Lu-Hf dating of sedimentary successions: Lessons learned

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It is notoriously difficult to obtain geochronological constraints for sedimentary formations with few or no biostratigraphic tracers and ash layers. The reasons for this are the necessity that the mineral phases chosen for dating 1) are truly authigenic, 2) remained closed systems since deposition and 3) do not include minor inherited phases such as clays at the time of analysis. Furthermore, the mineral must be rich in the radioactive parent isotope relative to the daughter product for the radiometric dating scheme. Phosphates, such as apatite and francolite, occur widely in sedimentary rocks as fossils and nodules, and are suitable candidates for sedimentary dating. In these phases, rare earth elements and uranium are favorably incorporated into the crystal lattice making them potentially suitable for dating by the lutetium-hafnium (Lu-Hf) and uranium-lead (U-Pb) systems. This talk presents a review of the results from sedimentary phosphates obtained to date, as well as the pro's and con's of the technique. Despite its limitations, dating of sedimentary phosphate by the Lu-Hf and U-Pb systems provides new age constraints for the sedimentary record that may lead the way for a better understanding of Earth history.

Sr isotope constraints on extent and character of fluid flow in EPR crust

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Crust formed at the super-fast-spreading southern East Pacific Rise ~3 my ago has been sampled at the north of the Easter microplate (22ºS) from two NW-SE striking escarpments at Pito Deep. The escarpments expose lavas, sheeted dikes and plutonics and provide a unique opportunity to investigate the lateral variations in hydrothermal alteration in the ocean crust. We use Sr isotope and trace element analyses integrated with petrographic indications of alteration to examine heterogeneity of fluid flow though the ocean crust.

The mobile metals Cu and Zn are variably depleted relative to magmatic concentrations but this depletion is decoupled from enrichments in $^{87}Sr/^{86}Sr$. Strontium isotopic enrichment is also decoupled from Sr concentration suggesting that uptake of seawater Sr, for example into epidote, is not the principal control on the changing $^{87}Sr/^{86}Sr$.

Two escarpments at Pito Deep allowed sampling of sheeted dykes over vertical extents of 700 m and 1000 m respectively. Sheeted dykes from two escarpments show $^{87}Sr/^{86}Sr$ of 0.70252-0.70364 and 0.70267-0.70466 respectively. Fresh MORB in this area has a $^{87}Sr/^{86}Sr$ of 0.70239. Localised (few to 10's m) anomalously high $^{87}Sr/^{86}Sr$ (> 0.703) are associated with proximal faults. We interpret these data as indicating that these acted as conduits to channel fluid flow at high-temperatures. This provides compelling evidence for significant modification of rock and consequently fluid compositions during channelised flow.

In order to compare the extent of Sr-isotopic exchange between hydrothermal fluids and the crust at Pito Deep with the other two areas that have been studied in detail (Hess Deep and ODP Hole 504B) we have modelled the fluid flux through the system. We use the modelling approach developed by Bickle (1992) that assumes pervasive, kinetically hindered, isotopic exchange during one dimensonal fluid flow. Although this does not appear to describe the hydrology of the system it allows quantitative estimates of the differences in fluid flux between these areas to be considered.

Modelling of Sr isotopic differences between the two escarpments at Pito Deep reveals spatial variability in fluid flux through the ocean crust formed in one location. Comparison with Hess Deep and ODP site 504B indicates that Pito Deep has experienced greater Sr isotopic exchange and consequently higher fluid flux. Interpretations will be discussed in the context of structural and thermal variations on regional and local scales.

References

Bickle. M.J., (1992) *Am J Sci* **292** 289-316.