

# *Pontifex & Associates Pty Ltd*

MINERALOGY – PETROLOGY · SECTION PREPARATION

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## **MINERALOGICAL REPORT No. 9397**

*by Alan C. Purvis, PhD & Ian R. Pontifex MSc.*

September 15th, 2008

**TO :** Mr Jim McKinnon-Matthews  
Mithril Resources Ltd  
60 King William Road  
GOODWOOD SA 5034

**YOUR REFERENCE :** Samples received from Jim 4/9/08

**MATERIAL & IDENTIFICATION :** Five rock samples ORC-005, 013, 016, 018, 019  
One gossan sample ORC-011. Believed to be from "Blackadder"

**WORK REQUESTED :** Section preparation, initial urgent report on sulphides, followed by this written petrology/mineralogy assessment.

**SAMPLES & SECTIONS :** Returned to you with this report.

**DIGITAL COPY :** Text only emailed 15/9/08 to:  
<gascough@mithrilresources.com.au>  
Hard copy and CD with photos to be despatched 16/9/08.

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## **SUMMARY COMMENTS**

Five samples labelled ORC-005, 013, 016, 018, 019 and one gossan sample ORC-011 received from Jim McKinnon-Matthews are assessed in this report from polished thin sections. These are believed to be from Blackadder Prospect, NT. The rock samples are identified petrographically by Alan Purvis, as augite-norite and (olivine)-augite-norite and are sufficiently similar to described and discussed as a group, as presented immediately below. Geochemical data were provided by Graham Aschough 11/9/08 and these were used together with the petrology to classify the rock types, also to allow brief comment on some metal values. Some of these mafic rocks contain trace to accessory, small primary magmatic disseminated grains of ilmenite, pyrrhotite > pyrite ± pentlandite, violarite and chalcopyrite. The accessory pentlandite is most abundant in sample 013, which reports 945ppm Ni (but the observed sulphide seems to suggest a marginally higher value).

An individual description and interpretation is then provided for the gossan sample ORC-011, which is found to consist of goethite/limonite developed within an apparent sillimanite-garnet rock (interpreted to have contained “significant ex-pyrrhotite”). This sample therefore appears to represent a different precursor from the five mafic samples, possibly a contact metamorphic rock adjacent to the intrusive norite. Minor miscellaneous finer boxwork in this gossan may represent other ex-sulphides, perhaps including pentlandite since it has anomalous Ni, Cu and Co assays, but such boxwork could not be categorically identified. Trace malachite was seen on a saw cut through this sample.

Composition and textures in the gossan, the petrology and accessory sulphides in selected noritic rocks are appended.

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**DISCUSSION: FIVE mafic rock samples, ORC-005, 013, 016, 018, 109**

The mafic rock samples are identified as augite norite and one sample (013) of (olivine)-augite norite. Mineralogies estimated from thin sections and considered together with the geochemistry provided by Mithril, are tabulated below.

	<i>ORC-005</i>	<i>ORC-013</i>	<i>ORC-016</i>	<i>ORC-018</i>	<i>ORC-019</i>
Olivine	0	4	0	0	0
Orthopyroxene	55	45	52	46	37
Clinopyroxene	6.5	9	11	13	15
Plagioclase	35	38	32	36	38
Biotite	2	2	3	4	6
Hornblende	1	0.2	0.5	0	3
Opaque grains	0.5	1.2	0.5	1	1
Amphibole-spinel	0	0.6	0	0	0
	100	100	100	100	100

Samples ORC-005, 016, 018 and 019 are poikilitic augite norites with granular to prismatic orthopyroxene, granular to euhedral clinopyroxene and interstitial plagioclase. Sample ORC-005 differs from the others in having larger orthopyroxene crystals (to 10mm long), smaller plagioclase (to 2mm) and less abundant biotite. Samples ORC-016, 018 and 019 have smaller orthopyroxene crystals (to 3 or 4mm long), larger interstitial plagioclase grains (to 10mm), more abundant clinopyroxene (augite ± pigeonite?) and more abundant biotite, especially in ORC-019, with biotite to 3mm in grainsize in decussate aggregates. Sample ORC-019 also contains hornblende.

All samples have minor (1-2%) scattered inherent ilmenite. In ORC-015 the ilmenite has minute lamellae of either rutile (parallel to rhomb faces) or hematite (parallel to the base). Trace to accessory disseminated magmatic sulphides are pyrrhotite > pyrite, chalcopyrite and pentlandite ± trace violarite. The sulphide-rutile association suggests low  $fO_2$  conditions possibly due to contamination. Sample 013 has “significant” accessory pentlandite composite with other sulphides. Relatively rarer, very fine probable pentlandite occurs in other norites. There are also pre-existing accessory disseminated sulphide grains in these rocks, which have been partly (and selectively) oxidised to goethite. These may have included pentlandite.

The petrography of norite sample ORC-013 indicates an (olivine)-augite norite with minor anhedral olivine veined by serpentine and magnetite and rimmed by orthopyroxene  $\pm$  magnetite and by rare amphibole-spinel symplectites. In this sample, mostly fine-grained orthopyroxene is evenly scattered, locally rimmed by clinopyroxene, with some fine-grained separate clinopyroxene, as well as biotite and hornblende. The plagioclase is fine-grained and not obviously interstitial. Small single and composite grains of sulphide in 013 are 1.5 to 3mm in diameter and consist of pyrrhotite > pentlandite  $\pm$  violarite > pyrite and chalcopyrite. One composite has melnikovite pyrite and violarite together with chalcopyrite and sparse pentlandite. Minor ilmenite is also disseminated as in the other mafic rock samples.

As a group, these samples appear to represent a layered intrusion with cumulus layering and accessory disseminated magmatic sulphide. The four olivine-free samples have early, probably cumulus pyroxene and interstitial plagioclase, but the olivine-augite norite (013) has partly cumulus plagioclase. Minor late magmatic and deuteric minerals (biotite and hornblende) occurs locally.

Correlation within the element group Na-K-Ti-P suggests that these elements indicate trapped magma. The olivine-augite norite 013 is the only one with significant sulphide but reports Ni (954ppm) which is less than ORC-005 (1300ppm). The polished thin section and the polished section of 013 (selectively cut to include a 3mm sulphide grain) suggests a marginally higher Ni-content than 945ppm. The orthopyroxene-rich samples also have more abundant Cr (476-881ppm) than ORC-013 (327ppm), and these values are considered to be relatively high for mafic lithologies.

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## INDIVIDUAL DESCRIPTION, GOSSAN ORC-011

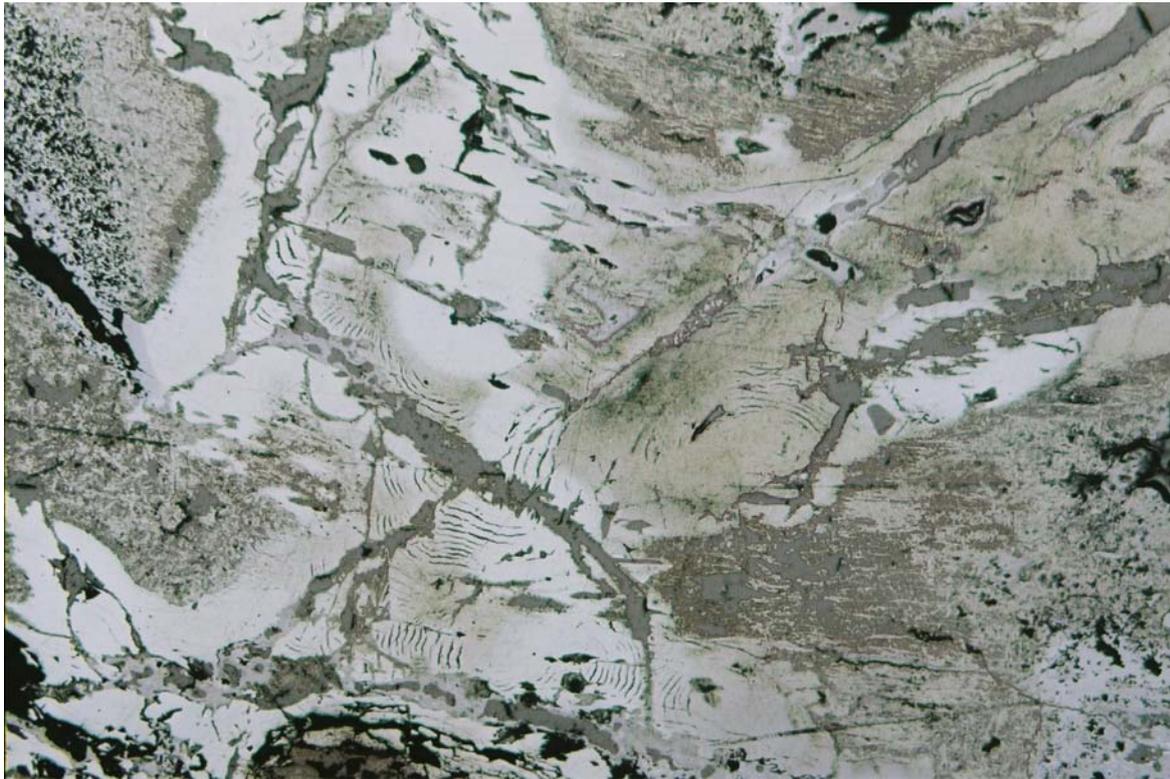
In summary, this sample is identified in polished thin section as a sillimanite-garnet rock (possibly a contact-metamorphic adjacent to norite intrusives described in this report. Gossanous boxwork is interpreted to represent approximately 20% pyrrhotite, there is also trace malachite, but no other ex-sulphides could be positively identified.

This handspecimen has the distinct macro-characteristics of a gossan, being dominated by an irregularly granular aggregate of goethitic-limonite boxwork and replica textures, on a scale of 2mm to 10mm, with finer cellular goethite between and within these coarser components. Minor sporadic silica grains within limonite are also seen under binocular microscope.

Individual textures (and interpretations) are shown in photomicrographs, Fig nos 1 to 10 appended (together with photos of host rock and sulphides, Figs 11 to 19). In summary, the gossan components are:

- relicts of garnet crystals (optically high RI and isotropic as seen in transmitted light) in grains up to 3mm, internally microfractured (and permeated by limonite). These occur in pale yellowish limonitic macro areas in the handspecimen between darker goethitic boxwork. Sparse minute bleb-like inclusions of pyrrhotite and chalcopyrite occur in these garnets.
- Random small fibro-lamellar-form prismatic crystals of apparent sillimanite occur as individuals and in random clusters of limonite-goethite.
- Several irregular micro-grains/vermiform clusters of quartz, intricately intergrown oxidised mafic silicate or ex-plagioclase, are interpreted as possibly the result of contact metamorphism partly melting this otherwise metasediment. .
- Goethitic replica > boxwork after quite coarse lamellar-form pyrrhotite (~20%), locally gradational into colloform textures typical of pre-existing melnicovite pyrite (an intermediate supergene oxidation phase after pyrrhotite) and shown in fresh sulphide in Figs 13-15. Minute relict residuals of fresh apparent pyrrhotite (~10 µm) occur in some of these replicas (see Fig 10).
- Goethitic finer scale cellular boxwork of indefinite genesis, possibly ex-sulphide which may include ex-pentlandite or pyrite.

**APPENDIX: SELECTED PHOTOMICROGRAPHS OF GOSSAN 011**

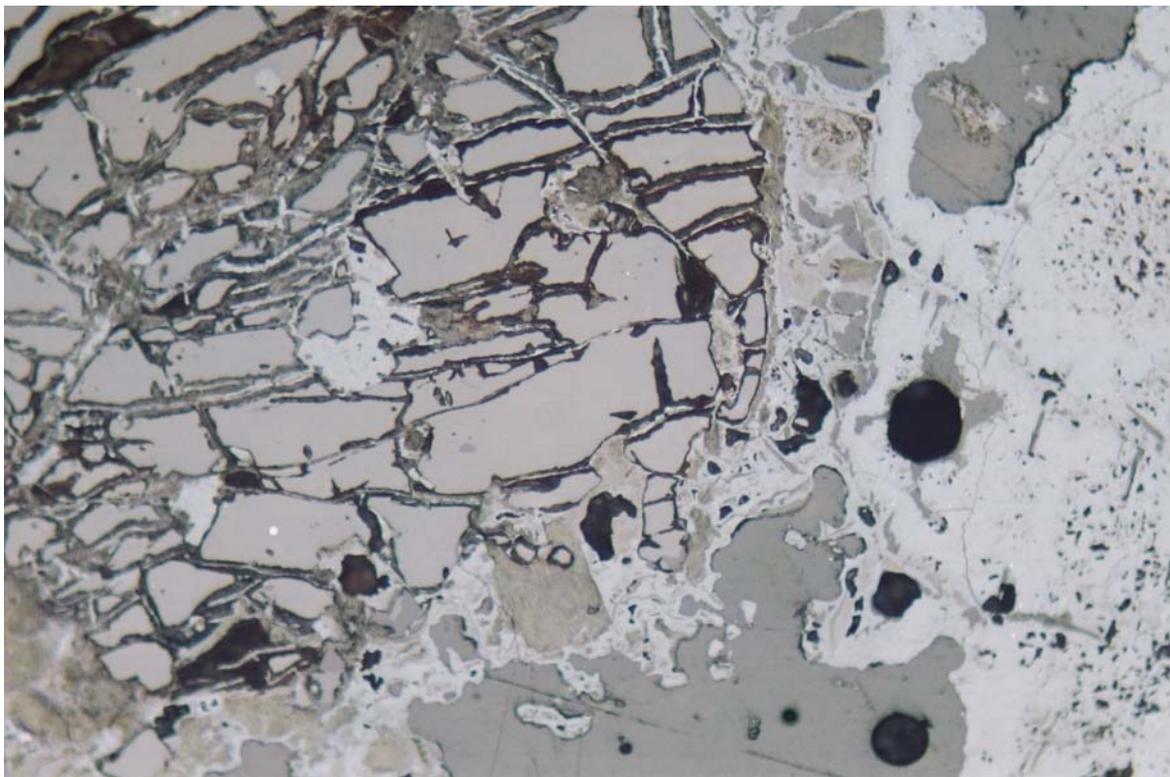


**Fig 1**

**Gossan ORC-011**

0.18 mm

Polished section (PS). Relatively low magnification (x50) showing various replica textures of goethite after former minerals. The irregular pale grey area in central part of the photo, with local microcolloform texture is interpreted as ex-pyrrhotite (see similar textures in altered but relatively fresh sulphide in sample 013, figures 13, 14, 15 below. Other areas in outer quadrants have finer goethitic fine boxwork possibly after other sulphide (?or mafic silicate).

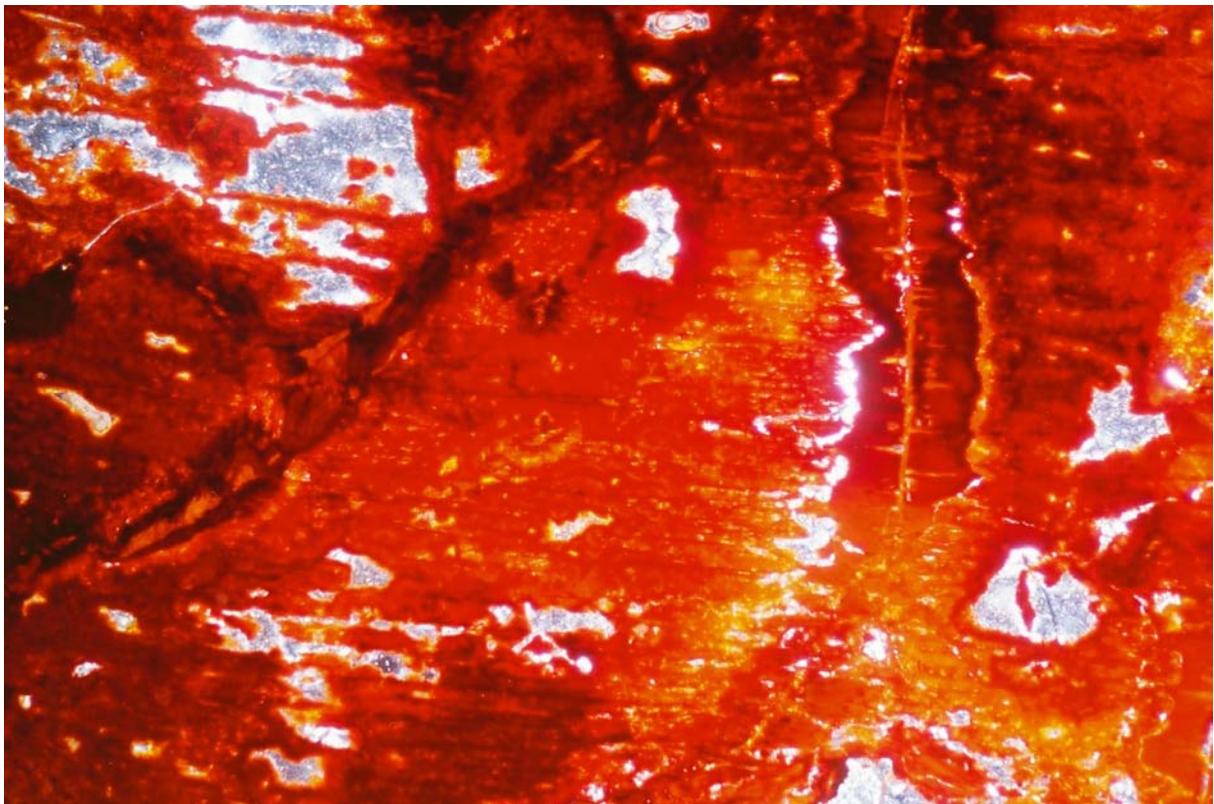
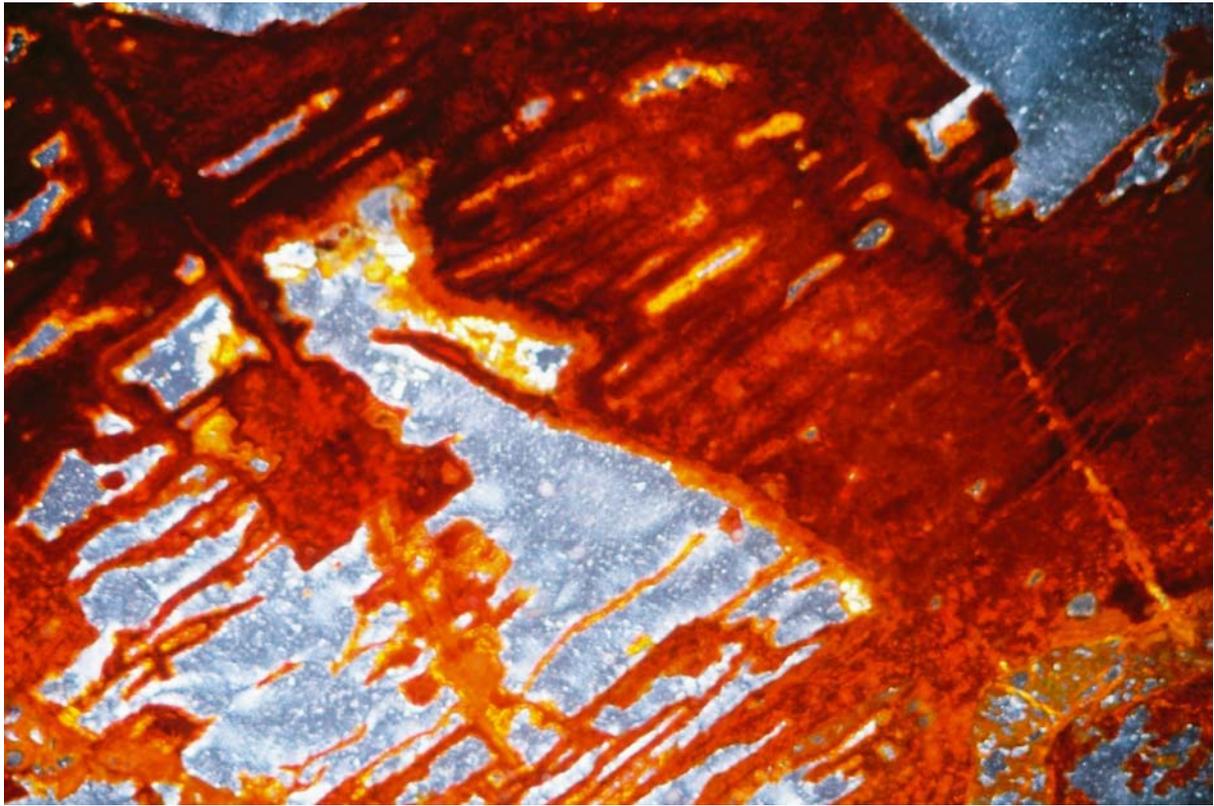


**Fig 2**

**Gossan ORC-011**

0.09 mm

PS. Higher magnification (x100), showing typical fractured subrounded garnet, left half of photo, permeated by limonite. Trace minute bright inclusion of pyrrhotite.

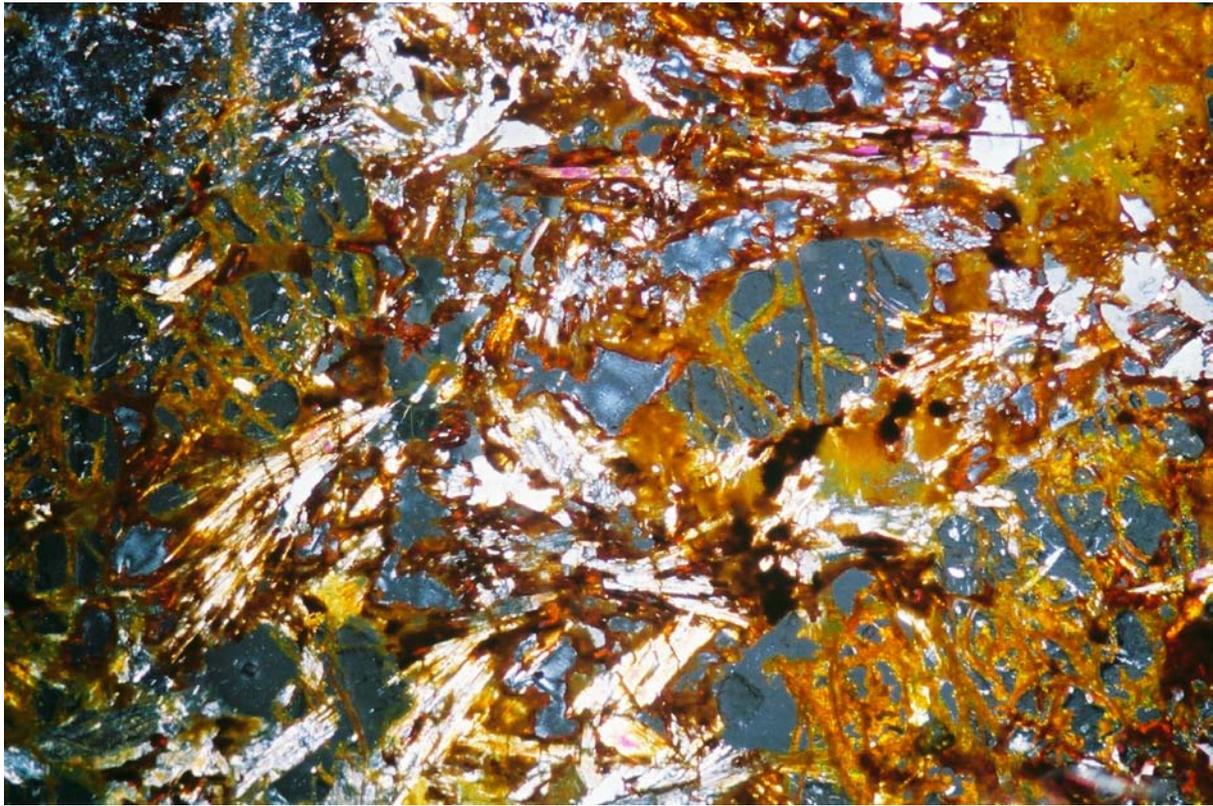


**Figs 3 & 4**

**Gossan ORC-011**

0.18 mm

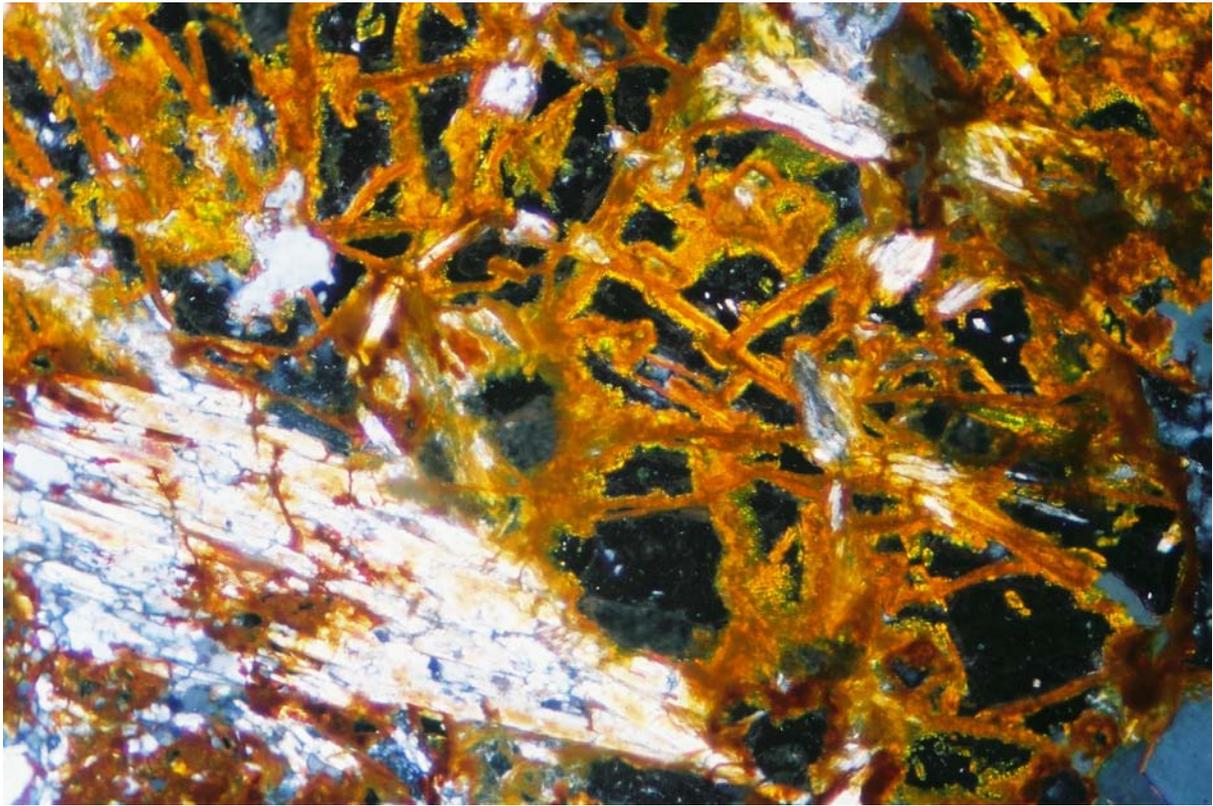
Transmitted light, thin section (TS), (x50) examples of goethitic boxwork/replica interpreted as leached and completely oxidised former lamellar-form pyrrhotite. [Penetration textures in Fig 4 along lamellae consistent with former marginal replacement by violarite, if present, but cannot be confirmed.]



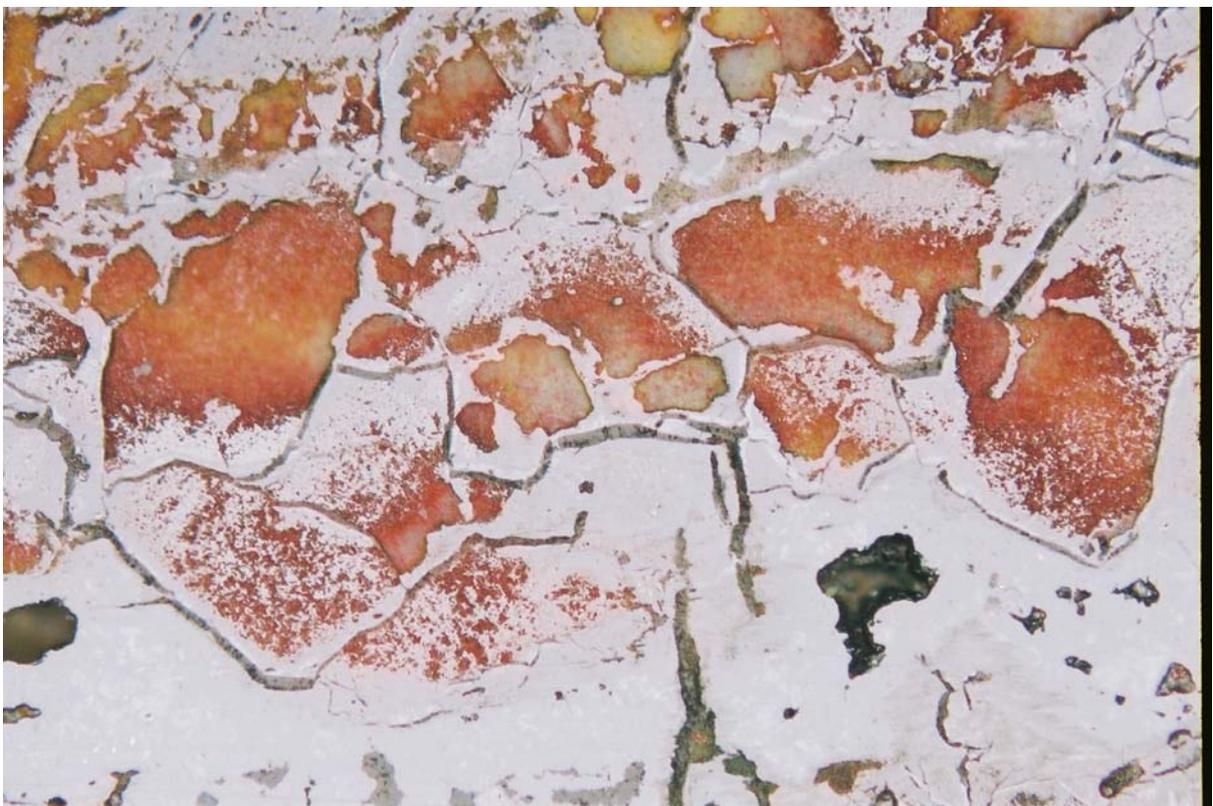
**Fig 5** **Gossan ORC-011** 0.04 mm  
TS (x200). Random fine boxwork of uncertain genesis, incorporating numerous (white) chaotic fibrous prisms identified as sillimanite.



**Fig 6** **Gossan ORC-011** 0.18 mm  
TS. Xnic (x50). Eutectic texture of blebby/vermiform quartz within oxidised leached former silicate, which may have formed by partial melting of host rock (due to adjacent norite intrusive).



**Fig 7** **Gossan 011** 0.18 mm  
TS, Xnic (x200). Random boxwork of uncertain genesis but possibly after ex-sulphide. White bladed prism SW quadrant is sillimanite.



**Fig 8** **Gossan 011** 0.18 mm  
PS (x200). Other goethitic boxwork replica of uncertain derivation (??possibly ex-pentlandite).



**Fig 9** **Gossan 011** 0.018 mm  
PS (x500). Composite sulphide bleb (pyrrhotite + chalcopyrite) within residual garnet, fractured and permeated by limonite.



**Fig 10** **Gossan 011** 0.018 mm  
PS (x500). Minute residuals of pyrrhotite (2 to 10  $\mu\text{m}$ ) within solid goethite apparently replacing coarse massive pyrrhotite.

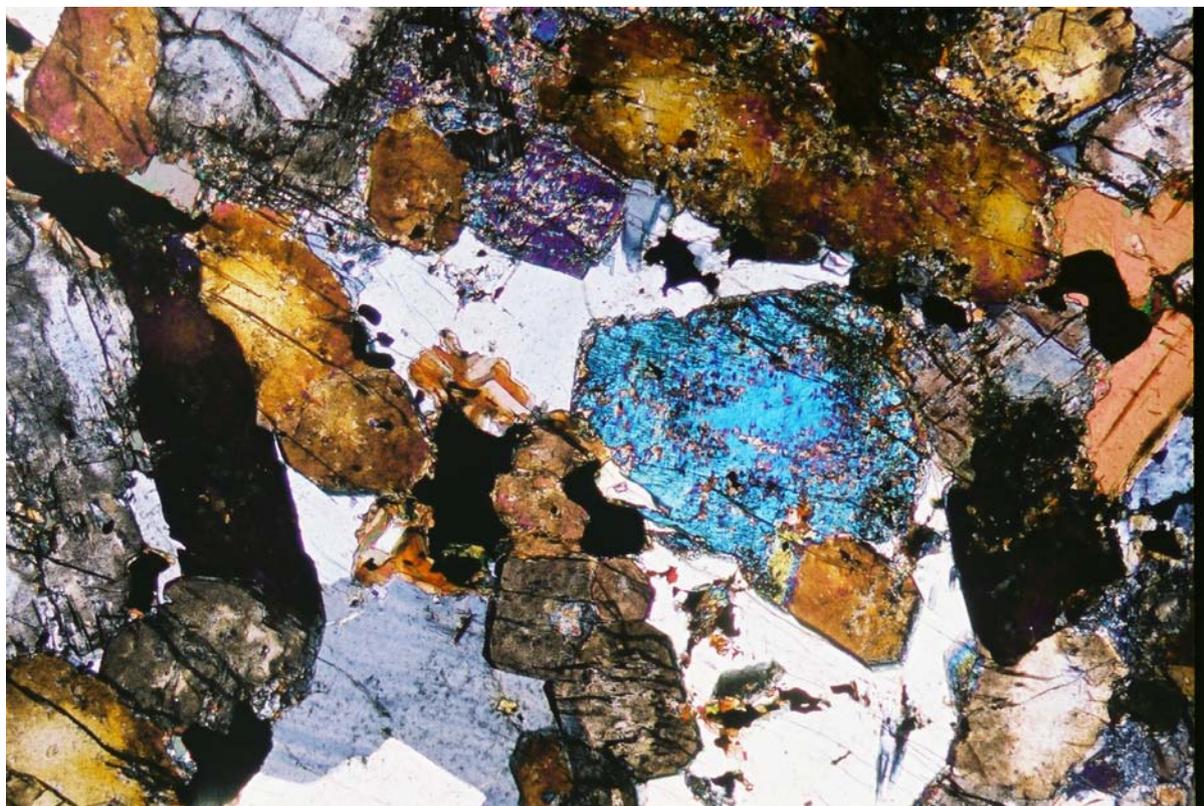


**Fig 11**

**Rock sample 013**

0.18 mm

TS. Ordinary light (x50). Olivine augite norite with random coloured prisms of augite, local brighter olivine in SW quadrant, within abundant coarse plagioclase mosaic. This rock has accessory disseminated ilmenite and sulphides, including pentlandite.



**Fig 12**

**Rock sample 005**

0.018 mm

TS. Xnic. (x50). Loose aggregate of coloured crystals orthopyroxene >> clinopyroxene, pinkish-brown biotite right margin. Pale grey/white poikilitic plagioclase between.

EXAMPLES OF ACCESSORY DISSEMINATED SULPHIDES IN NORITES

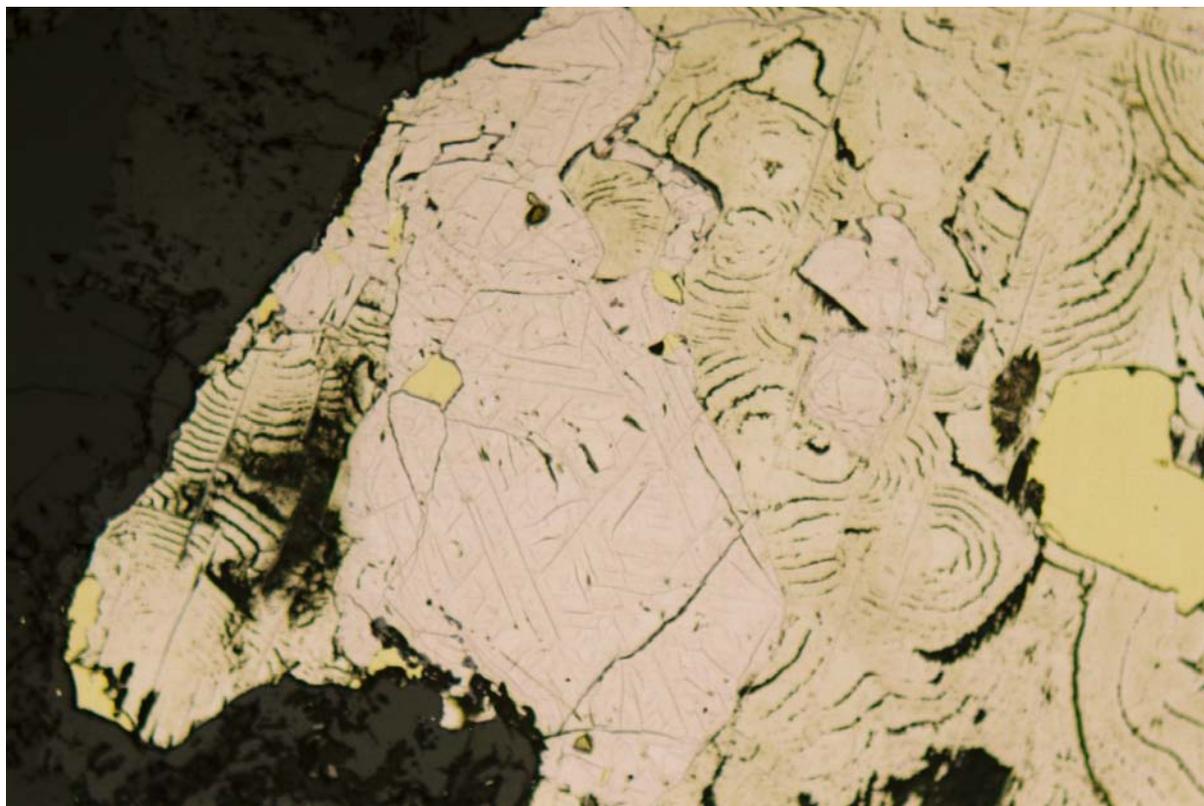


**Fig 13**

**013**

0.18 mm

PS (x50). Composite sulphide grain pentlandite (pn), pyrrhotite altered to partly colloform secondary pyrite (po), local pale yellow chalcopyrite.

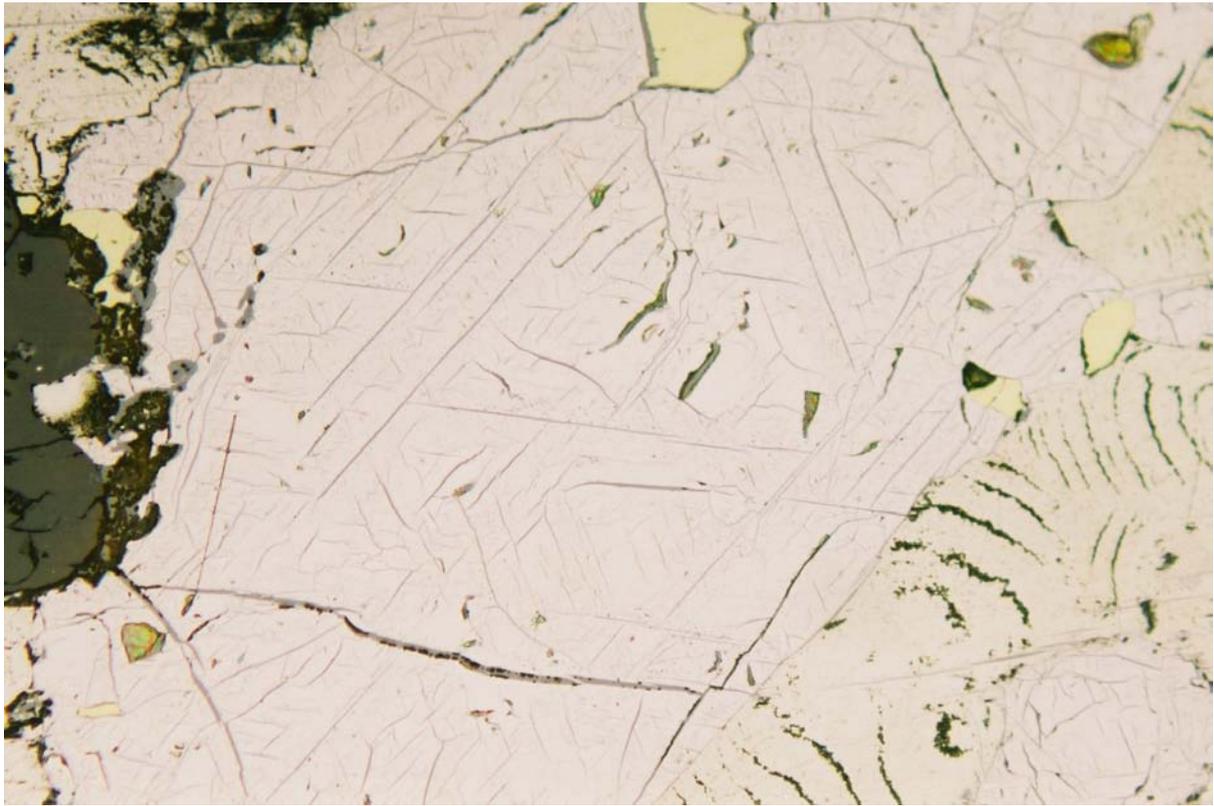


**Fig 14**

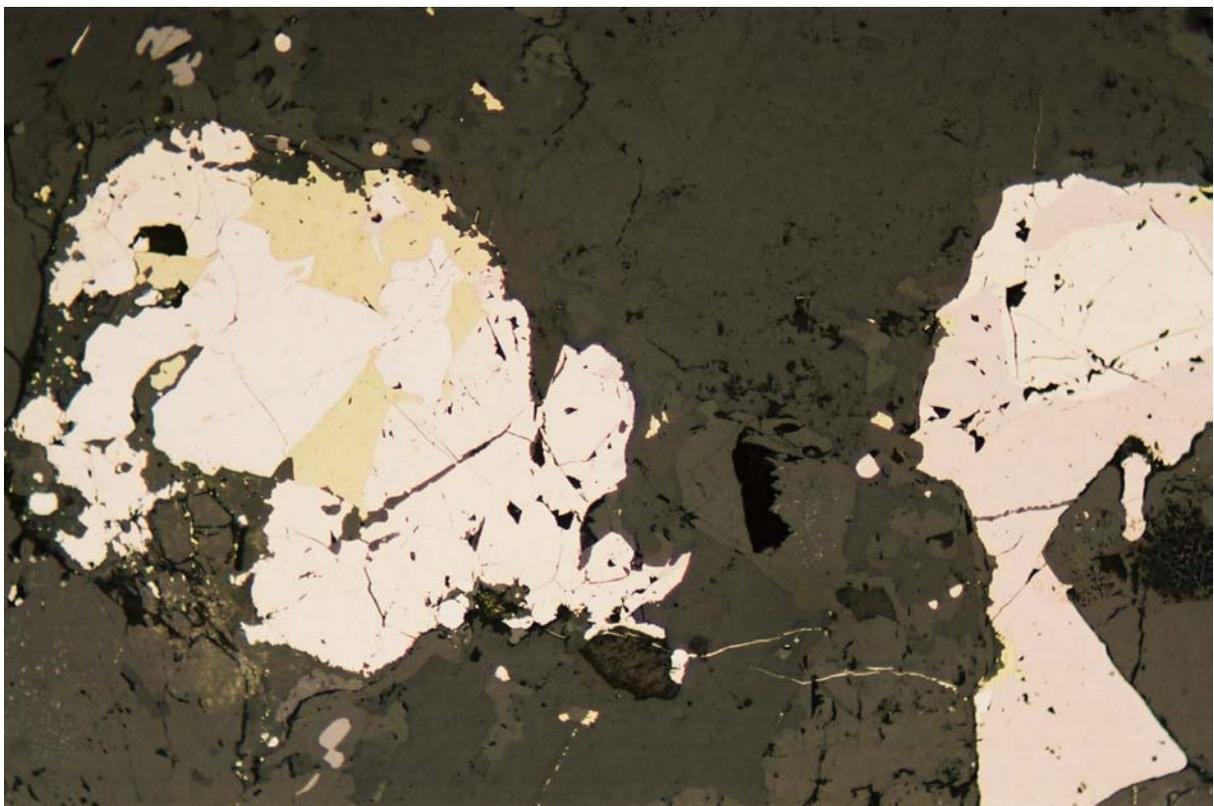
**013**

0.09 mm

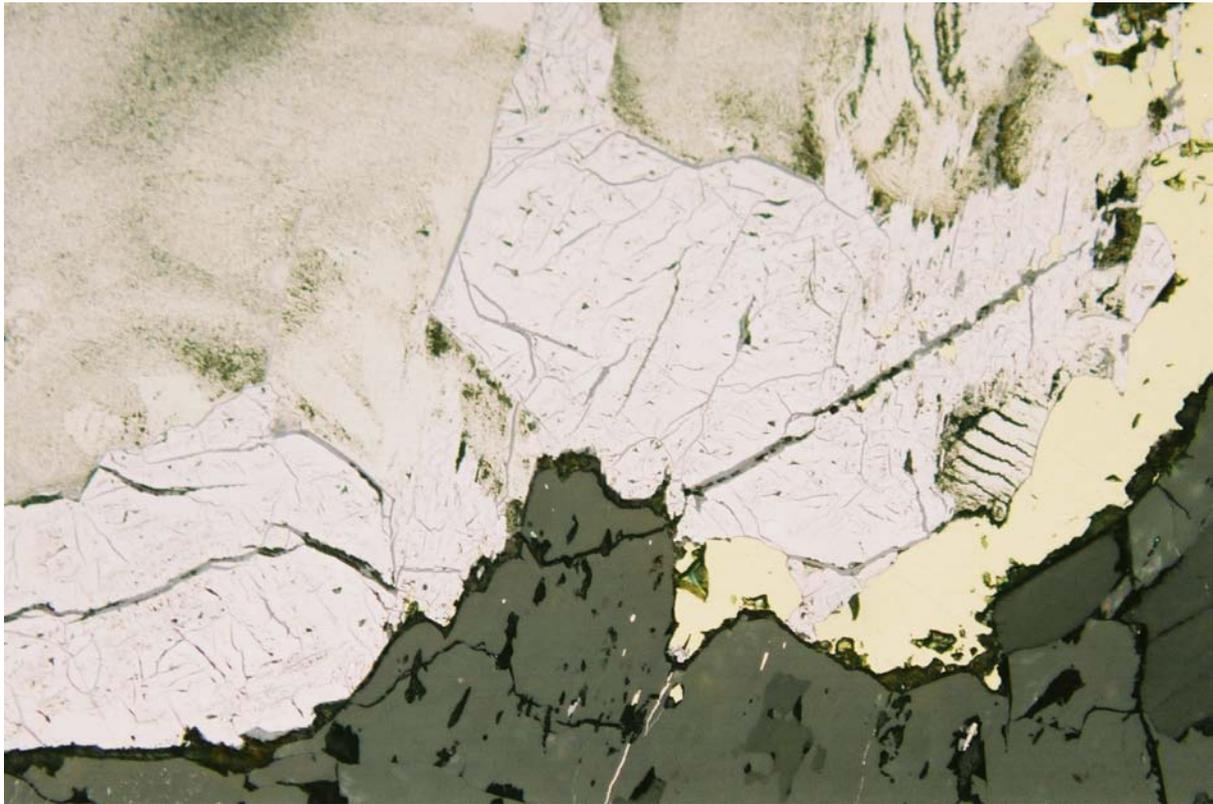
PS (x100). Detail of Fig 13. pn = pentlandite, po = altered pyrrhotite, sparse yellow chalcopyrite.



**Fig 15** **013** **0.04 mm**  
PS (X200), detail specifically of typical pentlandite (“white”) with triangular partings defined by incipient violarite alteration. Also shows colloform secondary pyrite after pyrrhotite, rare chalcopyrite.



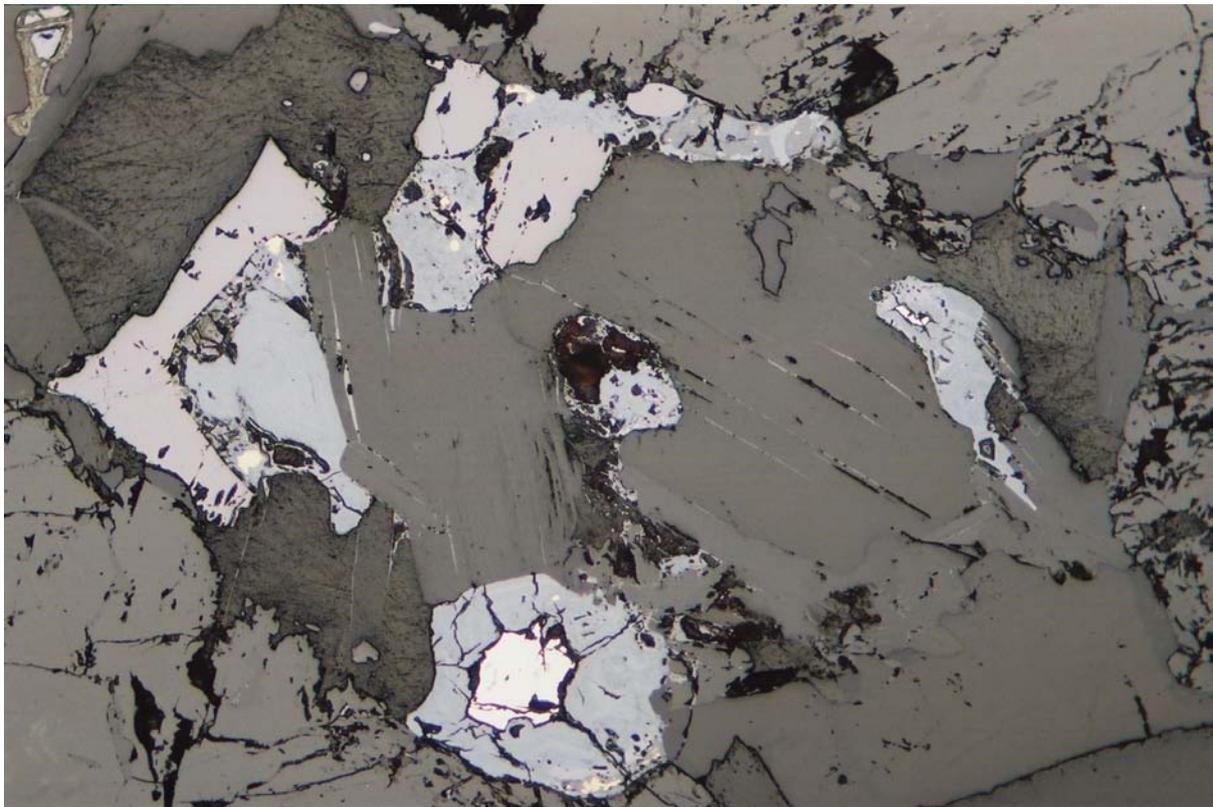
**Fig 16** **013** **0.09 mm**  
PS (X100). Two adjacent composite sulphide grains, pn = pentlandite, py = pyrite, po = pyrrhotite and yellow chalcopyrite.



**Fig 17** **013** **0.04 mm**  
PS (x200). Further example of a composite of pentlandite (pn), oxidised pyrrhotite (po), altered to secondary 'sooty' pyrite, yellow chalcopyrite around rim.



**Fig 18** **013** **0.04 mm**  
Ps (X200). Small composite of orange-brown oxidised probable ex-pentlandite (indicated by relict internal partings). Central 'lath' of very pale yellow chalcopyrite. Double grey zoned rectangular crystals of ex-pyrite or pyrrhotite. Several satellite much smaller sulphide grains in host norite.



**Fig 19**

**019**

0.09m

PS (X100). Further example (apart from sample 013) of former inherent/magmatic sulphides now oxidised to (bluish)-grey goethite, with trace to minor residual inclusions, in this photo mainly pyrite, but with trace chalcopyrite. (The possibility/probability of ex-pentlandite not established). Larger lath-form to subrounded very pale brownish-grey grains more or less composite with sulphides are ilmenite.