Metamorphosed Permian vertebrate fossils: geochemistry and mineralogy of “white” sharks

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The intra-mountainous Saar-Nahe Basin (SNB), SW Germany, a strike-slip-fault basin formed during the Variscian orogeny, was filled by a large freshwater lake system during the Early Permian. The SNB experienced intense syn- and post-depositional magmatic activity, resulting in a complex volcano-sedimentary sequence of magmatic intrusions, lava flows and tephra deposits intercalating in continental red beds and limno-fluvial sediments. Fossils preserved in white color are found in Permo-Carboniferous fluvio-lacustrine siliciclastic floodplain sediments with thin intercalated limestone banks, of the Remigiusberg Formation in the SNB. The oldest amniote fossil of Germany and other partly articulated tetrapod remains were recovered from it at the Remigiusberg quarry near Kusel (e.g., Fröbisch et al., 2011; Voigt et al. 2014). These terrestrial tetrapods were discovered together with aquatic vertebrate fossils in close proximity (< 5 m; within the contact aureole) to an underlying decameter thick sill of kuselite, an auto-hydrothermally altered andesite. We aim to assess the thermal and chemical impact of post-depositional contact metamorphism and hydrothermal activity associated with this sill on the bioapatite of vertebrate skeletal remains by characterizing the elemental, isotopic and mineralogical composition of these fossils. White-colored, likely hydrothermally altered teeth of the freshwater shark Lebachacanthus were analyzed and compared to shark teeth of the same species retaining their original black color, from contemporaneous unmetamorphosed lacustrine black shale deposits in the SNB.

In situ Electron Microprobe analysis and Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) elemental profiles reveal distinct diagenetic histories for the black- and white-colored shark teeth. This is further supported by apatite δ¹⁸O and δ¹³C values, which indicate different secondary alteration by fluids for both facies. Raman spectroscopy and X-ray diffraction on bulk powder samples identify fluorapatite as the major mineral phase in all teeth. Apatite crystallinity of both dentin and enameloid is higher in white- than in black-colored fossils, consistent with crystallite growth due to thermal overprint of > 500 °C. For both, white- and black-
colored shark teeth, LA-ICP-MS U-Pb analyses yield inconclusive data and unexpectedly young ages inconsistent with known ages of deposition or metamorphism.

We are currently analyzing the petrology of the kuselite to constrain the metamorphic evolution of sediments in the contact aureole by modelling. Additionally, heating experiments of modern bioapatite samples are performed to further constrain the alteration temperature. Altogether, these data will enhance our understanding of the particular thermometamorphic/hydrothermal conditions required to form white-colored, recrystallized vertebrate fossils in the context of the magmatic-metamorphic evolution of the SNB.

References
