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A New Approach to U-series Dating of Bone Using TIMS

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Until now, U-series dating of archaeological or fossil bone could not be considered reliable. The fundamental problem is that bone does not conform to the standard U-series dating assumptions - that U is present since formation, and is neither gained nor lost except through radioactive decay. Bone is an 'open system' and acquires U from the burial environment. Dating bone requires understanding and mathematical modelling of the uranium uptake process. Traditional models of U uptake (e.g. early uptake and linear uptake) are based around mathematically convenient models that have no basis is the physics or chemistry of uranium-bone interaction. Furthermore, these models are often applied without justification for the application of a particular uptake model to a particular bone. Millard & Hedges' (1996) diffusion adsorption (D-A) model, on the other hand, represents a physico-chemical description of U uptake in bone. It predicts the rate of U uptake and the spatial distribution ('profiles') of U and U-series isotopes across a bone section. The D-A model can also be used to rationalise the effect of geochemical changes in the burial environment on U profiles and U-series dates and to show how the U uptake history of a bone is reflected in these profiles. For example, an increase or decrease in the U concentration of the groundwater at a burial site can lead to characteristic 'leached' or 'recent uptake' profiles.

We present the measurement of U concentration profiles by ICP-MS and U-series date profiles by TIMS for bones from a number of sites of different ages, burial hydrology and geochemistry. Of the U profiles, all but a few 'irregular' profiles agree qualitatively with the D-A model. Both 'leached' and 'recent uptake' bones can be identified (and rejected for dating) on the basis of their U concentration and date profiles as predicted by the D-A model. For those cases where the U concentration profiles indicate that constant diffusive uptake has occurred, the D-A model has been applied to calculate 'open system dates'. Good agreement has been found between these calculated U-series dates and (mostly ^{14}C) control dates, demonstrating the validity of the D-A model as applied to archaeological or fossil bone. When both the U concentration and date profiles fit predictions of the D-A model, the dates presented are considered the first truly reliable U-series dates on bone.

In addition, the early uptake process can be explored using the D-A model along with geochemical and hydrological models of the burial environment and measurements of bone diagenesis. A number of mechanisms by which early uptake can occur are presented.

Millard, AR & Hedges REM, *Geochimica et Cosmochimica Acta*, **60**, 2139-2152, (1996).