Flying through time: New microXRF techniques create opportunities to view the past.

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Abstract

New advances in microprobe technology at beamline X26A, at the National Synchrotron Light Source at Brookhaven National Laboratory, are allowing rapid and high resolution imaging of the distribution and concentration of elements in a sample. With this technique, called a fly-scan, we collect high resolution images in few hours that with conventional XRF scans would take a day. Currently the beam size is approximately 6 x 9 microns, giving a practical limit for the sampling interval of 4 -6 microns. The output of the fly-scan contains the full energy spectra for every detector at each point. To create an image, at each point, a window around the desired spectral peak is summed from each detector. This stacking helps eliminate noise, and provides an additive effect to the sampling time. Thus images of the distribution and concentration of any element whose florescence spectra is within the detection range of the sensors can be created after the data has been collected (Fig. 1).

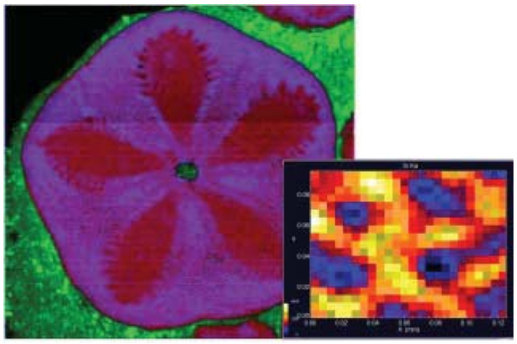

Figure 1: Flyscan image of echinoderm fossil showing distribution of Ca (red) Fe (green) and Sr (blue). Inset of high resolution Sr map from conventional XRF scan showing the typical ossicle structure where the shell is high Sr and the ferroan calcite cement is low Sr.

Carbonate fossils, such as echinoderms, can be used as proxies for the Sr/Ca and Mg/Ca ratios in paleoseawater. However diagenesis and other factors can change the composition of the carbonates. Echinoderm ossicles have a complex porous structure that can rapidly fill with encapsulating cement. This encapsulating cement protects the original carbonate material and creates a microscopic time capsule of the original chemistry [1]. We use fly scan imaging to identify extremely well preserved samples of fossil echinoderms, and measure the composition of the fossil stereom. We then calculate the Sr/Ca ratio of seawater then the fossil was formed. Our results confirm the observations that Sr changes inversely with Mg, and the total strontium concentrations is seawater have fluctuated by a factor of 5, throughout the Phanerozoic [2].

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The petrogenesis of monogenetic volcanoes inferred from Lunar Crater Volcanic Field, Central Nevada

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The origin of chemical and isotopic variability observed over small spatial scales in basaltic monogenetic volcanic fields is highly controversial, and may be attributed to mantle heterogeneity [1] or to shallow lithospheric assimilation [2, 3], or both. The Lunar Crater volcanic field provides an opportunity to address the importance of shallow versus deep processes in the petrogenesis of basaltic monogenetic volcanoes and the nature of their mantle sources. We have performed Sr, Nd, Pb, Hf and Os isotopes measurement on 19 basaltic lavas from four closely spaced volcanic centers in the northern LCVF. Three eruptive centers (named YMB, OPB and PB [4]) are located within ~500 m of each other; the Marcath volcano, which represents the youngest eruptive center in the field, is located ~6 km SW of these cones. Detailed isotopic studies of the volcanic rocks show a limited range in Nd and Hf isotope ratios, but significant heterogeneity in Sr and Pb isotopes, and superchondritic Os isotope ratios. The lavas are characterized by ^{87}Sr/^{86}Sr ranging from 0.7030-0.7037, ^{143}Nd/^{144}Nd 0.51286-0.51291, ^{176}Hf/^{177}Hf 0.28293-0.28298, ^{206}Pb/^{204}Pb 19.16-19.49, ^{207}Pb/^{204}Pb 15.55-15.61 and ^{208}Pb/^{204}Pb 38.44-38.82. Os concentrations vary from 2 to 241 ppt and ^{187}Os/^{188}Os ranges from 0.1336 to 0.61. The lavas produce a well-defined negative correlation between Sr and Pb isotopes that could be attributed to lower crust assimilation. However, the lack of correlation of Sr, Nd or Os isotopes with indices of fractionation (e.g. MgO) suggests a limited role for crustal assimilation. In addition, high (OIB-like) Nb/U ratios and a positive correlation of ^{187}Os/^{188}Os with Nb/U argue against an important role for either upper or lower crustal assimilation. These data suggest instead that the basalts are generated by tapping a heterogeneous, enriched mantle source, consistent with trace element chemistry [5]. The HIMU-like trace element patterns and Sr and Pb isotope signatures of the OPB and PB lavas are consistent with derivation from an enriched mantle source with a component of recycled oceanic crust. In contrast, the relatively high Ba, Rb and Cs coupled with lower ^{206}Pb/^{204}Pb and higher ^{87}Sr/^{86}Sr of the Marcath and YMB lavas are consistent with derivation from an EMI-like mantle source that may be produced by a component of recycled oceanic crust plus sediment. These data indicate that the mantle in this region is characterized by chemical and isotopic heterogeneity over very small spatial scales.

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