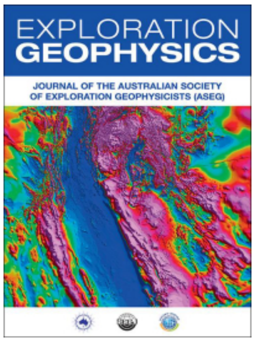

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Preliminary dating of martite goethite iron ore in the Hamersley Province (Western Australia)

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SUMMARY

In Western Australia, iron ore deposits are divided into three types, Channel Iron Deposits (CID), Detrital Iron Deposits (DID) and Bedded Iron Deposits (BID). The latter are hosted in the banded iron-formation (BIF) of the Marra Mamba and Brockman Iron Formations. Two types of BID are mined, the Martite-Microplaty and the Martite-Goethite (M-G), the latter representing the current bulk of the direct shipping ore. The Upper to Lower Miocene CID have been successfully dated using the (U-Th)/He method. Here we report the first dating of three samples from M-G mineralisation occurring in the Dales Gorge member from the Brockman Iron Formation. In unweathered MG ores, the original texture of the BIF, from the micro- to the macroscale, is fully preserved. The primary hematite is unchanged, but primary magnetite is oxidised to martite and the original gangue minerals such as chert, silicates, and iron-rich carbonates are pseudomorphed by goethite. Three samples were collected from a diamond drill hole at depths of 163m, 116m and 90m from the surface. The samples were characterised using an optical microscope and after microscopic identification of goethite and martite, samples were microdrilled. The average ages of iron oxides were 45 ± 6 Ma or Mid-Eocene for the sample at 163 m; 42 ± 5 Ma or Mid-Eocene for the sample at 116 m and 28 ± 3 Ma or Early Oligocene for the sample at 90 m.

Key words: Iron Ore, Martite-Goethite, Western Australia, (U-Th)/He Dating.

INTRODUCTION

The classification of the different types of high-grade iron ores is multifaceted as they are the consequence of several, superimposed hypogene and supergene processes. In Western Australia, iron ore deposits are divided into three types: Channel Iron Deposits (CID), Detrital Iron Deposits (DID) and Bedded Iron Deposits (BID) that are banded iron formation (BIF)-hosted and result from an enrichment process. The BID are subdivided into two main types: (1) Hematite (martite-microplaty) and (2) Martite–goethite ores. These enriched BIF-hosted iron ores and the hematite iron ores are widespread in Australia, Brazil, Guinea, India and South Africa, and represent the main direct shipping ores (DSO). In Australia, hematite iron ores currently represent only 20% of the BID DSO whereas 80% consist of martite–goethite ore. Both martite–goethite and hematite ores are affected by weathering. These deposits are hosted in the Archean Marra Mamba and in the Proterozoic Brockman Iron Formations. Morris (1980) showed that one of the key features of the martite–goethite ores is that the original texture of the BIF, from the micro- to the macroscale, is completely preserved. While primary hematite is unchanged, primary magnetite is oxidised to martite (hematite after magnetite) and gangue minerals such as chert, silicates, and iron-rich carbonates are pseudomorphed by goethite or, in part, leached out.

Although some authors, such as MacLeod (1966), Taylor et al (2001) and Morris and Kneeshaw (2011), suggested Tertiary ages, no geochronology studies were undertaken. This is the first time that direct dating of M-G ore is reported. After successfully dating the CID in the Hamersley Province using the (U-Th)/He method (Danišík et al, 2013), a similar approach was taken to date three samples of M-G ore. The measured ages range from age Mid-Eocene for the sample at 163 m; 42 ± 5 Ma or Mid-Eocene to Early Oligocene.

METHOD AND RESULTS

Three BID M-G samples were collected from a diamond drill core derived from the Dales Gorge Member. The three samples were collected from the small diamond drill holes at depths of 163 m, 116 m and 90 m from the surface. The samples are located in the Hamersley Province, however for confidentiality reasons, their exact location is not provided. Polished sections of the samples were prepared for petrological work underpinning the dating analysis. The samples were characterised using an optical microscope and after petrological and mineralogical identification of the location of the iron oxides, goethite and martite, samples were microdrilled and ultrasonically cleaned. The samples were then analysed for ^{4}He, ^{238}U and ^{232}Th using isotope-dilution mass spectrometry (noble gas quadrupole mass spectrometer and ICP-MS, respectively) at the John de Laeter Centre for Isotope Research in Perth (Australia) following the procedures described in Danišík et al (2013).

The (U-Th)/He dating results for the goethite present in the shallower sample at 90 m (Table 1) show the various steps involved in the calculation of the age of the samples. For each sample, 5 aliquots were measured and show the good reproducibility of the measurements.

The goethitisation and martitisation are almost synchronous. The age of the mineralisation increases with depth; the older ages are found at 163 m with an average Mid Eocene age for goethite at 45 Ma and martite at 47 Ma (Table 2). The ages of the sample at 116 m are also Mid Eocene being slightly younger with goethite and martite at 42 Ma (Table 2). The sample at 90 m is much younger with an Early Oligocene age with goethite at 28 Ma and martite at 30 Ma.

CONCLUSIONS

The results from the (U-Th)/He dating for three samples from an M-G iron ore diamond drill hole located in the Hamersley

Province of Western Australia show that goethitisation and martitisation are synchronous. The older samples are the deepest with Mid-Eocene ages for 163 m and 116 m and Early Oligocene for the sample located at 90 m. This are just preliminary data and a larger selection of samples should be measured to confirm these early results.

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Sample	Mineral	^{232}Th (ng)	± (%)	^{238}U (ng)	± (%)	^{4}He (ncc)	± (%)	TAU (%)	Th/U	Raw age (Ma)	±1σ (Ma)	Ft	Cor. Age (Ma)	±1σ (Ma)
90B1-1	goethite	0.003	15.9	0.015	2.2	0.062	4.3	4.8	0.17	33.1	1.6	1.0	**33.1**	**3.7**
90B1-2	goethite	0.007	2.3	0.009	2.7	0.035	4.9	5.4	0.72	26.6	1.4	1.0	**26.6**	**3.0**
90B1-3	goethite	0.004	8.1	0.008	2.2	0.033	4.9	5.3	0.54	29.5	1.6	1.0	**29.5**	**3.3**
90B1-4	goethite	0.007	4.8	0.010	2.2	0.034	4.7	5.1	0.78	24.9	1.3	1.0	**24.9**	**2.8**
90B1-5	goethite	0.006	5.2	0.008	2.2	0.031	4.8	5.2	0.77	26.1	1.3	1.0	**26.1**	**2.9**

Table 1. Steps involved in the calculation of the age of the samples. The goethite present in the shallower sample at 90 m.

Depth (m)	Mineral	Age ± 1σ (both in Ma)	Epoch
90	Goethite	28 ± 3	Early Oligocene
	Martite	30 ± 3	Early Oligocene
116	Goethite	42 ± 5	Mid Eocene
	Martite	42 ± 5	Mid Eocene
163	Goethite	45 ± 6	Mid Eocene
	Martite	47 ± 6	Mid Eocene

Table 2. Average ages for three samples