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U-Pb Geochronology of Hydrous Silica (Siebengebirge, Germany)

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Low-temperature, hydrous weathering eventually leads to characteristic products such as silica indurations. Elevated U concentrations and the ability of silica to maintain a closed system permits silica to be dated by the U-Pb method, which, in turn, will potentially allow constraining the timing of near-surface processes. To test the feasibility of silica U-Pb geochronology, we sampled opal and chalcedony from the Siebengebirge, Germany. This study area is situated at the terminus of the Cenozoic Lower Rhine Basin on the Rhenish Massif. The investigated samples include silicified gravels from the Mittelbachtal locality, renowned for the embedded wood opal. Structural characterization of the silica phases (Raman spectroscopy) was combined with in situ isotopic analyses, using ion microprobe and LA-ICPMS techniques.

In the Siebengebirge area fluviatile sediments of Upper Oligocene age were covered by an extended trachyte tuff at around 25 Ma. Silica is known to indurate some domains within the tuff and, in particular, certain horizons within the subjacent fluviatile sediments ("Tertiärquarzite"). Cementation of the gravels occurred during at least three successive growth stages: early paracrystalline silica (opal-CT), fibrous chalcedony, and late microcrystalline quartz. It has traditionally been assumed that this silica induration reflects intense weathering, more or less synchronous with the deposition of the volcanic ashes.

Results from U-Pb geochronology returned a range of discrete ^{206}Pb-^{238}U ages, recording a protracted silicification history. For instance, we obtained 22 ± 1 Ma for opal-CT cement from a silicified tuff, 16.6 ± 0.5 Ma for silicified wood and opal-CT cement in the fluviatile gravels, as well as 11 ± 1 Ma for texturally late chalcedony. While silicification of the sampled tuff might be contemporaneous with late-stage basalts, opaline silicification of the subjacent sediments and their wood in the Mittelbachtal clearly postdates active Siebengebirge volcanism, and the clastic sedimentation by about 8 Myr.

To account for the age discrepancies, opal-CT formation might be a local and episodic phenomenon, reflecting progressive denudation of the trachyte tuff cover. Alternatively, the dominant silicification event of the Mittelbachtal silcretes could be of regional significance (Middle Miocene Climatic Optimum). Our relatively fast approach by LA-ICPMS analysis will be used to further expand the database.