High precision uranium isotope analysis of very small samples by MC-ICPMS

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Accurate and precise measurements of uranium isotopes for dating geological materials are challenged by the available sample size, the sensitivity of the mass spectrometer and the limited abundance sensitivity of the mass spectrometer. Since the U isotope abundances are spread across a large dynamic range a mixture of Faraday Cup detectors and high sensitivity ion counting detectors combined with an high abundance sensitivity energy filter device to discriminate against peaktailing effects have to be used

Here we describe an analytical approach where we use high stability ion counting detectors as well as high gain current amplifiers (10^{12} Ohm) to accurately measure $^{234}U/^{235}U$ and $^{234}U/^{238}U$. In order to correct for mass bias and gain of the ion counters, a ^{233}U-^{236}U double spike can be added to the samples. Experiments were carried out using the Thermo Scientific NEPTUNE.

The following strategy has been considered. The major U isotope was measured on a 10^{12} Ohm amplifier. All minor U isotopes, including the double spike peaks ^{233}U and ^{236}U were measured on ion counters. To improve abundance sensitivity on the minor U isotopes, an RPQ/energy discrimination lens was used. The sensitivity of the Thermo Scientific NEPTUNE was optimized by a modified ICP interface.

Heat-producing elements in the Earth's core revisited

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Recent examination of mantle plume heat fluxes has revealed that the heat flux at the core mantle boundary could be higher than previously thought and a heat core loss as high as 12 TW has been suggested. In this context, the presence of heat producing elements (HPE) in the core needs to be reconsidered. Experimental studies of K, Th and U partitioning between metal and silicate liquid generally indicate that the HPE are not strongly enriched in the metal. There are, however, some conditions that would allow greater HPE contents in the core. First, in order to incorporate a substantial level of U, the conditions need to be reducing in comparison with the generally assumed oxygen fugacity at IW-2. Recent models of siderophile elements suggests that oxygen fugacities could actually have been variable during terrestrial accretion with a reducing early stage. Second, although the liquid metal/liquid silicate partition coefficients for HPE are small, if one considers a crystal mush below the base of the magma ocean as the point of last equilibration, the incorporation of HPE in the liquid metal becomes much greater because HPE are highly incompatible in silicate minerals.

There are however potential issues with such a scenario: Under reducing conditions, Nb is incorporated in the core and the Nb/Ta ratio of the mantle after core extraction should be consistent with observations. Similarly, other siderophile elements could be affected by the process. Based on a model for other siderophile elements, we found that the most siderophile elements are only weakly affected and that if the reducing stage represents only a fraction of the total accretion, Nb/Ta ratios in the mantle can be accomodated. Although we cannot prove that this scenario was effective, it would predict a substantial fraction of heat due to HPE and this in turn would affect estimates of the heat flow at the core-mantle boundary, models for the age of the inner core and the available heat for generating the geodynamo.