Geophysical Research Abstracts
Vol. 16, EGU2014-14619, 2014
EGU General Assembly 2014

Early diagenesis of travertine deposits from the Tibetan Plateau – implications for ^{230}Th/^{234}U dating and palaeoenvironmental reconstruction

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Travertine is calcium carbonate precipitated from hydrothermal springs. These terrestrial carbonate deposits can be used as high-resolution archives for reconstructing palaeoclimatic and palaeoenvironmental change and are also suitable for uranium-series disequilibrium (^{230}Th/^{234}U) dating. In many instances such spring deposits are associated with archaeological remains (e.g. stone artifacts and other traces of prehistoric human activity) and are therefore of interest for palaeoclimatologists and archaeologists alike. However, travertines are often affected by early diagenesis that can impact on the closed-system U-series behavior and on their geochemical signature. Hence, careful evaluation of the travertine microfabrics is required before these types of hot spring deposits can be accurately dated and used for paleoenviromental reconstruction.

The Tibetan plateau hosts numerous hydrothermal spring deposits that occur along neotectonic faults. In this study, samples were collected from two archaeological travertine sites, i.e. Chusang and Tirthapuri, located in southern and western Tibet, respectively. Microscopic analysis of thin sections reveals a wide variety of crystal fabrics, including micrite, microspar and sparite, the latter can be composed of columnar or mosaic crystals, respectively. Areas where dendritic crystals are preserved are identified in our micrographs as well. Many of the Chusang and Tirthapuri travertine samples are porous. Drusy sparite is rimming most of the pore walls and a complex succession of secondary calcite phases precipitated in these pore spaces as well. The different generations of pore cement comprise micrite and sparite that can be laminated or fibrous in character and show sometimes evidence of an aragonite precursor. Detrital material like quartz, feldspar and other grains as well as humic and fulvic acids have been washed into the travertine pores too.

Based on our microscopic analysis a complex growth history can be reconstructed for these Tibetan travertine samples with evidence for early diagenetic alteration. In particular the dendritic calcite is known to form under hydrothermal conditions and can thus be regarded as a primary hydrothermal fabric. However, this fabric is preserved as a relict in some samples only, suggestive of widespread early diagenesis. In other samples primary - biologically mediated – calcite precipitation can be inferred from microfabrics; however, recrystallization to mosaic sparite took place soon after deposition for most of them, too.

Here we combine detailed petrographic investigations with XRD, microprobe as well as stable isotope analysis and a systematic ^{230}Th/^{234}U dating approach. We show that certain fabrics act as closed system with respect to radiogenic isotopes and are thus suitable for U-series dating. For the majority of fabrics encountered in our Tibetan samples, however, early diagenesis can be inferred and these fabrics also suffer from open-system behavior, hence, require and ‘isochron’ dating approach. Guidelines are established for identifying early diagenesis in these Tibetan travertine samples and implications for palaeoenvironmental reconstruction are discussed.