Searching for ancient crusts: Integrating Pb isotopes in plagioclase with Hf isotopes in zircon

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The composition of the Earth's early crust is a topic of much interest in geology today. We present *in situ* analyses by LA-MC-ICPMS for the Pb isotope compositions of preserved igneous plagioclase (An 75-89) megacrysts and the Hf isotope compositions of BSE-imaged domains of zircon grains from 21 samples from two anorthosite complexes in southwestern Greenland, Fiskenæsset and Nunataarsuk, which represent two of the best-preserved Archean anorthosites in the world. *In situ* LA-ICPMS U-Pb geochronology of the zircon grains suggests that the crystallization age of the Fiskenæsset complex is 2936 ± 13 Ma (2σ, MSWD = 1.5) and the Nunataarsuk complex is 2914 ± 6.9 Ma (2σ, MSWD = 2.0). Initial Hf isotope compositions of zircon grains from both anorthosite complexes fall between depleted mantle and a less radiogenic crustal source with a total range up to 5 ε_{Hf} units. In terms of Pb isotope compositions of plagioclase, both anorthosite complexes share a depleted mantle end member yet their Pb isotope compositions diverge in opposite directions from this point: Fiskenæsset toward a high-μ, more radiogenic Pb crustal composition and Nunataarsuk toward low-μ, less radiogenic Pb, crustal composition. By using Hf isotopes in zircon in conjunction with Pb isotopes in plagioclase we are able to constrain both the timing of mantle extraction of the crustal end member and its composition. At Fiskenæsset, the depleted mantle melt interacted with an Eoarchean (~ 3600 – 3800 Ma) mafic crust with $^{176}Lu/^{177}Hf$ ~ 0.026. At Nunataarsuk, the depleted mantle melt interacted with a Hadean (~ 4200 Ma) mafic crust with $^{176}Lu/^{177}Hf$ ~ 0.032. Using our new *in situ* approach, contamination of mantle derived magma by ancient mafic crust has been discovered in both the Fiskenæsset and Nunataarsuk anorthosite complexes of Greenland. The isotope data presented here suggest the survival of Hadean and Eoarchean crust until ~ 2900 Ma. There is potential that this old mafic crustal could be preserved at the surface within the Nunataarsuk and Fiskenæsset regions today.

REE and isotope (Sr, S, Pb) geochemistries to constrain the genesis of the F-(Ba-Pb-Zn) ores of the Zaghouan District (NE Tunisia)

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The F-(Ba-Pb-Zn) ore deposits of the Zaghouan District, which are located in NE Tunisia, occur as open space fillings or stratabound orebodies, hosted in Jurassic, Cretaceous and Tertiary layers. Ore fluids are hydrothermal (80 to 200°C) brines (10 to 30 wt % NaCl equiv.). The chondrite-normalized REE patterns may be split into three groups: (i) 'Normal marine' patterns characterizing the wallrock carbonates; (ii) REE patterns sloping to the right-hand side, with small negative Ce and Eu anomalies, characteristic of the early ore stages; (iii) Bell-shaped REE patterns displaying LREE depletion, as well as weak negative Ce and Eu anomalies, characterizing fluids of subsequent stages. The $^{87}Sr/^{86}Sr$ ratios, show that the Sr of the epigenetic carbonates (dolomite, calcite) and ore minerals (fluorite, celestite) is more radiogenic than that of the country rocks. The uniformity of this ratio throughout the District, provides evidence for the isotopic homogeneity and, consequently, the identity of the source of the mineralizing fluids. The $\delta^{34}S$ values of barite associated to mineralizations, are close to the $\delta^{34}S$ of Triassic sea water (17%). The $\delta^{34}S$ values of sulphide minerals show a wide range for galena (-13.6 to +11.4%), but restricted for sphalerite (-2.6 to +2.1%). However, considered individually, each deposit is characterized by a restricted range of $\delta^{34}S$ values for both sulphides, which requires that reduction took place in closed systems. The more negative $\delta^{34}S$ values are assigned to bacterial reduction, while the more positive are assigned to thermo-chemical reduction of Triassic sulphates. Taking account of the homogeneity in the Pb-isotope composition of galenas, a single upper crustal source for base-metals is accepted. The Late Paleozoic basement seems to be the more plausible source for F-Pb-Zn concentrated in the deposits. The formation of the Zaghouan District ore deposits is considered as the result of the Zaghouan Fault reactivation during the Upper Miocene period.