Nanoparticles in hydrothermal magnetite from the Los Colorados IOA deposit in Chile

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Trace elements (TE) in magnetite provide a geochemical signature which informs about the origin, formation, and alteration processes of Fe-ore deposits. This work reports nanoscale details of TE in the samples of zoned hydrothermal magnetite from diorite of the Kiruna-type, Los Colorados, iron-oxide apatite (IOA) deposit, Chilean Iron Belt.

Two generations of hydrothermal magnetite were deposited: (i) primary, forming 1 mm thick aggragate of isometric crystals (50-200 μm in size) with TE accumulated in growth and sector zones; and (ii) secondary 3-5 mm thick layer of alternate TE-rich and TE-poor growth zones, deposited on magnetite-(i). EMPA elemental maps of magnetite revealed presence of nanoparticles (NPs) in TE-rich sector and growth zones of magnetite-(i) and –(i). The maximum concentrations of TE are (in ppm): Si (15000), Al (12000), Mg (6700), Ca (5300), K (2400), Ti (3000), Na (2200), Mn (2700). The V content decreases from magnetite-(i) to –(ii), from 2500-2700 to 2200-2300 ppm.

TEM-EDX-SAED studies revealed three types of crystalline NPs: (a) crystallographically oriented, euhedral, needle-like NPs of diopside, 50x500 nm in size, foming core-rim textures. The chemical composition is (in wt. %): (i) core, Mg-8.4, Si-28, Ca-18.5, O-44.1, Al-0.7; rim: Mg–12.6, Al–9.4, Si–19.7, K-2.8, O–54.5. (b) isometric NPs of rutile, ~100x200 nm in size; and (c) anhedral (Al,Mg,Si,Ca)-rich NPs. All NPs and hosting magnetite are single crystals, which is indicative of significant recrystallization. The zoning in TE in magnetite indicates abrupt fluctuations in the content of TE in the fluid and suggest changes from equilibrium conditions to kinetically-induced precipitation, respectively.