Fluorapatite-monazite-allanite relations in the Grängesberg apatite-iron ore district, central Sweden

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Magnetite-fluorapatite ore bodies of the Kiruna type occur worldwide and are generally associated with volcanic rocks. The current consensus suggests that they represent highly evolved igneous bodies, associated with volcanism with a concurrent or slightly later metasomatic component. Kiruna-type deposits of the Bergslagen province in south central Sweden not only represent the biggest iron ore resource in central Sweden, but also a significant occurrence of REE and phosphorous.

We present data from comprehensive mineralogical studies of the major REE-bearing assemblages in the Grängesberg deposit, primarily comprising REE-substituted fluorapatite, allanite-(Ce), monazite-(Ce) and xenotime-(Y). Fluorapatite and accessory silicates mostly dominate bands in the ore, occurring as fine-grained aggregates. Fluorapatites have mean Cl and H_2O values lower than 0.17wt.%. Mean concentrations of Na_2O, SiO_2, FeO and MnO do not exceed 0.13, 0.29, 0.35 and 0.04, respectively. Fluorapatite in all types of ores occurs in two main textural varieties. One variety exhibits visible concentric zoning. In BSE, this fluorapatite variety is darker in the cores and lighter towards the rims, but darker again in the outermost rims. This trend is rarely reversed. Light zones are enriched in Y+REE (up to 2.5wt.% of $(Y+REE)_2O_3$) and Si. Rare tiny (<5μm) and scattered, in some cases epitaxially oriented, monazite (±xenotime) inclusions are present in the dark zones.

It is evident that relatively intense fluid-mediated over-printing has led to alteration of the more reactive phases. This likely occurred in two stages, where the first introduced acidic fluids along apatite grain boundaries during the later stages of crystallization of the apatite-iron oxide deposit. This resulted in the formation of monazite and xenotime inclusions in the apatite. The second stage may have occurred in association with fluid mobility related to the amphibolite-facies metamorphism of the ores and host rocks. This resulted in mass transfer of (Y+REE+P) and elements from the surrounding groundmass, which in turn led to the formation allanite along with minor monazite and xenotime in the host rocks.