Noble gas geochronology: new tools for constraining the landscape evolution of Scandinavia

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Deep-weathered crystalline basement is relatively common in Scandinavia. Offshore blanketing by Mesozoic sedimentary sequences provides minimum ages for these potential reservoir rocks. Onshore, the occasional ocurence of kaolinite suggests formation in a warmer, Cenozoic or older climate. On-shore western Norway, saprolites appear to be preserved mainly in fracture systems. Therefore, constraining saprolite formation and landscape evolution goes hand in hand with constraining the brittle deformation history of the crystalline basement.

Chemical weathering and faulting lead to the break-down and transformation of rock-forming minerals into various clays, including illite, whose neoformation can be precisely dated using the K-Ar system. However, altered rock typically hosts a range of metastable K-bearing minerals such as feldspar and amphibole, the relative concentrations of which decrease towards smaller grainsizes (<0.4 and <0.1 μm).

At NGU, clay-bearing samples are disaggregated using freeze-thaw cycles in a cryostatic bath, then suspended in de-ionized water. Illite is subsequently isolated from other K-bearing phases using continuous flow centrifugation, and particle sizes down to 0.014 μm are monitored with LPS-PIDS. Dry clay size fractions are degassed in a specially engineered ultra-high vacuum system, and argon isotopic concentrations are quantitatively determined using a new IsotopX NGX multicollector noble gas mass spectrometer using isotope dilution. Accurate determinations of the concentrations of K and other cations are made using ICP-OES, and clay mineralogy is quantitatively determined using XRD.

The IsotopX NGX noble gas mass spectrometer was commissioned in November 2015 to complement the existing $^{40}Ar/^{39}Ar$ facility at NGU. The high mass resolution of the NGX (>600) permits accurate determinations of stable cosmogenic nuclides ^{3}He, ^{21}Ne and ^{38}Ar, and future applications may include dating of paleosurfaces, fault scarps and landslides. Unlike cosmogenic radionuclide ^{10}Be, the scope of cosmogenic noble gases extends well beyond the Quaternary.