<td>M 304 P80/75 μ</td>
<td>Major pyrite and gangue, subordinate sphalerite, minor boulangerite, arsenopyrite; trace galena. About 10% composites of various sulphide/sulphide, sulphide/gangue combinations, especially the &gt; 200 μ grains.</td>
</tr>
<tr>
<td>M 625 +75 μ</td>
<td>Major pyrite, gangue; subordinate sphalerite, minor arsenopyrite, boulangerite; trace galena. About 5-10% composites, in the form of fine inclusions of one sulphide in another or in gangue; rare ternary or more complex composites.</td>
</tr>
<tr>
<td>M 626 +53 μ</td>
<td>About 3% composites, generally as small inclusions of one sulphide in another. Major pyrite, subordinate sphalerite and gangue; others minor. Arsenopyrite dominantly free; occasional &lt; 20 μ inclusions in sphalerite.</td>
</tr>
<tr>
<td>M 627 +38 μ</td>
<td>About 1-2% composites; many of these are fine pyrite in sphalerite, or boulangerite in pyrite; occasional galena/sphalerite as simple composites.</td>
</tr>
<tr>
<td>M 628 -38 μ</td>
<td>Very good liberation of all sulphides and gangue; very occasional sphalerite grains with &lt; 10 μ inclusions of pyrite or galena; rare pyrite/sphalerite composites.</td>
</tr>
</tbody>
</table>

**Summary**

Although the ore from this intersection is pyritic and contains more than the normal amount of gangue, and its textures are more complex, it nevertheless seems to liberate quite well. The evidence of minor oxidation, however, could suggest possible flotation problems due to conditioning of mineral surfaces; undue stockpiling would presumably worsen this situation.
Sample No. | Brief Mineralogical Description | Surface Samples
--- | --- | ---
M 643 (MBS 1) | Major, coarsely crystalline sphalerite, pyrite and boulangerite, minor well-crystallized arsenopyrite and galena, very minor gangue. Pyrite contains < 20 µm boulangerite and sphalerite inclusions. Pyrite is corroded by sphalerite, forming interlocking boundaries. Sphalerite/boulangerite sometimes as complex intergrowths, but textures generally fairly simple and relatively coarse. Much of the gangue is very fine tourmaline (needles), scattered through sulphides - the needles are mostly < 20 µm in diameter.

M 644 (AFS 1) | Major pyrite and boulangerite, with subordinate sphalerite, minor galena, arsenopyrite and gangue. Boulangerite as large masses, but with well-formed arsenopyrite crystals 20-600 µm common. Boulangerite also as small inclusions in pyrite, sphalerite. Galena and sphalerite generally coarsely crystalline. A few partly to completely oxidised pyrite masses, and grains of heavy-metal oxidation-products (?bindheimite). A few patches of fine sphalerite/tourmaline needles with other associated sulphides. Most textures are simple.

M 645 (CS 1) | Mixture of fresh, partly oxidised and completely oxidised sulphides; these include pyrite, sphalerite, arsenopyrite, boulangerite, traces of galena. The sulphides most prone to oxidation are pyrite, galena and arsenopyrite, followed by boulangerite; sphalerite appears to be most resistant. The sulphides are generally coarse, but oxidation-products are very fine-grained, "earthy", and are difficult to distinguish from each other and from ferruginous clays. Many of the sulphide grains are tarnished or coated. Oxidation-products identified include pyromorphite, bindheimite and goethite-limonite; there may be others, too fine to readily identify.

M 646 (CS 2) | All the sulphides are represented, and some grains appear fresh, but most are corroded and partly oxidised; oxidation-products are abundant as more or less compact masses. The main sulphide is pyrite, with subordinate sphalerite, very minor boulangerite, arsenopyrite, and a trace of galena; the sulphides are mostly coarse-grained. Oxidation-products are very fine-grained, spongy, cellular, earthy and compact; it can be assumed that they are the same minerals as in M 645. The sulphide grains (in M 645 and M 646), which appear internally fresh, are often lightly tarnished. The sample contains a small amount of graphite.
Mr. S. Cross
Mill Superintendent
Woodcutters J.V.
P.M.B. 60
WINNELLIE / N.T. 5789

17th February, 1986

REPORT CMS 86/2/4

YOUR REFERENCE: Letter
DATE RECEIVED: 10th February, 1986
SAMPLE NOS.: 32 Samples
SUBMITTED BY: L. McCrabb
WORK REQUESTED: Mineralogy

Copy to:
The Manager
Woodcutters J.V.
Suite 304
203, South Head Road
EDGECLIFF / N.S.W. 2027

H.W. Fander, M. Sc.
Sets of size fractions from samples 655 (CS 1), 656 (MBS 1) and 658 (C/OF), as well as sample 745 (head sample C/OF 28/29) were received for mineralogical examination; the head samples CS 1 and MBS 1 had already been examined and reported (report CMS 86/2/1). In order to be as economical as possible, all the samples were examined, but results presented in summary form to avoid unnecessary repetition.

Sample 655 (10 size fractions) CS 1

1. The coarsest fractions contain the most sulphides; these show signs of corrosion and oxidation.

2. Gangue minerals and oxidation-products increase in the finer fractions, at the expense of the sulphides, especially sphalerite, boulangerite and galena. The C/S 4 and 5 fractions especially, consist dominantly of gangue and oxidation-products (i.e. bindheimite, pyromorphite and others) with only minor pyrite and traces of other sulphides.

3. Liberation of the sulphides is very good; composites are < 5 % in the +106 µ fraction, and < 2 % in the +75 µ fraction; below this, liberation is virtually complete.

4. Inevitably, recoveries will be poor, especially of Pb, Ag and Sb, mainly because of the oxidation-products and partly because of the conditioning/modification of sulphide surfaces.

Sample 656 (10 size fractions) MBS 1

1. The sulphides all appear to be fresh, though very thin surface effects would not be mineralogically detectable in any case (i.e. < 1 µ). No oxidation-products were seen.

2. There is an increase in gangue in the finest fractions, mainly due to fine liberated tourmaline needles, many of which are < 10 µ in diameter and are evidently relatively easily liberated.

3. Percentages of composites are as follows:
   
   20 % in the +150 µ fraction, 10 % in the +106 µ fraction, 5-7 % in the +75 µ fraction, 2-3 % in the +53 µ fraction, 1-2 % in the +45 µ fraction, < 1 % in the finer fractions.

   Many composites are in the form of small inclusions of one sulphide in another, especially of pyrite or boulangerite in sphalerite and boulangerite in pyrite; the coarsest composites are often more complex. The inclusion-type composites are difficult to liberate.
It is suspected that the pyrite itself may well contain a significant amount of As (in the crystal lattice), in which case it cannot be regarded simply as a diluent, but as a deleterious mineral; this would need to be verified by electron-probe microanalysis. Thus, small pyrite inclusions in sphalerite would increase the As content of a Zn concentrate.

658 (11 size fractions) Cy. O/F 28/29

+300 µ. This fraction consists dominantly of gangue particles; most are free, but some have sulphide inclusions (mainly pyrite, minor boulangerite, sphalerite). Coarse pyrite occurs and contains small (<50 µ) boulangerite inclusions; coarse free and composite sphalerite is present. There are aggregates of smaller (<100 µ) sulphide grains, mainly pyrite and sphalerite. Particles of spongy goethite are present.

+150 µ. The gangue component is considerably reduced, to about 50 %; sulphides are mainly free pyrite and sphalerite, with traces of arsenopyrite and boulangerite. Sulphide composites are mainly sphalerite/pyrite, with minor pyrite/boulagerite, sphalerite/galena and sphalerite/pyrite/boulangerite. Gangue is free and also composite with sulphides. Minor spongy goethite is present.

+106 µ. Gangue is <5 %. Dominant minerals are free pyrite and sphalerite, with very minor arsenopyrite and boulangerite (free and as small inclusions in pyrite). Composites are mainly as inclusions of one sulphide in another, with a few simple binary composites. A trace of goethite is present.

Finer Fractions (i.e. <106 µ). These contain progressively fewer composites (+75 µ = <5 %; +53 µ = 1-2 %; +45 µ = 1 %; remainder = <1 %); gangue levels are low (2-3 %), except in Cy. 5 which contains 50 % or more. Composites are mainly in the form of small boulangerite inclusions in pyrite.

745 Cy. O/F Head

This sample contains many aggregates of small sulphide grains; whilst many of these are evidently sufficiently friable to break down during sizing, some are compact and thus report in coarse fractions (see above). The presence of goethite in this sample and in the size fractions indicates that limited oxidation has occurred in the ore and could be responsible for abnormal flotation response.

H.W. Fander, M. Sc.
REPORT CMS 86/1/17
Supplement

YOUR REFERENCE: Verbal request
Order No. to be advised

DATE RECEIVED: 28th January, 1986

SAMPLE NOS.: C 2

SUBMITTED BY: S. Cross

WORK REQUESTED: Mineralogy

Copy to:
The Manager
Woodcutters J.V.
Suite 304
203, South Head Road
EDGECLIFF / N.S.W. 2027

H.W. Fander, M. Sc.
Central Mineralogical Services

Mr. S. Cross
Mill Superintendent
Woodcutters J.V.
P.M.B. 60
WINNELIE / N.T. 5789

24th January, 1986

REPORT CMS 86/1/17

YOUR REFERENCE: Verbal request
DATE RECEIVED: 21st January, 1986
SAMPLE NOS.: C1 - C4
SUBMITTED BY: S. Cross
WORK REQUESTED: Mineralogy

Copy to:
The Manager
Woodcutters J.V.
Suite 304
203, South Head Road
EDGECLIFF / N.S.W. 2027

H.W. Fander, M. Sc.
Four samples of oxidised material were received for mineralogical examination, with special reference to the occurrence of oxidation-products. The samples were examined optically and by X-ray diffraction.

**C 1 - 17.1**

2.4 % Pb, 0.8 % Sb, 2.1 % Zn

This consists mainly of a brown ferruginous clay, and minor particles of fresh and superficially oxidised sulphides which probably account for the assays.

**C 2 - 17.1**

7.25 % Pb, 2.65 % Sb, 1.8 % Zn

This appears to be a completely homogeneous yellow ochreous limonitic clay, with no recognisable heavy metal oxides which would account for the assays; they may be so intimately mixed with the clay as to be optically undetectable, or the elements may be absorbed/adsorbed in some way without occurring as separate compounds.

A more detailed investigation may shed some light on this somewhat puzzling material, but would be costly and not necessarily very useful.

**C 3 - 17.1**

32 % Pb, 21 % Sb, 0.5 % Zn

Much of the sample consists of a bright yellow, earthy mineral which is extremely finely crystalline, isotropic (cubic) with high refractive index; it was identified by XRD and optical data as bindheimite, Pb₅Sb₂O₆(OH). The sample also contains minor tarnished arsenopyrite and pyrite, sphalerite and quartz.

Dana's "System" quotes bindheimite as being an oxidation-product of boulangite.

**C 4 - 17.1**

0.05 % Pb, 0.67 % Sb, 5.5 % Zn

This consists dominantly of sulphides, chiefly pyrite, with minor sphalerite, arsenopyrite and a trace of boulangite. There is a white earthy mineral which was hand-picked and tentatively identified by XRD as stibiconite, (H₂Sb₂O₅), of variable composition and properties.

H.W. Fansett, M. Sc.
b. Microscopic:

A portion of the sample was subjected to repeated careful washing and disaggregation, leaving a residue of coarser particles which were hand-panned in a 15 cm glass dish to produce a heavy fraction.

Examination of this fraction, using optical and XRD techniques, showed that it consisted dominantly of small, well-formed yellow hexagonal crystals < 300 μ in size, with minor fresh pyrite, sphalerite and boulangerite, traces of a white crystalline mineral and a pale yellow substance.

The yellow crystals consist of pyromorphite partly replaced by bindheimite and limonite; the white mineral is clean pyromorphite, and the pale yellow substance is finely crystalline bindheimite. No doubt some of the bindheimite occurs in very finely dispersed form, as crystallites < 2 μ in size, in the limonitic clay.

H.W. Fander, M. Sc.
Report CMS 86/1/10

Your Reference: Purchase Order No. 002138

Date Received: 15th January, 1986

Sample Nos.: 24 Samples

Submitted By: L. McCrabb

Work Requested: Mineralogy

Copy to:
The Manager
Woodcutters J.V.
Suite 304
203, South Head Road
EDGECLIFF / N.S.W. 2027

H.W. Fander, M.Sc.
Four sets of samples were received for mineralogical examination; they comprised crushed core ( -2 mm), the P80/75 μm mill discharge, and four size fractions (+75 μm, +53 μm, +38 μm, -38 μm). Polished sections were prepared and examined, and the results are presented in the attached tables.

Comments

The samples appear fresh and there is very little mineralogical evidence of oxidation; two grains of covellite were detected, and (in sample S 1010) a few galena grains appeared to be corroded. Superficial effects due to "acid" groundwaters would, however, be difficult to detect mineralogically whilst possibly affecting surface properties.

The sulphides in all drillholes were, on the whole, coarse to very coarsely crystalline, and thus liberation was very good; S 1011 and S 1012 were outstanding in terms of the coarseness of the sphalerite (and galena, in S 1011), and S 1012 is sphalerite-rich.

Galena and boulangerite are the major Pb minerals, and geocronite appears to be very minor; boulangerite generally predominates over galena, except in S 1011, where galena is the main Pb mineral.

Arsenopyrite is variable, being more conspicuous in S 1009 and S 1010; it is generally well-crystallized and thus easily liberated.

In all the size fractions, the coarser sizes tend to be enriched in the harder components (pyrite, gangue, arsenopyrite), whereas the finer fractions contain increased amounts of the softer minerals (galena, boulangerite, sphalerite).

H.W. Fander, M. Sc.
Sample No.  

Brief Mineralogical Description

S 1009

M 099
-2 mm
Major coarse pyrite, and coarse pyrite-arsenopyrite masses; free sphalerite up to 2 mm, also very fine sphalerite in gangue intergrowths, and sphalerite-boulangerite-galena. Boulangerite sometimes with < 50 μ arsenopyrite inclusions. Galena is scarce, ?geocronite present. Arsenopyrite conspicuous, as well-defined crystals (?easily liberated).

M 269
P80/75 μ
Good liberation, especially in the < 75 μ grains; composites are generally > 100 μ, mostly sphalerite/gangue, with various combinations of two sulphides; very occasional ternary composites.

M 270
+75 μ
Good liberation of all components; < 10 % composites (total), comprising sphalerite/boulangerite, sphalerite/gangue, pyrite/sphalerite, others. Most are simple intergrowths, with occasional very fine sphalerite/gangue particles.

M 271
+53 μ
Very good liberation; < 2 % of all grains are composite, most commonly sphalerite/pyrite or sphalerite/boulangerite. Mainly simple intergrowths; some grains have small inclusions of one sulphide in another.

M 272
+38 μ
Excellent liberation, with < 1 % composites, generally as binary particles between two sulphides.

M 273
-38 μ
Virtually complete liberation of all components; abundant < 10 μ particles.

S 1010

M 101
-2 mm
Major pyrite, sphalerite and boulangerite, with minor galena and arsenopyrite and gangue. Generally coarsely-intergrown, some sphalerite as free grains up to 2 mm. Arsenopyrite sometimes as clusters of < 50 μ crystals with interstitial sphalerite, boulangerite. Pyrite contains veinlets, < 20 μ inclusions of boulangerite. Some gangue is very fine.

M 274
P80/75 μ
Good liberation, with < 10 % composites, generally as binary sulphide/sulphide or sulphide/gangue particles. Mainly pyrite, sphalerite and gangue, minor boulangerite, very minor galena. Possible superficial oxidation of some galena grains.

M 275
+75 μ
Good liberation; about 5-10 % composites, mostly as < 50 μ inclusions of one sulphide in another or in gangue; a few grains up to 1.5 mm across, generally more complex composites with 3 or 4 components. Mainly pyrite, sphalerite, gangue.

M 276
+53 μ
Good liberation; 3-5 % composites, generally as small (< 30 μ) inclusions of one sulphide in another; a few simple sulphide/sulphide composites, e.g. pyrite/sphalerite, pyrite/boulangerite.

M 277
+38 μ
Very good liberation; < 1 % composites, mostly as small boulangerite inclusions in pyrite.

M 278
-38 μ
Virtually complete liberation, except for stray oversize grains (up to 100 μ), a few of which are composite.
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Brief Mineralogical Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S 1011</strong></td>
<td></td>
</tr>
<tr>
<td><strong>M 067</strong></td>
<td>Major pyrite, sphalerite and galena, minor boulangerite, arsenopyrite and gangue; some galena and sphalerite are very coarse and free or with a few scattered inclusions only. Intergrowths generally coarse and simple; pyrite and arsenopyrite as well-defined crystals/clusters with interstitial galena, boulangerite; some arsenopyrite is microfractured, finely veined.</td>
</tr>
<tr>
<td><strong>P 80/75 μ</strong></td>
<td>Good liberation of &lt; 100 μ grains; a few simple composites, generally binary particles; sphalerite/pyrite, sphalerite/boulangerite.</td>
</tr>
<tr>
<td><strong>M 279</strong></td>
<td>Good liberation, with &lt; 5 % composites, which are almost all &gt; 150 μ, mostly sphalerite/pyrite or boulangerite or galena.</td>
</tr>
<tr>
<td><strong>P 75 μ</strong></td>
<td>Very good liberation; &lt; 1 % composites. Mainly pyrite, sphalerite, subordinate galena, minor boulangerite. Isolated covellite.</td>
</tr>
<tr>
<td><strong>M 280</strong></td>
<td>Virtually totally liberated, except for isolated simple binary composites; increased galena.</td>
</tr>
<tr>
<td><strong>+53 μ</strong></td>
<td>Complete liberation except for isolated sphalerite/boulangerite grains. Increased sphalerite, galena, boulangerite (differential grinding).</td>
</tr>
<tr>
<td><strong>M 281</strong></td>
<td></td>
</tr>
<tr>
<td><strong>P 38 μ</strong></td>
<td></td>
</tr>
<tr>
<td><strong>M 282</strong></td>
<td></td>
</tr>
<tr>
<td><strong>+38 μ</strong></td>
<td></td>
</tr>
<tr>
<td><strong>M 283</strong></td>
<td></td>
</tr>
<tr>
<td><strong>-38 μ</strong></td>
<td></td>
</tr>
<tr>
<td><strong>S 1012</strong></td>
<td></td>
</tr>
<tr>
<td><strong>M 091</strong></td>
<td>Abundant coarse sphalerite, with free grains up to 2 mm; minor pyrite, galena, boulangerite; occasional free galena up to 2 mm. Little gangue, mostly as small inclusions in sulphides. Simple, straightforward textural relationships between sulphides. Arsenopyrite apparently scarce, as occasional well-formed crystals in sphalerite.</td>
</tr>
<tr>
<td><strong>P 80/75 μ</strong></td>
<td>Very good liberation, with &lt; 5 % composites, generally consisting of small pyrite inclusions in sphalerite, or galena/sphalerite. Dominantly composed of free sphalerite, with subordinate pyrite and gangue.</td>
</tr>
<tr>
<td><strong>M 284</strong></td>
<td>About 10-12 % composite grains, dominantly as small (&lt; 50 μ) inclusions of pyrite in sphalerite; larger grains (up to 1 mm) are more complex, but as simple, coarse intergrowths of two or three sulphides. Isolated covellite.</td>
</tr>
<tr>
<td><strong>P 75 μ</strong></td>
<td>About 2-3 % composites, generally binary; most are inclusions of pyrite in sphalerite, with occasional sphalerite/boulangerite or galena. Trace to minor arsenopyrite.</td>
</tr>
<tr>
<td><strong>M 285</strong></td>
<td>Very good liberation, with &lt; 1 % as composites. Very clean product, predominantly sphalerite, with subordinate pyrite, galena and boulangerite, trace arsenopyrite.</td>
</tr>
<tr>
<td><strong>+53 μ</strong></td>
<td>All components liberated, except for occasional binary composites of sphalerite/pyrite or sphalerite/boulangerite.</td>
</tr>
</tbody>
</table>
Central Mineralogical Services

Mr. D. Mann
Woodcutters J.V.
P.M.B. 60
WINNELIE / N.T. 5789

7th January, 1986

REPORT CMS 86/1/2

YOUR REFERENCE: Order No. 1949
DATE RECEIVED: 3rd January, 1986
SAMPLE NOS.: F 40
SUBMITTED BY: D. Mann
WORK REQUESTED: Mineralogy

Copy to:
The Manager
Woodcutters J.V.
Suite 304
203, South Head Road
EDGECLIFF / N.S.W. 2027

H.W. Fander, M. Sc.
b. Microscopic:

This sample was examined in polished section; a portion was also carefully de-slimed and examined as a grain-mount, to identify any non-opaque, non-sulphide phases.

The sample consists mainly of quartz gangue and sulphides, with minor goethite; the sulphides are pyrite and arsenopyrite, with rare sphalerite and very isolated grains of galena. All components are very fine-grained; few sulphide grains are > 50 μ. Thus, Pb losses cannot be due to sulphides.

Examination of the non-opaques shows that the major Pb mineral present here is pyromorphite, a Pb chloro-phosphate \( \text{Pb}_5\text{Cl}_3\text{P}_3\text{O}_{12} \); the grains are inconspicuous and are obscured by limonite coatings. Some arsotite is also present. The pyromorphite is an oxidation-product; together with goethite it indicates that a portion of the ore is oxidised, perhaps in fault zones.

H.W. Fander, M. Sc.
Mr. E.J. McLean  
Mining & Process Engineering  
Services (N.T.) Pty. Ltd.  
P.O. Box 4810  
DARWIN / N.T. 5790

2nd January, 1986

REPORT CMS 85/12/12

DATE RECEIVED: 17th December, 1985
SAMPLE NOS.: 12 Samples
SUBMITTED BY: E.J. McLean
WORK REQUESTED: Mineralogy

H.W. Fander, M. Sc.
The sample numbers for the following drill holes are:

<table>
<thead>
<tr>
<th>Description</th>
<th>S1007</th>
<th>S1008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushed ore</td>
<td>M059</td>
<td>M063</td>
</tr>
<tr>
<td>Ground product</td>
<td>M081</td>
<td>M080</td>
</tr>
</tbody>
</table>

Size: $+75$

- $75 + 53$: M082, M086
- $53 + 38$: M083, M087
- $38$: M084, M088

Chemical analyses from the head of each of these holes not available yet.
Two sets of ground ore and size fractions were received for mineralogical examination, representing drill holes S 1007 and S 1008; polished sections were prepared, and the mineralogy and textures are briefly described in the attached tables, emphasizing the nature of the composites in each fraction. Summaries of the main ore characteristics are provided with each drill hole.

Comments

Both intersections are zinc-rich, and the main Pb-mineral is boulangerite; S 1007 contains more galena than S 1008, but S 1008 carries more arsenopyrite.

Whilst there are fine sulphide-sulphide intergrowths, the bulk of the material is quite coarsely crystalline and seems to liberate well; minor losses can be expected in the form of boulangerite and sphalerite as minute inclusions in pyrite. A very small proportion of the arsenopyrite occurs as fine composites with sphalerite or boulangerite, but hopefully below penalty limits.

The sulphides appear fresh and there is virtually no evidence of oxidation.

H.W. Fander, M. Sc.
Sample No.  | Brief Mineralogical Description                      | S 1007
---            |-----------------------------------------------------|------
M 059         | Major sphalerite; apparently free up to 1 mm or more, also composites, mainly with pyrite, or containing inclusions of other sulphides - boulangerite (< 50 μ), tetrahedrite (rare, < 20 μ), arsenopyrite (> 100 μ). Minor pyrite, galena, trace only of boulangerite. Galena mostly coarse and free; some with < 50 μ sphalerite inclusions, or as intergrowths. Pyrite contains very small (< 30 μ) sphalerite, galena inclusions or very thin geocronite veinlets. Very minor gangue. |
M 081         | Major sphalerite, dominantly free; a few grains with pyrite inclusions 10-100 μ, rarely gangue; subordinate pyrite, dominantly free - some with very small sulphide inclusions; minor galena, dominantly free; boulangerite, arsenopyrite well-liberated. |
M 082         | Dominant, free sphalerite. All sulphides very well-liberated; occasional simple composites between two sulphides, and small pyrite inclusions in sphalerite. |
M 083         | Very few composites, excellent liberation of all sulphides. Major sphalerite, subordinate pyrite and galena, minor boulangerite, arsenopyrite; very minor gangue. |
M 084         | Rare composites only, but these tend to be complex and intricately intergrown; a few are simple, binary composites of sphalerite/galena, sphalerite/pyrite. |
M 085         | Generally well-sized free sulphides, but some oversize (50-150 μ) material occurs. Rare binary composites. |

Summary

A zinc-rich intersection, with sphalerite as the major sulphide. Components are mostly coarsely crystalline, with occasional fine intergrowths, small-scale inclusions and veinlets. Arsenopyrite is very minor, generally as good crystals. Galena is the main Pb mineral, with very minor boulangerite and a possible trace of geocronite.
Major coarse sphalerite; much is free. Major pyrite, conspicuous arsenopyrite up to 500 μm; minor boulangerite and gangue; trace galena, fine ?geocronite. Most components are coarse, but there are finely intergrown composites of sphalerite with gangue (? tourmaline needles), pyrite and arsenopyrite (50-200 μm crystals). Pyrite tends to contain < 20 μm inclusions of boulangerite and ?geocronite. There are aggregates of small pyrite and arsenopyrite crystals with interstitial, < 50 μm patches of sphalerite, boulangerite.

All components are well-liberated. There are some composites, both on a coarse scale of simple binary intergrowths of sphalerite/boulangerite, sphalerite/pyrite, as well as on a fine scale between sphalerite/gangue and as fine inclusions of one sulphide in another (mainly with pyrite or sphalerite as the host).

Very well-liberated components; mainly sphalerite, pyrite and gangue, with minor arsenopyrite, very minor boulangerite. Composites mainly in the form of sphalerite with < 30 μm pyrite inclusions; occasional sphalerite/boulangerite, sphalerite/arsenopyrite, and pyrite with minute sulphide inclusions.

All minerals liberated except for occasional composites of sphalerite/pyrite, sphalerite, arsenopyrite, sphalerite/boulangerite, sphalerite/gangue, and fine ?boulangerite inclusions in pyrite. Increase in boulangerite.

All components are free or substantially free (minor inclusions only). Increased pyrite, arsenopyrite at the expense of all other minerals.

Rare composites, mainly as pyrite with minute sulphide inclusions. High proportion of grains < 10 μm.

**Summary**

This ore intersection consists of major sphalerite, pyrite, and more arsenopyrite than in the other intersections; boulangerite is minor and galena is sparse. The minerals on the whole are fresh and coarsely crystalline, with simple textures, but there are patches of finely, complexly intergrown sulphides with gangue - thought to be tourmaline needles. An isolated grain of covellite was seen, indicating incipient oxidation, but the minerals seem fresh and clean. Possible overgrinding.
Central Mineralogical Services

Mr. E.J. McLean
Mining & Process Engineering Services (N.T.) Pty. Ltd.
P.O. Box 4810
DARWIN / N.T. 5790

23rd December, 1985

REPORT CMS 85/12/9

DATE RECEIVED: 16th December, 1985
SAMPLE NOS.: 16 Samples
SUBMITTED BY: E.J. McLean
WORK REQUESTED: Mineralogy

H.W. Fander, M. Sc.
Sample numbers for the following drill holes are:

<table>
<thead>
<tr>
<th>Description</th>
<th>S1001</th>
<th>S1002</th>
<th>S1003</th>
<th>S1004</th>
<th>S1005</th>
<th>S1006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>M033</td>
<td>M034</td>
</tr>
<tr>
<td>Mill discharge</td>
<td>M035</td>
<td>M036</td>
<td>M037</td>
<td>M038</td>
<td>M039</td>
<td>M040</td>
</tr>
<tr>
<td>+75 μm</td>
<td>M041</td>
<td>-</td>
<td>M047</td>
<td>M050</td>
<td>-</td>
<td>M056</td>
</tr>
<tr>
<td>-75-45 μm</td>
<td>M042</td>
<td>-</td>
<td>M048</td>
<td>M051</td>
<td>-</td>
<td>M057</td>
</tr>
<tr>
<td>-45 μm</td>
<td>M043</td>
<td>-</td>
<td>M049</td>
<td>M052</td>
<td>-</td>
<td>M058</td>
</tr>
</tbody>
</table>
1. The sample numbers for the following drill holes are:

<table>
<thead>
<tr>
<th>Description</th>
<th>S1002</th>
<th>S1005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill discharge</td>
<td>MO61</td>
<td>MO62</td>
</tr>
<tr>
<td>Sizing: +75 μm</td>
<td>MO68</td>
<td>MO72</td>
</tr>
<tr>
<td>-75 to 53 μm</td>
<td>MO69</td>
<td>MO73</td>
</tr>
<tr>
<td>-53 to 38 μm</td>
<td>MO70</td>
<td>MO74</td>
</tr>
<tr>
<td>-38 μm</td>
<td>MO71</td>
<td>MO75</td>
</tr>
</tbody>
</table>

2. Chemical analyses of heads from the drill holes:

<table>
<thead>
<tr>
<th>Drill Hole No.</th>
<th>Pb (%)</th>
<th>Zn (%)</th>
<th>S (%)</th>
<th>Ag (ppm)</th>
<th>As (ppm)</th>
<th>Sb (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1001</td>
<td>3.48</td>
<td>1.58</td>
<td>40.5</td>
<td>56</td>
<td>1.57</td>
<td>3680</td>
</tr>
<tr>
<td>S1002</td>
<td>4.4</td>
<td>19.1</td>
<td>33.1</td>
<td>260</td>
<td>1.09</td>
<td>1.37</td>
</tr>
<tr>
<td>S1003</td>
<td>10.3</td>
<td>21.7</td>
<td>33.7</td>
<td>195</td>
<td>2.43</td>
<td>1.21%</td>
</tr>
<tr>
<td>S1004</td>
<td>1.75</td>
<td>14.7</td>
<td>37.3</td>
<td>150</td>
<td>1.66</td>
<td>1.26%</td>
</tr>
<tr>
<td>S1005</td>
<td>8.65</td>
<td>15.7</td>
<td>30.5</td>
<td>195</td>
<td>1.34</td>
<td>6250</td>
</tr>
<tr>
<td>S1006</td>
<td>4.40</td>
<td>16.8</td>
<td>37.6</td>
<td>70</td>
<td>4.60</td>
<td>9300</td>
</tr>
</tbody>
</table>

Note: Fe assays from this batch were in error (XRF method) and are being repeated (wet chemical method). Previous assays on head samples have shown a range of Fe of 25 - 30% in the ore zone.
Sixteen samples were received for mineralogical examination; they included six mill discharge samples (M 035 - M 040) and two sets (each of five) of mill discharge and size fractions from S 1002 and S 1005. It is assumed that M 061 and M 062 (mill discharges from S 1002 and S 1005) are equivalent to M 036 and M 039, and the examinations confirmed this.

It is believed that fractions M 068 - M 071 and M 072 - M 075 were transposed, i.e. that M 068 - M 071 originated from S 1005 and M 072 - M 075 were from S 1002, judging from the mineralogy; S 1005 is characterised by an abundance of gangue with small sulphide inclusions (see description of M 039).

Comments

1. Comparison of head sample assays for As with the corresponding mineralogy strongly suggests that only a proportion of the As occurs as arsenopyrite; the remainder is most probably within pyrite, but this would need to be verified by electron-probe microanalysis. If this is the case, then pyrite in Zn or Pb concentrates cannot be regarded simply as a "harmless" diluent, but as a contributor of deleterious As in those concentrates.

2. Liberation is good in the mill discharge samples, except for S 1005 where fine sulphide inclusions in gangue are a problem. It would, however, be preferable to reduce the amount of +200 μ (say +72 mesh) material, since composites tend to be more common > 200 μ, and also because coarser free sulphides are difficult to float and tend to be lost to tailings.

3. Oxidation effects were not detected, though (as mentioned previously) some acid solutions may have been generated and could have had an adverse effect on sulphide grains.

4. The mill discharge from S 1001 (sample M 035) confirms the very high pyrite content of that drill hole, as noted in the report describing the size fractions (M 041 - M 043, report CMS 85/12/4).

H.W. Fander, M. Sc.
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Brief Mineralogical Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 035</td>
<td>Dominant pyrite, major gangue, very minor sphalerite, galena, boulangerite, arsenopyrite. Good liberation of all minerals; &lt; 20 μ boulangerite inclusions in pyrite; small pyrite inclusions in sphalerite.</td>
</tr>
<tr>
<td>M 036</td>
<td>Major sphalerite, subordinate boulangerite and pyrite, minor gangue and galena, very minor arsenopyrite. A few sulphide/sulphide composites, between sphalerite-pyrite-boulangerite, otherwise good liberation; free sphalerite, galena up to 600 μ.</td>
</tr>
<tr>
<td>M 037</td>
<td>Major sphalerite, pyrite; subordinate boulangerite, minor galena and arsenopyrite, very minor gangue. Good liberation on the whole; larger sulphide grains contain inclusions of other sulphides, especially pyrite in sphalerite and galena or boulangerite in sphalerite, and small inclusions in pyrite.</td>
</tr>
<tr>
<td>M 038</td>
<td>Major pyrite, subordinate sphalerite, minor boulangerite and gangue, very minor galena and arsenopyrite. Good liberation; larger grains (&gt; 200 μ) tend to be composite, mainly pyrite/sphalerite, boulangerite/sphalerite.</td>
</tr>
<tr>
<td>M 039</td>
<td>Major gangue, minor pyrite and sphalerite; very minor boulangerite, arsenopyrite and galena. Many gangue particles are composite on an extremely fine scale with sphalerite, boulangerite, pyrite, and sulphide/sulphide composites are also common. Liberation problematical, affecting both grade and recovery.</td>
</tr>
<tr>
<td>M 040</td>
<td>Major pyrite, subordinate sphalerite, minor arsenopyrite, very minor boulangerite and gangue, trace galena. Grains &lt; 100 μ very well-liberated; a few composites &gt; 100 μ, especially &gt; 200 μ.</td>
</tr>
<tr>
<td>Sample No.</td>
<td>Brief Mineralogical Description</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>M 061</td>
<td>See M 036</td>
</tr>
<tr>
<td>M 062</td>
<td>See M 039</td>
</tr>
<tr>
<td>M 068</td>
<td>The mineralogy strongly suggests that M 068 - M 071 are from S 1005, not S 1002, and that M 072 - M 075 are from S 1002; they will be described on that assumption, based on M 036/M 039, i.e. M 068 - M 071 are ex M 062/M 039, and M 072 - M 075 are ex M 061/M 039.</td>
</tr>
<tr>
<td>M 068</td>
<td>Major gangue, mostly composite with numerous &lt; 20 μ inclusions of sphalerite, boulangerite, pyrite; also many sulphide/sulphide composites; about 50% of sphalerite and of boulangerite is free. Subordinate pyrite, sphalerite; minor boulangerite; very minor galena, arsenopyrite.</td>
</tr>
<tr>
<td>M 069</td>
<td>Major pyrite, subordinate sphalerite and gangue; minor boulangerite, very minor arsenopyrite and galena. Quite well-liberated, but with some gangue/sulphide composites as very fine intergrowths.</td>
</tr>
<tr>
<td>M 070</td>
<td>Good liberation of all components, predominantly pyrite and sphalerite, subordinate gangue. However, some composites persist, both sulphide/gangue and sulphide/sulphide.</td>
</tr>
<tr>
<td>M 071</td>
<td>Significant increase in gangue. All components are very well-liberated, but a few coarser grains occur as composites.</td>
</tr>
<tr>
<td>M 072</td>
<td>Major sphalerite, subordinate pyrite, with minor boulangerite and galena, very minor arsenopyrite, gangue. All minerals are well-liberated; a few composites, mainly as small inclusions of one sulphide in another, mostly in coarser sizes (&gt; 200 μ).</td>
</tr>
<tr>
<td>M 073</td>
<td>Major sphalerite and pyrite, subordinate boulangerite; minor galena, gangue and arsenopyrite; all very well-liberated. Very occasional sulphide/sulphide composites in various combinations.</td>
</tr>
<tr>
<td>M 074</td>
<td>All minerals substantially liberated. Increase in gangue, boulangerite and galena.</td>
</tr>
<tr>
<td>M 075</td>
<td>Noticeable increase in boulangerite and galena. All liberated except for occasional composites, mostly as &lt; 10 μ boulangerite inclusions in pyrite.</td>
</tr>
</tbody>
</table>
17th December, 1985

REPORT CMS 85/12/3

DATE RECEIVED: 4th December, 1985
SAMPLE NOS.: 4 Samples
SUBMITTED BY: E.J. McLean
WORK REQUESTED: Mineralogy

H.W. Fander, M. Sc.
The sample numbers for the drill holes are:

<table>
<thead>
<tr>
<th>Description</th>
<th>S1001</th>
<th>S1002</th>
<th>S1003</th>
<th>S1004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushed ore -&lt;2mm</td>
<td>m/001</td>
<td>m/002</td>
<td>m/003</td>
<td>m/004</td>
</tr>
<tr>
<td>Ground to nominal 75 x 75µm</td>
<td>m/016</td>
<td>m/012</td>
<td>m/014</td>
<td>m/009</td>
</tr>
<tr>
<td>Sized ground product: +7Sµm</td>
<td>m/019</td>
<td>m/022</td>
<td>m/025</td>
<td>m/028</td>
</tr>
<tr>
<td>-75+45µm</td>
<td>m/020</td>
<td>m/023</td>
<td>m/026</td>
<td>m/029</td>
</tr>
<tr>
<td>-45µm</td>
<td>m/021</td>
<td>m/024</td>
<td>m/027</td>
<td>m/030</td>
</tr>
</tbody>
</table>

Note: Digging, sampling (depth, km; sec.) not carried out.
Four sets of samples were received for mineralogical examination, including head samples and ground products from four drill holes (S 1001 - S 1004); for various reasons discussed by Mr. McLean, the ground products were not entirely satisfactory, and thus only the head samples were examined and are described in this report.

**S 1001** (Sample M/001; P.S. 55130)

Pyrite is the dominant mineral, followed by quartz (and other) gangue, with lesser amounts of sphalerite, galena and boulangerite, with very minor arsenopyrite.

The components are generally coarsely crystalline and form simple intergrowths; some of the pyrite occurs as granular masses, with < 50 μ inclusions and thin veinlets of galena, boulangerite and sphalerite. There are occasional galena-sphalerite intergrowths on an ultrafine scale, as patches within coarse galena-sphalerite masses.

There is evidence of oxidation, in the presence of coarse pyrite crystals largely represented by goethite containing remnants of unoxidised pyrite.

**S 1002** (Sample M/002; P.S. 55131)

Whilst the mineral assemblage is the same as S 1001, the proportions are different, with much more sphalerite and boulangerite, less pyrite, galena and gangue; arsenopyrite is scarce. A minute trace of chalcopyrite was seen.

The galena is generally very coarse, occurring as free grains up to 2 mm across even in this product; sphalerite is also very coarse, and often free, though with inclusions of small pyrite crystals (10 μ to 150 μ) as well as boulangerite and ?geocronite (5 μ to 300 μ). The massive pyrite is also sprinkled with very small (< 20 μ) inclusions of galena and boulangerite. There are occasional fine intergrowths of galena/boulangerite, but these are not likely to be of much metallurgical significance. Rarely, boulangerite contains arsenopyrite 10-100 μ in size. Pyrite and sphalerite form granular intergrowths on an intermediate scale. There was no evidence of oxidation.

**S 1003** (Sample M/003; P.S. 55132)

Pyrite and sphalerite are the major minerals, with subordinate boulangerite, minor arsenopyrite, gangue minerals and galena, and traces of geocronite and tetrahedrite.
Pyrite, sphalerite and boulangerite occur as free grains up to 1 mm across, though generally containing a few small inclusions of other sulphides; galena also occurs as clean, free cleavage-fragments. A whole range of intergrowths/composites of various sulphides is seen, on various scales from very fine to coarse, mostly combinations of pyrite and sphalerite with or without minor amounts of the other sulphides. Arsenopyrite occurs as single crystals (mostly > 50 μ) and clusters, sometimes veined or partly replaced by fine geocronite.

Thus, although all the main sulphides are present as coarsely crystalline material, the textures and intergrowths are more complex and on a finer scale than in 1001 and 1002. There is no evidence of oxidation.

S 1004 (Sample H/004; P.S. 55133)

Pyrite, sphalerite and boulangerite are the main minerals present; minor components are gangue, galena and arsenopyrite.

Pyrite commonly contains very small inclusions of galena, boulangerite and geocronite, and forms intergrowths with sphalerite, generally as euhedral crystals 10-200 μ scattered through coarse sphalerite masses.

Boulangerite is present as free grains up to 1.5 mm across, and also as smaller masses and veinlets in granular pyrite, ranging from 10 μ to 200 μ. Rare geocronite veinlets(< 50 μ wide) cut pyrite. Galena is reasonably coarse and free or simply intergrown with sphalerite. Arsenopyrite is generally intergrown with pyrite, as good crystals; it also occurs as clusters of crystals with interstitial boulangerite and sphalerite.

Summary

The economic minerals (sphalerite, boulangerite, galena) are generally coarse and predominantly simply intergrown, on a reasonable scale, so that liberation should be good; a minor proportion forms more complex, finer intergrowths. Fine inclusions in pyrite are a source of losses, but should not be of great significance. It should be feasible to produce a very high-grade zinc concentrate.

There is evidence of minor, patchy oxidation which may generate acid solutions affecting the amenability of some sulphides to flotation, but it should be possible to correct this.

H.W. Fander, M. Sc.
Mr. E.J. McLean  
Mining & Process  
Engineering Services (N.T.) Pty. Ltd.  
P.O. Box 4810  
DARWIN / N.T. 5790

16th December, 1985

REPORT CMS 85/12/4

DATE RECEIVED: 10th December, 1985
SAMPLE NOS.: 14 Samples
SUBMITTED BY: E.J. McLean
WORK REQUESTED: Mineralogy

H.W. Fander, M. Sc.
Two head samples (M 033, M 034; holes S 1005, 1006) and four sets of size fractions were received for mineralogical examination; the mill discharge samples (M 035-040) were received later and will be reported in a subsequent report. The head samples are described below and the size fractions are described in the attached tables.

Comments

Liberation characteristics appear to be good, with effective liberation at +45 μ; even in the +75 μ fraction, it is generally the > 100 μ particles which tend to occur as composites, i.e. the < 100 μ material is very well-liberated. Mineral intergrowths on the whole are simple. The commonest composites are between pyrite and sphalerite, which is predictable since these are the two main sulphides.

Although there is a suggestion that traces of oxidation-products (possibly acid solutions) are present – affecting the setting of the resin mounting material – the sulphides appear fresh and with clean surfaces.

The mineralogy is simple; very little geocronite was positively identified (it is very difficult to distinguish from boulangerite). A noteworthy feature is the complete absence of chalcopyrite in sphalerite; this is quite unusual. The sphalerite itself is a pale, low-Fe variety.

Head Samples

M 033. The mineral components, in approximate order of abundance, are: sphalerite, pyrite, gangue, boulangerite, galena and arsenopyrite, with a trace of geocronite and rare, fine-grained tetrahedrite.

A surprising proportion of each mineral is free, indicating coarse grainsizes in the original ore. Fine intergrowths of galena and carbonate are occasionally seen, and there are 10-50 μ arsenopyrite crystals in boulangerite; some sphalerite/boulangerite intergrowths are also fairly fine.

M 034. The mineralogy is similar, but arsenopyrite and pyrite are more abundant, boulangerite and galena less abundant; there is a trace of marcasite.

Many grains are free or occur as simple intergrowths of sulphides, usually two, or infrequently three species. There are fine inclusions of galena in pyrite or of pyrite in sphalerite, as well as 50-200 μ arsenopyrite crystals in boulangerite.

H.W. Fander, M. Sc.
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Sphalerite</th>
<th>Boulangerite</th>
<th>Galena</th>
<th>Pyrite</th>
<th>Arsenopyrite</th>
<th>Others - Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 041</td>
<td>Minor; 90% free; 10% composite with pyrite, galena or gangue.</td>
<td>Very minor; dominantly free.</td>
<td>Trace only; dominantly free.</td>
<td>Very abundant; &gt; 90% free.</td>
<td>Trace only; free.</td>
<td>Abundant pyrite - because of hardness/resistance to grinding.</td>
</tr>
<tr>
<td>M 042</td>
<td>Very minor; almost all is free; rare composites.</td>
<td>Very minor; dominantly free.</td>
<td>Very minor; &gt; 90% free; a few composites with sphalerite.</td>
<td>Very abundant, free; rare small inclusions.</td>
<td>Very minor. Free.</td>
<td>Dominant pyrite (&gt; 70%); subordinate free gangue; others total &lt; 10%.</td>
</tr>
<tr>
<td>M 043</td>
<td>All minerals are free, except for occasional &lt; 20 μ inclusions of galena in pyrite.</td>
<td>90-95% free; 5-10% with small inclusions of other sulphides.</td>
<td>Very minor; dominantly free.</td>
<td>&gt; 90% free.</td>
<td>Minor; &gt; 90%</td>
<td>Very little gangue. Occasional free geocronite grains.</td>
</tr>
<tr>
<td>M 047</td>
<td>80-90% free; 10 to 20% with small inclusions of other sulphides.</td>
<td>90-95% free; 5-10% with sphalerite or pyrite.</td>
<td>Very minor; dominantly free.</td>
<td>&gt; 90% free.</td>
<td>Minor; &gt; 90%</td>
<td>Very little gangue. Occasional free geocronite grains.</td>
</tr>
<tr>
<td>M 048</td>
<td>All minerals very well-liberated; occasional small inclusions of one sulphide in another, mainly sphalerite/pyrite, sphalerite/boulangerite.</td>
<td>90-95% free; 5-10% with sphalerite or pyrite.</td>
<td>Very minor; dominantly free.</td>
<td>90% free; 10% with inclusions of other sulphides.</td>
<td>Minor; dominantly free.</td>
<td>&lt; 20 μ geocronite inclusions in arsenopyrite. Minor gangue, mainly free.</td>
</tr>
<tr>
<td>M 049</td>
<td>&gt; 98% liberation of all components even at upper limit of size range. Significant proportion of &lt; 15 μ material.</td>
<td>90% free; 10% composite with pyrite, boulangerite.</td>
<td>Very minor; dominantly free.</td>
<td>90% free; 10% with inclusions of other sulphides.</td>
<td>Minor; dominantly free.</td>
<td>&lt; 20 μ geocronite inclusions in arsenopyrite. Minor gangue, mainly free.</td>
</tr>
<tr>
<td>M 050</td>
<td>90% free; 10% composite with pyrite, also galena, boulangerite.</td>
<td>95% free; 5% with sphalerite, pyrite.</td>
<td>Very minor; dominantly free.</td>
<td>As above.</td>
<td>Minor; &gt; 90% free.</td>
<td>Rare arsenopyrite/boulangerite composites.</td>
</tr>
<tr>
<td>Sample No.</td>
<td>Sphalerite</td>
<td>Boulangerite</td>
<td>Galena</td>
<td>Pyrite</td>
<td>Arsenopyrite</td>
<td>Others - Comments</td>
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<tr>
<td>M 052</td>
<td>Excellent liberation of all components; rare composites only, between two sulphides. Good size distribution without excessive sliming; some oversize particles up to 150 μ.</td>
<td>Minor; 80 % free, Trace only; free and composite.</td>
<td>80 % free; 20 % with sphalerite, arsenopyrite.</td>
<td>Conspicuous; mainly free.</td>
<td>Pyrite contains &lt; 20 μ inclusions of other sulphides. Minor gangue.</td>
<td></td>
</tr>
<tr>
<td>M 056</td>
<td>70-80 % free (smaller grains); 20-30 % with pyrite, boulangerite, arsenopyrite.</td>
<td>90 % free; 10 % with sphalerite, dominantly free.</td>
<td>95 % free; 5 % with other sulphides.</td>
<td>Minor; dominantly free.</td>
<td>Minor free gangue. Rare sphalerite/arsenopyrite composites.</td>
<td></td>
</tr>
<tr>
<td>M 057</td>
<td>&gt; 90 % free; remainder with pyrite, boulangerite, gangue.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>M 058</td>
<td>All components well-liberated; pyrite and gangue are dominant; much of the gangue is very fine (&lt; 10 μ). Some pyrite has small sphalerite inclusions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>
Central Mineralogical Services

Mr. S. Cross
Mill Superintendent
Woodcutters J.V.
P.O. Box 4810
DARWIN / N.T. 5789

29th November, 1985

REPORT CMS 85/11/28

YOUR REFERENCE: Verbal request
DATE RECEIVED: 20th November, 1985
SAMPLE NOS.: 3 Samples
SUBMITTED BY: S. Cross
WORK REQUESTED: Mineralogy

H.W. Fander, M. Sc.
File Note

Telecon with Wally Fander 28/11/85

1. WF has received further grab samples of Mill Feed, Pb Con, Pb Scav tail - both oven dried and washed with acetone and air dried.

2. The acetone washed samples would not set.

3. The oven dried samples show no evidence of corrosion/oxidation.

4. He could make no comments of significance re the mill feed.

5. He described the Pb con as being very fine (mainly less than 30um), predominantly free particles, predominantly boulangerite with less galena than previously observed, no noticable or identifiable geochronite or arsenopyrite, 90% + liberated sphalerite and free pyrite. He had observed one grain of tetrahedrite and one grain of covellite.

6. The Pb Scav tail was much coarser than the Pb con, contained predominantly free particles with some free sphalerite up to 500um. There was significant free Pb minerals although he observed some sphalerite/Pb composites and some boulangerite/pyrite composites (he felt the boulangerite composited with pyrite was so fine it could not be liberated). In general composites were simple and he felt a regrind to reduce particle size by about 5um may assist Zn flotation. Arsenopyrite was fairly abundant and some As/pyrite composites occur.

7. He is suspicious that boulangerite may be carrying some As. Some time in the future he will use a probe to identify Ag and As bearing species.

S Cross
28.11.85

C.C.: R Hutton
      C Bolger
      P Appleby
Two duplicate sets of three mill products were received for mineralogical examination; one set was air-dried, the other was acetone-washed. All were mounted and polished; the acetone-washed samples reacted with the resin and were unsatisfactory, but the air-dried material gave good results, in contrast with the previous batch of mill products; this strengthens the evidence that the previous batch was affected by oxidation unrelated to drying procedures. This implies that parts of the ore are incipiently oxidised (or affected by solutions from oxidising material).

**Pb Rougher Feed** (P.S. 55029)

In approximate order of abundance, this sample consists of pyrite, sphalerite, gangue, boulangerite, arsenopyrite, galena, and very minor geocronite.

The grains are well-liberated; many grains are < 30 μ. A few of the coarser grains (> 50 μ) are composites between various sulphides, generally binary (two components only). It is possible that some of the galena may be thinly coated with oxidation-products.

**Pb Concentrate** (P.S. 55030)

This consists dominantly of free boulangerite, with significant free sphalerite, minor galena and pyrite, rare grains of covellite and isolated tetrahedrite.

An estimated 5-10 % of the sphalerite is composite with boulangerite, the remainder is free. No arsenopyrite was detected; geocronite is probably present, but is difficult to distinguish from boulangerite, especially at such fine grainsizes (most grains are < 30 μ, with a very minor proportion in the 30-100 μ range). Any arsenic present in this concentrate will be contained in geocronite or in boulangerite (assays reported in the references give up to 1.06 % As, but the figure may well be higher).

This sample will be used to study the Ag distribution.

**Pb Scavenger Tail** (P.S. 55031)

This product has a wide grainsize range, compared with the Pb concentrate in particular, with sizes up to 500 μ.

It consists of pyrite, gangue, arsenopyrite, sphalerite, minor boulangerite and a trace of galena.

The grains are dominantly free; composites of pyrite/arsenopyrite, boulangerite/sphalerite, arsenopyrite/sphalerite, arsenopyrite/galena, and pyrite with < 20 μ boulangerite inclusions, are seen. Free boulangerite grains up to 150 μ, and free sphalerite up to 500 μ, are present.

H.W. Fander, M. Sc.
Central Mineralogical Services

Mr. S. Cross
Mill Superintendent
Woodcutters J.V.
P.O. Box 4810
DARWIN / N.T. 5789

14th November, 1985

REPORT CMS 85/11/4

YOUR REFERENCE: Verbal request
DATE RECEIVED: 4th November, 1985
SAMPLE NOS.: 42 Samples
SUBMITTED BY: S. Cross
WORK REQUESTED: Mineralogy

H. W. Fander, M. Sc.
FILE NOTE

TELECON WITH WALLY FANDER (CMs) 6.11.85

Wally had examined both polished sections (using reflecting light) and samples 'as is' (using a binocular microscope) of heads of mill feed, Pb con, Pb scav tail, Zn con and final tail taken from weekly composite samples for the weeks ending 22.9.85 and 13.10.85.

1. Initially WF made the comment that the ore had been overground.

2. WF commented that the resin used to mount the polished sections had not set properly due to the high proportion of oxidised limonitic material in the samples (clays).

3. He pointed out that all samples showed marked oxidation to varying degrees. All minerals except pyrite showed tarnishing, 'oxide-type' coatings or corrosion. When asked if this could have occurred during sample prep, WF replied that it was possible.

4. When it was pointed out that the metal distributions did not indicate an abnormally high slime content on the tailings WF revised his initial comment. He decided that we may not necessarily be overgrinding however liberation was good at the size of grind achieved.

5. WF pointed out that for the week ending 22.9.85 galena was more abundant than the Pb sulfosalts. Boulangerite was the most abundant sulfosalts with geochronite being significantly less abundant. For the week ending 13.10.85 boulangerite was more abundant than galena and again geochronite was subordinate.

6. WF pointed out that in the tailings for the week ending 13.10.85 a high proportion of a dark variety of sphalerite occurred.

7. I pointed out that the good liberation he had observed had come as a surprise as I had been expecting a liberation problem.

Conversation with WF closed.

Following discussions with CB rang WF back.

1. Pointed out that samples examined coincided with ore samples previously submitted by CB. Asked if corrosion/oxidation was severe enough to expect to see it in ore samples. WF agreed that he would have expected to have seen some evidence of this in the ore samples but this had not occurred. Decided to check that samples were not oxidised during sample prep by sending him samples 'undried' for examination.

2. WF said that following my expectations of liberation problem and discussions with his assistant re-fine grain size previously observed he had decided to examine size fractions in closer detail.

S Cross
REPORT CMS 85/11/4

Woodcutters Mill Products
W.E. 22/9/85, 13/10/85

Forty-two samples of mill products were received for mineralogical examination; they comprised head samples and size fractions of Pb rougher feed (i.e. mill feed), Pb concentrate, Zn concentrate, Zn rougher feed and final tails, from two periods. For the sake of expediency and economy, only the head samples of the various products were examined at this stage, and preliminary results were phoned to S. Cross.

From the point of view of delineating recovery problems, the most meaningful samples were the mill feeds, the Pb scavenger tails (i.e. Zn rougher feeds) and the final tails.

Re-examination of some of the material received from C. Bolger (report CMS 85/7/40) showed that, although the ore intersections appear to be fresh, some of the sulphide-bearing (pyritic) host rocks are actively oxidising; it is suspected that any stockpiled ore, under prevailing conditions of heat and moisture, are bound to be affected by acid waters, resulting in undesirable films and coatings. These effects can occur in 24 hours or less. Some difficulty was experienced during briquetting of the samples, due to the reluctance of the mounting resin to polymerise; this was ascribed to the incipient oxidation of the samples.

It is clear from the examination of the mill products that superficial changes have occurred on the surfaces of many grains, and there is evidence of oxidic minerals such as goethite and cerussite-anglesite. Thus, the examination of run-of-mine samples would be more realistic than of fresh core, especially material from stockpiles.

Recovery and processing problems are not due to excessive composites; the minerals are well-liberated and composites are present only in coarser sizes, generally > 200 μ particles, in amounts which would be considered as normal for this type of ore. In fact, the overall impression is of a large proportion of very fine material, in the < 5 μ to 20 μ range. This seems particularly to apply to the 13/10/85 products, although it must be emphasized that the observations are empirical and need to be verified by sizing analyses.

Description of Samples

Mill Feed Head - 22/9/85. Consists of free pyrite, gangue, sphalerite, boulangerite, arsenopyrite, galena, geocronite, goethite, rare anglesite; some of the pyrite is spongy and easily oxidised. There are a few larger (> 200 μ) composites of various combinations of sulphides and gangue.

Mill Feed Head - 13/10/85. This is similar, with more sphalerite, pyrite and arsenopyrite; oxidation effects seem to be more pronounced.

Zn Con. Head - 22/9/85. Well-liberated. Apart from free sphalerite, the sample contains pyrite as the main diluent, with arsenopyrite (up to 200 μ), boulangerite, rare galena and geocronite; there are a few composites of sphalerite with pyrite and other sulphides. The Pb minerals are generally fine-grained, hence the higher Pb values in the cyclosizer fraction.

Zn Con. Head - 13/10/85. Contains less pyrite and arsenopyrite. Ultrafine material is very conspicuous.
Pb Con. Head - 22/9/85. The main Pb mineral is galena, with subordinate boulangerite and very minor geocronite. Much of the material is very fine (< 20 μ). Other minerals include spongy and compact free pyrite, free sphalerite, arsenopyrite with oxidised surfaces, and a few galena/sphalerite composites.

Pb Con. Head - 13/10/85. There appears to be less galena and more boulangerite. Ultrafine material (< 10 μ) is very abundant. Many grains appear to be coated. Other minerals include compact and spongy pyrite, free sphalerite, and conspicuous, partly oxidised arsenopyrite.

Pb Scavenger Tail (Head) (Zn Rougher Feed) - 22/9/85. This consists of free sphalerite, gangue, pyrite, arsenopyrite and boulangerite (up to 200 μ); there are a few coarse composites, of sphalerite/pyrite and sphalerite/galena. Larger grains, up to 500 μ, are present.

Pb Scavenger Tail (Head) (Zn Rougher Feed) - 13/10/85. This sample contains more pyrite and arsenopyrite. Galena and boulangerite grains are free but coated/oxidised. There are composites of boulangerite/pyrite and galena/pyrite/sphalerite. Traces of goethite occur.

Final Tail (Head) - 22/9/85. The major components are pyrite and gangue, as free grains; sphalerite occurs as free but coated grains, and boulangerite is present. Oxidic Pb minerals were detected, as well as goethite. Pyrite occasionally carries small inclusions of boulangerite, sphalerite, galena.

Final Tail (Head) - 13/10/85. A similar sample, but with more conspicuous free sphalerite. The presence of goethite indicates some oxidation.

H.W. Fander, M. Sc.
REPORT CMS 85/7/40

YOUR REFERENCE: Order No. 1116
DATE RECEIVED: 24th July, 1985
SAMPLE NOS.: WF 100 - WF 115
SUBMITTED BY: C. Bolger
WORK REQUESTED: Petrology/Mineralogy

H.W. Fander, M. Sc.
Banded pyrite, with fine grained and coarse grained sphalerite - are there any differences between the coarse grained and fine grained sphalerite? - Is the banding a sedimentary feature?

Sphalerite, sulphosalts (which one?), and galena which is banded? - A stress effect?

Fine grained pyrite, and acicular arsenopyrite - I have not seen AP like this before, at first I thought it may be a sulphosalts, but it is too hard, please inform.

Coarse grained sphalerite, with pyrite and sulphosalts.

Pyrite ore, coarse grained sphalerite in contact with fine grained sphalerite.

Mineralised lithic breccia.

Mineralised lithic breccia.

Mineralised lithic breccia - I am particularly interested in the lithic components with respect to alteration.

Sphalerite fine and coarse grained.

Galena and sulphosalts.

Sulphosalts and sphalerite.

Dyke north east corner of pit to the west of the "dolomite" dyke.

"Dolomite" dyke south east corner of pit.

Dyke next to bore no. 18 to the east of the "dolomite" dyke and possibly a stringer off it - the dykes in these samples infill major fractures and faults commonly occurring with white quartz veins and graphitic contacts (sharp) with the wall rocks. I would like your comments on the foliation? I think I can see.

Dyke south east end of pit to the west of the "dolomite" dyke possibly the same as WF 111.

Mixed sulphides, most varieties.
Dear Chris,

I trust you have made a satisfactory climatic adaption from the cold and wet to the hot humid and seasonally wet.

Your report is attached together with a few photomicrographic transparencies. The report is a little voluminous, but should serve as a basis for future work.

We have a few reports on file relating to Woodcutters, dating back to 1969. Wally has requested approval from Geopeko prior to him supplying copies. Perhaps you could make an enquiry on this point? Alternately, these reports may be on file in Peko's office. Unfortunately, the descriptive material on file here is in the form of partly-faded photocopies of handwritten reports. I assume you have Roberts' 1973 paper (Min. Deposita Vol. 8 No. 1).

Incidentally, I suspect there may be a typographic error in your descriptive comments accompanying the letter of 11th July, relating to samples WF 114 and WF 113 which appear out of order. Our section numbers follow the list. The notes on WF 114 appear more appropriate to WF 113?

It would be nice to see one of the dykes in unaltered form, similarly some ore-distal samples of the pelite, if only to tie down the origin of the tourmaline. It is clear that an overall structural control, composite with reactive dolomitic zones (both calc-pelitic and altered lamprophyric) pertains at Woodcutters, but tourmaline-rich pelites ± pyrite and arsenopyrite are rather common in the Pine Creek Geosyncline.

Regards,

David Cowan
REPORT CMS 85/7/40

A suite of sixteen samples from the Woodcutters S 36 pod and adjacent dyke rocks was received for petrological and mineragraphic examination. Representative polished sections were prepared from ore samples and thin-sections from the dyke rocks. Sample WF 105 was examined in thin- and in polished section. Mineragraphic and petrological descriptions are attached, with some sample described in relative detail and others partly by analogy.

A few photomicrographs were prepared to illustrate certain aspects of the sulphide mineralisation. All available data on the Woodcutters situation, in the form of previous CMS reports and published papers, were reviewed together with Taube's recent paper.

Summary

The bulk of samples examined represent variably pyritic and arsenopyritic Pb-Zn mineralisation, with the Pb component dominated by Pb-Sb sulphosalts rather than galena. Mineralisation is variously replacive to vein-type, with carbonaceous pelitic sediments the major host rock type, at least as represented in this suite.

General features are in accord with Taube's interpretation of the Woodcutters situation as a hydrothermal epigenetic style of mineralisation.

Lithologies

Apart from examples of mineralisation, two distinct lithologies are represented - carbonaceous pelites and altered igneous rocks of lamprophyric character.

Pelites reflect low-grade regional metamorphism and are represented by carbonaceous sericite-quartz slates, grading into phyllites. Carbonaceous matter is partly recrystallized to sub- or pregraphite. These rocks carry more or less ubiquitous very fine pale tourmaline which, in its present context, is of metasomatic character. Accessory pyrite is recrystallized syngenetic in part, as confirmed by rare relics of framboidal pyrite.

Pelites include altered dolomitic types, with carbonate rhombs of typical diagenetic habit pseudomorphed by quartz and tourmaline (e.g. WF 105).

Mineralised pelites are variously massive with sulphide and sulphosalt impregnations, to brecciated, veined and mineralised (e.g. WF 105, 106, 107). Replacive sulphides are typically tourmaline-gangued and may be compositionally banded (e.g. WF 100), apparently a reflection of (metasomatised) bedding-controlled compositional variations (dolomite content).

Brecciated pelites are typically quartz-sulphide-matrixed, with silicification as a major alteration trend, but selective to the degree that thoroughly silicified clasts appear in contact with relatively weakly silicified types.
Dyke rocks, as sampled, exhibit marked quartz-mica alteration and mild shearing effects. These rocks carry altered "ocelli" in addition to (ferromag) phenocrysts in an altered ferromag-lathic groundmass with conspicuous leucoxenised opaques. Primary mineralogy is obscured by alteration, although these rocks appear to have comprised feldspathoid (?analcite)-olivine-titanpyroxene-mica assemblages. Two distinct types may be delineated on the basis of presence or absence of apatite. The inferred primary composition is broadly monchiquitic and use of the term lamprophyric is thus appropriate.

These rocks are flow-structured, with a weak, essentially concordant phyllitic overprint suggestive of subsequent movement along the dyke-controlling fractures. Carbonate alteration, a widespread phenomenon in lamprophyric and related rocks, is not represented in the four examples examined, but evidently represents a control to mineralisation at Woodcutters.

As sampled, the mineralisation is complex and is further complexed by post-mineralisation stress and partial recrystallization effects.

Major sulphides are sphalerite, pyrite, arsenopyrite, lead-sulphosalts, and galena. Accessories include stannite and tetrahedrite and extremely rare ?miargyrite. Roberts (1973) lists additional accessory sulphides.

Mineralisation is partly metasomatic and partly vein-type in origin. Metasomatic assemblages tend to be dominated by Pb-sulphosalts and veins by sphalerite and galena in terms of "economic" minerals, but this may reflect sampling. Overall, vein and metasomatic assemblages are identical.

The paragenetic sequence is obscured by stress, recrystallization and remobilisation effects, although a generalised trend from pyrite-arsenopyrite to Pb-sulphosalts-pyrite + sphalerite, sphalerite + Pb-sulphosalts and late galena-sulphosalts is apparent. Sulphosalts and sphalerite are not infrequently arsenopyrite-replacive. Pyritic assemblages include a certain, albeit ill-defined recrystallized-syngenetic component. Pyrite-arsenopyrite composites include a certain pyrite-included sulphosalt component and grade into the sulphosalt-pyrite assemblage.

The dominant Pb-sulphosalts phase in this suite is boulangerite on the basis of optical properties. Geocronite and jamesonite appear as minor accessory components, and bournonite and meneghinite were not detected.

This data is in partial conflict with previous descriptions of Woodcutters' assemblages by Roberts and also Fander. This, again, may reflect sampling or, alternately, a zonal distribution conceivably complexed by stress-induced recrystallization and remobilisation phenomena.

Metasomatic zones of sulphosalt mineralisation are sub- to metallic and bluish-grey mesoscopically, dependent on the proportion of sulphosalt present. These zones are potentially metallurgically problematical due to extremely fine grainsizing and a generally fine, tourmaline-interstitial habit. Both factors would tend to promote "sliming". Similarly, metasomatic- and vein-quartz hosted boulangerite is typically fine-grained, with an acicular, variously quartz- or pyrite-included habit. In contrast, pyrite-interstitial and the bulk of vein sulphosalt is medium-grained and relatively massive with excellent potential liberation at normal flotation grinds.
Metasomatic sphalerite is colour-variable, but typically pale, with a microtextural habit closely analogous to that of metasomatic Pb-sulphosalts. Again, in comparison, vein sphalerite is markedly coarser-grained.

Galena is typically interspersed with Pb-sulphosalts and is generally medium-grained.

Apart from a single microscopic clot of Ag-sulphosalts tentatively identified as miargyrite, no optically specific silver phases were detected. Sphalerite-included tetrahedrite and stannite represent potential loci of Ag as do similarly the Pb-sulphosalts.

Gangue components, at least in respect of the present suite, comprise quartz, tourmaline, white mica, and carbonaceous matter. In this context, these samples appear poorly representative of the carbonate-altered, veined and metasomatised dyke paragenesis which evidently represents the major mode.

D. Cowan, B. Sc.
REPORT CMS 85/7/40

Petrological Descriptions

WF 105  
(T.S. 54077)  
This section represents the mineralised breccia paragenesis and comprises random clasts of variably altered and mineralised pelite with a sparse matrix of mineralised vein-type quartz.

Pelite clasts are variably sericitic to thoroughly silicified, the two types locally occurring in contact. Fine to ultrafine near-colourless (incipiently pale green) tourmaline is pervasive throughout and defines relict bedding traces in the silicified zones. This phase appears to be of metasomatic origin and occurs with quartz, pseudomorphing dolomite rhombs in sericitic pelite. Tourmaline orientation is random despite a faint "spotted" phyllitic cleavage in sericitic zones.

Silicified clasts consist of tourmaline-stained, granular to subhedral, fine-to locally medium-grained quartz, with the tourmaline inherited from a temporally early alteration phase. Matrix quartz is similarly tourmaline-stained, but grades into late, relatively clear quartz with, locally, a little associated muscovite. Discontinuous quartz-muscovite veinlets occur sporadically and correspond with the boulangerite-sphalerite-mineralised films noted in the polished section.

The differential alteration in this breccia apparently reflects primary compositional variations, with relatively dolomitic pelite, or perhaps impure dolomite, selectively silicified.

WF 111  
(T.S. 54083)  
This sample represents an altered and extensively weathered, foliated, fine-grained igneous rock which may be broadly classified as lamprophyric.

Frequent equant to ovoid, lensoid and dumb-bell-shaped, fine-grained aggregates (mean 200 µ) of partly degraded albite with subordinate microcline and quartz are present. These features have the general appearance of amygdales, but conceivably represent altered analcite ocelli. Relatively minor, slightly coarser aggregates of fine to semi-sericitic white mica, quartz and partly degraded biotite represent altered ferromag (70livenine) phenocrysts. These features are enclosed in a groundmass of similarly altered ?titanaugite laths with a muscovite-biotite-altered indeterminate mesostasis, conspicuous fine leucoxenised opaques, and conspicuous fine sub-acicular apatite.

Accessories include thinly disseminated fine oxidised pyrite, rare corroded ?xenocrystal quartz grains and rare blebs of sphalerite.

This rock is weakly phyllitic in response to incipient post-alteration shearing, and is weakly flow-structured. Apatite is partly of "tubular" habit, a feature of the so-called calcareous dyke.

Yeast  18  15
WF 112
(T.S. 54084)
This rock may be categorised as a partly weathered pyritic mica-quartz phyllite and represents an altered "lamprophyric" facies with broad affinities to WF 111.

Major constituents are fine, partly chloritised phlogopitic mica and fine-grained quartz. Leucoxenised opaques are conspicuous throughout with an evenly disseminated distribution slightly modified by the weak phyllitic overprint. Frequent ovoid to lensoid cavities, with shapes analogous to the quartzofeldspathic clots in WF 111, may similarly represent altered and selectively weathered analcite ocelli. Partly oxidised semi-dimensionally orientated pyrite euhedra are partly concentrated into discontinuous lenses.

In contrast to WF 111, this rock is devoid of apatite, at least in the area sectioned.

WF 114
(T.S. 54085)
An altered and weathered "lamprophyre", this rock is similar to WF 111 to the degree that the two rocks are clearly closely related.

Major features are analogous to those of WF 111 to the degree that no special comment is warranted. Alteration features are essentially identical to those previously noted, and this rock is similarly very incipiently sheared. Ubiquitous accessory apatite, analogous to that in WF 111 enhances the comparison. Corroded ?xenocrystal quartz grains are relatively abundant. This rock is relatively flow-structured, with orientated (altered) laths and dimensionally orientated phenocrysts.

WF 113
(T.S. 54086)
An altered and incipiently sheared "lamprophyre", this rock is similar to WF 112 and may be contrasted with WF 111 and WF 114.

The rock is weakly phyllitic and consists largely of fine-grained white mica with subordinate quartz, phlogopite and partly degraded microcrystalline albite. Altered (albitised, pervasively mica-stained) "ocelli" are disseminated throughout. These features are of poikilitic/late magmatic habit, with internal relics of a fine-scale flow-banding, features suggestive of analcite ocelli. The altered and recrystallised groundmass includes "ghosts" of fine ferromag silicate laths, defined partly by leucoxenic stainings, and biotite flakes.

Leucoxenised opaques are conspicuous throughout, but apatite is absent. Disseminated pyrite, and subordinate arsenopyrite, occur as semi-dimensionally orientated an- to euhedral grains of metablastic habit.

D. Cowan, B. Sc.
Mineragraphic Descriptions

WF 100
(P.S. 54072)
This sample exhibits a pyrite-lead sulphosaltsphalerite-arsenopyrite assemblage.

The host rock is a fine-grained tourmaline-rich pelite. Pyrite and the accessory proportions of arsenopyrite exhibit a banded distribution, variably poikilitic, euhedral, medium-grained habits, and represent probable recrystallized "syngenetic" components. These two phases have a mean grain size about 150 μ and exhibit "mutual" intergrowths.

Sphalerite and lead sulphosalts occur dominantly as ultrafine-grained tourmaline-interstitial disseminations, grading into spongy, fine-grained, semi-massive bands ranging to about 1 cm in width and studded throughout with pyrite euhedra and thinly disseminated arsenopyrite. Individual bands consist either of sulphosalts-, or of sphalerite-rich aggregates and the rock, as a whole, is distinctly compositionally banded. Sphalerite bands grade locally into relatively quite massive aggregates. Sporadic crosscutting veinlets include disseminations of sphalerite and sulphosalts. This assemblage appears metasomatic in detail, with the banded distribution apparently a reflection of primary compositional variations.

Arsenopyrite is extensively replaced by sulphosalts and sphalerite. Sulphosalts replacements are concentrated in core zones and sphalerite is marginal areas of the host arsenopyrite euhedra. Both types grade into pseudomorphous aggregates studded throughout with microscopic corroded relics of arsenopyrite, and composite (i.e. sulphosalts-sphalerite) pseudomorphs are developed.

Finer-grained sulphosalts aggregates include accessory traces of galena. The dominant phase is boulangerite, with relatively minor geocronite as sporadic intergrown laths. Vein-hosted boulangerite exhibits extremely rare micro-inclusions of stannite.

WF 101
(P.S. 54073)
Exhibits variably pyritic-arsenopyritic "massive" sphalerite aggregates with accessory proportions of boulangerite, a little galena, rare microscopic blebs of stannite, and a sparse gangue of milky quartz. These composite aggregates appear as millimetric-scale clasts in irregular to lensoid masses and "stringers" of medium- to coarse-grained galena, typically flanked by discontinuous masses of boulangerite. The lead sulphosalts in this context exhibits a semi-directed polygonal mosaic texture, reflecting stress-induced recrystallization. These zones include disseminations of closely microfractured to granulated pyrite and arsenopyrite and grade into discontinuous mylonitic fracture zones, comprising finely granulated pyrite, arsenopyrite and quartz in a matrix of boulangerite.
In contrast to the virtually colourless variety in WF 100, sphalerite in this rock is reddish brown. Arsenopyrite is locally semi-pseudomorphed by boulangerite, but is more typically euhedral and uncorroded. The temporally late galena is conceivably remobilised rather than introduced, is unstressed, and includes thinly disseminated microscopic laths of jamesonite.

(P.S. 54074)

This sample represents a semi-massive pyritic sulphide assemblage with a fine- to medium-grained tourmaline gangue.

The major sulphide is pyrite as finely poikilitic grains (mean 100-125 µm to 1.5 mm), ranging from an- to euhedral in habit. Relatively euhedral and slightly coarser-grained subacicular arsenopyrite is conspicuous throughout. Interstices consist of semi-felted tourmaline with interspersed intergranular, spongy, and near-massive aggregates of sphalerite ranging to a few millimetres diameter. Relatively thinly disseminated patches of Pb-sulphosalts (boulangerite, subordinate geocronite) are interspersed with sphalerite. Accessory proportions of Pb-sulphosalts occur as micro-inclusions (mean 10 µm) in pyrite and as thin films healing sporadic irregular discontinuous microfractures. Sphalerite exhibits rare microscopic inclusions of stannite and chalcopyrite.

(P.S. 54075)

Exhibits near-massive dark red-brown, coarse-grained sphalerite as an- to subhedral grains (mode 2-5 mm). Fine-grained pyrite (mean 60 µm) is thinly disseminated throughout as weakly corroded an- to subhedral grains representing fragmented euhedra, and is accompanied by slightly coarser-grained, similarly weakly fragmental and weakly corroded arsenopyrite euhedra (mean 100 µm).

Accessory traces of Pb-sulphosalts (boulangerite) and minor traces of stannite occur as inclusions (to 75 µm, typically < 25 µm) in sphalerite. Late crosscutting microfractures, with associated granulation of sphalerite, occur sporadically.

(P.S. 54076)

This sample exhibits a composite of WF 103 and WF 100 characteristics.

The bulk of the area sectioned comprises near-massive red-brown sphalerite, analogous to that noted in WF 103, but finer-grained (mean 250 µm), and with relatively conspicuous included and intergranular boulangerite, supplemented by a little pyrite, minor traces of stannite and thinly disseminated blebs of carbonaceous matter. Sphalerite is polygonal mosaic-textured and more or less pervasively twinned, consistent with stress-induced recrystallization. Minor clots of very fine tourmaline are present, representing corroded and replaced 'pelite'. These features grade into isolated irregular zones of fine-grained sphalerite-tourmaline rock analogous to the sphaleritic zones in WF 100, and are accompanied by stringer-like veinlets of pyrite and pale microcrystalline sphalerite.
The relatively massive pale sphalerite zone is analogous to the sphalerite-mineralised clasts, but exhibits disseminated sphalerite-pseudomorphed arsenopyrite euhedra in addition to thinly disseminated pyrite. Microcrystalline Pb-sulphosalts is locally interspersed with the tourmaline-interstitial spongy sphalerite and, in detail, is sphalerite-replacive in an arcuate zone transgressing the faint relict banding.

The interspersed stringer-like pyrite aggregates carry disseminated variably boulangerite-pseudomorphed arsenopyrite, interspersed aggregates of boulangerite with minor associated galena or, locally, tetrahedrite, and tend to be flanked with subhedral crystals of colourless sphalerite with included blebs of carbonaceous matter.

(P.S. 54077)
A mineralised breccia with clasts of variably pyritic, tourmaline-rich carbonaceous pelite, semi-pervasively stained with extremely fine-grained Pb-sulphosalts (?boulangerite). The matrix consists of tourmaline-stained milky quartz with more or less pervasive fine acicular boulangerite, partly as discrete crystals and subradiating clusters, but more typically enclosed in highly poikilitic striated cubes of pyrite (mean 250 μ, to 2 mm). The pyrite forms irregular aggregates of millimetric proportions, variably microfractured, with more or less ubiquitous intergranular directed polygonal mosaic (i.e. recrystallized) boulangerite.

Zones of vein-type (matrix) quartz locally include disseminations and clusters of sub- to acicular arsenopyrite. Proximal host rock clasts are weakly arsenopyrite-impregnated. Rarely, acicular arsenopyrite appears as inclusions in pyrite.

Sporadic late films of microcrystalline boulangerite and quartz with accessory sphalerite and extremely rare marginal microscopic blebs of Ag-sulphosalts (?miargyrite) transect the clasts and the pyritic matrix.

(P.S. 54078)
A mineralised breccia with sulphide host rock relationships closely analogous to WF 105.

The millimetric- to centimetric-scale clasts of carbonaceous pelite are variably stained with ultrafine Pb-sulphosalts and are weakly but variably pyritic, with rare relict framboids indicating the Fe-sulphide is partly recrystallized syngenetic in origin. Thinly disseminated arsenopyrite euhedra are present, typically proximal to quartzose veinlets carrying clusters of arsenopyrite and accessory traces of sphalerite.

The matrix is pyritic, with a siliceous gangue. Sub- to radiating fine-grained boulangerite appears in the sparse quartz and is pervasively as inclusions in the poikilitic pyrite euhedra. Sporadic interspersed patches of polygonal mosaic-textured boulangerite range to a few millimetres diameter and enhance the similarities with WF 105.
WF 107  (P.S. 54079)
A veined and mineralised carbonaceous pelite similar to WF 105 and WF 106, but relatively weakly brecciated, at least as sampled and sectioned.

The host rock is variably impregnated with spongy clots and semimassive zones of microcrystalline Pb-sulphosalts intergrown with very fine felted tourmaline. Thinly disseminated fine-grained pyrite euhedra are of bedded distribution and of recrystallized syngenetic character.

Discordant discontinuous veinlets of sulphide, selvedged with quartz, consist variously of poikilitic pyrite with included acicular boulangerite and thinly disseminated arsenopyrite or, elsewhere, of sphalerite with disseminated pyrite and arsenopyrite-pseudomorphous boulangerite. Both types range to a few millimetres in width. Sphalerite veinlets appear temporally late and may be correlated with those in WF 105.

WF 108  (P.S. 54080)
Represents a massive sphalerite paragenesis with accessory pyrite and boulangerite and a sparse, fine-grained tourmaline gangue.

Sphalerite is medium-grained (mean 200-250 μ), internally-reflectant in red, and exhibits a weakly directed polygonal mosaic fabric with more or less pervasive twinning. Ultrafine-stannite, locally supplemented by tetrahedrite, is more or less ubiquitous in trace amounts as inclusions and sphalerite grain-boundary-controlled disseminations.

The bulk of sphalerite exhibits (recrystallized) vein-type characteristics. The sectioned area includes a zone of relatively banded, slightly finer-grained, slightly paler sphalerite of metasomatic character, with the banding enhanced by the distribution of tourmaline and pyrite.

In this zone, pyrite exhibits two semi-distinct habits. Individual pyritic bands carry either weakly fragmented and corroded euhedra ("syngenetic") or strongly poikilitic subhedra in a matrix of boulangerite and with ubiquitous fine (mean 20-25 μ) boulangerite inclusions and accessory traces of arsenopyrite. The latter mode appears to represent conformable veinlets, with textural affinities to the pyrite/Pb-sulphosalts matrix in the mineralised breccias (WF 105, WF 106, WF 107).

WF 109  (P.S. 54081)
This sample represents a "massive" boulangerite paragenesis, the sectioned area consisting largely of medium-grained subacicular boulangerite partly recrystallized to polygonal mosaic aggregates pseudomorphing the primary crystals.
Gangue consists of thinly disseminated single grains and small clusters of quartz and tourmaline. Accessory proportions of galena are present in irregular coarse-grained patches to a few millimetres diameter. Minor sphalerite appears in crudely lensoid patches, with a boulangerite-interstitial habit.

(P.S. 54082)

This sample is a composite of massive sphalerite and massive boulangerite zones.

Sphalerite is a medium-grained, granular, red internally-reflectant variety with pervasive intergranular blebs (mean 15-20 μ) and included to grain-boundary-dispersed acicular grains of boulangerite. Pyrite is thinly disseminated throughout as fine corroded particles, supplemented by sparse poikilitic crystals with included boulangerite, texturally similar to the pyrite in WF 105, WF 106 and WF 107.

The "massive" sphalerite is veined by, and appears as clasts within, boulangerite aggregates, typically polygonal mosaic-textured, but including relatively conspicuous pyrite euhedra (to 1.2 mm) with included acicular boulangerite. These aggregates may then be compared with the partly recrystallized pyrite-boulangerite breccia matrix paragenesis. General features are consistent with the sphalerite (-boulangerite) representing the later vein assemblage (i.e. postdating boulangerite-pyrite), but with subsequent fracturing, and remobilisation of boulangerite.

(P.S. 54087)

This sample represents essentially massive sulphides with a minor fine-grained tourmaline gangue component.

The major constituents are medium-grained, an- to euhedral pyrite, euhedral growth-zoned arsenopyrite and red to locally pale sphalerite. Pyrite and arsenopyrite form composite aggregates, typically with interstitial sphalerite, with interspersed millimetric-scale patches of massive sphalerite. These aggregates are extensively fractured, with the relatively brittle arsenopyrite relatively affected.

Composite aggregates and irregular discontinuous films of galena and boulangerite are semi-pervasive, forming the matrix to sphalerite aggregates and pervading the fractured pyrite-arsenopyrite composites. Accessories include minor traces of stannite and tetrahedrite as micro-inclusions in sphalerite, and rare microscopic laths of tjasmonite as inclusions in galena.

Sphalerite is typically dark, but is near-colourless where fine-grained and intergrown with tourmaline in irregular clots, representing altered and mineralised "pelite" intraclasts.

D. Cowan, B. Sc.
REPORT CMS 85/7/40

Explanation of Photomicrographs

1. **WF 100**  Magnification = 67x
   Pyrite, arsenopyrite-pseudomorphous sphalerite (grey) with traces of boulangerite (grey-white) in metasomatic, tourmaline-interstitial sphalerite.

2. **WF 100**  Magnification = 67x
   Pyrite, arsenopyrite-replacive boulangerite in metasomatic tourmaline-interstitial boulangerite.

3. **WF 110**  Magnification = 16x
   Pyrite with included acicular boulangerite in a composite of boulangerite and sphalerite.

4. **WF 109**  Magnification = 16x
   Acicular boulangerite in vein-type sphalerite.

5. **WF 105**  Magnification = 33x
   Acicular boulangerite in pyrite with interstitial coarser-grained boulangerite.

6. **WF 100**  Magnification = 33x
   Pyrite with arsenopyrite-replacive boulangerite and traces of sphalerite.

Magnifications relate to the 35 mm transparency image. Notes to determine magnification of projected images and prints are attached.

D. Cowan, B. Sc.
MINERALOGICAL REPORT NO. 5428

April 19th, 1989

TO:
Mr Warren Ormsby
Exploration Geologist
Woodcutters Joint Venture
Mine Office
Stuart Highway
PMB 60
WINNELIE N.T. 0821

YOUR REFERENCE:
Order No. 14812

MATERIAL:
Rock samples

IDENTIFICATION:
No. 1; No. 2; 5033-4A

WORK REQUESTED:
Thin and polished thin sections, also
descriptions as specified.

SAMPLES & SECTIONS:
Returned to you with this report.

Ian R. Pontifex
PONTIFEX & ASSOCIATES PTY LTD
No. 1

Limonitised vaguely crenulated-laminated mass of extremely fine, diffuse quartz-clay-sericite, apparently a tectonised meta-pelitic-sediment; incorporating numerous distorted and disrupted quartz stringers; bleached and enriched in clays along fractures.

In hand specimen, most of this rock is massive, compact and very fine grained and extensively permeated by yellowish to dark brown limonite. There are minor scattered discrete grains 1 to 2 mm size and several disrupted quartz stringers. Fractures and voids within the rock, also outer surfaces of it (which probably represent breaking selectively along broader scale fractures), are pale grey, apparently due to depletion of limonite (leached and bleached), and relative enrichment in clays.

As far as can be seen in this section, through the limonite impregnation, the bulk of the rock consists of a compact but diffuse mass of indefinite, clay-sericite and extremely fine quartz, with a vague crenulated-laminated structure, and very weak shredded schistosity.

This mass incorporates numerous quartz stringers (about 15% of the rock) which are crenulated to virtually pytymatic, and commonly disrupted which gives rise to isolated fragments of vein quartz and the 'scattered discrete (quartz) grains 1 to 2 mm in size', noted above in the hand specimen description. Individual quartz grains in these disrupted stringers are very strongly stressed, partly recrystallised, and comminuted.

The rock in the pale grey (bleached) areas is devoid of limonite, and dominated by clay-sericite which appears to have basically two preferred orientations (apparently two S planes). The distorted quartz stringers, and scattered fragments of stressed, disrupted quartz veinlets also occur in these domains.
No. 2

Limonitised, thin planar bedded very fine quartz-muscovite schist ('silty-shale'), in contact with a distorted very fine mica schist, incorporating abundant crenulated, disrupted and completely recrystallised quartz veinlets.

Part of this rock, over a thickness of about 20 mm, consists of a planar, thin bedded, extremely fine, relatively weakly limonite-stained quartz sericite schist. This consists of a slightly elongated metamorphic micromosaic (0.06 mm) of quartz (50%), incorporating a subequal abundance of very closely spaced, braided foliae of fine (limonite stained) muscovite foliae.

This fine planar schist is in contact with a 35 mm thickness in the thin section, composed of a similar fine schist but with substantially less fine quartz micromosaic and correspondingly far more fine schistose phyllosilicate but which is relatively intensely permeated by yellowish limonite.

Also this compact micaceous schist has a crenulated, distorted schistosity (in contrast to the planar layers above), and it incorporates numerous quartz veinlets which are crenulated, distorted (and disrupted), in sympathy with the host schist. The quartz in these deformed veinlets is completely recrystallised into a micro-comb-like, (individually micro-mylonitic-like), fabric.

A single white lens in the rock, 10 mm x 20 mm consists of isotropic, opaline silica.
Coarse carbonate gangue carrying: coarse granular bournonite composite with (and possibly replacing) tetrahedrite; trails and patches of fine euhedral arsenopyrite; trace pyrite and chalcopyrite.

Macroskopically, this small sample consists of a gangue of quite coarse crystalline white carbonate 65%, incorporating stringers, variably continuous veins and patches to 5 x 10 mm size of a largely microcrystalline grey sulphide, but with another coarser granular sulphide.

In the polished section, the small euhedral grey sulphide crystals are identified as arsenopyrite. These have an average and fairly consistent size of about 0.05 mm, they occur in rather loose clusters in irregular patches and trains throughout the carbonate gangue to form 10-15% of the section.

Coarser (to 1 x 3 mm) subhedral-granular crystals of pale slightly bluish grey colour (in reflected light), and distinctly anisotropic in colours from slate-blue to gold brown are the major component of most of the coarser patches of sulphide. This mineral commonly has a twinning, locally with parquet-like pattern. It is identified optically as:

\* bournonite - 2PbS.Cu₂S.Sb₂S₃

and it forms about 10% of the section examined.

Many grains of bournonite enclose minor to abundant, irregularly surrounded anhedral grains commonly about 0.5 mm in size, of a relatively darker brownish-grey sulphide, which is isotropic. This mineral is identified as:

\* tetrahedrite - Cu₃SbS₃.25

To a large extent, the tetrahedrite appears to be replacing the bournonite.

The patches and trails of loose packed small euhedral crystals of arsenopyrite commonly tend to cut through the coarse granular composite grains of bournonite-tetrahedrite, and locally they form rims around these coarser minerals.

Rare (<1%), small (0.1 mm), grains of pyrite occur in some bournonite
and trace smaller grains of chalcopyrite occur on one contact between bournonite and tetrahedrite.

NOTES

* bournonite has optical properties which overlap some of the Pb, Sb, sulphosalts minerals, and so if the identification is highly critical, the optical assessment should be checked by SEM or XRD.

** tetrahedrite forms a complete solid solution series with tennantite, thus some As would be expected in this mineral. It may also contain minor Fe, Zn, Hg, Bi, Te, Pb, Ag.
Selected Photomicrographs to Accompany
Report No. 5428 to Warren Ormsby,
Woodcutters J.V., 19/4/1989

Fig. 1  Sample No. 2  length of photo 4.4 mm
Thin section, crossed nicols, x37.5; part of this rock, as a planar-bedded
very fine quartz-muscovite schist.

Figs. 2 and 3  Sample No. 2  length of photo 4.4 mm
T.S., Xnicols, x37.5; same sample as Fig. 1 above, but showing an area of
disrupted and contorted fine layer-veins, showing elongated recrystallisation
fabric within the veins.

Fig. 4  Sample 5033-4A  length of photo 1.4 mm
Polished section, x120; coarse euhedral crystal of bournonite (pale-brown-grey);
enclosing several small patches of tetrahedrite (darker brown-grey), which may
be relics after extensive replacement by the bournonite. Cut across by
irregular band of small euhedral arsenopyrite crystals (white).