



Downhole fluid sampling and noble gas analysis of saline waters from the Outokumpu Deep Drill Hole, Finland

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The 2516 m deep Outokumpu Deep Drill Hole is situated at the NW-SE trending boundary between the Archaean and Proterozoic domains of the eastern Fennoscandian Shield (Finland). In August 2011, eight fluid samples were collected with a Leutert positive displacement sampler (PDS) from 500 m to 2480 m depth in the open bore hole. The PDS allows sampling at *in situ* pressures, thus minimising fractionation from degassing during sampling. At the surface, the samples were transferred into an evacuated sampling line connected with a Cu-tube and a glass bulb for gas sampling, a pressure gauge, and a thermometer. Gas was liberated with a heated ultrasonic bath and then admitted to the sampling devices. Gas/water ratios were already determined in the field during gas extraction.

Saline groundwaters rich in methane, nitrogen, hydrogen and helium and with water stable isotope composition distinctive from meteoric and sea water have been found to host isolated ecosystems within the Precambrian crystalline bedrock of Outokumpu (Kietäväinen et al., 2013). In order to characterise the geochemical and microbiological evolution of the deep subsurface of the area, noble gas residence times have been calculated based on radiogenic (^4He , ^{40}Ar), nucleogenic (^{21}Ne) and fissionogenic (^{134}Xe , ^{136}Xe) noble gas nuclides. Geochemical and microbiological variations together with hydrogeological and geophysical data indicate negligible vertical fluid flow in the bedrock. Moreover, noble gas diffusion models show that diffusion is not likely to affect noble gas concentrations of groundwater at or below 500 m depth in Outokumpu. Therefore *in situ* accumulation was assumed as a basis for the age determination. In general, residence times between 10 and 50 Ma were indicated by ^4He and ^{21}Ne , while somewhat younger ages were obtained by ^{40}Ar , using average values for porosity, density and concentration of radioactive elements in the bedrock of Outokumpu.

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