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Hydrogen and oxygen isotope geochemistry of amphiboles from alkaline igneous complexes

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It is now well established that the hydrogen isotope composition of amphiboles from alkaline complexes have an extremely wide range, but also extremely low δD values. For example, amphiboles from the Ilímaussaq (Greenland) and Khibina (Russia) complexes have δD values as low as –227 and –178‰, respectively, in peralkaline to agpaitic rocks (silica-undersaturated and oversaturated); has amphibole δD values between -143 and -110‰ in the Tugtutoq Complex (Greenland); and about –152‰ in the Canadian Mount Saint Hilaire complex. All of these complexes, however, have syenitic rocks with values more typical of mantle-derived magmatic rocks (about –90‰). In contrast, amphiboles from the Okenyenya and Messum alkaline complexes (NW Namibia) have values between –70 and –89‰, supporting a normal mantle origin. It has been suggested that extremely negative H isotope compositions may be controlled by internally buffered magmatic processes that may be unique to rocks developing extreme alkalinity (Marks et al., 2004). To address this possibility further, a complete mineralogical and geochemical characterization of selected minerals from a number of petrogenetically well-characterized sites has been undertaken. The study concentrates on well-known complexes in Greenland, the Kola peninsular of Russia, and NW Namibia. Amphiboles selected have compositions typical for calcic, sodic-calcic, and sodic amphiboles.

The δ^{18}O values of amphiboles (values close to 5.5‰) from all complexes studied are quite homogeneous, and are consistent with formation from mantle-derived magmas. The possible effects of Fe content and/or Fe^{3+}/Fe^{2+} and high alkali content on hydrogen isotope fractionation between amphiboles and fluids have been investigated. In the amphiboles, the influence of Fe^{3+}/Fe^{2+} and iron content on δD values is small

($R^2_{Fecontent}$= 0.6558; n=23), but a significant correlation (R^2_{Na+K}= 0.8196; n=23) between the alkali content and δD value from the Ilímaussaq complex is observed. This suggests that complex isotope fractionation processes and/or the appearance of other hydrous phases (eg. eudialyte) may accompany the evolution to highly alkaline magmas in these systems.

Marks M., Vennemann T.W., Siebel W., and Markl G., 2004. Nd-, O-, and H-isotopic evidence for complex, closed-system fluid evolution of the peralkaline Ilímaussaq Intrusion, South Greenland. Geochimica et Cosmochimica Acta, V. 68, p. 3379–3395.