PRECISE RB/SR DETERMINATIONS BY MAGNETIC-SECTOR MASS SPECTROMETRY

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Introduction

The invention of isotopic dating by mass spectrometry revolutionized the discipline of geology by providing precise information on the absolute timing of geological events. One of the most widely used geochronometers is based on the beta decay of $^{87}$Rb ($\lambda=1.42\times10^{-11}$ yr$^{-1}$) to $^{87}$Sr. Precise measurements of the Rb/Sr ratio and the $^{87}$Sr/$^{86}$Sr isotopic composition are required for application of the chronometer. Methods for precise determination of the Sr isotopic composition were worked out over 30 years ago. Determination of the Rb/Sr ratio by mass spectrometry involved the stable isotope spiking and chemical separation of Rb from Sr [1]. Here, we report a new method developed at NHMFL for the rapid and precise determination of Rb/Sr ratio by magnetic sector, inductively coupled plasma mass spectrometry (magnetic sector ICP-MS), which complements our existing capabilities in Sr isotope ratio measurement.

Experimental

Following on a method developed for Fe/Mn ratio measurement [2], we developed a precise method for Rb/Sr ratios. Geological rock samples were dissolved in HF-HNO$_3$ acids. These solutions were then directly measured without elemental separation of Rb and Sr from the rock matrix or from one another. Measurements of the peaks: $^{85}$Rb$^+$, $^{86}$Sr$^+$, $^{88}$Sr$^+$, were performed by ICP-MS, using a ThermoFinnigan Element at NHMFL. Ion count rates were in the 10-100 MHz range. Isobaric interference of $^{86}$Kr$^+$ from the Ar plasma gas was monitored on acid blank solutions, and was found to be negligible (<100 Hz). Conversion of measured ion intensities to elemental ratios was accomplished by analyzing gravimetrically prepared Rb-Sr solutions with known ratios. The Rb/Sr results from the two separate ratios, $^{85}$Rb/$^{86}$Sr and $^{85}$Rb/$^{88}$Sr, were averaged to obtain a single more precise measurement of the Rb/Sr ratio. This is possible since stable isotope ratios of $^{85}$Rb/$^{87}$Rb and $^{86}$Sr/$^{88}$Sr are constant in nature to better than 0.1%.

Results, Discussion & Conclusions

The new method provides for rapid and precise analysis of the Rb/Sr ratio. The precision obtained on standards run with geological samples was ±0.2-0.3%. For comparison, the best isotope dilution analyses achieved precisions of ±0.2%, limited by the ability to determine the $^{85}$Rb/$^{87}$Rb ratio by thermal ionization mass spectrometry (TIMS). The analysis time per sample for our ICP-MS method is 5-10 minutes, compared with hours by TIMS. Many additional hours of sample preparation time are also saved resulting in higher sample throughput by our method. The method was applied to two USGS rock standards, G-2 and AGV-1, which yielded Rb/Sr ratios that were accurate to within 2% (Table 1). These data are within the reported uncertainties of the Rb/Sr ratios of the two standards (2-5%) (Table 1). The method was then applied to a set of Galts Ferry Gneisses, Georgia, USA, with a resulting improvement of about an order of magnitude over conventional Rb/Sr ratios obtained by X-ray Fluorescence spectrometry. The Galts Ferry Gneisses are approximately 460-440 million years old [3]. Our method is generally applicable to other samples analyzed at NHMFL. The growing popularity of magnetic sector ICP-MS will allow for the broad application of this method in $^{87}$Rb-$^{87}$Sr dating.

Table 1. Comparison of Rb/Sr reported for international standards with Rb/Sr determined by our ICP-MS method.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Rb/Sr (literature)</th>
<th>Rb/Sr (ICP-MS)</th>
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<tbody>
<tr>
<td>USGS G-2</td>
<td>0.356±0.016</td>
<td>0.3521±0.0008</td>
</tr>
<tr>
<td>USGS AGV-1</td>
<td>0.1015±0.0021</td>
<td>0.0992±0.0003</td>
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References