



Murdoch
UNIVERSITY

MURDOCH RESEARCH REPOSITORY

Simon, A., Reich, M., Bilenker, L., Knipping, J., Lundstrom, C., Deditius, A., Bindeman, I. and Barra, F. (2014) Iron and oxygen isotope and element systematics of magnetite from the Los Colorados IOA deposit, Chile: A paradigm shift for IOA deposits? In: Society of Economic Geologists (SEG) Building Exploration Capability for the 21st Century, 27 - 30 September, Keystone, CO, USA.

<http://researchrepository.murdoch.edu.au/26177/>

It is posted here for your personal use. No further distribution is permitted.

Iron and oxygen isotope and element systematics of magnetite from the Los Colorados IOA deposit, Chile: A paradigm shift for IOA deposits?

Corresponding author: Adam Simon, University of Michigan, simonac@umich.edu

Co-authors:

Martin Reich, Dept. of Geology and Andean Geothermal Center of Excellence (CEGA),
mreich@ing.uchile.cl

Laura Bilenker, University of Michigan, bilenker@umich.edu

Jaayke Knipping, University of Michigan, jaaykek@umich.edu

Craig Lundstrom, University of Illinois Urbana-Champaign, lundstro@illinois.edu

Artur Deditius, School of Engineering and Information Technology,
A.Deditius@murdoch.edu.au

Ilya Bindeman, University of Oregon, bindeman@uoregon.edu

Fernando Barra, Dept. of Geology and Andean Geothermal Center of Excellence (CEGA),
fbarrapantoja@ing.uchile.cl

The origin of iron-oxide apatite (IOA) and iron-oxide copper gold deposits (IOCG) remains debated, with few observational data able to distinguish among working hypotheses that invoke meteoric fluid, magmatic-hydrothermal fluid, and liquid immiscibility. Testing these hypotheses requires peeling back layers of metasomatism that possibly obscure the original (unaltered) chemistry of the deposits. In this study, we combine 1) high-precision Fe and O isotope data, 2) high-resolution chemical analyses of magnetite grains, and 3) analyses of magnetite-hosted saline melt inclusions to peel back these layers in a world-class IOA deposit. Samples were collected from the Cretaceous aged Los Colorados (LC) IOA deposit in the Chilean Iron Belt, which hosts more than 40 IOA deposits within the southern segment of the Atacama Fault System in the Coastal Range of northern Chile. LC contains 70 Mt Fe in two parallel, magnetite-rich (>90 modal %) dykes that measure 1500m strike, 150 m wide, and ~500m deep. The West dyke contains ~63% total Fe and the East dyke ~55% total Fe. The dykes are bounded on the west by a fault and the east by a brecciated zone, which contains ~25% total Fe. LC is hosted in igneous rocks of the Punta del Cobre Formation.

We measured the ratio of $^{56}\text{Fe}/^{54}\text{Fe}$ of magnetite grains from fifty samples from drill core from the West dyke and East dyke, reported relative to the $^{56}\text{Fe}/^{54}\text{Fe}$ ratio of the IRMM-14 standard (reported as $d^{56}\text{Fe}$). Values of $d^{56}\text{Fe}$ range from 0.08‰ to 0.26‰, which are within the global range of ~-0.06 to 0.5‰ for magnetites crystallized directly from silicate melts (i.e., magmatic magnetite). The variation of $d^{56}\text{Fe}$ outside of the 0.05‰ analytical error accords with evidence of subtle alteration and/or local magnetite dissolution/precipitation. High-precision O isotope measurements of magnetite and actinolite give largely normal $\delta^{18}\text{O}$ values: $\delta^{18}\text{O}(\text{magnetite}) = 2.04\text{‰}$; $\delta^{18}\text{O}(\text{actinolite}) = 6.08\text{‰}$, yielding $\delta^{18}\text{O}$ (actinolite-magnetite) temperatures $>700^\circ\text{C}$, consistent with a magmatic (above solidus) origin.

We performed high-resolution electron probe microanalyses (EPMA) across magnetite grains. Magnetite cores are enriched in Ti, V, Al, and Mn, whereas these element abundances decrease systematically from core to rim of individual crystals. Plotting the elements [Al + Mn] vs. [Ti + V] indicates that magnetite cores are consistent with magmatic and/or magmatic-hydrothermal

(i.e., porphyry) magnetites, based on a comparison to global data for magnetite chemistry in ore forming systems. Decreasing [Al + Mn] and [Ti + V] is consistent with a cooling trend from porphyry to Kiruna to IOCG systems.

Lastly, we quantified the compositions of magnetite-hosted saline melt inclusions, which are only present in the cores of magnetite grains. The chemistry of melt inclusions is consistent with silicate liquid residual to the crystallization of magnetite.

The data for Los Colorados indicate that primary magnetite is magmatic, and alteration by later hydrothermal events manifests in measurable changes in the isotope and trace element signature of individual magnetite grains. If LC is representative of other Chilean IOA deposit, these data appear to unequivocally link the deposits to a magmatic genesis.