U-Pb, Hf, O, trace element, and H_2O, 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, but whose origin has been debated for many years. Two opposing theories for their formation suggest that these iron ores were emplaced through either: 1) immiscible silicate liquid-iron oxide melts; or 2) that the iron was transported and emplaced by hydrothermal fluids. 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 country 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 that were dated from the ore main body are similar to the granite intrusion (ca. 1874 Ma). The oxygen and Hf isotopic composition has also 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. The low oxygen isotopic values strongly indicate the involvement of high temperature hydrothermal fluids. Zircon from the volcanic host rock and granite have near stoichiometric compositions. However, crystals from the ore and syenite contained elevated Fe and P concentrations and have low analytical totals. FTIR spectroscopy done on selected zircon grains from the ore and syenite intrusion revealed that they contained several weight percent of H_2O. A magmatic-hydrothermal fluid system is proposed to have mobilised iron and subsequently concentrating it in these massive iron oxide deposits.