Contribution of fine exsolution lamellae of hematite-ilmenite to magnetic properties

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Hematite-ilmenite minerals play an important role in acquisition of rock magnetism. Samples of igneous rock with hematite exsolution in ilmenite, visible by optical microscopy, have indicated high and stable NRM, although the acquisition mechanism of magnetization is still unknown (McEnroe *et al.* 2001a). McEnroe *et al.* (2001b) have identified fine scale exsolution microstructures of hematite and ilmenite in metamorphic rocks with high natural remanent magnetization (NRM) using energy-filtered TEM, and suggested that the microstructure was related to the magnetic properties. In this study samples from the Sokndal Region, Norway, provided by S. McEnroe, have been examined by SEM, TEM with EDS, high-resolution TEM (HRTEM), magnetic force microscopy, and measurements made of the temperature dependence of the magnetic susceptibility to determine the interaction between exsolution microstructure and magnetism.

SEM observations indicated various scales of exsolution of hematite within ilmenite. TEM observations showed that within both the ilmenite and hematite, there are abundant fine lamellae (~ in the order of a few tens on nm in length) of hematite and ilmenite respectively. TEM-EDS analyses revealed that the chemical compositions of the hematite and ilmenite were $Ilm_{14-19}Hem_{81-86}$ and $Ilm_{99}Hem_{1}$. Our EDS results are similar to those reported by McEnroe *et al.* (2001b) who suggested that these phases alone cannot account for the magnitude of the NRM.

The strong strain contrast around the lamellae and observation of the interface between hematite and ilmenite by HRTEM revealed that the lamellae were parallel to (001) planes and the coherency strain is partially relieved by formation of the interface dislocations. Harrison and Becker (2001) calculated that the ferrimagnetic moment of the intergrowth could be due to the arrangement of cations and spins at the interface between hematite and ilmenite. We suggest that the semicoherent interfaces of the many fine lamellae are related to acquisition of magnetization.

References

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Calcium isotope variation in Neoproterozoic carbonate rocks

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Neoproterozoic carbonate rocks from the eastern Kaokoveld (Namibia) house two glacial intervals each with a cap carbonate. Samples span the preglacial Ombaatje Fm, the postglacial Keilberg cap carbonates and the post-cap Maieberg Fm bracketing the glacial Ghaub Fm. The preglacial samples are fine grained limestones and dolostones near the top of the succession. The cap carbonates are pure dolomites, and dolomite is also present in the post-cap succession alternating with fine grained limestone. Samples have been analysed using a $^{43}Ca/^{48}Ca$-double spike and the Finnigan-TRITON TIMS. Ca isotope ratios are given relative to NIST SRM 915a in the conventional ($\delta^{44}Ca$) way. Calcium isotope data from the Namibia samples show consistent $\delta^{44}Ca$ values of -0.02 ± 0.17‰ (2σ std) through the both pre- and postglacial succession. Carbon isotope data from the same samples are characterised by positive isotope values in the preglacial rocks that decline to negative values within the postglacial carbonate rocks. The postglacial cap carbonates and the associated negative $\delta^{13}C$ values have been interpreted to reflect the physical record of carbon transfer from the atmosphere to the sedimentary reservoir by high weathering rates after glaciation (Hoffman *et al.* 1998). However, an increase in silicate weathering should affect the Ca isotope composition of seawater and hence, the $\delta^{44}Ca$ values of the precipitated carbonates. As yet, no such evidence has emerged from the study of Ca isotopes in these rocks. Ca isotope ratios of foraminifera display systematic temperature-dependent fractionation and are potentially a new proxy for past sea surface temperatures (SST). Recent data suggest that a 1°C change in temperature results in 0.24 ± 0.02‰ fractionation of $\delta^{44}Ca$ (Nägler *et al.* 2000). Thus, the uniform Ca isotope composition of the Namibia carbonates in rocks thought to reflect a wide range in temperatures suggests either (1) that the use of $\delta^{44}Ca$ as a SST proxy requires a biological contribution that was not present during the formation of these rocks, or (2) the temperature range during deposition was less than initially suggested.

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