

High precision measurement of Ti isotopes in terrestrial and extraterrestrial materials

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Ti is an element of considerable geochemical and cosmochemical importance. But its isotope system remains largely unexplored due to the lack of suitable analytical techniques. Here we report high precision results of Ti isotopes in both terrestrial and extraterrestrial material, of Ti isotopes using MC-ICPMS.

To avoid potential matrix effects and isobaric interferences, a three-column procedure has been developed for Ti purification. The first column uses an anion exchange resin, where Ti, Zr and Hf are separated from the other major and trace elements. In the second column, Ti is separated from Zr and Hf using U/TEVA resin. Trace amounts of Al and P are further removed using the same anion exchange resin in a third column.

After chemical purification, Ti isotope ratios are measured using a Nu Instruments MC-ICPMS with a standard-sample bracketing approach. Solutions of standard and samples are introduced into the mass spectrometer through a Cetac MCN6000 desolvation nebulizer in 0.1M HF. The Ti isotope results are expressed in ϵ units which are deviations in parts per 10⁴ from the Ti isotope reference material:

$$\epsilon^x\text{Ti} = \left(\frac{{}^x\text{Ti}_{\text{sample}}}{{}^x\text{Ti}_{\text{standard}}} - 1 \right) \times 10000$$

where ${}^x\text{Ti}_{\text{sample}}$ and ${}^x\text{Ti}_{\text{standard}}$ are measured ratios of ${}^x\text{Ti}/{}^{46}\text{Ti}$ for the sample and the standard, respectively, and x denotes a mass number of 47, 48, 49 or 50. The long-term repeatability (2SD) is 0.4, 0.6, 0.7 and 0.8 ϵ units for $\epsilon^{47}\text{Ti}$, $\epsilon^{48}\text{Ti}$, $\epsilon^{49}\text{Ti}$ and $\epsilon^{50}\text{Ti}$, respectively.

A number of natural samples have been analysed, including basalts, mantle xenoliths, loess, and bulk chondrites and achondrites. An overall variation of ca. 15 $\epsilon^{50}\text{Ti}$ units has been observed. When plotted on a multiple isotope diagram, the Ti isotope results of the natural materials fall on the same lines with those resulting from instrumental mass fractionation. This correlation is consistent with theoretical expectation if the Ti isotope composition of the analysed materials evolved from a single isotopically uniform source in a mass-dependent manner.

The new techniques reported here makes possible for the first time the measurement of both mass-dependent fractionation and anomalies of Ti isotopes to high precision. The project in progress will make further investigation of Ti isotope compositions in meteoritic materials of chondrules and CAIs. Those results are expected to provide important new insights into processes of early solar system evolution.

Geochemical Information of Ore fluid from Fluorite in Qinglong Antimony Deposit, Southwest Guizhou, China

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Geologic Setting

The Qinglong antimony deposit is located on the platform near the northwest margin of Youjiang Basin, southwest Guizhou, China. Stratabound antimony and paragenetic fluorite deposits were found on paleokast surface between lower and upper Permian.

REE and Sr Isotope Geochemistry

The fluorite is origin of hydrothermal processes. The REE partition pattern for the fluorite shows depleted LREE, enriched MREE and HREE, and negative anomaly for Ce ($\text{Ce}_{\text{Ce}}: 0.46 \sim 0.76$). From early to final stage fluorite, the REE content decreased from (11.62~26.538) $\times 10^{-6}$ to 6.911 $\times 10^{-6}$ and enriched more LREE, Eu developed from negative anomaly ($\text{Eu}_{\text{Eu}}: 0.72 \sim 0.89$) to positive anomaly ($\text{Eu}_{\text{Eu}}: 4.47$). The reduced and oxidized conditions were responsible for the negative and positive Eu anomaly, respectively. The fact that Ce anomaly did not change with oxidized and reduced condition implies that ore fluid is basin fluid, which inherited negative Ce anomaly of seawater.

$^{87}\text{Sr}/^{86}\text{Sr}$ of two fluorite samples (0.71038, 0.70829) were much different from that of their host rock (0.73733), it indicated that ore fluid is introduced fluid.

Organic Geochemistry

Biomarkers such as normal alkane, isoprenoid alkane, terpane and sterane in extract of bitumen from the fluorite inclusions are similar to that in extract of kerogene (pyroclastic rock) from the Permian Linghao Formation in Youjiang Basin. It suggested that ore fluid was from Youjiang Basin.

Conclusion

Mineralization is related to lateral migration of basin fluid from Youjiang Basin to platform, there is an obvious change from reduced condition to oxidized condition from early to final mineralization stage.

Reference

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