In-situ analysis of Pb isotope ratios by LA-MC-ICP-MS: Applications to ore genesis and igneous petrogenesis

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UV laser ablation systems and sector field ICP-MS instruments, particularly those with multi-collection capacity, allow rapid in-situ measurement of isotopic ratios in small sample volumes. We report here details of in-situ Pb isotope measurement technique using a 193 nm ArF Excimer laser and NuPlasma MC-ICP-MS instrument and discuss applications to studies of igneous petrogenesis and ore genesis.

Pb isotope ratios can be measured in materials with Pb contents as low as a few ppm. Limitations on analytical precision and accuracy derive from the mass bias correction, instrumental drift and isobaric interference of ^{204}Hg on ^{204}Pb, however the primary limit of precision is the Pb ion beam intensity. This is largely a function of Pb contents and the analytical volume available for analysis and thus may vary considerably between applications. Mass bias is monitored via external normalization based on analysis of standard glasses, and instrumental drift rates require analysis of standards only every ~20 minutes. ^{204}Hg background is relatively low, typically contributing < 1% of the total ^{204}Pb signal. Overall this protocol enables accurate and reproducible analyses of basaltic and rhyolitic glasses, silicate groundmass, plagioclase and alkali feldspar, and sulfide phases. Ratios of ^{208}Pb-^{207}Pb-^{206}Pb can be measured to internal and external precisions of better than 0.1-0.5% at total Pb intensities as low as 5-10 mV, however ratios involving ^{204}Pb require either use of on an electron multiplier, or if using a Faraday cup, total Pb beam intensities of >100 mV.

Applications of this technique to Mount St Helens dacite and the Bushveldt intrusion are described in other presentations. Analysis of hydrothermal and igneous feldspars from the Butte mining district, Montana constrain sources of Pb and other ore elements. Pb isotope compositions of hydrothermal K-feldspar from main stage ore veins suggest that both the porphyry and main stage hydrothermal systems introduced hydrothermal Pb that cannot be derived entirely from the host Butte quartz-monzonite. This interpretation is consistent with the presence of abundant inherited zircons of Proterozoic age, also found in the mineralizing porphyries.

In situ Sr isotopes measured by LA-MC-ICPMS: Utility for the average Joe

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In situ analysis of Sr isotopes measured by laser ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICPMS) holds great promise for a broad range of scientific fields from igneous petrogenesis to fish ecology. Although the potential for such analyses has been apparent from at least the early 1990's, it has only been in the last few years that this technique has become refined to the point to have wider applicability, mainly as a result of technological advances in both inductively coupled mass spectrometry and lasers. To date however, most applications have focused on minerals with abnormally high Sr concentrations, giving researchers the inaccurate impression that common minerals with normal Sr contents cannot be successfully analyzed. In fact, minerals from typical alkalic and tholeiitic basalts can be successfully targeted, usually with adequate measurement precisions to evaluate and constrain open-system effects and mineral residence times. For Sr isotopes, accuracy of analyses has proven to be critically dependent on successfully accounting for the interfering effects of both elements and molecules such as Ca-dimers/Ca-argides, Fe-oxides, Rb, Kr, doubly positive Er and Yb, and potentially others. Current literature suggests the presence of such interfering elements are not only material dependent but also machine dependent in regard to both manufacturer and individual machines. These traits combine to make accurate measurement of Sr isotopes very difficult to obtain *in situ*. Great strides have been made however, and we can now accurately measure Sr isotopes on a variety of complex materials. We present an overview of current successes, analytical challenges, and future directions for Sr isotopes obtained by LA-MC-ICPMS. We incorporate results for carbonate fish otoliths and typical volcanic rock phenocrysts including basaltic and dacitic plagioclase, alkalic and tholeiitic clinopyroxene, and basaltic, basaltic andesite, and andesitic groundmass analyzed by LA-MC-ICPMS.