Triple oxygen isotope variations in magnetite from iron oxide deposits, central Iran, record devolatilization of evaporite and carbonate rocks

STEFAN T.M. PETERS[1,2]*, NARGES ALIBABAIE[3,4], DAVOOD RAEISI[4], SEANN J. MCKIBBIN[1], ANDREAS PACK[1], BERND LEHMANN[3]

[1]University of Göttingen, Department of Isotope Geology, 37077 Göttingen, Germany; speters2@gwdg.de
[2]University of California San Diego, Department of Chemistry and Biochemistry, 92093 La Jolla, USA
[2]Technical University of Clausthal, Mineral Resources, 38678 Clausthal-Zellerfeld, Germany
[3]Tehran University, Earth Sciences, Tehran, Iran

Oxygen (O) isotope ratios in magnetite can be used to study the origin of iron oxide ore deposits. Traditionally, only $\delta^{18}O$ values of the magnetite were determined. Here, we report triple O isotope data ($\delta^{17}O$, $\delta^{18}O$) of magnetite from the iron oxide-apatite deposits of the Bafq and Sirjan areas in central Iran. In contrast to previous interpretations of magnetite from similar deposits, our data show that only few of the samples were potentially in equilibrium with magmas or with magmatic waters wen they formed ("orthomagmatic" magnetite). None of the samples were in equilibrium with waters of a marine or meteoric origin.

The majority of the magnetite samples has similar $\delta^{18}O$ to orthomagmatic magnetite, but has lower $\Delta'^{17}O$ values down to -180 ppm (where $\Delta'^{17}O$ is expressed relative to VSMOW, using $\lambda = 0.5305$ with zero intercept). Such low $\Delta'^{17}O$ values are best explained by involvement of mass-independently fractionation oxygen (MIF-O). The iron oxide deposits are associated with evaporite rocks of Neoproterozoic to Lower Cambrian age, i.e. an age for which the most negative $\Delta'^{17}O$ values in evaporitic sulfate were reported [1]. We propose that the magnetite formed from hydrothermal fluids that had incorporated MIF-O from these evaporite rocks, either directly by fluid-rock interaction at low water/rock ratios or, alternatively, by flushing of the hydrothermal system with volatile SO_2 that, in turn, had formed by the breakdown of evaporitic sulfate in a magma. Some of the magnetite samples have elevated $\delta^{18}O$ values (up to 6.7 ‰) compared to orthomagmatic magnetite and also have lower $\Delta'^{17}O$ values. These samples were potentially in O isotope equilibrium with mixed H_2O-CO_2 fluids in which the CO_2 had been derived from the magmatic or metamorphic breakdown of marine sedimentary carbonate rocks.

[1] Bao et al. *Nature* 2008 **453** (7194), 504