U-Pb, Hf, O and Nd constraints for the Kiruna apatite iron oxide deposits, Sweden

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The world-class iron deposits in the Norrbotten region of northern Sweden (e.g., Kiirunavaara) are considered the type locality of apatite iron oxide (IOA) deposits with a debated origin. Similarities with iron oxide copper gold (IOCG) deposits and related origins from hydrothermal fluids have been suggested, while traditionally, iron oxide melts have been proposed. Here, for the first time using spatially well constrained samples, detailed in situ U-Pb dating accessory minerals and tracer isotope geochemistry on the mineral and whole-rock scale are combined to provide as better understanding of the ore genesis of these ore deposits.
Our U-Pb dates of zircon agree with previously reported dates (1900 to 1880 Ma), but our data provide a more accurate time frame of 1884 to 1880 Ma for the emplacement of the metavolcanic rocks that host the main ore body at Kiirunavaara. A syenite and granite that intrude the footwall of the deposit at have been dated at ca. 1880 and ca. 1874 Ma, respectively. Zircon crystals dated from the ore main body are similar to the age of the granite intrusion. The oxygen and Hf isotopic composition has been determined in situ on the zircon grains that were previously dated in these samples. Zircon grains from metavolcanic host rocks and the granite and syenite intrusions have $\delta^{18}O$ ~3‰, and εHf_i=-6 to -10, whereas the zircon grains from the ore samples have $\delta^{18}O$ ~7‰, and εHf_i=-5 to +3, and are distinctly different. Whole rock Sm-Nd data shows a similar contrast with εNd of ~ -6 for host rocks and εNd ~ -3 for the ore.
The U-Pb data suggests that the ore formed a few million years after the metavolcanic host rocks were emplaced, but close to the emplacement of the granite intrusion. The differences observed in all isotopic systems points towards an origin for the iron ore distinct from its magmatic host rocks. Furthermore, the low oxygen isotopic values strongly indicate the involvement of high temperature hydrothermal fluids. Therefore, a magmatic-hydrothermal fluid system, driven by the heat produced by the intrusions, seems most likely to have mobilised iron and concentrating it in these massive iron oxide deposits.