ANNUAL REPORT

Waterhouse West Project
EL24563

NORTHERN TERRITORY

FOR THE PERIOD
18 January 2013 to 17 January 2014

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TENEMENT NO: EL24563
TENEMENT OWNER: Royal Resources Limited
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REPORT TYPE: Annual
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REPORT PERIOD: 18 January 2013 to 17 January 2014
AUTHOR: B. Lawrence, I. Faris & G. England
DATE OF SUBMISSION: February 2014
DATUM: GDA94_Zone 52
1:250,000 SHEET AREA: Pine Creek (SD52-08)
1:100,000 SHEET AREA: Reynolds River (5071)
MINERAL FIELD: Rum Jungle Mineral Field
COMMODITY: Uranium, Iron Ore
ABSTRACT

LOCATION: The Waterhouse West Project is centred approximately 10 kilometres southwest of the Batchelor township. The project is defined by a single Exploration Licence, EL24563, which covers an area of 128.4km² (48 sub-blocks) and is located on the Pine Creek 1:250 000 Sheet (SD52-08) and the Reynolds River 1:100 000 sheet (5071).

GEOLOGY: The Waterhouse West Project overlies the Archaean Waterhouse Dome, part of the Rum Jungle Mineral Field. The core of the Waterhouse Dome comprises schist, gneiss and granitic units and blocks of the Stanley Metamorphics. Exposures of the Early Proterozoic sedimentary units include the Manton Group, Mount Partridge Group, South Alligator and Tolmer Group sediments, which are folded around the margins of the granitic dome.

WORK DONE: Reconnaissance, rock chipping and petrology was carried out on areas prospective for iron.

CONCLUSIONS: The Waterhouse West Project is prospective for iron within three geological units; Stanley Metamorphics, Crater Formation and Geolsec Formation which differ in age, composition and mineralisation style, occurring within (Stanley Metamorphics) and along the margins of the Waterhouse Dome. Further work is recommended to evaluate the two newly defined iron prospects; Crater Prospect and the Camp Creek Prospect.
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1 INTRODUCTION AND TENURE

This report details exploration completed on the Waterhouse West Project for the seventh year of tenure during the period 18 January 2013 to 17 January 2014 by Royal Resources Limited (“Royal”). The reporting area comprises one granted Exploration Licence EL24563 of 48 graticular blocks, overlying the Waterhouse West Dome, part of the Pine Creek Orogen. Tenement details are listed in Table 1. During the reporting period, an extension of term was granted by the Department of Mines and Energy to commence exploration focused on reviewing the iron potential. In addition, ownership was acquired from Aldershot Resources Ltd, whereby Royal now holds 100% interest since the initial venture into the project in 2009.

The Waterhouse West Project is prospective for iron within three geological units; Stanley Metamorphics, Crater Formation and Geolsec Formation which differ in age, composition and mineralisation style and occurring within (Stanley Metamorphics) and along the margins of the Waterhouse Dome, respectively. Further work is recommended to evaluate the two newly defined iron prospects; the Crater Prospect and the Camp Creek Prospect.

Field activities included reconnaissance to the outcropping prospective areas, rock chipping and petrology of the three different iron units. Field site accessibility was significantly restricted due to the thick, high growing gamba grass impairing vision.

Table 1: Tenement Details for the Waterhouse West Project

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2 LOCATION AND ACCESS

EL24563 is located 100 kilometres south of Darwin, approximately 10 kilometres southwest of the historic mining township of Batchelor in the Northern Territory (Figure 1). The tenement abuts the eastern boundary of the Litchfield National Park and covers an area of 128.4 km². It lies between longitude 130.93ºE and latitude -13.27º S, and longitude 131.0ºE and latitude -13.02º S on the Pine Creek 1:250 000 map sheet (SD52-08) and the Reynolds River 1:100 000 map sheet (5071).

The project area comprises savannah woodland with localised patches of tropical forest lining creeks, as well as areas of open black soil plains and experiences a wet season from November–April and a dry season from May–October. The average rainfall is 677mm with a mean temperature of approximately 34º C.

Access to the tenement area is by the Stuart Highway and turning off toward Batchelor along the Litchfield Park road. The tenement is then accessed via gravel roads heading south and then west via various properties gates and tracks. The flat, relatively open country is generally accessible by 4WD.

Access to the newly defined Crater Iron Prospect is either via Chin Road (dirt track) travelling west to the Litchfield National Park fenced boundary or southwards along the Litchfield Park boundary fenceline from the Litchfield Park road. A track marks the boundary on both sides of the fence. Access to the newly defined Camp Creek Prospect is via Camp Creek Homestead.
Figure 1: Waterhouse West Project Location
3 REGIONAL GEOLOGY

The Waterhouse West project is situated around the Archaean Waterhouse Dome part of the historic Rum Jungle Mineral Field on the western side of the Pine Creek Orogen (Figure 2). The Archaean Rum Jungle and Waterhouse Complexes are domal structures containing mixed schist, gneiss, and granitic units and metasediments and Banded Iron Formations (BIF) assigned to the Stanley Metamorphics, upon which early Proterozoic sedimentation has taken place. The Proterozoic sedimentary sequences consist of repeated cycles which commence with the deposition of high energy conglomerate and sandstone, which fine upwards to shallow-water limestone.

In the western part of the Rum Jungle Mineral Field the oldest sedimentary rocks in the sequence are exposed against granitic contacts. These units belong to the basal Manton Group sediments which are overlain by the Mount Partridge Group. The basal member of the Mount Partridge Group is the Crater Formation, overlain by the Coomalie Dolostone, Whites Formation and Wildman Siltstone.

The units of the Mount Partridge Group are unconformably overlain by rocks of the South Alligator Group. The Koolpin Formation lies along the eastern edge of the project area and isolated outcrops of Zamu Dolerite have been mapped along the north eastern edge overlying the Koolpin Formation.

Overlying the South Alligator Group are sediments of the Burrell Creek Formation of the Finniss River Group. The formation consists of siltstone, shale and greywacke and extends through the western sector of the project area. The Geolsec Formation unconformably overlies the Finniss River Group and marks a period of deformation, metamorphism and granitic intrusions, resulting in uplift and erosion. The basal member of the Geolsec is a haematitic quartzite breccia unit which in places unconformably overlies the Coomalie Dolostone. The Late Proterozoic sandstones of the Tolmer Group unconformably overlie the Early Proterozoic sediments at Rum Jungle and elsewhere. These sandstones are essentially flat lying and were deposited upon erosional surfaces of the older rocks, with siliceous iron-rich breccias developed in places.

The Rum Jungle area within the Pine Creek Orogen has undergone greenschist facies regional metamorphism associated with the Nimbuah Event of the Barramundi Orogeny (1860-1840Ma). A slight increase in metamorphic grade occurs along the boundary of the granitic complexes. Geological mapping by the Northern Territory Geological Survey (NTGS) has identified in order of seven deformational events occurring pre-Manton Group and post-South Alligator Group. The major structural feature of the region is the Giants Reef Fault. The Giants Reef Fault is a north-northeast to northeast trending dextral strike-slip structure with up to 7km lateral offset and >600m vertical movement, northwest-side down. It laterally displaces the Early Proterozoic sediments where structural trends are generally striking north–south but also swing concentrically around the two granitic complexes.

4 LOCAL GEOLOGY

EL24563 is situated on the central, southern and western regions of the Archaean Waterhouse Dome. The core of the Waterhouse Dome comprises schist, gneiss and granitic units and blocks of the Stanley Metamorphics. Exposures of the Early Proterozoic sedimentary units include the Manton Group, Mount Partridge Group, South Alligator and Tolmer Group sediments which are folded around the margins of the granite dome.

Exposures of outcrop within the Waterhouse Dome are poorer than those of the Rum Jungle Dome due to areas of extensive surficial cover. Along the south-western margin of the Waterhouse Dome the stratigraphic correlations can be difficult due to a number of the units missing in the sequence and due to a series of northeast trending fault structures. The Whites Formation and the Wildman Siltstone are absent and in general the sediments thin in this area compared to the northern margin of the Waterhouse Dome and to the Rum Jungle Dome.
Figure 2: Geology & Iron Ore Prospects
Along the southwest region of the Waterhouse Dome there are areas of outcropping, extensively brecciated, fault controlled Coomalie Dolostone. Previous mapping and drilling in this area has identified a major northwest trending thrust which repeats the Coomalie Dolostone South Alligator Group succession (Lally, 2002).

EL24563 also covers a portion of the north-western margin of the Waterhouse Dome. To the east outcropping Beestons Formation of the Manton Group sediments unconformably sits on top of the granites of the Waterhouse Dome and is overlain by the Crater Formation of the Mount Partridge Group. In this region the Whites Formation is preserved in conformable contact with the Coomalie Dolostone and both units show a thickening of stratigraphy compared to the southern margin.

Geology is steeply dipping to the southwest in the southern part of the tenement and towards the west in the north. The Giants Reef Fault cuts across the project area and offsets the northern tip of the Waterhouse Complex, exposed to the west is the Tolmer Group sediments.

5 EXISTING IRON ORE MINERALISATION

Within EL24563, the iron potential is considered to be for; small surficial or distal hydrothermal type deposits. The nearest significant occurrence to Royal’s Waterhouse West Project (EL24563) is the Yarram Deposit, 6 km north of Waterhouse. It is listed as an undeveloped deposit with 730,000 tonnes @ 56.9% Fe (non-JORC compliant).

5.1 Yarram Deposit

The Yarram Deposit is the extended/renamed old Rum Jungle iron ore prospect and has been described as four massive hematite lenses. It is hosted within a purple siltstone bed, which is thought to be interbedded with the Coomalie Dolostone, but may represent a variant of siltstone within the Geolsec Formation, which hosts the phosphate deposits. Geological mapping, costeaning, geochemical sampling and shallow drilling identified four massive haematite lenses (Burban and Svenson 1970). The largest (Lode B) is about 6 m thick and has a strike length of 100 m. The lenses trend northeast, are stratabound and are hosted within purple hematitic siltstone and shale of the Whites Formation. Lodes A, B and C contain an inferred resource of 101,600 t grading 61.8% Fe with phosphorous averaging 0.07% at the surface and 0.14% at depth (Burban and Svenson 1970). Airtrac and diamond drilling were carried out on a 122 m (400ft) grid. Shallow airtrac holes about 10m apart were also drilled along costeans. Limited geochemical assays indicate that the massive hematite ore contains <0.01% S, 4.1% SiO2, 2.7% Al2O3, <0.05% Cu and <0.01% Ni (Burban and Svenson 1970). Lateritic ore developed over the Coomalie Dolostone, about 0.5 km to the west, contains an additional inferred resource of 8.8 Mt grading 40–50% Fe and 0.16% P2O5 . Burban and Svenson (1970) reported chemical analyses of eight samples for Cu and Ni, which were less than 0.05% and 0.01%, respectively.

Thiess Exploration Pty Ltd conducted the geological mapping, costeaning, geochemical sampling and drilling programs on this prospect (Burban and Svenson 1970). In 2005, Territory Iron conducted a RABD drilling program which indicated that outcropping goethite/haematite mineralisation is also present at depth (Territory Iron 2005).

5.2 Beestons Deposit

The Beestons’s Iron Ore Prospect is located about 18 km to the north-northwest of Batchelor on the western side of the Rum Jungle Inlier. The northerly-trending, stratabound gossanous lode has a strike length of 300m and averages 20m in width. Ironstone is contained within an interval of shale and ferruginous sandstone (Crohn 1970). Angular, up to 3 cm- sized fragments of quartz were reported to be present in the host rock (Dunn 1962a). The stratigraphic position of this interval is unclear and, as is the case with the Rum Jungle prospect, it may belong to the Geolsec Formation. The surrounding rocks are silicified Coomalie Dolostone. Two exploratory shafts were sunk near the southern end of the prospect (Pritchard, 1969). Sampling of the shafts returned 63% Fe and 0.14% P over 7 m (Shaft 1) and 55.2% Fe and 0.08% P over 4.6 m (Shaft 2). Based on these results, Pritchard (1969) estimated a resource of 1.5 Mt grading 52-66% Fe to 60 m depth, plus 100 000 t
(grading 52% Fe) of iron ore rubble around the gossan outcrop. A single line of drillholes, across the ridge and about 60 m north of the shafts, indicated that only minor amounts of iron ore material containing >50% Fe is present in this area (Crohn, 1970). Nevsam Mining Co Pty Ltd (Pritchard 1969) and the BMR (Dunn, 1962a, Crohn, 1970) conducted geological mapping, costeaning and drilling in this area.

5.3 BW Iron Claim
The BW Iron Claim is a small iron ore prospect located about 16 km to the west-northwest of Adelaide River Township and ~800m south of the Kylie uranium prospect, adjacent EL24563. Investigations by the BMR (Dunn, 1962b) suggested that the stratabound massive hematite- and specularite-bearing lenses and pods are hosted in pyritic slate of the Whites Formation. However, investigations by BMR (Dunn 1962b) suggested that a stratabound massive haematite lens is within ferruginous shale and breccia of what is actually the Geolsec Formation. The Mount Mable prospect, located about 3 km to the north, is also within the Geolsec Formation. It is considered to have been formed by superficial enrichment of ferruginous sandstone of the Geolsec Formation. The area also contains a few outcrops of magnetite schist containing 10–30% magnetite (Crohn 1968). A possible 15 000 t of ore grading 60% Fe was estimated for a single ironstone lens, 36x20x6 m in size. There is also about 70 000 t of loose hematite rubble present (Pritchard 1969).

6 EXPLORATION
During the reporting period, field reconnaissance was achieved to test the areas potential for iron mineralisation, albeit with difficulty of extensive thick gamba grass coverage which reduced visibility and access to a number of outcropping areas. Three prospective lithologies for iron mineralisation and two iron Prospects were identified and include in summary:

1. Magnetite / haematite-quartz rocks of the Archaean Waterhouse Complex (Stanley Metamorphics), Camp Creek Prospect;
2. Banded Iron Formation magnetite mineralisation in the Paleoproterozoic Crater Formation, Crater Prospect;

6.1 Camp Creek Prospect - Stanley Metamorphic BIF
The Camp Creek Prospect consists of a magnetic feature of approximately 3.3 km in strike length, containing coincident sparse outcrop/sub-crop of high metamorphic-grade Banded Iron Formation (Figure 3). These iron-rich units are contained within the Stanley Metamorphic rocks within the Archaean Waterhouse Complex and have not been previously explored for iron.

6.2 Crater Prospect – Crater Creek BIF
The Crater Prospect was identified from open file magnetic imagery as a ~ 1.1 km strike length magnetic feature, and is coincident with an outcropping ridge of highly sheared, magnetite-quartz rock of the Crater Formation (Figure 3).

6.3 The Geolsec Formation
The Geolsec Formation is a haematite-quartz breccia (HQB), haematitic sandstone, siltstone, mudstone and rare shale breccia (palaeo-regolith) overlying the Coomalie Dolostone and less commonly, the Whites Formation. HQB is the dominant rock type within the Geolsec Formation and contains laterally discontinuous interbeds of haematitic sandstone, siltstone and mudstone. The breccias are thought to be the product of in situ weathering and collapse of Coomalie Dolostone due to karst processes or reworked talus slope breccias deposited in fault-bounded blocks of Coomalie Dolostone. Structure is considered to play a key role for the enrichment, hence the
hydrothermal tag. There are no recorded iron ore prospects or occurrences of the Geolsec Formation within the Waterhouse project area.

6.4 Geochemical Sampling
In total, there were 40 rock chip samples collected from the three different lithologies as mentioned above. Samples were ~2kg in weight and sent to ALS Laboratories in Adelaide for magnetic susceptibility and XRF iron ore analysis including; Al2O3%, As2O3%, As%, BaO%, Ba%, CaO%, Cl%, CoO%, Co%, Cr2O3%, CuO%, Cu%, Fe2O3%, Fe%, K2O%, MgO%, MnO%, Mn%, Na2O%, NiO%, Ni%, P2O5%, P%, PbO%, Pb%, SO3%, S%, SiO2%, SnO2%, Sn%, SrO%, Sr%, TiO2%, V2O5%, V%, ZnO%, Zn%, ZrO2%, Zr%, LOI%, magnetic%. Sample data and assay results provided in Appendix 1.

6.5 Petrology
Representative samples of each of the 3 iron units were submitted to Pontifex and Associates in Adelaide for thin section analysis, locations shown in Figure 3 and report provided in Appendix 2.

Figure 3: Surface sample and petrology locations over TMI
7 DISCUSSION OF RESULTS

The following is an extract from Royal ASX announcement 25th November 2013; Royal Acquires NT JV Identifies Major Gold and Iron Targets (England, 2013).

7.1 Camp Creek Prospect - Stanley Metamorphic BIF
Thin section analysis of surface rock chip samples by Royal and previous exploration work completed by Idemitsu, show that these rocks contain coarse-grained (0.2 to 1mm) sized, lozenge-shaped magnetite (often oxidized at surface) or retrograded haematite replacement of magnetite, with relic inclusions of magnetite (Figure 4). Royal rockchip assay results returned grades of between 37 to 44% Fe (Figure 6). See Table 2 and Appendix 1 for assay results. Much of the material was partially oxidised at surface, but SATMAGAN analysis of samples showed several containing high magnetic susceptibility, suggesting magnetite content of 30% to 40%.

Royal plans further work at the Camp Creek Prospect next field season, including a high resolution ground magnetic survey, field mapping and eventually drilling. While still at a conceptual stage, if it is found that the iron mineralisation is of economic size and grade, the coarse nature of the magnetite / haematite grains may make the prospect financially attractive, in regards to coarse grinding and inexpensive beneficiation methods (e.g. dry coarse cobbing or gravity spirals), which could produce a suitable concentrate product for sale.

Figure 4: A) Photograph of parasitically folded banded iron formation sub crop material from recent field visit by Royal to the Camp Creek Prospect. B) Photomicrograph reflected-light image of outcrop material, containing coarse-grained lozenge-shaped haematite (light grey), containing inclusions of magnetite (medium grey), surrounded by quartz gangue (dark grey), Camp Creek Prospect

7.2 Crater Prospect – Crater Creek BIF
The rock fabric suggests either the protolith was a quartz pebble conglomerate (with pebbles now highly deformed) with a magnetite-quartz matrix; or a banded iron formation, that has remobilised through shearing into lenticular bands of quartz and magnetite. Thin section analysis of rock chip samples by Royal show partially oxidised magnetite, coarse-grained (0.05 to 0.5mm), with a strongly metamorphic mosaic-texture, (Figure 5). Royal rockchip assays returned grades of between 22 to 60% Fe (Figure 6). See Table 2 Assay Results in Appendix 1. The thickness of the BIF unit is unclear, as both hangingwall and footwall contact are not observed in the field and the unit dips 40 to 60 degrees.
Figure 5: A) Photograph of sheared banded iron formation outcrop from recent field visit by Royal to the Crater Prospect. B) Photomicrograph reflected-light image of outcrop material, containing coarse-grained mosaic-textured martitised (light grey) magnetite (medium grey) grains, Crater Prospect

7.3 Geolsec Formation Haematite Mineralisation
The HQB mineralisation appears to occur around the unconformable contact of the Coomalie Dolomite and may be linked to structurally-controlled hydrothermal activity. Royal assay of the HQB show iron levels to be generally at that considered uneconomic (6 to 40% Fe), however several small poorly exposed pods of more massive haematite siltstone of grades of 50 to 64% Fe were identified (Table 2 Assay Results in Appendix 1). The geological contexts of these pods are still to be further investigated, but appeared to occur below the HQB and near major structures. It is of note that the Yarram Prospect is predominantly hosted in a haematite siltstone similar to what is observed in Waterhouse West.

Table 2: Waterhouse West rock chip sample results

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8 CONCLUSIONS AND RECOMMENDATIONS

Further work in reviewing the iron potential is planned to explore for up-scaled versions of what is already observed in the Project and includes:

1) integrating all the previous mapping and drilling information to define target areas;
2) a gravity/ground magnetic survey; and
3) field mapping / observation.

In addition, drilling is planned to determine the unit thickness and thus gauge the mining potential. Like the Camp Creek Prospect, the Crater Prospect may have positive beneficiation qualities. The thin section analysis and observations in the field suggest the quartz – magnetite is weekly bonded, friable and may crush and grind easily. In addition, magnetite grain size is generally 100 to 500 micron in diameter, which may make beneficiation amendable to a coarse grind size, so reducing operating costs.
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10 REFERENCES


Compass Resources N.L., 1992 & 1993; Annual Reports to Shareholders.


APPENDIX 1: Exploration Activities – EL24563

*Digital files supplied*

EL24563_2013_A_02_SSampling.txt
EL24563_2013_A_03_SSAssay.txt
EL24563_2013_A_04_SSQAQC.txt
APPENDIX 2: Exploration Activities – EL24563

Digital files supplied

EL24563_2013_A_05_Petrology Report.pdf
MINERALOGICAL REPORT No. 10336

by Ian R. Pontifex MSc.

01 October 2013

TO: Bethany Lawrence
Royal Resources Ltd
262 Melbourne Street
NORTH ADELAIDE SA 5006

YOUR REFERENCE: Your email 02/09/2013

MATERIAL: 5 Ironstone Samples, Waterhouse West Project,
Pine Creek Geosyncline, Northern Territory

IDENTIFICATION: WHWTS 001 to WHWTS 005

WORK REQUESTED: Polished thin section preparation,
description and report.

SAMPLES & SECTIONS: Returned with hard copy of this report.

DIGITAL COPY: Emailed 01/10/13 to:
<Bethany.Lawrence@royalresources.com.au>

PONTIFEX & ASSOCIATES PTY. LTD.
INTRODUCTION

Five “ironstone” samples from Royal’s Waterhouse West Project, Pine Creek Geosyncline, Northern Territory are petrographically described from polished thin sections in this report, with integrated photomicrographs to illustrate aspects of hematite and magnetite mineralisation in each.

Sample numbers and geological unit representation, and field notes provided by Royal are shown at the head of each description, together with a concise assessment of the petrology, which “doubles” as a summary commonly provided in Pontifex Reports, but in this suite each sample is essentially a separate entity.
INDIVIDUAL DESCRIPTIONS

| WHWTS 001 | Massive homogeneous medium grained quartz sandstone, with extensive interstitial / intergranular partly oxidised illite and / or kaolinite. Patchy domains with interstitial fine decussate specularite, in random patches locally in veins. Probable (possible) low temperature hydrothermal, or supergene. Fe mineralisation, but no evidence of carbonate replacement. |

Field Note


Petrography

Examination of the thin section confirms all of the above except that there is no apparent evidence of “carbonate-replacement”. Basically at least 65% of the area of the section is seen as a homogeneous aggregate of subangular to more subrounded single crystal quartz sand grains, quite well sorted with a size range of 0.2mm to rarely 0.5mm, i.e. essentially medium-grained.

These grains are moderately well packed, but clearly as individuals and no suggestion metamorphic fabric. Ubiquitous interstitial / intergranular “matrix” between grains over this 65% area consists of variably but mostly weakly oxidised clays, which may be illitic or kaolinitic (XRD identification required).

In the other approximately 35% areas of the thin section, interstitial / intergranular spaces between quartz grains are dominated by fine decussate micaceous hematite (specularite), together with less distinctive earthy hematite ± minor clays. Apart from being “randomly interstitial” in these areas the decussate specularite crystals also locally from discontinuous threads and veinlets.
Figs 1 and 2.  

**TS 001**

Reflected light / polished section (PS), magnification (x50). Host rock of loose packed subrounded quartz grains. **Figure 1** shows ubiquitous earthy hematite and extremely fine specular hematite interstitial / intergranular. **Figure 2** shows same decussate fine specularite in a veinlet.
Fig 3. TS 001

(PS), higher magnification (x200). Showing detail of intergranular red earthy hematite with minor specific fine flakes of specularite.
Figs 4 and 5. (PS), even higher magnification (x500), showing detail of decussate intergranular specularite, coarser and more concentrated in figure 5 than in figure 4.
WHWTS 002

Apparent precursor layered chemical sediment of silica / Fe-oxide / iron silicate composition, metamorphosed to quartz-magnetite (-probable) -grunerite BIF, (jaspilite or taconite). Subsequently retrograded with magnetite converting to hematite (35%) with minor small residuals of magnetite inclusions (<5%). More or less selective silicification of grunerite.

Field Note

Rock chip (sample I.D. 490397). Stanley Metamorphics, sub crop, metajaspilite, magnetite / martite content. [Some bands weakly to moderately magnetic].

Petrography

This is a homogeneous, laminated rock with fairly regularly intercalated planer layers individually 1mm to 3mm thick, of fine inequigranular quartz mosaic, overall ~ 60%, with intercalated relatively discontinuous attenuated lenticular layers of quite coarse crystalline black-opaque iron-oxide, overall ~ 40%. If may be classified as metajaspilite (as indicated in your notes), more broadly as (meta) BIF.

The siliceous layers are mostly dominated by fine to medium-grained “simple” metamorphic quartz mosaic, however about half of each of these layers incorporate irregular conformable lenses of decussate / interlocking short prisms of a former fibrous silicate mineral, now completely pseudomorphically replaced by micro / cryptocrystalline secondary quartz. In the context of BIF this former mineral seems most likely to have been a metamorphic Fe-rich amphibole (grunerite or cummingtonite).

Individual and somewhat discontinuous, elongate-lenticular layers of hematite, mostly about 0.5mm thick, are enclosed within the quartzose layers to 3mm and rarely to 6mm long. Some of these contain minor (<5%) very small inclusions of magnetite which are residuals of precursor whole grains of magnetite, but now overwhelmingly metamorphically retrograded to hematite pseudomorphs, (not martite). Total magnetite content now <5%, within the hematite ~ 35%. 
Fig 6.  

Thin section (TS). Ordinary light, low magnification (x20). BIF with irregularly alternating, discontinuous layers of quartz (white translucent) and hematite (black-opaque). The third component is relics of random fibro-lamellar-form short prisms of possible ex-grunerite replaced by quartz and fine secondary iron-oxide.

Fig 7.  

(TS), crossed nicols (Xnic), higher magnification (x50), showing detail of figure 6, and textures within quartz.
Fig 8.  

TS 002

(PS), (x50), discontinuous layers of hematite with intercalated quartzose layers.
Figs 9 and 10. TS 002

(PS), (x200). Figure 9 ordinary light. Irregular segment of a hematite layer, enclosing minor scattered small residuals of magnetite. Figure 10, same segment, part crossed nicols highlighting optical anisotropic mosaic as a metamorphic fabric (not martite). Adjacent patchy microporous “earthy” hematite quartzose interlayer.
WHWTS 003: Streaky / lenticular-fine-layered BIF, layers with internal “low grade” metamorphic fine mosaic textures. Approximate 45% magnetite, 15-20% martite-oxidised. Minor oxidised mica and / or amphibole crystals [No evidence of carbonate or carbonate replacement].

Field Note
Rock chip (sample I.D. 490919). Crater Formation, banded iron, dense, less frequent carbonate banding, quartz boudins.

Petrography
Macroscopically this is seen as basically BIF, with a sequence of subequal streaky-lenticular thin layers of dark fine grained iron oxide, intercalated with similarly thin lenticular-streaky layers of pale fine crystalline / granular and partly friable quartz.

The quartzose layers consist of a somewhat inequigranular and loosely bonded, metamorphic mosaic of irregularly polygonal quartz grains, size range of 0.15 to rarely 0.4mm, i.e. medium grained. Those incorporate minor discontinuous layers and trains of fine martites.

The Fe-oxide-rich layers are dominated by patchy metamorphic mosaics of subhedral magnetite crystals, similar size range of 0.1mm to about 0.5mm, and these incorporate up to 20% scattered quartz grains. Also there are up to 5% scattered metamorphic mica and / or amphibole crystals, oxidised to goethite.

Individual magnetite grains consistently show about 15-20% oxidation to martite, around grain boundaries for less internally. Single magnetites in quartz lens are completely martitised.

Estimated gross mineral abundances:
- Quartz grains 45%
- Magnetite (i.e. unoxidised) 35%
- Martite replacing magnetite 10-15%
- Oxidised micas / amphiboles 7-10%
Fig 11. TS 003

(PS), (x20). BIF with interlayers of fine metamorphic mosaic of bright martitised magnetite and auld quartz.

Fig 12. TS 003

(PS), (x50). Core of original magnetites in this photo about 80%, with rim of white martite oxidation <20%.
Figs 13 and 14. (PS), (x200). Detail of partly martitised magnetites, showing relationships to intercalated quartz layer in figure 14.
Fig 15. TS 003

(PS), (x200). Example of rare local complete martite oxidation with further leaching causing porosity.
**WHWTS 004**

Laminated fine metamorphic-crystalline hematite BIF. (Hematite after magnetite). Minor interstitial quartz > oxidised sericite sparse carbonate. Interpreted as metamorphosed ex-magnetite-rich BIF. [No clear evidence of “siltstone” mentioned in the field notes.]

**Field Note**


**Petrography**

The polished thin section indicates that approximately 70% of this sample is a fairly homogeneous compact, laminated aggregate of fine crystalline hematite. The other ~ 30% consists of interstitial voids, mostly about 0.5mm size, with a layered but otherwise sporadic distribution throughout this sequence.

Reflected light microscopy (noteably through crossed nicols) indicates that individual hematite crystals, in layers of variably small to larger-continuous aggregates, have mostly external pseudomorphous morphologies after magnetite, but internally composed of fine patchy metamorphic mosaic, (i.e. not martite), ± sparse supergene microporosity. There are sparse <<1%, minute <5µm, inclusions of residual magnetite.

Scattered interstitial voids are occupied mostly by metamorphic quartz (15-20%), lesser oxidised sericite (10%) > supergene carbonate and voids.
(PS), ordinary light (OL), (x50). BIF dominated by layered aggregates of original magnetite crystals completely converted to metamorphic micromosaics of hematite (not marlite), with interstitial voids.
Figs 17 and 18.

(TS) 004

(PS), (x200). Crossed nicols highlights the anisotropic metamorphic mosaic throughout the hematite aggregate. Rare very small residual inclusions circled.
Breccia dominated by massive matrix of secondary silicified bundles of ex fibro-lamellar-form crystals, permeated by earthy hematite, followed by veins of microsparry quartz, and of later decussate specularite (± opaline quartz). Local botryoids of concentrated micaceous hematite. Possible epithermal mineralisation within breccia, with ex-fibrous bundles possibly ex-gypsum or anhydrite.

Field Note

Rock chip (sample I.D. 49115). Geolsec Formation Hm-quartz breccia, ~ 80 matrix-quartz, ~20% clasts of elongate specular hematite.

Petrography

Approximately 70% of this sample consists of heterogeneous massive fine crystalline quartz, macroscopically reddish due to patchy widely dispersed fine hematite (oxidation). The other 30% consists of pale-pinkish angular and some tabular fragments / clasts very fine siliceous apparent siltstone, (hence field classification of breccia).

Petrographically the bulk hematitic quartz ‘matrix’ has three components:

1. About 60%, random single crystals, and more pre-existing bundles of fibro-lamellar-form crystals, now completely replaced by clouded cryptocrystalline to microcrystalline quartz. These are also crowded with diffuse patches of earthy hematite ± rarer extremely fine micaceous specularite. The precursor to this fibrous mineral is uncertain, but if this sample represents epithermal mineralisation it may have been anhydrite or gypsum.

2. About 20% very irregular networks of clearer veins of microprismatic quartz mosaic, more or less between patches.

3. About 10% later veinlets of clear ultrafine to possibly opaline quartz. Minor random sporadic veinlets of medium to coarser decussate specularite appear to be another late mineralising event, more or less between breccia fragments and seen macroscopically to form possibly up to 10% of the sample. This seems to be slightly later than, but possibly a continuation of permeations of the earthy hematite. Locally fine specularite is concentrated into small patches.
Figs 19 and 20.  
(TS), (OL), Crossed Nicols (Xnic) low magnification (x20), showing clusters of fine lamellar to fibrous crystals, suggested as possible ex-sulphate replaced by extremely fine secondary silicification with dispersed very fine “earthy” hematite. Patches and veins of microprismatic quartz mosaic between and cut by stringers of fine specularite.
Fig 21. TS 005

(PT), (TS), (x100), Detail of “spray” of bundled ex-fine lamellar-prismatic crystals, silicified together with “earthy” minor fine micaceous hematite.
Figs 22 and 23. (PT), (TS), (x100). Dark veinlets of very fine specularite, cutting across the above silicified / hematised sprays, also between breccia fragments in figure 23.
Fig 24. TS 005

(PT), (x200). Cross cutting vein of decussate specularite.

Fig 25. TS 005

(PT), (x50). Breccia area, with complex of irregular patchy-veins between and within siliceous domains. Localised botryoidal concentrations of fine specularite.