On the Interpretation of Zircon U-Pb ages from (U)HP Host Gneisses in the Woodlark Rift of Papua New Guinea

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Abstract

Conventional analysis of accessory minerals in 'spot-mode' in polished sections samples crystal volumes, that even in high-sensitivity secondary ionization mass spectrometry (SIMS), have diameters of ~10-20 µm. These 'spot mode' analyses can reveal the ages and trace element compositions of crystal domains if the domains are larger than the lateral beam dimensions. They cannot, however, be used to characterize variations that occur over smaller dimension, or that occur at sharp boundaries between discrete domains often observed in cathodoluminescence (CL) images. Because of this spatial limitation, conventional spot analysis cannot be used to investigate processes operative at scales <10 µm, and the relationship between the U-Pb isotopic and trace element records in the same crystal volume.

In this study SIMS depth-profiling was used to characterize zircons from felsic and intermediate gneisses that host the world's youngest (U)HP eclogites in southeastern Papua New Guinea. Many zircon CL images show cores overgrown by dark CL rims. SIMS depth profiling perpendicular to unpolished zircon surfaces, and penetrating to a depth of ~15 µm, effectively measured the U-Pb isotopic and trace element composition at a depth resolution of <1 µm. Crystal domains up-to and across the sharp transition from overgrowth into inherited core were investigated. These depth profiles are augmented by U-Pb data collected in 'spot mode' on 1) polished cross sections, and 2) external (i.e., unpolished) surfaces.

The U-Pb results reveal zircon grew in the Pliocene as individual crystals, and as overgrowths on Late Jurassic to Cretaceous cores. Zircons lacking Cretaceous cores and with uniformly Pliocene ages also displayed complex internal zoning patterns under CL. The Pliocene zircons are within error of $^{40}Ar/^{39}Ar$ mineral ages on the (U)HP host gneisses and indicate zircon crystallization during (U)HP exhumation. The U-Pb zircon systematics in the host gneisses provide information about the protolith age followed by zircon growth at temperatures of ~590 to 690 °C based on Ti-in-zircon thermometry. Small scale geochemical disequilibrium within the host gneisses at the time of zircon crystallization is indicated by contrasting trace element compositions for different zircons that crystallized simultaneously under similar conditions. The fact that zircons of uniform age display complex CL zoning patterns indicates that the zoning observed in CL images is not a function of growth rate, but instead may be related to changes in trace element concentration at the zircon-matrix interface during zircon growth.

Temporal resolution of LA-ICPMS analyses of fish hard parts

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As far as elemental and isotopic distributions vary locally in natural ecosystems, they are also taken up by living organisms and consequently incorporated in time resolved manner in incrementally growing tissues. Increasingly, this phenomenon is also used to answer key questions in fish ecology, such as seasonal habitat use, migration and dispersal.

Unfortunately, basic hydrobiological processes are increasingly disturbed by human activities in river systems all over the world. Understanding the spatio-temporal behaviour of fish and their connectivity needs is crucial for e.g. coordinated river rehabilitation and management.

Beside the local differences in the elemental distributions the naturally varying Sr isotopic composition of river water, derived from geological differences within the river catchment, provides the basic prerequisite for studying these phenomena based on the microchemical analyses of different fish hard parts.

In order for the elemental and isotopic signature of water getting unambigously reflected in hard parts of fish (like otoliths, scales, vertebrae or fin rays), fish have to stay a certain time in an habitat for equilibration and sufficent uptake of the environmental information. However, the time needed for equilibration and for incorporating a unique signal is unknown and differs between species and life stage.

Laser ablation coupled to multi-collector inductively coupled plasma mass spectrometry (LA-(MC)-ICPMS) was used for the determination of elemental concentrations and Sr isotope ratios in fish hard parts for studying the potential reflection of short term migrations and habitat changes. Much effort has been made with respect to the optimization of laser parameters in order to achieve best spatial resolution on different hard parts of fish while keeping uncertainties as low as possible. Fish from different sources (natural, aquaculture) and the related water chemistry were investigated. In addition, a caging experiment was conducted to study the uptake of environmental information into fish hard parts under semi-controlled conditions. European chub, *Squalius cephalus* (L.), for example, were moved between rivers with contrasting water chemistries and exposed in cages for three and six months. The main aim was to determine the required time of residence of a fish in a certain habitat to create a unique signal matchting the river environment when LA-(MC)-ICPMS is used for the determination of both elemental concentrations and Sr isotope ratios. The major focus was set on the analyses of otoliths, vertebrae, scales and fin rays, with the latter two options representing important non-lethal sampling alternatives.

Herein, we present our latest results on on different fish hard parts measurements using LA-ICMPS, including a discussion about the implications of the results for an application of this technology to fish ecological questions.