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Exploring for natural hydrogen in peralkaline nepheline-syenite plutons: the Kola peninsula, NW Russia

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Serpentinization of ultramafic rocks producing natural hydrogen is extensively investigated at seafloor and continents seepage sites. Much less know is that remarkable amounts of hydrogen are detected in peralkaline plutons (e.g. Ilímaussaq, Greenland; Strange Lake, Canada). The most spectacular occurrences are Khibiny and Lovozero (Russia) where up to 40 mol % H_2, along with CH_4 and other gases have been detected in fluid inclusions[1] and found to migrate freely in fractures and mine workings[2]. Previous studies have documented extremely uneven distribution of both occluded and free gases[2,3]. Most researchers consider that these gases formed abiogenically, either through magmatic processes or during subsolidus hydrothermal alteration. Elevated concentrations of subsurface H_2 are found in loose sediments near lithological boundaries, e.g. in fenitized Archean gneiss surrounding both Paleozoic plutons, at the contact between layered and eudialyte-rich units in Lovozero, and in the Central Arch in Khibiny, host of large REE and phosphate deposits.

Our team seeks to understand how and when hydrogen and associated gases were produced, their migration pathways and where they are stored in Khibiny-Lovozero. To constrain these processes, our efforts combine geochemical, geophysical, mineralogical and environmental approaches. Thus far, field investigations include: (1) mapping soil gases using multi-gas detectors; (2) collecting different rock samples from outcrops and boreholes; (3) sampling spring water and soils. Complementary laboratory analyses include: (1) detailed petrology of rock samples (SEM-EDS, microprobe); (2) bulk-rock gas chromatography, using mechanical grinding; (3) microthermometry and Raman investigation of fluid and melt inclusions. We also experimentally simulated the hydrothermal alteration of pure eudialyte and eudialyte- and arfvedsonite-bearing rocks (250°C, 2 months) to assess their capacity to produce hydrogen and discuss H_2-producing reactions[4].

The study of the origin, migration, and storage of natural hydrogen in peralkaline rocks will provide a better understanding of H_2 production during the formation of ore deposits and its role in environmental disturbances. It is also essential for an adequate assessment of natural H_2 as a potential energy resource from continental sources.

[1] Potter, Salvi & Longstaffe (2013) *Lithos*. [2] Nivin (2019) *Minerals*. [3] Nivin *et al.* (2005) *Lithos*. [4] Truche *et al.* (2021). *Geochim. Cosmochim. Acta*.