Geological and metallurgical characteristics of BIF-associated detrital iron mineralisation in Gabon

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ABSTRACT

Recent exploration has identified the presence of detrital iron deposits (DID) associated with Banded Iron Formation (BIF) units in the northwest of the Congo Craton, Gabon. The regional geology comprises a complex of granitoids and gneisses assigned to the Archaean Chaillu Complex, within which older slivers of lower amphibolite-grade greenstones are preserved including muscovite-biotite-garnet-bearing felsic schist, amphibolite and BIF. These units are typically overlain by several metres of colluvium, eluvium and duricrust. The residuum is overlain by a regionally extensive loess cover from 2-10m thick.

The DID occur within the weathered residuum as mostly unconsolidated gravels with lesser canga duricrust draped over deeply weathered hematite BIF. Headgrades are in the range of 45 to 55% Fe. Fresh BIF, located from 30 to 50m below surface, is comprised of magnetite–quartz ± amphibole. The DID gravels are comprised of rod- and plate-shaped clasts of hematite (martite)–maghemite–goethite composition, in a ferruginous sand to clay-sized matrix. The DID form ridges and plateaus that coincide with magnetic highs defined using high-resolution ground magnetic surveys.

The field relations and petrography indicate that the DID accumulations are the result of weathering (including enrichment) and erosion of primary BIF. This includes removal of quartz, further oxidation and recementation of BIF to form ferruginous cap rock. This cap and the in-situ oxidised BIF were subsequently disaggregated and liberated to form the detrital iron accumulations.

Metallurgical test work on bulk DID samples has shown this material can be upgraded to lump and fines iron ore products with grades of 62 to 65% Fe using simple scrubbing and wet-screening, followed by dense media separation with mass yields from 70 to 85%. The test work indicates a high ratio of lump to fines products, sometimes exceeding 50%.
Long-range ground penetrating radar for iron ore resource definition

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ABSTRACT

Since its commercialisation in the 1970s, ground penetrating radar (GPR) has evolved into an accepted geophysical technique employed for numerous mineral exploration challenges. Recently, custom-designed GPR instruments have been trialed on iron ore resource definition projects with results ranging from no penetration to excellent resolution to over 100 m, depending on the ore type and setting.

In general, all GPR technologies require electrically resistive lithologies to penetrate appreciable depths into the subsurface. High clay fractions and saline groundwater are two typical factors which severely decrease resistivity and therefore limit radar's effectiveness in a given environment. Although counter-intuitive, some iron ore deposit types are sufficiently resistive to permit useful radar penetration, whilst other specific types are amongst the most resistive ground in the world.

GPR has been found to be generally ineffective in Australia’s channel iron deposits, due to the presence of saline groundwater found in the Pilbara. Conversely, iron sand deposits in New Zealand, Indonesia, Alaska and Eastern Canada have been shown to be excellent radar environments. Banded iron formations in Brazil and West Africa have been tested to delineate friable and non-friable ore, as well as phyllite bodies to over 100 m. Perhaps the best results thus far have been recorded in detrital or canga deposits in West Africa, where GPR has been able to accurately map the base of these deposits rapidly and at a resolution far higher than possible with typical geophysical tools.

Case examples are presented herein which illustrate the utility of modern GPR technologies in reducing exploration costs and increasing resource confidence in specific types of iron ore deposits.
A metallogenic study of high-grade iron ores on North Baffin Island in the ‘granulite facies’ domain south of the Central Borden Fault Zone

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ABSTRACT

Baffinland Iron Mines’ Rowley River prospect is located 120 km ESE of the main Mary River camp. Regional geological mapping has identified direct shipping iron ore (DSO) within high-grade gneisses correlated to the Mary River Group (MRG). The MRG forms the northern extension of the central Rae Committee Bay Belt. On north Baffin the MRG is characterized by lower metagreywacke overlain by a BIF-komatiite-quartzite cover sequence. Regionally, the BIF member hosts high-grade magnetite ores, with grades averaging 65 wt % Fe.

At Rowley River, an erosional remnant of Mary River BIF, capping a unique topographic plateau, preserves a lenticulated 20 m sheet of coarsely granular martite approximately 1000 m long. These martite lenses are characteristically armored by magnetite. Individual lenses plunge 20 degrees east; boudinaged morphology suggests an east-west extensional overprint. Mixed mafic-felsic orthogneiss overlain by transposed garnetiferous paragneiss structurally underlies BIF. Typical BIF, with variable garnet in silica bands, is best preserved on the south margin. However, BIF enveloping massive martite has been predominantly replaced by hematite and coarse porphyroblasts of cordierite-cummingtonite-sillimanite. Coarse amphibolite units occurring in the hangingwall may stem from original silicate BIF or komatiite. Petrography and mineral chemistry has identified granulite to anatectic metamorphic conditions. Whole rock geochemical analysis shows a 250% increase in Fe₂O₃ and preferential removal of SiO₂, CaO, Na₂O, K₂O and P₂O₅.

This investigation is focused on detailed petrography, bulk rock geochemistry and microprobe mineral analyses to determine the protoliths of the host-rock units to try to correlate them to traditional MRG stratigraphy. U-Pb dating is being used to establish the timing of ore formation, and correlate it to regional metamorphic events. P-T modeling is being used to establish the P-T-t path. Creating a geologic fingerprint of these prospects will aid in prospecting of new terrain for DSO on North Baffin.
High accuracy 2.5D AEM inversion method for banded iron – formation (BIF) and other geological settings

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ABSTRACT

New 2.5D airborne electromagnetic (AEM) algorithm has been developed by Intrepid Geophysics. The advantage of 2.5D (2D geology, 3D source) AEM inversion in 3D geological mapping applications and the identification of conductive drilling targets compared to the more commonly used CDI transforms or simple 1D inversions are demonstrated using the examples from BIF and other geological settings.

The 2.5D inversion application used in this work and described in Silic et al, 2015 is a substantially changed version of ArjunAir, Wilson et al., 2006, a product of CSIRO/AMIRA project P223F. The changes include a new forward model algorithm and a new inversion solver. The application enables the accurate simulation of 3D source excitation for full domain models inclusive of topography, non-conforming boundaries and very high resistivity contrasts. Solution is accurate for a geoelectrical cross-section which is relatively constant along a strike length that exceeds the AEM system footprint.

The major innovation includes a new inversion solver with adaptive regularisation which allows the incorporation of a misfit to the reference model and the model smoothness function.

Memory usage has been dramatically reduced and provides a usage estimate prior to execution. For speed the software has been parallelised using Intel MPI and can be used on standard computing hardware or computing clusters. Data from survey lines with lengths exceeding 30 kilometres can be inverted on high end laptop computers.

We allow flexibility in the selection of components and in the estimation of noise.

We show inversion examples from BIF, minerals (VMS) and geological mapping AEM surveys projects and compare the results with known geology and drilling. We demonstrate the much improved mapping and target definition delivered by this inversion method when compared with the other more common transforms or inversion methods used on these projects.

Particular issues associated with very high susceptibility ferrous minerals is also discussed, and a solution indicated that resolves the ambiguities.
Using airborne electromagnetics (AEM) to solve a structurally complex geological puzzle in the Hamersley Province, Western Australia

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ABSTRACT

The Cobra Project is located 14 km east of the NNW trending Menindee Fault Zone which defines the western margin of the Hamersley Province, Western Australia. The region comprises an extensive plateau of Brockman Iron Formation cut by a series of horst and grabens with a regional dextral strike-slip component. The 330° striking horst and grabens and associated 060° striking conjugate faults have approximate frequencies of 400 and 2000 m, respectively, and control the bulk of the iron mineralisation. Syn to late 330° trending dykes in part intrude the faults.

In the Cobra region, elucidating the structurally dislocated stratigraphy without closely spaced drilling is very challenging. Geological mapping is hindered by the paucity of mappable stratigraphic markers within the BIFs and kinematic indicators. Airborne magnetic and remote sensing datasets highlight the dense lineament network, but provide limited assistance in quantifying relatively small apparent displacements, or distinguishing faults from dykes with reasonable confidence.

Interpretation of modelled conductivity cross-sections generated from laterally constrained one-dimensional inversion of AEM data offers invaluable insight where the quality of mapping or drilling is wanting. Subsequent targeted field checking and infill drilling validated the geological model interpreted from the integration of these datasets.

The AEM technique alone cannot decipher the complex geological environments often present in the Hamersley Province but can facilitate effective iron ore exploration by focusing precious field time and assisting structural and stratigraphic interpretations in areas with sporadic and shallow geological data.
The “bromance” between iron ore and hyperspectral technology blossomed in the 90s, matured in the 3rd millennium and is the consequence of the successful combination of key ingredients: (1) technology, (2) fundamental mineral and spectral understanding, (3) strong commitment from iron ore companies at an early stage, (4) adoption of the technology by private laboratories, (5) technology transfer from CSIRO to iron ore companies and strong implementation within iron ore companies. (1) Hyperspectral technology is based on reflectance spectroscopy and has been used since the early 90s with the production of portable instrument such as the PIMA (portable infrared mineral analyser). The development of faster instrument such as the ASD with extended wavelength range covering the 350 to 2500 nm has allowed this technology to measure the main ore and waste minerals in iron ore. The building of automated hyperspectral system such as the CSIRO- designed HyLogging system brought speed and objectivity into exploration of iron ore. The development of hyperspectral imaging with system such Corescan technology even brought greater speed and quantification. (2) CSIRO’s fundamental understanding of iron ore mineralogy is second to none and covers all areas from exploration to mineral processing and metal production through mining with a very strong knowledge of spectral mineralogy. (3) The vision, the need and the commitment by iron ore companies to assess upcoming objective and fast technology when iron ore demand drastically increased in the early 2000s was instrumental in the real life trial of the hyperspectral technology in exploration camp but also in (4) Perth-based laboratories. (5) The technology transfer both in term of software but also staff and the strong leadership of the hyperspectral team in within the companies were the last key ingredients for the successful implementation of the technology in a routine basis.
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The iron bridge magnetite deposits

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ABSTRACT

The Iron Bridge Magnetite deposits are a large resource of magnetite mineralisation located in the Northern Pilbara region of Western Australia. Although these Archaean aged magnetite BIFs were well known as having potential for iron mineralisation for many decades, they were not recognised as being an economical resource until the large upturn in Iron Ore production and sale price which occurred in the early 21st century. Exploration drilling and Resource development by Fortescue Metals group beginning in 2007 has now defined them as being Australia’s largest magnetite Resource at over 6 Billion tonnes of contained iron mineralisation.

The geology of the deposits is akin to many other Pilbara hematite deposits, in that an iron-carbonate-silicate rich sedimentary sequence was deposited and has been subsequently altered over time. The large difference with the Iron Bridge Magnetite deposits is the extent of alteration which has greatly enriched the parent (fresh) magnetite in the host rocks. This BIF is then able to be processed to magnetite concentrate (approximately 66% Fe) and sold to customers as a premium product for making pellets as feed to a blast furnace.

This paper covers the fundamental geology of the deposits that make up the Iron Bridge project.