Geochemical analyses in fossil tooth apatites: Determining U uptake processes and paleoenvironmental conditions for diagenetic alteration

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Geochemical analyses from NAA (neutron activation analyses) can elucidate the geochemical conditions that controlled secondary mineralization and particularly U uptake during fossil diagenesis. Mammalian teeth were collected from 98 archaeological and paleontological sites from 12 geochemically distinct paleoenvironmental settings. Minor and trace element concentrations for 14 elements were measured using instru-mental and delayed neutron counting (DNC) NAA in 1540 fossil tooth tissues and 260 sediment samples collected in association with the teeth.

For fossils deposited in non-saline paleoenvironments, U concentrations never exceeded 4 μg/g in enamel or 50 μg/g in dentine, and ^{235}U and ^{238}U did not fractionate during fossil diagenesis. For fossils from saline paleoenvironments, U concentrations in dentine often exceeded 100 μg/g with maxima near 420 μg/g, while those in enamel had concentrations as high as 45 μg/g.

Strong correlations existed between Fe vs. Sc and Sc vs. La in the sediment for most sites, but no significant correlations occurred between Fe vs. Sc or Sc vs. La in either tissue, suggesting different mechanisms for their absorption.

Fe concentrations were highest in teeth from spring deposits, whereas Mn concentrations were highest for enamel and dentine from fluvial systems. For several sites, Mn plotted against U concentrations showed strong positive correlations in both enamel and dentine under diverse reducing conditions, in peat bogs to open air alluvial sites. Mn, therefore, may prove to be a suitable proxy for U uptake studies in fossil teeth. The lack of correlation between Mn vs. Fe and U vs. Fe suggests that diagenetic conditions, possibly bacterially mediated, favoured Mn over Fe precipitation. Mn^{2+} and $UO_2(CO_3)_2^{2-}$ probably co-precipi-tated or were co-adsorbed onto the apatite crystal surfaces.

Dating mineral containing a significant common Pb component–The benefits of *in situ* LA-ICP-MS analysis

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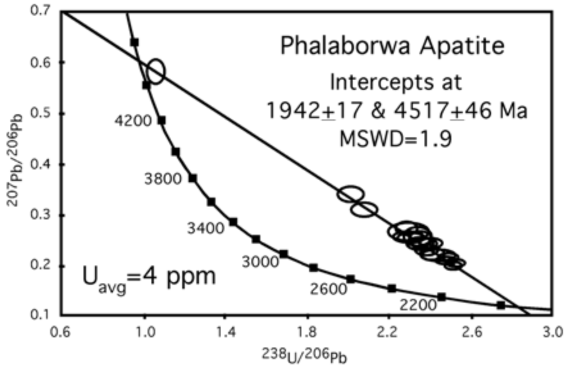
Uranium-Th-Pb dating is targeted at zircon because it is robust, has a high closure T, and has a very low common Pb content. Nonetheless, many rock types do not contain zircon. For example mafic rocks lack zircon as do many syenites, and most carbonatites. Here we present data for apatite and titanite analyzed either in thin section or mineral mounts that have been successfully employed to date these rock types in 1-2 hour sessions.

Minerals with relatively high common Pb contents have been eschewed for geochronology because common Pb composition must be measured or estimated. The LA-Q-ICP-MS can date parts of individual mineral grains at the 30-60 micron scale, which takes advantage of the imperfections of the crystallization process, namely parent-daughter ratios that vary from one ablation to the next. Usually there is sufficient parent/daught spread to construction chords (discordia) based on tens of analyses that yield *both* reliable lower intercept ages (precise to 1-3%) and upper intercept values (towards common Pb composition).

Here is an example of apatite from Phalaborwa carbonatite. The crystallization age as determined by TIMS U-Pb analyses of baddeleyite is 2060+/-1 Ma (Heaman and LeCheminant, 1993). Dolerites that cross-cut the complex are ~1950 Ma (Morgan and Briden, 1981).



References

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