# PETROGRAPHIC SAMPLES

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Location</th>
<th>Lithology</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRANCES CREEK IRON ORE PROVINCE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIN 826</td>
<td>Helene 6/7 (pit)</td>
<td>Iron ore</td>
<td>~ 50 m from AIN 826</td>
</tr>
<tr>
<td>AIN 827</td>
<td>Helene 6/7 (pit)</td>
<td>Dolerite</td>
<td>The rock in appearance looks similar to Hamersley MacRae shale. The sample is from the chert (hematite) band.</td>
</tr>
<tr>
<td>AIN 828</td>
<td>Helene 6/7 (pit)</td>
<td>Iron ore</td>
<td>The rock in appearance looks similar to Hamersley MacRae shale. The sample is from the chert (hematite) band.</td>
</tr>
<tr>
<td>AIN 829</td>
<td>Helene 6/7 (pit)</td>
<td>Iron ore</td>
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<tr>
<td>AIN 830</td>
<td>808900 8494100</td>
<td>Iron ore</td>
<td>Breciated</td>
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<tr>
<td>AIN 831</td>
<td>808500 8496300</td>
<td>Protoe reasonably mineralised</td>
<td></td>
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<tr>
<td>AIN 832</td>
<td>808500 8496300</td>
<td>Soft micaceous hematite</td>
<td></td>
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<tr>
<td>AIN 833</td>
<td>810700 8497500</td>
<td>Shaly ore</td>
<td></td>
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<tr>
<td>AIN 834</td>
<td>821500 8497700</td>
<td>Weathered ore</td>
<td>Frances Creek East</td>
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<td>AIN 835</td>
<td>805800 8526800</td>
<td>Jessops Prospect</td>
<td></td>
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<tr>
<td>AIN 836</td>
<td>Boot 800700 8517900</td>
<td>Chert/Qtrz with iron</td>
<td>Chert/Qtrz with iron along fractures</td>
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<tr>
<td>AIN 837</td>
<td>Millers 804500 8512200</td>
<td>Hematite with Mn</td>
<td></td>
</tr>
<tr>
<td>AIN 838</td>
<td>Millers 804500 8512200</td>
<td>Hematite with Mn</td>
<td>No Fe fracture filling. Ore slightly magnetic</td>
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<td>AIN 839</td>
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<tr>
<td>AIN 840</td>
<td>Porcupine</td>
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<td>AIN 841</td>
<td>Helene 6/7 (pit) DDH 2 64'</td>
<td>Spe. hematite</td>
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<td>AIN 842</td>
<td>Helene 6/7 (pit) DDH 2 89'</td>
<td>Micaceous hematite</td>
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<td>Helene 6/7 (pit) DDH 2 108'</td>
<td>Micaceous hematite with Qtz crystals</td>
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<td>Micaceous hematite with Qtz crystals</td>
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<td>Massive micaceous hematite</td>
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<td>Helene 6/7 (pit)</td>
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<td>AIN 848</td>
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<td>210'</td>
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<td>AIN 849</td>
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<td>DDH8</td>
<td>215'</td>
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<tr>
<td>AIN 850</td>
<td>Helene 6/7 (pit)</td>
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<td>218'</td>
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<td>Ochre Hill</td>
<td>DDH 5</td>
<td>170'</td>
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<td>Ochre Hill</td>
<td>DDH 5</td>
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<td>Ochre Hill</td>
<td>DDH1</td>
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<tr>
<td>AIN 857</td>
<td>North Miller</td>
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<td>Big Hill</td>
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<td>Helene 6/7 (pit)</td>
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<td>74'</td>
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<tr>
<td>AIN 869</td>
<td>DDH2</td>
<td>177'</td>
<td>Hematite</td>
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<tr>
<td>AIN 870</td>
<td>Helene 6/7 (pit)</td>
<td>DDH2</td>
<td>177'</td>
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<td>AIN 871</td>
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<td>AIN 872</td>
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<tr>
<td>AIN 873</td>
<td>Helene 6/7 (pit)</td>
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SUMMARY AND COMMENT ON GENESIS
Helene 6/7, samples AIN826 to 829, AIN841 to 850, AIN868 to 873

Iron ore samples from the most abundantly represented location Helene 6/7 consist mostly of massive micaceous to bladed hematite, variably extremely fine (including earthy) through to coarse bladed. Somewhat diagnostic are scattered clusters of quite coarse bladed hematite which have a vaguely "porphyroblastic" or "metacryst" and some disrupted vein-like? textural relationship to the enclosing much finer hematite matrix. Broader textures in the matrix of these massive hematite samples (shown in numerous photomicrographs) are variably heterogeneous dominal, lenticular to layered. Many of these are vaguely zoned commonly interpreted in the descriptions as 'fluidal fonts' as may be visualised within a system of low-temperature hydrothermal to possibly metasomatic-replacement) style mineralisation within breccias.

Minor gossanous boxwork and replica after pyrite occurs in some samples but evidence of former sulphide is not widespread. The presence of the euhedral authigenic quartz crystals noted above, also the heterogeneity described as possible replacement of former breccia, and indeed the presence of actual relict breccia material within accumulations of the host hematite, all tend to support this broad genetic interpretation.

Other non-ore Helene samples are shale and fine schist pervasively replaced by mostly very fine to earthy hematite (e.g. AIN829), also they have occasional crosscutting veins and void infill of fine micaceous to microplaty hematite related to the above. One anomalously different sample is AIN870, which is a sandstone of rounded grains of earthy hematite (?possibly oxidised glauconite or sedimentary oolites) with quartz grains, with only minor interstitial micaceous hematite which may be supergene or a distal expression of fine micaceous hematite in the massive ores.

If the mineralisation event did involve metasomatic replacement, implying the conversion of pre-existing largely in-situ iron-rich material, by introduced fluids, the evidence suggests an inherently pyrite-rich shale facies, (?brecciated) as the most liked primary source of the iron.

The conclusion is that iron ores at Helene 6/7 have formed by broadly low temperature hydrothermal mineralising processes, involving some introduction of fluids, and subsequent metasomatic conversion and replacement of a former, inherently iron-rich (pyritic) and brecciated shale facies. Other non-ore samples from Helene show only peripheral evidence of these processes.
Some sample suites from other locations, including subsuites from within the Frances Creek Iron Ore Province, have mineralogy and textures indicating essentially the same genesis as discussed for Helene 6/7. Other groups of samples seem to have developed as a result of basically supergene in-situ oxidation and enrichment, and are regarded as relatively superficial, lateritic, and/or gossanous (or pseudogossanous) which at some localities, appear to have developed within former carbonate facies and at Millers are accompanied by minor Mn-oxides.

Comments on these other sample suites, in order of their listing in the introduction to this report, are:

1) **Samples AIN830 to 835, specific location representation not given, but probably Helene.** Samples 830 to 834 in this group consist of ferruginised silty shale, including breccia, replaced by massive fine earthy to micaceous (feathery) to microplaty and bladed hematite, locally with zoned domains, also with layering and clustered coarser hematite. These four samples are interpreted to have the same genesis discussed above for Helene 6/7.

Sample AIN834 is different as a largely lateritised regolithic breccia, including apparent ferruginised wood fragments, and AIN835 is a laterite-cemented breccia with fragments of hematised shale similar to the four samples above, also with scattered boxwork after pyrite.

2) **Ochre Hill AIN851 to 856**

These samples include two silty to fine sandy sericitic shale to fine quartz muscovite schist, carrying minor oxidised pyrite, with fairly intensely ferruginised micas. The other four are dominated by massive iron oxide including quite coarse random bladed hematite cemented by extensive goethite, and a breccia of fine quartz-muscovite schist in extensive, apparently mostly supergene, hematite.

Genetically, this subsuite is interpreted as predominantly superficial/supergene/ lateritic, but the local coarse blades of hematite seem to relate to the Helene-type genesis.

3) **North Miller AIN857 to 863**

This subsuite is characterised by the presence in all samples of minor Mn-oxide, probably pyrolusite, within more extensive microporous, massive to patchy to vaguely colloform accretionary goethite, limonite and supergene hematite. The gross genesis of the material as now seen is essentially 'lateritic', but it is of interest that carbonate
boxwork can be tentatively interpreted mostly within massive goethite in several of these North Miller samples. This, considered with the Mn-oxide suggests intense oxidation of an ex-carbonate facies (to produce pseudogossan and the presence of low grade skarn may even be questioned??).

4) **Millers AIN837 and 838**
Both of these samples are (like North Millers) essentially accretionary masses of migratory goethite/limonite together with minor Mn-oxide in 837. Boxwork after carbonate or pyrite occurs in 838. [Indeed, a totally objective, separate interpretation of the relict fabric in this massive goethite-limonite could be of ex-pyrite or pyrrhotite aggregate i.e. a true gossan, however, lateritised weakly-pyritic carbonate facies seems more likely.]

5) **Miller Hill AIN874**
This single sample consists of massive cryptocrystalline to microcrystalline micaceous hematite, with vaguely zoned patches, and minor euhedral (authigenic) quartz crystals. This rock has the same genesis as the Helene Pit suite, and in particular compares with AIN869. [Its spatial relationship to the Miller samples groups 3 and 4 above is not known.]

6) **Big Hill AIN864 to 867**
The first 3 of these samples are breccias with clasts of ferruginised quartzose shale or fine schist with an extensive cement of supergene goethite and hematite, and are genetically categorised as relatively superficial. The other AIN867 is "massive granular" cryptocrystalline goethite, also regarded as due to supergene-enrichment (lateritic) with a homogeneous texture which is perhaps anomalous, and just may replace pre-existing a massive carbonate facies, but this is highly speculative.

7) **Porcupine AIN839, 840**
Sample 840 consists of vaguely layered to massive micromosaic to microplaty hematite, and 839 is a breccia with clasts basically the same as 840, but with crosscutting veins of the same hematite species. Both of these samples have the same genesis as the Helene 6/7 suite, but there is localised, goethitic lateritisation, partly cementing 839 and partly superimposed on the breccia clasts.

8) **Boot AIN836**
This is a chert with patchy recrystallisation and with minor fissures lined by supergene colloform goethite.
INDIVIDUAL PETROGRAPHIC/MINERAGRAPHIC DESCRIPTIONS

AIN826

Almost entirely massive decussate microplaty (to microbladed) hematite, but with slightly larger euhedral rhombohedral/hexagonal hematite crystals, scattered and lining irregular voids. Minor clays and quartz.

Field Note: Helene 6/7 (pit). Iron Ore.

Macroscopic: This hand specimen is dominated by a massive aggregate of platy to fine bladed hematite, with generally minor interstitial porosity. Numerous scattered irregular voids 2 to 5mm across which are lined by randomly interlocking, small (<1mm) euhedral plate-like (tabular) hematite crystals, with prominent basal planes, and a distinctive rhombohedral (hexagonal) outline. Minor (5%) small patches of quartz and/or clays occur in this massive aggregate.

Microscopic: In polished thin section, at least 60% of this sample is seen to consist of intricately randomly interlocking fine platy to microbladed crystals of hematite, individual size <0.5mm. This mass incorporates coarser plate-like crystals of hematite, poorly defined but with basal partings seen in crystals described in the hand specimen, optically continuous over 0.5mm to 2mm dimensions.

These coarser crystals tend to be superimposed upon by the fine massive decussate hematite possibly representing two periods of crystallisation. Indeed 'sets' of the oriented microplaty hematite over similar dimensions may more or less pseudomorphically replace earlier coarse tablet-like hematite crystals.

There is no layering, and the rock is interpreted, at least objectively and initially, to probably have a broadly low temperature hydrothermal genesis.
Fig 1

Reflected light (RL). Low magnification (x20). General view, mass of randomly interlocking (decussate) microplaty to microbladed hematite crystals, incorporating minor scattered irregular voids.
Fig 2

RL. Higher magnification (x50) showing internally commonly oriented platy to bladed hematite crystals, possibly replacing earlier (recrystallised) larger ex-crystals.

Fig 3

RL. Example of coarser tablet-like euhedral hematite crystals more or less lining an irregular void, within massive finer hematite.
AIN827  
Microdolerite, completely weathered with original primary undeformed texture preserved by kaolinitic ± limonite replicas after plagioclase and finer chloritic clay ± limonite replicas after pyroxene. Accessory scattered leucoxene after original Ti-oxide crystals.

Field Note:  Helene 6/7 (pit) dolerite, ~50m from 826

Macroscopic: Massive homogeneous rock, composed of fine speckled, brownish limonitic clay, mixed with fine cream clay spots, reflecting an original medium to fine holocrystalline texture. No quartz, accessory fine probable leucoxene. All typical of completely weathered microdolerite (or basalt).

Microscopic: Petrographically, this rock is seen to consist of a homogeneous mass of randomly interlocking prismatic replicas now composed of very fine kaolinitic clay > even finer chloritic clay, with ubiquitous extremely fine limonite interstitial and within some replicas. These replicas are confidently interpreted to be after plagioclase and pyroxene crystals, in subequal abundance, consistently about 0.5mm in size, and representing an original primary, undeformed, dolerite, which has been altered, subsequently weathered.

Accessory replicas of limonitic-leucoxene after original disseminated titaniferous magnetite are (typically) scattered throughout the rock.
Fig 4

Thin section (TS), Crossed nicols (Xnic). Altered and weathered massive dolerite. Randomly interlocking kaolinitic-sericitic and chlorite replicas respectively after plagioclase and pyroxene, variably limonite-stained. Central "square" leucoxene replica after ex-magnetite crystal (circled).
AIN828 Mass of decussate fine platy hematite with minor fine interstitial porosity, minor irregular voids lined by euhedral small hexagonal platy crystals of hematite. Rare quartz. Vague domainal and zoning structures seen in reflected light may relate to iron-rich fluids (?hydrothermal), now hematite, replacing a former breccia.

Field Note: Helene 6/7 (pit), 808920E; 8494220N. Iron Ore sample similar to Hamersley MacRae Shale. From a chert-hematite band.

Macroscopic: This handspecimen is similar to AIN826 as a massive aggregate of decussate microplaty hematite with generally minor interstitial porosity. It incorporates numerous irregular voids 1mm to 4mm in size, also enclosing minor (<5%) small patches of quartz ± rare clay. The voids are internally lined by randomly clustered very small euhedral platy crystals, with a rhombohedral/hexagonal shape.

Microscopic: The polished thin section confirms that 95+% of this sample is a mass of decussate fine platy hematite, (exclusive of interstitial microporosity (?15%), and which is marginally more than in 826]. This includes scattered voids lined by random microplates or blades of hematite.

A difference with 826 however is the presence of patchy-domainal-zonal structures on a scale of about 5mm, poorly defined as variations of compactness/porosity. Minor domains consist of relatively massive cryptocrystalline non-porous hematite, also with vague (?colloform) zoning.

These broader structures may be interpreted to represent a cumulative build-up and crystallisation of mobile-iron-rich fluid of hydrothermal, or possibly metasomatic hematitic mineralisation, with the patchiness reflecting a pre-existing fragmental breccia (of indeterminate original composition) but invaded and replaced by this mineralisation.
Fig 5  AIN828

RL. Low magnification, showing patchy heterogeneity and irregular dislocated possible fluidal-fronts, within massive cryptocrystalline to extremely fine micromosaic hematite.
Figs 6 and 7

RL. Higher magnification showing detail in a selected domain with Fig. 5. (Reflecting breccia texture).
Fig 8
RL, part Xnic. Irregular voids lined by randomly interlocking small plates/ blades.

AIN828
0.18 mm
AIN829

Breccia of metamorphosed, silty to fine sandy pelitic schist. Matrix pervasively replaced by "earthy hematite" ± goethite. Accessory minute rutile or hematite grains. Patch of irregular stockwork of hydrothermal quartz-hematite and locally with graphite. Local colloform goethite, hematite replica after pyrite?

Field Note:  Helene 6/7 (pit) Iron Ore.

Macroscopic: This handspecimen is heterogeneous, apparently due to brecciation. Major domains consist of intensely ferruginous massive shale/mudstone are basically hematite (85% of the sample), which locally incorporates a breccia domain 25mm across of hydrothermal quartz-hematite.

Microscopic: In polished thin section, the major ferruginous domains are seen to consist of about 40%, very fine (<0.1mm) vaguely layered irregularly granular quartz, and lesser oriented/schistose inherent but ferruginised micas (10%) throughout a more extensive and finer 'massive' matrix of apparent earthy hematite ± goethite. This hematite seems to be a replacement product. These domains are interpreted as a fine schistose, silty meta-pelite, pervasively hematised. Sparse extremely fine (0.02mm) discrete 'solid' grains of hematite and/or rutile are disseminated.

A single small lens of graphite flakes occurs locally within this ferruginised rock. The area of heterogeneous brecciation seen in the handspecimen consists largely of an irregular stockwork of (hydrothermal) quartz veins, which carry abundant fine platy hematite and the patch of graphite also seems to occur within hydrothermal quartz, (or could this be metamorphically mobilised quartz).

Colloform goethite occurs on one rock margin. There are rare earthy hematite replicas after pyrite or carbonate near one vein.
Fig 9  
AIN829  
RL (Magnification x100), fine schist with scattered small irregular quartz grains, and oriented micas (dark), all within a matrix of massive extremely fine earthy (?to amorphous) hematite (?+ goethite). Sparse, minute, discrete bright grains of hematite and rutile (typical of meta pelitic lithology).

Fig 10  
AIN829  
RL. (Higher magnification x200) of Fig 9.
Fig 11
RL. Coarser patchy concentrated and probable hydrothermal quartz (left half of photo) irregular patchy vein of extremely fine hematite/goethite (probably essentially supergene).

Fig 12
RL. SW half of photo is apparent hydrothermal (?)or metamorphic) vein quartz, carrying an irregular lens of grey-brown graphite flakes. A seemingly more definite north-south vein of hydrothermal quartz crowded with hematite, right half of photo.
AIN830

Breccia of apparent shale pervasively and 'completely' replaced by massive microfeathery hematite. Cut by veins of coarse random platy hematite, some with sharp contacts, some with zoned possible hydrothermal or metasomatic fluidal fronts, against host hematite rock.

Field Note: Specific location not named. 808900, 8494100. Iron Ore. Brecciated.

Macrosopic: About 60% of this hand specimen consists of irregular areas of dull, apparent intensely hematised mudstone or shale to 30mm across. These occur between one simple vein and a small area of more complex veins, of coarse lustrous bladed hematite.

Microscopic: The areas of ferruginised 'mudstone' noted in the handspecimen in reflected light are seen to be dominated by massive microfeathery hematite, with minor scattered fine feathery microporphyroblastic spots of hematite. These areas are generally devoid of relicts of fine metasediment (as seen for example, within massive relatively earthy hematite replacement in AIN829), except in several local areas to 2mm across, which have remnants of fine quartz and schistose micas.

The veins of bright coarse hematite noted above, consist of randomly interlocking platy hematite crystals up to 0.2mm wide x 0.8mm long, some in local subradiating sprays. [These are not composite with quartz like those in 829.] In some places, there is a fairly sharp contact between the coarse bladed hematite veins and the microfeathery hematised host rock breccia fragments. Elsewhere there appears to be a zoning with slightly different concentrations and crystal size of hematite, locally involving silica.
Fig 13

AIN830

RL. Left $2/3$ of photo is a breccia fragment remnant of ferruginised (fine sandy) shale, with scattered, feathery, microporphyroblastic spots. Right $1/3$ is concentration of feathery/bladed hematite. Contact reasonably sharp.
Fig 14

RL. More gradational contact between vein of concentrated coarse feathery hematite (NW corner) and moderately ferruginised sediment.

Fig 15

RL. Higher magnification, detail of relatively coarse, random bladed hematite in vein, in contact with an apparent ferruginised shale composed of massive decussate microfeathery hematite.
Hematitic/hematised quartzose shale, oblique crosscutting veins in sub-parallel contact including an early quartz carrying leached out pyrite and a later (locally crosscutting) vein of hematite clustered plates, some partly colloform.

Field Note: Specific location not named. 808500, 8496300. Protore reasonably mineralised.

Macroscopic: Intensely ferruginised (hematised) shale, with a vein to 5mm wide along one edge of the sample of lustrous crystalline hematite, together with minor fine quartz and limonitic boxwork.

Microscopic: In polished thin section, the ferruginised shale is seen to consist, at least 35%, of extremely fine hematite, variously gradational from indistinct-earthy, together with minor to subordinate microgranular, and more specifically microplaty crystals, which have an individual size mostly <20 micron. These are intricately intergrown with equally fine quartz > schistose sericite as the major rock-forming silicate minerals. Minor "earthy hematite", gradational to possible "earthy goethite", occurs sporadically within the general rock matrix but these two oxide species are difficult to distinguish separately by optical microscopy.

A bifurcating hematite vein to 5mm wide is oblique at a low angle to the weak fine foliation, with widest segments dominated by coarse bladed to finer platy and compact subradiating hematite, randomly intergrown, also with local discontinuous colloform zoning. A bifurcating quartz vein more or less coincides with the hematite vein, but in specific detail, it is seen to be earlier than the hematite (it is cut by the hematite vein).

This quartz vein selectively carries several boxworks to 0.5mm across of oxidised and leached-out pyrite crystals, and trace minute grains of fresh pyrite.
Fig 16  AIN831
RL. Hematised shale with schistose fine micaceous hematite, through layered quartz silty component.
**Fig 17**

RL. Veins as described, of bifurcating hematite (bright white) with shale between, the lower part of the hematite vein also along margin of quartz vein and partly cutting quartz vein. Rare small pyrite grain within quartz vein.

**Fig 18**

RL. Part of quartz vein with a train of several large boxwork after pyrite. White veins, are hematite, partly zoned very fine micaceous.
AIN832

Mass of irregularly colloform lenses of fine to coarser platy/micaceous hematite, incorporating local small lenses of solid-crystalline hematite, also extensive porosity. Interpreted as low temperature hydrothermal hematite mineralisation.

Field Note: Specific location not names. 808500, 8496300. Soft micaceous hematite.

Macroscopic: Soft ( friable) texturally heterogeneous mass of micro to coarser platy hematite.

Microscopic: This sample consists of a vaguely layered mass of elongate patchy lenses of hematite, each on a scale of about 4mm x 10mm. These domains and areas between consist of vaguely internally zoned, irregularly colloform clusters of fine micaceous to microplaty hematite, with individual crystals ranging in size from 0.05mm, compacted into solid to microporous bands, varying to less compact and correspondingly far more porous platy hematite crystals to 0.4mm long. Also, about 20% of the whole mass consists of lenses to 3mm x 8mm of relatively solid crystalline hematite.

Areas between the various domains have a fine irregular porosity the same as some of the irregularly colloform zones within those domains. The gross texture/fabric of this rock suggests an accumulation of low temperature hydrothermal hematite mineralisation. The textures throughout the hematite compare to those in hematite-rich veins in AIN831.
Fig 19

RL. Irregularly lenticular, vaguely zoned domains of extremely fine micaceous hematite, mostly porous, some solid.

Fig 20

TS. Transmitted light photo showing detail of randomly interlocking platy crystals of hematite, extensive porosity between.

Field Note: Specific location not named. 810700, 8497500. Shaly ore.

Macroscopic: Weakly schistose/shaly massive extremely fine earthy (?to ochreous) hematite, incorporating minor extremely fine micaceous hematite.

Microscopic: Reflected light microscopy indicates approximately 40% of the rock composed of layers to 5mm thick, somewhat discontinuous and disrupted, of fairly compact and massive, but microporous micaceous hematite, locally incorporating apparent clay? Local disruption structures seem to be basically intraformational micro-slumping, possibly including inherent sedimentary dykelets. Minor veinlets of microplaty hematite cut across the layering. The other approximately 60% of the rock consists of intercalated streaky to lenticular fine layers of ferruginised-pelitic-shaly composition. Minor scattered quartz grains to 0.4mm may represent ex-detrital sand grains, but they are similar to several patches to 3mm of composite quartz micromosaic and seen elsewhere in samples of similar composition to be authigenic or low temperature hydrothermal. Minor extremely fine oriented muscovite flakes are disseminated. This sequence seems to represent pervasive replacement genesis of the hematite of a former meta-pelite, including minor late stage discrete veinlets of hematite.
Fig 21

RL. Lens of fairly compact but microporous mass of extremely fine micaceous hematite (NE half) in contact with earthy-hematite-replaced low grade meta-pelite.
Figs 22 & 23

RL. Detail of hematised pelitic sediment, including earthy and fine micaceous hematite, with scattered quartz grains which may be authigenic (possible relict detrital).
AIN834  Heterogeneous (?regolithic breccia) of apparent
hematised shale (± goethite and similar to part of
833), also micromicaceous hematite in vague zones
which may be supergene or low temperature
hydrothermal. Merges into lateritic, extremely fine
hematite ± goethite, including micropisolitic and
cellulose (lateritised woody) material.

Field Note:  821500, 8497700. Weathered Ore Frances Creek East.

Macroscopic: Small sample with poorly defined layers or zones of ultrafine compact
'earthy' hematite and/or goethite, with variable porosity. Some areas 1mm to 2mm scale,
distinctly "lateritic". Incorporates minor lustrous microplaty hematite.

Microscopic: Reflected light microscopy indicates basically two irregular merging
domains, possibly of regolithic breccia type genesis, forming this heterogeneous and partly
lateritic rock.

Approximately one half of the sample, in somewhat separate areas, seems to represent host
rock of hematised/oxidised pelitic facies, similar to that forming in AIN833, with minor
scattered fine grains of quartz and fine flakes of (apparently detrital) ex-muscovite. Porosity
is partly lined by ultrafine micaceous hematite, which seems to be supergene (although in
other samples, where this is more extensive, a low temperature hydrothermal genesis is
proposed).

A second component is basically laterite, as massive texturally heterogeneous, including
porous earthy to cryptocrystalline hematite to goethite, variably (nondescript) massive,
locally with micropisolitic structures, and locally with patches having an internal micro-
cellulose texture, apparently lateritised woody material.

The composition and textures seem to confirm the field identification of "weathered ore".
Fig 24

RL. Most of photo is irregularly spherulitic, massive earthy hematite of lateritic genesis. SE quadrant is vaguely zoned and vein-form extremely fine micaceous hematite, which may be supergene or low temperature hydrothermal.
Fig 25

RL. Flamboyant microtextures of apparent lateritised cellulose-woody material hematite includes ultrafine micaceous hematite.

Fig 26

RL. Breccia with random clasts of hematised shale. Rimmed by and cemented by microcolloform goethite, but immediately internally to these rims in ultrafine micaceous hematite (which must surely be supergene).
AIN835 Lateritic-cemented breccia of ferruginised (hematised) pelite (shale), with minor scattered goethitic boxwork cells after (oxidised and leached) pyrite.

Field Note: 805800, 8326800. Jessops Prospect.

Macroscopic: Similar to AIN834. Several vague layers to 12mm thick of relatively massive, extremely fine, earthy hematite and/or goethite with irregular porosity between of apparent lateritic- genesis.

Microscopic: Mineragraphically, this polished thin section indicates a random, loose-packed aggregate of angular fragments mostly <12mm across, of apparent hematite shale, dominated by a matrix of compact ultrafine hematite. These fragments incorporate numerous scattered, inherent components, notably silt to fine sand quartz grains (10-15%). More distinctively (and not seen elsewhere in ferruginised shale), there are 5-7% scattered limonitic boxwork after ex-single pyrite crystals up to 0.5mm in size.

Interfragmental areas are void and/or occupied by lateritic matrix/cement, locally microspherulitic, and including very narrow rims of supergene microcolloform hematite around some clasts.
Fig 28

RL. Scattered boxwork of single oxidised and leached ex-pyrite crystals within supergene/lateritic ferruginised former shale host rock.

Fig 29

RL. Heterogeneous lateritic mass of ferruginous shale incorporating oxidised ex-pyrite crystals (e.g. centre bottom), also quartz crystals (dark) probably authigenic. Central band of microspherulitic lateritic cement.
Fig 27

RL. Low magnification. Irregular breccia clasts of ferruginous/ferruginised pelite. Lateritic oxides as very thin rims, and patchy to earthy cement between.
AIN836  Chert with apparent patchy recrystallisation. Minor local microfissures lined by colloform/microcrystalline goethite, also filled by goethite to form veinlets and adjacent intergranular networks. All goethite is migratory/supergene.

**Field Note:**  *Boot. 800700, 8517900. Chert/Qtz with iron along fractures.*

**Macroscopic:**  As indicated above, this handspecimen is a chert, with local microfractures and associated patchy stainings of iron oxide, almost certainly goethite.

**Microscopic:**  The petrography also confirms that the greater bulk of this sample consists of patchy, massive cryptocrystalline to microcrystalline quartz, which by definition, is a chert, with apparent irregular domains of recrystallisation.

The iron oxides are microcrystalline goethite as largely colloform linings to fissures, and adjacent to these, goethite is intergranular as continuous networks over 1mm to 5mm, also as isolated and locally scattered single patches <1mm in size.
Fig 30

RL. Bulk of this rock is cherty micromosaic, as seen in reflected light. Fissures largely occupied by irregularly colloform microcrystalline supergene goethite.
Fig 31  AIN837

RL. Low magnification showing extensively microporous (leached) mass of goethite, with polygonal boxwork and some replica of essentially lateritic genesis. (Pseudo-gossanous as discussed in the description).
Fig 32 & 33

RL. Detail part of Fig 31. Mn oxide not specifically evident.
AIN837

Basically leached laterite. Heterogeneous, extremely fine microporous mass of goethite/limonite (± minor Mn-oxide?) of supergene, migratory origin, extensively leached.

Field Note: Millers 804500, 8512200. Hematite with Mn

Macroscopic: Binocular microscope examination indicates a texturally heterogeneous (basically non-descrip) mass of microporous very dark brown to near-black, extremely fine supergene oxide. The widespread dark colour would suggest some Mn-oxide and there are small yellowish areas of limonitic clay. Whole rock has very low SG.

Microscopic: Mineragraphic study confirms extensive (50%) porosity throughout (within and between) irregular merging domains about 5mm across. Microscopic cells, individually about 0.1mm (but with even finer scale internal partitions) constitute these domains, mostly with a vague micro-polygonal pattern locally with combined relict microcolloform microtexture.

Most of these microcells and the patchy domains they form appear to be goethite, but with minor to locally subordinate admixed Mn-oxide. Local microbotryoidal linings and in-fill of 'solid supergene' hematite all <1mm size are scattered to form up to 5% of the section area.

The gross texture/structure, also the detailed microcellular fabrics, and the goethitic/limonitic ± minor possible Mn-oxide forming these, are interpreted to be entirely of supergene, lateritic-migratory origin, subsequently extensively leached. There is no clear evidence of a recognisable in-situ precursor rock type.

[A totally objective interpretation of the boxwork and replica textures seen in this sample, and emphasised in the following photomicrographs, could be considered as possible gossan after massive pyrite and/or pyrrhotite. In the context of this suite however, this seems less likely than "basically laterite".]
AIN838  Vaguely layered fine porous mass of supergene, intricately intergrown, accretionary/migratory goethite, and hematite. Local areas however of possible boxwork after possible ex-pyrite or carbonate?

Field Note:  Millers 804500, 8512200. Hematite with Mn. No fracture filling, and slightly magnetite.

Macroscopic:  Although from the same locality as AIN837, this rock is relatively more solid (higher SG), albeit with extensive patchy microporosity, within massive extremely fine goethite. The rock has a vague layering. The "slightly magnetic" character mentioned in the field note could not be confirmed and there is no obvious Mn-oxide.

Microscopic:  Microporosity is obvious in polished section, forming up to 20% of the whole rock, more abundant in some poorly defined layers than in others. Mostly this occurs through masses of crowded microbotryoidal (accretionary-migratory) supergene oxide, on a scale of about 0.1mm. As well as can be assessed optically, this oxide is goethite with intimately mixed hematite in apparent subequal abundance.

Minor single crystals and clusters of small elongate specific 'prismatic' crystals, of goethite are randomly disposed, and appear to be broadly authigenic.

This rock is interpreted, like AIN837, as an accretionary mass of migratory, supergene Fe-hydroxides, basically lateritic, albeit without the distinctive leached micro-cellular fabric seen in AIN837. There are minor areas to 10mm long, 10% of the rock, within which there is a certain regularity of fine (but not ultrafine) goethitic boxwork, to suggest possible former in-situ pyrite, or carbonate. There is no clear evidence of Mn-oxide in the polished thin section, and no clear evidence of any recognisable precursor lithology.
Fig 34  
AIN838

RL. Typical field of view, massive microbotryoidal supergene oxide, with extensive microporosity.
Fig 35
RL. Detail of part of Fig 34. Intricate intergrowth of extremely fine apparent hematite (very pale grey) and goethite (darker), at least as far as can be resolved by optical microscopy.

Fig 36
PL. One of the areas of relatively "organised" boxwork, over several mm which may be after ex-coarse-pyritic or carbonate, within the typical massive matrix of Fig 34.
Heterogeneous ironstone breccia, with scattered small to large clasts of massive, very compact decussate microplaty/micromicaceous hematite, and of smaller short solid hematite blades. Matrix with variably mixed extremely fine hematite and microporous goethite. Probable lateritised hematite breccia. (Some textures as in same Helene samples).

Field Note: Porcupine

Macroscopic: The macrophoto indicates a large roughly rectangular clast of 'solid' extremely fine hematite, and rarer smaller fragments of the same, within an extensive irregularly porous fine goethitic-hematitic matrix.

Microscopic: Microscopically, the large solid fragment is seen to consist of a very compact mass of extremely fine decussate microplaty to micaceous hematite, a fabric which is highlighted along the margins of irregular porosity, but merging into diffuse micromosaic where these crystals are more compact.

The whole-rock breccia matrix is far more complex, composed of irregular domains commonly mixed, of massive microporous goethite and extremely fine decussate microplaty hematite, with local small concentrations of each. The gross texture indicates a probable precursor breccia. Discrete solid short blades of hematite, and clusters of several of these appear also to be breccia fragments (?or reconstituted porphyroblasts), the same as seen in several Helene samples. There are several veinlets, with internal void, lined by decussate microplaty hematite, and (separately) by microcolloform goethite (also seen in Helene samples e.g. AIN841).
Fig 37

RL. Part of the breccia forming this rock. Clusters of hematite blades (similar to those seen in some Helene samples) within an irregularly microporous goethitic amount.
Fig 38
RL. Veinlets of microplaty hematite with void core, cutting across breccia areas as in Fig 37, and an area of massive extremely fine porous hematite.

Fig 39
RL. Intricate mix of extremely fine hematite and (pervasively permeating) fine goethite including local area of botryoids of lateritic genesis.
AIN840  Vaguely layered but predominantly massive decussate microplaty to micromicaceous hematite, with variable microporosity. No existing or relict textures indicative of genesis, but may relate to breccia clasts in AIN839 however.

Field Note: Porcupine

This sample from the same locality as AIN839 is relatively homogeneous, in hand specimen. In the polished thin section, it is seen to consist almost entirely of massive, decussate microplaty to micromicaceous hematite, average individual crystal size mostly <0.2mm.

A vague layering is evident in the polished thin section on a scale of <5mm, manifest as minor variations in porosity form about 5% to 20%, and in the average size of crystals in the different bands.

There are no existing, or relict textures, (or any other mineralogy) to indicate any specific genesis. It does compare with some breccia fragments in AIN839 and it may represent the massive hematite facies which has been reconstituted to form the breccia of AIN839. Also it is similar to some of the more massive areas in AIN832 and to most of AIN828 from Helene.
Fig 40
RL. Typical mass of variably compact to porous, decussate microplaty hematite.

Fig 41
RL. Detail part of Fig 40.
AIN841

Massive extremely fine feathery hematite rock. Scattered very coarse hematite of uncertain genesis, with a broadly "porphyroblastic" mode of occurrence, but possibly disrupted veins. Local fine boxwork possibly after pyrite. Limonite stained kaolin. Interpreted as (low temperature?) hydrothermal mineralisation, possibly replacing a former breccia.

Field Note: Helene 6/7 (pit). DDH2, 64 ft, Spec hematite.

Macroscopic: This hand specimen shows numerous distinctly lustrous 'crystals' of hematite, 2 to 5mm in size, and small clusters of these, also minor small voids occupied by white clay/mica, all randomly disposed to form about 30% of an otherwise massive microporous extremely fine hematite rock.

Microscopic: The bulk rock is seen in reflected light to consist of diffuse patchy massive, extremely fine microplaty/microfeathery hematite, with individual crystals mostly <30 micron size, and with minor interstitial microporosity at a similar scale. The patchiness appears to reflect an inherent breccia texture. A cluster of very small 0.05mm cubic-form voids in this matrix may be after pyrite, but this is not certain.

The discrete hematite crystals obvious in the hand specimen consist of randomly interlocking to subradiating sheafs of coarse bladed hematite, to rarely granular. Some of these occur as more or less individuals with an essentially porphyroblastic or relationship to the bulk matrix. Some are more or less connected in a manner to suggest dislocated vague possible veins. Limonite-stained kaolinitic material accompanies some of this coarse hematite, more or less interstitial.
Fig 42

RL. Example of coarse clusters of bladed hematite, obvious in hand specimen but genesis uncertain, located within porosity, and massive ultrafine hematite matrix.
Fig 43
RL. Example of hematite matrix, patchy massive, micro-feathery hematite to ultrafine micaceous.

Fig 44
RL. Small (0.05mm) cubic form voids of uncertain genesis (possibly ex-pyrite) within massive fine hematite matrix.
AIN842 and 843

Massive extremely fine micaceous hematite rock, with a patchy heterogeneity including vaguely zoned domains suggesting pervasive low temperature hydrothermal or possible metasomatic hematite replacement of ex-breccia, especially in 842. In 843, local areas of very fine hematite boxwork/replica probably lateritic/pseudo-gossanous (but possibly ex-pyrite).

Field Note: 842 Helene 6/7 (pit). DDH2, 89ft micaceous hematite
843 Helene 6/7 (pit). DDH2, 108 ft, micaceous hematite

Both of these handspecimens and both thin sections at low magnification, are seen to be essentially the same, therefore described together. [The 'quartz crystals' mentioned in your field notes for 843 were not evident in the sample received, but these do occur in Ain844, also as noted in your field note.]

At least 70% or both samples are dominated by fairly compact massive extremely fine micaceous to virtually spicule-like crystals of hematite, mostly less than 20 micron size, with minor interstitial microporosity at this same scale. Within this mass however, and as an integral part of it, there are irregular domains from 2 to 10mm across, with shapes of contorted lenses to amoeboidal patches, outlined (especially in ACN842) by envelopes of coarse microprismatic to platy 'solid' hematite crystals, as possible colloform zones. These zones also occur within some patches. [These all compare with the same, more clearly developed zones in AIN832.]

This ore is interpreted to have formed by pervasive replacement of an apparent ex-breccia, of an unknown lithology, but possibly "mudstone or shale", with this process being passive metasomatic with local fronts forming zones around former breccia fragments.

Patches to 5mm across of very fine (individually <0.1mm) boxwork texture, have the same irregular boxwork texture and supergene partitions within earthy hematite as in AIN837 and interpreted as probable laterite-related (pseudogossanous), although possibly after pyrite.
Figs 45 & 46  AIN842 & AIN843
RL. Zoned layers and lenses of fine to ultrafine microplaty to micromosaic hematite which form up to 70% of these samples.
Fig 47

AIN843

RL. Localised area within fine hematite matrix shown in 45 and 46 above, comparable with the fine irregularly polygonal boxwork replica which compares with the same (although possibly after pyrite) in AIN837 (Millers), and interpreted as lateritic/pseudogossanous.
AIN844

Irregularly and vaguely (？spherulitic to colloform) zoned mass, of randomly interlocking very fine prismatic to micaceous hematite. Scattered large patches of coarse polygonal/euhedral quartz, apparently authigenic (low temperature hydrothermal).

Field Note: Helen 6/7 (pit) DDH2, 146 ft. Micaceous Hematite with Quartz Crystals

Macroscopic: This hand specimen shows irregular coarse patches of white quartz, lesser dark voids, randomly disposed through massive extremely fine hematite.

Approximately 65% of this rock consists of massive, very irregular patchy domains of randomly interlocking very fine prismatic to micaceous (platy) crystals of hematite, individual size mostly 0.3mm. Vague circular (?partly colloform) zones seem to occur through this mass. [This is very similar to AIN840 except that in that sample, the fine hematite crystals are mostly distinctly micro-platy/micaceous without the micro-blockiness of microprisms.]

The distinctive characteristic of this sample however is the presence of irregular patches of the order of 2mm to 15mm across of coarse quartz mosaic with individual crystals polygonal to euhedral. These incorporate minor to subordinate fine hematite, indeed they appear to have crystallised together with, or perhaps slightly later than, the massive hematite and may be regarded as broadly authigenic.

The impression is of massive low temperature hydrothermal quartz-hematite mineralisation.
Fig 48  AIN844
RL. Low magnification, massive, overall vaguely layered extremely fine crystalline hematite (right half of photo). Patchy coarse polygonal mosaic of quartz, with minor fine scattered hematite (left half of photo).
Fig 49  
**AIN844**  
RL. Higher magnification showing decussate microprismatic hematite.

Fig 50  
**AIN844**  
TS. Xnic. Coarse quartz, transmitted light, incorporating scattered hematite (black opaque).
AIN845 Heterogeneous, patchy, vaguely zoned and layered, microporous extremely fine hematite. These textures probably 'fluidal' within low temperature mineralisation, combined with relict brecciation, now replaced.

Field Note: Helene 6/7 (pit) DDH2, 164 ft. Massive micaceous hematite.

This core sample compares in handspecimen and in polished thin section with AIN842, 843. It is essentially a mass of extremely fine micaceous hematite. The polished section viewed macroscopically shows sequences of fine, curved to incipiently convoluted layering, some with an apparent fluidal-flow or zonal-lamination fabric. At higher magnification, the layering seems to be superimposed on a breccia texture.

All of these textures are manifest as minor variations in individual crystal size and microporosity of otherwise massive decussate extremely fine micaceous hematite. They are all very poorly defined and merging into each other. There are rare grains of authigenic quartz.

As for other samples in Helene 6/7 DDH2, this seems to represent pervasive low temperature hydrothermal hematisation, possibly replacing a breccia, but no distinctive former lithology is indicated.
Figs 51, 52

RL. Lenticular layers, possibly at least partly formed by fluidal flow as may be expected in low temperature hydrothermal (pervasive) hematite mineralisation, which especially in Fig 52, at higher magnification, has a combined breccia texture.
Sericitic shale, minor very fine grains of quartz and/or leucoxene disseminated (and some oriented) along an apparent $S_i$. Minor coarser grains of authigenic quartz micromosaic ± rutile/anatase, oriented along a possible $S_i$ direction.

Field Note: Helene 6/7 (pit). DDH8, 138 ft. Shale, mainly micaceous-hematite.

Macroscopic: A pale grey-green shale (or very fine micaceous siltstone) with minor localised, reddish hematite staining, no clear evidence specifically of micaceous hematite.

Microscopic: Petrographically, this core sample is confined as a sericitic/fine muscovite shale with one major (?)$S_i$) extremely fine foliation/cleavage, but with common locally divergent orientations of the sericite to indicate an apparent later oblique $S_i$ plane.

Minor (5-7%) Irregular grains of fine quartz mosaic, ranging in size from 0.2 to 3mm long are scattered with a vague common orientation, possibly parallel to the later $S$-plane and distorting $S_i$. Much finer (<0.2mm) commonly elongate grains of leucoxene alone, quartz alone, and of composite quartz-leucoxene (5-7%) are scattered mainly along the prevailing fine foliation.

Very fine leucoxene and/or rutile/anatase is attached to the margins of some of the vein quartz fragments. Fine micas within some of these small quartz fragments have been replaced by earthy hematite, and there are trace minute sulphide grains.
Fig 53
TS. Xnic. Whole photo of extremely fine quartz sericite shale. Lens of authigenic quartz mosaic with inclusions, oblique to and distorting the essential very fine foliation/cleavage.
AIN847, AIN 848

Massive hematite ore, with scattered clusters of coarser crystals of hematite, veins, randomly within a matrix of ultrafine micaceous hematite. Irregular patches/zones/layers within the matrix appear to relate to fluidal flow, during pervasive hematite mineralisation, possibly replacing a breccia.

Field Note: 847 Helene 6/7 (pit) DDH8, 157ft. Micaceous hematite
848 Helene 6/7 (pit) DDH8, 210 ft. Micaceous hematite.

These two samples viewed macroscopically in handspecimen and in the polished section are seen to be essentially the same, and indeed, the same as DDH2 samples described above, especially AIN841, 842, 843, also 829.

Approximately 35% of each section consists of irregular lustrous crystals of hematite and small clusters of these to 3mm across, scattered and some connected throughout a matrix of massive (and relatively dull) extremely fine, random micaceous to hematite matrix.

The microscopic characteristics of these components are the same as in the comparative samples noted above. The coarse hematite may have a disrupted vein-like relationship to the matrix as suggested in some other samples. The matrix itself has a patchy and apparent relict breccia texture combined with poorly defined and irregular zonal patterns, suggesting fluidal flow. As for previous samples, the impression is a genesis of pervasive hematite replacement of a former breccia, representing low temperature hydrothermal or possibly metasomatic mineralisation.
Figs 54 & 55

RL. Various zonal domains in extremely fine hematite, again with irregular clusters of bladed hematite (enclosing quartz in SE corner of Fig 55). All typical of Helene.
Figs 56 & 57

Further examples, zoned lens in extremely fine hematite, also scattered clusters of bladed hematite, all typical of Helene.
AIN849

Sericitic shale (siliceous/silicified) with microfissures permeated by stringers/veinlets of extremely fine micaceous hematite, some coarse lustrous crystals of hematite. A major band with coarse granulose quartz kaolin dusted with hematite, also muscovite in shale may be a breccia band or possible tuff, and is permeated by the ultrafine and more abundant coarser hematite.

Field Note: Helene 6/7 (pit). DDH8, 215 ft. Shale/hematite.

Macroscopic: Pale compact/massive sericitic shale, incorporating a major hematite band about 12mm thick, and minor hematitic laminations oblique at about 45° to the core axis. Minor thin fractures at right angles to this banding permeated by ?remobilised hematite.

Microscopic: In polished thin section, the "host rock" is seen as basically a sericitic shale similar to AIN846, but fairly extensively siliceous/silicified and with coarser mica flakes (10-12%) to 0.5mm, randomly scattered (post schistosity meta crystals) and all oxidised to limonite-leucoxene. Fracture networks in this shale are permeated by veins/veinlets of ultrafine dull micaceous hematite (the same as matrix in AIN847, 848 and others) and some of these carry the same lustrous coarse crystals of hematite as scattered through the matrix in Ain847, 848 and others.

The main hematite band includes of the same ultrafine and coarser crystalline hematite, which are vein-like and permeating a lithology of 'shale' crowded with fragments of quartz muscovite schist, and of vein quartz, also scattered kaolin flakes dusted by hematite. [This may be a breccia band, or it may represent a relict tuffaceous bed within the shale.]
Fig 58
RL. Veins with fine to ultrafine hematite cutting silicified very fine schist. Possibly distal manifestation of Helene 6/7 hematite mineralisation.

Fig 59
RL. Shredded foliae of ultrafine hematite and fine granular hematite, along brecciated bedding (or possibly along a tuffaceous band). [This fragmental band does however compare with the ferruginised breccia AIN856 from Ochre Hill.]
AIN850

Sericitic (quartzose) shale, minor disseminated leucoxene and small hematite spots. Vein across cleavage, of coarse quartz, with a margin of kaolin and two drusy cores filled by ultrafine hematite + rarer coarse crystals of hematite (as seen in massive Helene ores).

Field Note: Helene 6/7 (pit) DDH8, 218 ft. Shale with micaceous hematite.

Macroscopic: Macroscopically this core sample represents the same shale as AIN846, but with a distinctive vein about 6 mm wide at one end (arrowed on the macrophoto).

Microscopic: Petrographically, this shale is dominated by compact sericite, with minor dispersed equally fine quartz. Also there are minor (5%) scattered minute grains and small clusters of rutile/leucoxene (also seen in AIN846) and there are scattered partly leached grains of hematite (5-7%), mostly about 0.1 mm in size, also threads of hematite along the prevailing very fine schistosity. The exact genesis of the disseminated hematite spots is uncertain, but they may be authigenic, or represent very incipient 'hematitic' alteration.

A vein cutting across the cleavage has a reddish stain-oxidation margin 2 mm wide. The vein itself consists of a more or less polygonal mosaic of interlocking subhedral/prismatic (to almost sparry) crystals of quartz, dusted with fluid inclusions and apparently of hydrothermal origin. Immediately inside the contact for a width of 0.5 mm, there is a band of kaolin flakes oriented at right angles to the contact. There are two internal bands composed of ultrafine micaceous hematite (the same as the matrix in AIN847, 848 and other Helene samples), with occasional coarse prisms of hematite (also as in those other samples). These bands seem to occupy continuous connecting drusy voids interstitial to the coarse crystalline quartz mosaic.
Fig 60
TS. Xnic. Low magnification. Right half of photo is sericitic shale with disseminated leucoxene and hematite. Left half is crosscutting quartz vein, central opaque core of hematite, alteration kaolin-rich margin see detail Fig 61.

Fig 61
TS. Xnic. Shale in SE half quartz vein NW half, with flakes of kaolin oriented at right angles with a base on the shale contact.
AIN851  Composite facies with bands of sericitic shale carrying minor fine oxidised pyrite. Intercalated ferruginised shale with earthy hematite > ultrafine micaceous hematite > accessory coarse crystals of hematite, incorporating scattered fine ?detrital quartz also apparently authigenic or low temperature hydrothermal quartz (+ trace sulphide and kaolin).

**Field Note:**  *Ochre Hill DDH4, 170ft. Ferruginous Shale*

**Macroscopic:**  Layered sequence on a 1cm to 2cm scale, including pale but weakly iron stained shale, with intercalated, more intensely, hematitic, irregularly porous but also partly shaly bands.

**Microscopic:**  The weakly ironstained shale is dominated by weakly schistose kaolin (?possibly after very fine muscovite), with minor (10%) disseminated silt-size quartz grains, also with minor (10%) disseminated very small 0.03mm grains of ex-pyrite, oxidised to earthy hematite and/or goethite.

More intensely hematitic layers consist of mostly ultrafine earthy hematite apparently intricately mixed with (but camouflaging) a clay/shale matrix, also with minor scattered ultrafine randomly micaceous hematite, and incorporating scattered irregular quartz grains to 0.5mm, also patches to several mm and local quite coarse kaolin. Objectively these bands seem to be hematitic/hematised shale. However the scattered quartz grains are enigmatic, some must surely be ex-detrital, but other slightly coarser quartz grains appear to be authigenic/low-temperature hydrothermal, including the presence of sparse minute sulphide inclusions. Kaolin accompanies some of these quartz grains/patches and there are accessory coarse grains of hematite.
Fig 62

TS. Xnic. Shale band in this sample, showing extremely fine oxidised pyrite disseminated through massive fine kaolin.
Figs 63 & 64

RL. Ferruginised shale with minor scattered fine micaceous hematite (most in Fig 63). Also scattered fine quartz (?relict detrital) but coarser patchy authigenic quartz, some (elsewhere in the rock) with minute sulphide inclusions.
AIN852 Weakly foliated to massive, fine quartz muscovite schist. Minor probable oxidised fine ex-pyrite, plus staining of foliae. Possible weak hydrothermal influence on fabric of (decussate) muscovite and quartz.

Field Note: Ochre Hill, DDH5, 172 ft.

Macroscopic: A homogeneous pale yellowish-brown ("ferruginous"), fine mica schist, without specific or discrete crystalline hematite.

Microscopic: The thin section shows a reasonably homogeneous and compact mass of very fine, weakly schistose to random muscovite, incorporating minor (10-15%) scattered very fine quartz (but microscopically elongated/ragged). Minor (10%) poorly defined but fairly discrete spots of hematite about 0.1mm in size, appear to be oxidised pyrite as in 851. The semi-decussate nature of the fine muscovite suggests that it may not be all specifically metamorphic.

Reflected light shows (only) accessory microcrystalline/micaceous hematite in shredded microlenses, and even rarer (small) equant crystals of hematite. There is a crosscutting veinlet of ultrafine hematite however.

The lithology is basically a very fine quartz muscovite schist, weakly ferruginous probably from oxidised pyrite, and staining derived therefrom.
**Fig 65**

TS. Xnic. Fine muscovite schist, but fine muscovite tends to be decussate, possibly reflecting hydrothermal influence. Intense black spots are oxidised pyrite, with adjacent brownish staining.

**Fig 66**

RL. Same sample as above, reflected light shows ragged nature of some quartz, comparing with authigenic quartz in 851. Also very sparse micaceous hematite along foliae.
AIN853

Heterogeneous mass of various hematite and goethite, including irregularly intergrown, (?early) ultrafine to medium crystalline micaceous hematite; minor scattered discrete small blades of solid hematite; more extensive micro-crystalline goethite as relict colloform/vein form incorporating the above. Single replica after pyrite.

Field Note: Ochre Hill DDH4. 180 ft. Slightly siliceous hematite with veins of specular hematite.

Macroscopic: There is a very fine/massive ferruginous rock, with heterogeneous irregular patches of darkish brown goethite ± hematite? with porous yellowish earthy limonite within an between these patches.

Microscopic: The polished thin section shows a heterogeneous mix of:

1. 30%, irregular microporous patches of massive ultrafine to very fine, crystalline micaceous hematite, apparently "early" but now isolated relicts, possibly as breccia clasts.
2. 15%, discrete bladed crystals of hematite about 0.5mm in size, randomly scattered, some loosely clustered, mostly within (1) above, mostly in (3) below.
3. 55%, irregular domains of microcrystalline goethite, some curved/rounded and possibly ex-colloform, variably separate and partly connected, and more or less incorporating hematite varieties (1) and (2) above. These patches also enclose small drusy voids.

Overall genesis uncertain, but the overall heterogeneity suggests an ex-breccia, but now completely ferruginised including possible early 'hydrothermal' later supergene goethite. A single goethite/hematite replica after pyrite is present.
Figs 67 & 68

RL. Example of the heterogeneous mix of iron oxides in this sample. 

① Blades and clusters of coarse hematite.
② Patchy goethite ③ Background/matrix of ultrafine 'earthy' hematite ± goethite ④ Goethite/hematite replica after pyrite/
Patchy masses 5 to 8 mm across, vaguely zoned, of massive decussate microplaty/micaceous hematite, intricately intergrown with, and partly replaced by, goethite. Coarser bladed hematite + goethite, as discontinuous networks in between. This intricate mix of oxidised compares with AIN853.

Field Note: Ochre Hill DDH5, 200 ft. hematite.

About 80% of this sample consists of irregular subrounded domains about 8mm across, of massive very fine decussate microplaty hematite, intricately mixed with and partly replaced by equally fine goethite. To a large extent, the goethite forms a matrix to the micaceous hematite crystals, which mostly have an individual size of <0.05mm.

A poorly defined network, reasonably continuous between the patchy domains, consists of coarser blades (to 0.5mm) of hematite, randomly interlocking, some as scattered individuals.

These veinlets are also permeated by and partly rimmed by goethite, which locally coalesces to form porous patches. The fine micaceous hematite, bladed hematite and goethite have markedly complex intergrowth relationships in these areas.
Fig 69

RL. Also in this sample different intergrowths including vague zones of (pale grey) bladed to micaceous hematite, largely within goethite (dark grey). Texture in some goethite suggests it may be oxidised ex-micaceous hematite.
AIN855

Texturally heterogeneous mass of irregularly colloform to botryoidal, microcrystalline goethite. Randomly scattered residuals of probable ex-micaceous hematite, completely altered, also random coarser blades of hematite (as in samples above in this drill hole), and probably a lateritised equivalent. Minor residuals of cherty quartz.

Field Note: Ochre Hill DDH4. 227 ft. Hematite.

Macroscopic: This is a mass of relatively dull grey to yellowish goethite, fairly compact, but with minor scattered microbotryoidal porosity on a <1mm scale.

Microscopic: In the polished thin section, at least 80% of this sample is seen to consist of a microcolloform to botryoidal microcrystalline goethite, seen to be distinctively yellowish in transmitted light.

This mass is crowded with dark reddish-brown patches, also as seen in transmitted light, which appear to be residuals of a pre-existing phase, probably the compact, massive decussate micaceous hematite seen in samples from higher in this drill hole 5 to be partly replaced by goethite.

The microcrystalline goethite also encloses minor single blades of hematite to 0.3mm size, and small clusters of these, randomly disposed to form about 10% of the samples. These are the same as also seen in samples above in this DDH5. Minor small patches of cherty quartz mosaic, up to 3mm in size, are scattered but of non-diagnostic genesis.
Figs 70 & 71

TS. Irregular masses of microcolloform goethite, reddish to yellowish, in transmitted light, incorporating (in Fig 7) clustered blades of hematite. Residuals of hematite notable in Fig 71.
AIN856

Breccia with fragments extremely rich in very fine colourless chlorite (± fine quartz and sericite) forming schist or shale, also with small fragments of vein quartz. Extensive matrix of finer equivalent composition. Fragments and matrix intensely permeated by earthy and ultrafine micaceous hematite. Rare gossanous fragments.

Field Note:  Ochre Hill DDH1, 214 ft. Micaceous hematite.

Macroscopic: This hand specimen is an intensely ferruginised micaceous schist, deceptively homogeneous in the cut slab, but some mm-scale heterogeneities are indicated on the naturally broken surface of this core sample.

Microscopic: Petrographically, at low magnification, the rock is seen to be a fine breccia, with numerous fragments rarely 10mm in size, but mostly <5mm. Most of these fragments (35%) consist of very fine (colourless) chlorite schist ± minor/subordinate sericite and equally fine quartz, permeated by extremely fine (earthy) hematite. There are also scattered fragments of vein quartz (10%) and chert, 0.3 to 1.5mm in size. These fragments are randomly disposed through a whole rock matrix of massive extremely fine chlorite flakes, rarer muscovite, and quartz grains, intensely permeated by earthy hematite. This is presumably the comminuted equivalent of the scattered fragments.

Although most of the extremely fine permeating hematite is 'earthy', equally fine micaceous hematite is seen at somewhat higher magnification to form probably up to 15% of the whole rock.

Trace minute sulphide inclusions occur in some quartz fragments and there are several fragments of gossan, (goethitic replica/boxwork after sulphide).
Figs 72 & 73

TS. OL. Chaotic breccia with chaotic unsorted fine schist fragments and dispersed single flakes dominated by extremely fine colourless chlorite and fine quartz in Fig 72. Larger clast of schistose kaolin or colourless chlorite in Fig 73. Earthy ultrafine hematite matrix.
Mottled laterite, including diffuse amoeboidal patches of goethite with apparent ultrafine MnO and rims of more definite crystalline ?pyrolusite. These components scattered through massive ultrafine goethite-limonite, microporous and with amoeboidal-patchy structure.

Field Note: North Miller, DDH1, 23 ft. Brecciated hematite.

Macroscopic: Approximately 35% of this core sample consists of dark grey to black, somewhat mottled patches of extremely fine 'oxide' to 10mm across and with amoeboidal outline, randomly disposed (to vaguely layered) through massive extremely fine and microporous 'earthy goethite'.

Microscopic: At least 70% of the polished thin section consists of the above-noted diffuse amoeboidal patches, which are ultrafine porous/massive to cryptocrystalline, to earthy goethite/limonite, and have variable colour from grey, reddish, brownish, yellowish, (as seen in partial cross nicols, reflected light). There is a common, vague very fine internal colloform to botryoidal zoning in these patches. Local vague network textures are of uncertain genesis.

The black patches seen macroscopically must surely include ultrafine Mn-oxide but the material is too fine to positively identify optically. Relatively more discrete but also very fine microplaty crystals <0.05mm of Mn-oxide, probably pyrolusite, form outermost rims of some colloform surfaces, thereby lining some drusy voids and these are clearly illustrated in the following photomicrographs.

The rock is broadly classified as a manganese-bearing laterite.
Fig 74
RL. Low magnification, diffuse patchy fine mottled laterite of ultrafine hematitic/goethitic oxide, right half of photo. Left half of photo, irregularly colloform masses of supergene goethite and/or hematite, rimmed by very pale brown microcrystalline Mn-oxide.

Fig 75
RL. Detail of Mn-oxide crystal rim, along massive porous extremely fine goethite/limonite.
Figs 76 & 77

RL. Part Xnic. Intricate mix of extremely fine yellowish limonite, reddish-earthy hematite and grey ultrafine apparent supergene hematite micronetworks.
AIN858, 859, 860

Three samples: all essentially laterite and similar to AIN857. Variably include mottled black patches with disseminated discrete very fine crystals and clusters of black Mn-oxide, within massive yellowish-brown microporous goethite, also minor ultrafine hematite. Local possible relict boxwork (?after carbonate), in 859 and 860 (?skarn relationship).

Field Note: 858 North Miller DDH1, 35 ft. Brecciated hematite
859 North Miller DDH1, 40 ft. Hematite + fractures with spec. hematite.
860 North Miller DDH1. 43 ft Hematite + fractures with spec. hematite.

Macroscopic: These three cores are seen in handspecimen to have essentially the same composition and textures, and indeed the same as AIN857 at 23 ft in this drill hole. Approximately 1/3 of each sample consists of near-black (mottled) patches about 5mm to 10mm in size, irregularly amoeboidal in shape in 358, 359 (like 357) but relatively elongated and similarly oriented in sample 860. These occur through a matrix of massive extremely fine reddish to brownish goethite, with forming up to 10%.

Microscopic: The scattered patches consist of extremely fine "earthy" oxide, probably largely goethitic but their black colour, also the presence of recognisable discrete crystals of Mn oxide in drusy voids in the core of these patches, also indicate "earthy" Mn-oxide throughout each patch. These Mn-oxide crystals are most abundant in 859 where they are spicule-like and also scattered in the goethite matrix outside the black mottles, and in 860 in micromosaics (inside the mottles) to 2.5mm across.

The matrix in each sample consists of massive ultrafine (reddish) goethite to (yellowish) limonite, with apparent microscopic networks of hematite, and a porosity on a micronscale within goethite and on a scale of up to several mm between a broader fabric through the massive goethite. Vague indications of boxwork possibly after carbonate are seen in 859 within massive Mn-oxide (Fig. 80) also defined by skeletal textures in goethitic matrix in 860. [If this was original carbonate, is it possible that these Fe-Mn oxide rocks represent oxidised skarns?]
Fig 78

RL. Part Xnic. High magnification, micromottled matrix within broader scale lateritic mottle; diffuse reddish earthy hematite and/or goethite, sporadic partial rims of opaque supergene hematite, local infills of yellowish limonite.
Fig 79
RL. Background lateritic matrix of macroporous hematite of goethite/limonite (like detail in Fig 78). Small and large voids occupied by clusters of small Mn-oxide crystals (of uncertain exact species possibly pyrolusite).

Fig 80
RL. Massive micromosaic of Mn-oxide (?pyrolusite) incorporating a network texture which may be after coarser carbonate.
Fig 81
RL. Localised patchy concentration of microcrystalline Mn-oxide in massive, ultrafine microporous goethitic matrix.

Fig 82
RL. Skeletal network within goethitic matrix, possibly a poorly pressured ex-carbonate relict texture.

Field Note: 861 North Miller, DDH1, 60 ft. Goethite with minor hematite.
863 North Miller, DDH1, 102 ft. Goethite limonite + minor hematite.

Macroscopic: These two samples are macroscopically similar to each other, (also similar to other Nth Miller samples). They are dominated by a massive matrix of yellowish to brownish, extremely fine limonite goethite; with minor stringers and small infillings of very fine crystalline black-lustrous mineral (seen in reflected light as Mn-oxide).

Microscopic: In reflected light the bulk matrix, which forms +85% of 861 and +75% of 863 is confirmed as massive microcrystalline and microporous yellowish to pale-brown limonite-goethite. The texture is massive, extremely fine micro-lateritic, which may represent complete pervasive (lateritic) replacement of a former microcrystalline mostly non-quartzose rock, (micritic-carbonate?) There is minor scattered fine mica (muscovite) in 861, and slightly more abundant decussate fine ferruginised mica in 863. Alternatively, the massive, fine texture may not be relic, but simply a 'new' lateritic texture formed by accumulation of migratory supergene oxides.

Minor stringers/infills of microcrystalline apparent pyrolusite occur in 861. Minor small patchy infills occur in voids in 863.

There is no definite hematite optically recognisable in either sample.
Fig 83

RL. Microporous goethitic/lateritic mass, scattered small patches of microcrystalline Mn-oxide.

Fig 84

RL. Microporous/lateritic/goethitic mass, with voids partly occupied by massive cryptocrystalline Mn-oxide.
AIN862

Massive "lateritic-ferruginised" rock cf. 861 and 863, but local areas of coarser (mm scale) possible boxwork after carbonate? sulphide??? Accessory very small crystals of Mn.

Field Note: North Miller. DDH1, 83 ft. Goethite-limonite.

As noted above, this sample appears in handspecimen to be essentially the same as 861 and 863, composed of massive fine mixed limonite, goethite and rare Mn-oxides. In polished section however, there are several areas (possibly veins) of goethitic boxwork, which may be at least considered as possible poorly preserved ex-carbonate structures.

The polished thin section confirms extensive but irregularly massive microporous brownish goethite > yellowish and semi-translucent limonite, with <5% microcrystals of Mn-oxide. The goethite is microscopically porous (micron scale) but has local apparent relict boxwork on a scale of 0.4mm to 1.5mm as noted above and shown in figure numbers 85 and 86.
Figs 85 and 86

Figs 85 and 86

RL. Medium density and more open goethite forming this 'laterite' but with vague possible relict boxwork which may reflect former carbonate.
AIN864, 865, 866

Breccias, with clasts of ferruginised and silty-quartzose shale, also minor scattered clasts of quartz-micromosaic and coarse single crystal quartz (probably hydrothermal). Extensive matrix/cement of colloform, botryoidal supergene goethite and hematite, most in 864, less in 865 and reduced to stringers permeating microfractures and sparsely interstitial in 866.

Field Note: 864 Big Hill, DDH3, 7ft. Hydrated hematite with clays and vugs
865 Big Hill, DDH3, 58 ft. Hydrated hematite with clays and vugs
866 Big Hill, DDH3, 74 ft. Siliceous shale.

In handspecimen (and in polished thin section) these three core samples are very similar. Basically, others are lateritised/ferruginised breccias, with angular to subangular fragments, commonly about 10mm in size, and mostly of yellowish-limonitised shale, cemented by goethite which also includes apparent supergene hematite. The ratio of clasts to cement/matrix varies however as follows:

- 864: clasts 30%, cement/matrix 79%
- 865: clasts 40-50%, cement/matrix 50-60%
- 866: clasts (or fractured shale basically in-situ) 85%, cement 15%

In 864, shale clasts are dominated by sericite, with sparse disseminated silt, all densely clouded by yellowish 'earthy' limonite. The cement between these clasts consists of scattered hematite mostly incorporated within colloform goethite, and the sympathetic/common contacts frequently seen between these two different oxides indicates that they have both accumulated from migratory iron-rich solutions, almost certainly supergene.

In 865, as noted, the clasts are more extensive and have a higher ex-silt content with less matrix than in 864. Also, there are more scattered quartzose fragments. Matrix cement is patchy microporous ferruginised shale, with some clasts also having scattered small quartz grains. Supergene hematite forms narrow colloform and micron botryoidal rims around clasts alternating with, and some on the outside of, rims of goethite.

Sample 866 has most fragments of ferruginised/limonitised silty shale. One clast of extremely fine kaolinite has a spaced cleavage, and at least x2 S fabrics, also disseminated minute crystals of rutile.
Fig 87

RL. Fragments of ferruginised shale within cemented by patchy colloform goethite (dark grey) and supergene hematite (white).

AIN864

0.45 mm
Fig 88, 89

Detail of cement, goethite (translucent dark grey in RL) and colloform botryoidal supergene hematite (pale grey in RL), basically opaque in transmitted light.
Fig 90

RL. Further example of clasts of ferruginised shale, rimmed by microcolloform to microbotryoidal goethite and supergene hematite.

Fig 91

TS. Xnic. Clasts of ferruginised shale, fissures and voids between of colloform goethite.
Fig 92  

**AIN866**  
0.18 mm

TS. Xnic. Clast of silty shale with relatively ferruginised spaced cleavages, cut by stringers of goethite.
Homogeneous "massive granular" aggregate of cryptocrystalline goethite (of uncertain genesis). Incorporates very small shredded lenses (20%) of apparent kaolin-altered sericite quartz shale.

Field Note: Big Hill DDH3, 74 ft. Siliceous Shale.

Macroscopic: Homogeneous ferruginised sericitic shale or siltstone, the iron oxide appears to be entirely goethite. [The compactness and homogeneity produces a (superficially) tougher rock than others from Big Hill but it does not seem to be especially 'siliceous' as suggested in the field note.]

Microscopic: In transmitted light, at least 75% of this core sample is seen to consist of homogeneous, "massive-granular" goethite, with a grain size consistently about 0.2mm. The grains have an irregular shape and form quite a compact massive aggregate, they consist of cryptocrystalline goethite with a distinctive brownish-orange-yellow colour in transmitted light, with darker-reddish-brown colour intergranular.

Approximately 25% of the rock consists of extremely fine elongate/micro-schistose quartz mosaic with intergrown schistose kaolin after sericite (and trace sericite) in ragged very small lenses to 0.5mm, and some vague foliae, similarly aligned but otherwise with sporadic distribution throughout the massive goethite.

Genesis is uncertain. If the "granular aggregates" of goethite is replacement, then an ex-microcrystalline carbonate rock may be considered. Alternatively, the goethite may be entirely a new supergene texture.
Figs 93 & 94

TS. Xnic. Massive granular aggregate of goethite possibly replacing ex-massive fine carbonate incorporating scattered irregular residuals of impure kaolinitic/sericitic chert.
AIN868

Massive coarse subhedral/euhedral quartz crystals, probably low temperature hydrothermal. Fine hematite fills voids in between, and is enclosed within. Tentatively interpreted as massive-authigenic, as a more massive equivalent of AIN844, also from Helene (DDH2).

Field Note: Helene 6/7 (pit). Specular hematite with quartz patches.

Macroscopic: This handspecimen is seen as massive, very coarse crystalline to weakly sparry quartz, incorporating minor (25%) scattered fine to coarse micaceous hematite.

Microscopic: Petrographically, the quartz is seen to consist of a mosaic of randomly interlocking coarse (1 to 5mm) subhedral to euhedral crystals. Many of these have inclusions of hematite, also internal ghost-like ?relic textures outlined by "goethite", (possibly ex-carbonate?).

Hematite occurs in irregular patches, between quartz crystals and this is variably massive, extremely fine micaceous, with individual random crystals <0.03 mm, and coarse micaceous to bladed hematite, which may be enclosed in the much finer hematite, or entirely and separately between the quartz crystals.
**Fig 95**

TS. Xnic. Coarse patchy authigenic quartz enclosing hematite, possibly low temperature hydrothermal (cf. Fig 50, AIN844, also from Helene).

**Fig 96**

RL. Coarse bladed hematite between coarse quartz crystals.
AIN869

Massive, extremely fine micaceous to somewhat coarser crystalline hematite with vague patchy zoning and minor scattered voids. Numerous euhedral quartz crystals scattered, essentially authigenic.

Field Note:  Location not listed (but probably Helene), DDH2, 177ft.

Macroscopic: A vaguely layered hematite ore with a patchy heterogeneity. Minor irregular voids <5mm and associated coarser micaceous hematite, scattered. Minor small loosely clustered quartz crystals.

Microscopic: The polished thin section shows a texturally heterogeneous mass of extremely fine micaceous hematite (with individual crystals <0.02mm), variable to slightly coarser and bladed crystals of hematite (to 0.1mm x 0.5mm). The coarser crystals are most concentrated, more or less surrounding irregular voids, some enveloped by a vague zoning within the hematite.

Numerous quartz crystals (total about 10%) are scattered and locally clustered mostly more or less euhedral/bipyramidal/prismatic, commonly about 0.5mm in diameter. These appear to be authigenic, conceivably low temperature hydrothermal. [The mosaic of quartz in AIN868 probably has the same genesis, but unusually concentrated/aggregated in that sample.]
Fig 97

RL. Example of massive decussate microplaty to very fine micaceous hematite, with vague zoning, with a single enclosed authigenic euhedral quartz crystal.
Unique sample for Helene. Massive hematite-rich sandstone, composed of abundant detrital rounded grains of 'earthy' hematite, subordinate-detrital quartz grains. Intergranular porosity (?ex-carbonate) occupied by micromicaceous hematite and goethite. Genesis of earthy hematite grains uncertain, but may represent authigenic oxidation of glauconite or possibly sedimentary oolites

Field Note:  Helene (pit). Hematite. NTGS #9556 coarse grained specular hematite.

Macroscopic: This handspecimen is a homogeneous massive hematite rock, seen particularly under binocular microscope to have an apparent detrital/ granular texture (as in sandstone) with most grains <1mm in size.

Microscopic: The polished thin section indicates a 'massive sandstone' composed of a loose-packed aggregate of subrounded to rounded and commonly somewhat flattened/elongate detrital grains, reasonably well sorted but with a size range of 0.2mm to (rarely) 1mm, average about 0.5mm. There are basically only two grain types, with ubiquitous original intergranular porosity as follows:

1. single crystal quartz grains, forming about 30% of the whole aggregate
2. grains now composed of extremely compact, ultrafine/earthy hematite, approximately 50%, some enclosing sparse minute micaceous hematite flakes.
3. intergranular porosity (~20%), largely occupied by extremely fine micaceous to decussate microplaty hematite, with sporadic goethite.

The genesis of the grains category (2) above is uncertain, they may be former sedimentary grains (conceivably glauconite-related) which have been totally oxidised/hematised. Alternatively, they may represent detrital/primary sedimentary hematite pellet or oolites.

Intergranular areas may represent former carbonate cement/matrix, since leached out to form porosity and subsequently partly filled by microcrystalline specular hematite (?supergene) with flakes within some hematite grains formed contemporaneously. The goethite sporadically filling intergranular areas is conceivably later, supergene.
Fig 98

RL. Low magnification, inherently hematite-rich sandstone, detrital aggregate of rounded to partly flattened mostly (dull) earthy-hematitic composition, subordinate scattered rounded (dark grey) quartz grains. Widespread interstitial, very fine crystalline hematite (white).
Figs 99 & 100

RL. Higher magnification Fig 98, showing detail of earthy hematite grains, quartz grains (very dark). Interstitial very fine micaceous to microplaty white hematite may be supergene or distal permeations from more massive Helene hematite ore mineralisation.
AIN871 Mass of coarse to very coarse micaceous to bladed hematite, mostly subradiating as randomly interlocking clusters. Local spherulitic textures with internal radiating crystals, and local scalloped colloform zonal fronts.

Field Note: Helene 67 (pit). Hematite NTGS #9553

This is a spectacular sample of massive, very coarse, lustrous bladed/micaceous hematite, as randomly and tightly interlocking single crystals to 20mm long, mostly subradiating and in poorly defined clusters.

There are local spherulitic aggregates to 3mm diameter of 360° radiating small crystals of hematite, some merging into adjacent spherulites.

Also locally seen macroscopically on the cut surface, there are irregular scalloped/colloform microbands, discontinuous but tending to join some of the zoned spherulitic textures, apparently representing "fluidal fronts".
Fig 101  
RL. Part Xnic Mass of randomly interlocking very coarse bladed, subradiating hematite.

Fig 102  
RL. Part Xnic Mass of coarse bladed hematite as above, incorporating a cluster of coarse spherulitic hematite.
AIN872 Mass of extremely fine decussate micaceous hematite, intricately mixed with a matrix of even finer indefinite earthy hematite. Minor scattered flakes of kaolin or colourless chlorite, rare hematite replicas after pyrite.

Field Note: Helene s7 (pit). Hematite. NTGS #9554.

In stark contrast to AIN871, this hematite ore consists of a mass of dull, extremely fine hematite (to almost earthy in handspecimen). Reflected light microscopy indicates that at least 70% of the sample consists of a compact mass of randomly intergrown extremely fine micaceous hematite, with individual crystals mostly <10 micron.

An apparent matrix within this mass, and diffuse very irregular patches throughout, consist of even finer hematite, which the optical microscope can only really resolve as 'earthy'.

The only other components are single flakes, 0.02mm wide, to 0.4mm long, of colourless chlorite, and grains of composite micro-crystalline equivalents, with a chaotic distribution to form about 10% of the rock, (and the same as reported locally more abundant in other samples from Helene described above).

Accessory (1-2%) hematite replicas apparently after ex-pyrite crystals to 0.3mm size are scattered. Accessory small irregular quartz grains are also present.
Fig 103
RL. Mass of extremely fine micaceous hematite, intricately mixed with a matrix of earthy hematite. Also coarse flakes of colourless chlorite.
Texturally heterogeneous massive hematite, variably coarse random bladed, to patchy and layered much finer micaceous hematite with porosity. Layering may relate to a hydrothermal (? or metasomatic) mineralisation fluidal fronts.

Field Note: Helene 6/7 (pit). Hematite. NTGS #9553

Approximately 1/3 of this sample compares with AIN871, as massive, compact, interlocking quite coarse bladed crystals of hematite. These domains however merge into and are partly incorporated within patchy domains of finer decussate micaceous to spicule-like crystals of hematite, with a higher proportion of porosity. Some of these are texturally very heterogeneous but others have zones or bands manifest as differences in concentration of fine micaceous hematite (and corresponding reverse differences in porosity) and with differences in average (fine) hematite crystal size. These structures are tentatively interpreted to relate to metasomatic or hydrothermal mineralisation fluidal fronts.

Minor very fine quartz grains (5-7%) are locally clustered, and regarded to be essentially authigenic.
Fig 104
RL. Part Xnic. Mass of randomly interlocking coarse hematite blades, enclosing a cluster of much finer micaceous hematite.

Fig 105
RL. Very coarse hematite aggregate right half of photo, gradational to area of extremely fine micaceous hematite, left 1/3 of photo.
Figs 106, 107

RL. Lenticular and layer-like zones within extremely fine micaceous hematite.

AIN873

0.45 mm
Massive cryptocrystalline to microcrystalline micaceous hematite with irregular patchy to vaguely banded zones, including scalloped microlayers, suggestive of fluidal fronts. Minor scattered euhedral authigenic quartz crystals cf. AIN869 (Helene Pit?)

Field Note: Miller Hill. Hematite.

Macroscopic: Massive, extremely fine crystalline hematite rock, with minor scattered quartz crystals to 1.5mm in size.

Microscopic: The polished section consists of a texturally patchy/heterogeneous mass of extremely fine to slightly coarser microcrystalline micaceous hematite, with individual crystal size range of <10 micron to say 100 micron, gradational also to clusters of slightly coarser bladed hematite to say 200 micron (rarely 300 micron). Hematite of this variable crystal size is commonly intricately intergrown in irregular domains varying to vague bands/zones, including local scalloped/colloform microbands along contacts with some of these microscopically dislocated. The slightly coarser crystalline hematite tends to surround minor small voids.

Several scattered authigenic quartz crystals to 1.5mm have overall euhedral outline, but with microscopically ragged margins scattered.
Figs 108, 109

RL. Further examples (essentially the same as AIN873) of massive extremely fine micaceous hematite with various zones and apparent fluidal fronts.
Fig 110
RL. Compares with Figs 108, 109 above, with subrounded domains of compact extremely fine micaceous hematite, slightly coarser "sparry" hematite between.

Fig 111
RL. Example of 'large' authigenic, euhedral quartz crystal enclosed with massive extremely fine hematite. Minor fine hematite within this crystal.
AIN875

Massive, dull ultrafine clay-rich earthy hematite rock, apparently mostly a matrix to a breccia of very fine muscovite-rich schist to silty shale, also kaolin fragments. Minor scattered ragged grains/crystals of fine brecciated quartz. Basically hematised metapelitic breccia.

Field Note: Ochre Hill DDH1, 180 ft. Hematite.

Macroscopic: Although not obvious in the macrophoto, the sawn surface through this sample indicates numerous small (<5mm) apparent breccia fragments of extremely fine ferruginised schist to shale (and one anomalously white bleached kaolin fragment) all within massive 'earthy' hematite.

Microscopic: The petrography indicates extensive ultrafine apparently earthy hematite mixed with (?kaolinitic) clay, incorporating minor disseminated silt to fine sand-size quartz and muscovite. Minor poorly defined (camouflaged) breccia fragments of ferruginised very fine quartz muscovite schist to shale as randomly disposed. Numerous scattered grains of quartz to 2mm size (10%) appear to represent fine brecciated to comminuted quartz.
Figs 112 & 113

AIN875

RL. Massive dull ultrafine earthy hematite, as a matrix to scattered grains and clasts of quartz, and of ferruginised shale to micaceous schist.
AIN876 Porous mass of microcrystalline goethite, incorporating minor very small spherulitic grains and trains of supergene hematite, also minor small grains of authigenic quartz. Rare graphite.

Field Note: Ochre Hill DDH3, 180 ft. Hematite/goethite.

In hand specimen and in the polished thin section, this sample is seen as a very fine porous mass of microcrystalline goethite. Microtextures within this mass are best developed around irregular voids, manifest as microprismatic/acicular crystalline crystal growth (which in some places, may just possibly replicate earlier microplaty, micaceous hematite?). Minute spheroidal/botryoidal grains and contorted trains of supergene hematite (7-10%) are randomly scattered, and minor irregular grains of authigenic quartz also have a random distribution. A single large contorted flake of graphite is enclosed in the massive fine goethite.
Fig 114 AIN876
RL. Massive microporous, microcrystalline goethite, incorporating quartz grains and a large contorted graphite.

Fig 115 AIN876
RL. Typical of this massive goethite rock, with prismatic goethite crystals protruding into void. Local ragged grains of hematite composite with goethite (SE corner).
AIN887

Massive aggregate of martite/hepatite (± possible maghemite) as replicas replacing a former medium to very coarse crystalline aggregate of ex-magnetite.

Field Note:  Mount Bundeby. DDH4A, 94ft. Hematite.

Macroscopic: Massive compact and tough very fine hematite rock, minor scattered small (<5%) small voids. The sample is strongly magnetic.

Microscopic: Reflected light microscopy indicates massive hematite, over about 1/3 of the area of the section forming a more or less isometric mosaic typical of clustered ex-magnetite crystals <0.3mm size. Typical textures are the relict outline morphology of the magnetites, also at least some visible internal crosshatch relict crystallographic fabrics, but mixed with the new diffuse micromosaic of the hematite. Sparse relict magnetite inclusions are present.

Local pseudomorphous/relict textures, and are individually anomalously large (to 10mm) where former euhedral margins line voids.

Local microshears, and apparent ex-breccia matrix between the replicas are also hematite-altered.
Fig 141  AIN887
RL. Part Xnic. Typical massive mosaic of martite (+ minor probable maghemite) replacing a former magnetite aggregate.

Fig 142  AIN887
RL. Part Xnic. Very coarse (former) euhedral crystal margins of ex-magnetite facing a void. These crystals completely pseudomorphed by hematite, with some leaching to form extremely fine internal boxwork.