Age and distribution of southern Appalachian metamorphism delimited by SHRIMP U-Pb metamorphic zircon ages

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SHRIMP U-Pb ages of metamorphic zircon from twenty-five samples across the GA-NC-SC Blue Ridge and Inner Piedmont delimit three distinct Paleozoic events that require modification of existing southern Appalachian tectonothermal models. Metamorphic zircon textures include overgrowth rims, and sparse dark gray to black, unzoned subhedral to anhedral metamorphic zircons and soccer ball-shaped morphologies. Th/U range from 0.01–1.2, with most less than 0.1. ^{206}Pb/^{238}U ages (>90% concordant) range from 500–300 Ma, and a relative probability plot defines peaks at 460, 450, 425, 389, 362, 344, and 325 Ma. The distribution of zircon metamorphic ages indicates that different parts of the southern Appalachian orogen experienced different tectonothermal histories. (1) All 460–450 Ma ages occur in the western and central Blue Ridge, and define a continuous section from greenschist to granulite facies that represents the intact Taconian orogenic core. (2) The Inner Piedmont contains metamorphic zircon ages of 399–311 Ma with peaks at 389, 362, 344, and 325 Ma, and represents the Neoacadian metamorphic core with an Alleghanian overprint. (3) The eastern Blue Ridge contains evidence of three possible tectonothermal events, 460–450, 360–340, and ~320 Ma, probably the result of overlapping Taconian, Neoacadian, and Alleghanian orogenies. Extensive 617-535 and local 457-444 Ma metamorphism and deformation in the peri-Gondwanan Carolina superterrane are not overprinted by a regional amphibolite facies or higher metamorphism at 360–350 Ma and precludes accretion prior to the Devonian. These Appalachian orogenies record the outward growth of the orogen, and closely parallel Varisican orogenies.

Combined Th-U isotope and multi-element analyses by LA-ICP-MS

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In situ Th and U isotope ratio determination with high spatial resolution in incrementally growing U-bearing geological (e.g. speleothems, soil carbonates, silicates) and biological (e.g. bones, teeth, corals) materials offer the possibility of dating precipitation processes in various fields of Earth science. In addition, multi-element analyses on these materials provide chemical proxies, such as Sr, Ba, Mn or Mg, related to, e.g. paleoenvironmental research.

We applied a recently developed *in situ* technique for determination of Th and U isotopic ratios applicable to samples with U concentrations as low as 1 μg g^{-1} using a single-collector sector-field ICP-MS connected to a 213 nm Nd:YAG laser ablation system [1]. Such instrumentation has the advantage of (1) high spatial resolution, (2) high sensitivity, (3) calibration of only one detection system, and (4) the option of multi-element and isotope analyses.

In order to develop a suitable technique for simultaneous multi-element concentration and isotope ratio determination, we used reference materials of different matrices. The material was ablated using line scans of 500 to 2000 μm length, consuming about 15 to 60 μg material. Calibration of low ^{230}Th/^{238}U ratios was performed using the USGS BCR-2G glass having a Th/U = 3.507 ± 0.018 (1SE) (GeoReM database) and a natural ^{238}U/^{235}U ratio of 137.88. Mass fractionation was determined from the measured ^{238}U/^{235}U ratio of the sample. Accuracy was tested using some USGS and MPI-DING silicate reference glasses as well as the carbonate reference material USGS MACS-3 and Zircon 91500. The synthetic MACS-3 sample yield a non-natural ^{238}U/^{235}U ratio of about 364. For a travertine sample we found, for instance, variable Th (0.0006 to 0.004 μg g^{-1}), U (2.35 to 2.56 μg g^{-1}), Sr (129 to 142 μg g^{-1}), and Ba (32 to 39 μg g^{-1}) concentrations. However, the travertine is homogenous with respect to Th and U isotope ratios, since ^{230}Th/^{238}U (2.49×10^{-5}) and ^{234}U/^{238}U (7.49×10^{-5}) are constant (RSD = 1%) and agree within 2% with precise TIMS data.

[1] Mertz-Kraus *et al.* (2009) *Eos Trans. AGU*, **90**(52).