Evidence for a magmatic origin for iron oxide-apatite deposits

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There are multiple working hypotheses for the formation of iron oxide-apatite (IOA) deposits that involve hydrothermal, magmatic-hydrothermal, and liquid immiscibility processes. Here, we report SEM-EDX observations of supersaline melt inclusions entrapped in main-stage magnetite from the Los Colorados (LC) mine in the Cretaceous Chilean Iron Belt. The deposit consists of two magnetite-rich dykes (1500m strike x150m width x 500m height; mean Fe: 48 wt%; max.: 72 wt%; 70 Mt Fe), which are hosted in meta-andesitic rocks. We intrepret the melt inclusions to evince a magmatic origin for LC, consistent with supersaline melt inclusions reported for the El Laco deposit (T_h > 800 °C) [1]. In addition, bulk rock analyses were conducted on LC samples from different depths (30 to 200 m) within the Fe rich dyke, as well as the dioritic host rock. REE concentrations of the dyke and the wall rock parallel each other as a function of depth. This is consistent with a syngenetic origin, rather than an Fe-rich intrusion into a genetically unrelated host rock. However, REE in the host rock are an order of magnitude higher than the oxide dyke rock, which could be explained by partition coefficients of REE between certain minerals and melt ($D_{REE}^{x/melt}$). Published data indicate that magnetite has a low $D_{REE}^{mag/melt}$ of 0.003 to 0.02 [2], while $D_{REE}^{apatite/melt}$ increases with increasing SiO_2 and decreasing T [3], which could therefore lead to higher REE concentrations in wall rock apatites. A similar observation was made for the top of the Bushveld Complex, assuming large-scale liquid immiscibility between a Fe-rich melt (L_{Fe}) and a more Si-rich melt (L_{Si}) [4]. Furthermore, the major element composition of the LC dykes and host rock is consistent with conjugate L_{Fe} and L_{Si} reported in published studies [5]. We suggest that the Los Colorados deposit formed by large-scale liquid immiscibility between L_{Fe} (dyke rock) and L_{Si} (wall rock), possibly followed by further chromatographic enrichment of Fe owing to exsolution of a high-T supersaline fluid(s). This interpretation agrees with the chemistry of magnetite at LC, which shows evidence for a magmatic origin [6].

[1] Bromann *et al* (1999), *GFF* **121**, 253–267 [2] Nielsen *et al* (1992), *Contrib Mineral Petrol* **110**, 488-499 [3] Watson & Green (1981), *Earth and Planetary Sciences Letters* **56**, 405-421 [4] Van Tongeren & Mathez (2013), *Geology* **40**, 491-494 [5] Kamenetsky *et al* (2013), *Geology* **41**, 1091-1094 [6] Reich *et al* (2014) Goldschmidt Conference.