Geochemical travertine records – Insights from μ-EDXRF and μ-XRD

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Natural travertines are deposited by hot springs (thermogene origin) or by low-temperature fluids (meteogene origin). Samples were chosen from a suite of travertines collected in Uganda and Tanzania along the western branch of the East African rift system. The travertine deposits are related to sites with hydrothermal activity, which are being investigated for their suitability of geothermal energy use within the BGR GEOTHERM programme. Travertines preserve a valuable record of paleo-fluid composition. Due to their inhomogeneity (thin layering) bulk analytical methods are in most cases not sufficient to unravel the small scale chemical and mineralogical changes. Hence, a combination of in situ methods with high spatial resolution (μ-EDXRF and μ-XRD) was applied. μ-EDXRF allows element mapping with a spatial resolution of 100μm by an assumed detection limit of 50 to 100μg/g for each element (>30 elements can be detected simultaneously). Locally precise measurements with a BRUKER D8-GADDS microdiffractometer allow a rapid phase analysis with a spot size down to 50μm. Such high resolution in situ analyses of mineralogical and chemical compositions are essential for reliable genetic interpretations. Due to their non-destructive and contact-less nature they are leading to a refined procedure to take sub-samples for further detailed investigations (e.g. stable isotope analysis to distinguish between meteogene and thermogene travertines).

Archetypal Archean lithosphere from West Greenland implicates shallow melting at >3.0Ga

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We present whole rock major, trace and Re-Os isotope systematics of garnet and spinel-facies peridotite xenoliths (n = 50) sampled across the North Atlantic Craton (~700km, NAC), West Greenland at c. 600 and 200 Ma. NAC whole rock peridotites have low Al/Si (0.002 to 0.06) and high Mg/Si (1.43 to 1.61), making them distinct from Kaapvaal and Siberian cratonic lithosphere. Furthermore, at a given MgO the NAC peridotites extend to distinctly lower Al_2O_3 compared with East Greenlandic lithosphere.

Samples from the Kangerlussuaq and Sarfartoq regions (northern margin NAC) appear to be compositionally more heterogeneous; extending to both more fertile and more depleted Al_2O_3 and Mg# in comparison to samples from Pyramidfjeld (southern margin NAC). Low Sc and Al_2O_3 systematics of all samples can be reconciled with approximately 25-40% melt extraction at shallow garnet-facies conditions (~4GPa). V abundances in conjunction with Sc and Al_2O_3 indicate that relatively low fO_2 prevailed during the last melt extraction, although subtle differences exist in samples from the northern and southern NAC.

Whole rock Os isotope data shows considerable variation in NAC samples, with the most unradiogenic γOs (e.g. -14.2) corresponding to T_{RD} model ages > 3.0Ga . Harzburgites and dunites from the southern NAC indicate Mesozoic Re disturbances, possibly due to the kimberlite activity. The T_{RD} model age probability distribution of these samples shows relevant peaks at 1.8 Ga and 2.3 Ga possibly relating the lithosphere to orogenies and crustal formation events that affected the Archean basement of this area. Notably, preliminary olivine Os isotope systematics point to a significantly older formation of the lithosphere (>2.5Ga) and Os disturbance on the whole rock scale.

Melting conditions and distinct Mg/Si and Al/Si systematics of the Archean NAC peridotites indicate that archetypal Archean lithosphere formed in a relatively shallow, anhydrous setting. Furthermore, this data suggests that the orthopyroxene-rich Kaapvaal and Siberian lithosphere records secondary Si enrichment, thereby eliminating these continental roots as classic examples of Archean melting environments. Further lines of investigation will include resampling of the NAC, profiling of whole rock and constituent minerals for Os isotopes; lithophile and siderophile trace element systematics together with Hf-Nd-Sr-Pb isotope determination measurements of pyroxenes.