Replacement of wood opal by chalcedony: Implications for U-Pb geochronology

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The U-Pb system of hydrous silica potentially provides age constraints on near-surface, low temperature processes, such as fluid migration during weathering or hydrothermal activity. Reliable application of the opal geochronometer requires an understanding of the processes that could cause complications for its U-Pb systematics. Silica can experience a complex structural evolution from amorphous to cryptocrystalline states (opal to chalcedony).

We studied a natural sample of petrified wood from the Siebengebirge, Germany, where uraniferous opal was replaced by chalcedony. The petrified wood occurs within quartzous sand and gravels of Upper Oligocene stratigraphic age. The sediments were covered by an extended trachyte tuff around 25 Ma and document a protracted history of silica indurations. Results from ionprobe and LA-ICPMS opal U-Pb measurements indicate that the dominant silicification event clearly postdates active volcanism and clastic sedimentation by about ~8 Myr. Fluorescence microscopy and Raman analyses revealed that some domains of Siebengebirge wood opal-CT are characterized by well-preserved tracheid cell structures and thus represent the texturally oldest silica generation. At a later stage, the early wood opal was partially transformed to chalcedony. Across the reaction front between both silica domains the inherited wood structure fades out and secondary μm-sized inclusions accumulated and pertruded as inclusion trails into the opal matrix. Carnotite and likely vanadinite (U- and Pb-vanadates, respectively) were identified as the primary inclusion phases. LA-ICPMS U-Pb analyses of the uraniferous, tracheid-textured wood opal returned a highly dispersed pattern within time-resolved spot segments. Measured isotopic ratios spread close to the concordia with apparent ^{206}Pb-^{238}U ages spanning from 10 to 200 Ma. The pattern suggests a heterogeneous redistribution of radiogenic lead (and less pronounced of uranium) within the analytical volumes. Probable hot spots are the secondary vanadate phases that readily recognized along a replacement front.