LASER ABLATION MICROANALYSIS OF TRACE METALS IN SILICATE GLASSES

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Introduction

The first piece of new equipment for the Plasma Analytical Facility, the Geochemistry program’s new mass spectrometry laboratory, has been installed. The New Wave UP213 laser ablation system is a powerful new tool for microanalysis in geochemistry, cosmochemistry, environmental chemistry and materials science. Here, we describe its general capabilities and the first application to analyses of low-level trace metals in silicate glasses.

Experimental

The UP213 system consists of a frequency-quintupled Nd-YAG 213 nm UV laser that is focused on a sample surface by an optical microscope. Laser ablation produces a fine aerosol of the target material that is transported in a continuous flow of He gas (~800 ml/min) and Ar (800-1400 ml/min) to the ion source of an inductively coupled plasma mass spectrometer (ICP-MS), the Finnigan Element™. In the ICP source, at an effective temperature of ~7000 K, the aerosol is vaporized and ionized. Ions are mass analyzed by a double-focusing reverse Nier-Johnson geometry mass spectrometer and detected using a MassCom secondary electron multiplier with a dark noise of ≤0.1 cps, and a dynamic range of $10^9$. The sample is mounted on a movable stage (1 µm spatial resolution). Sample preparation is minimal. A flat surface is convenient for imaging. Standard microscopy mounts are easily introduced into the ablation cell of the UP213 system. A CCD camera images the sample with a choice of transmitted or reflected light, and the images can be stored in bitmap format. An aperture controls the laser spot size with eight preset spot sizes from 4-100 microns.

The data below are averages ($±1σ$) of three points collected at a spot size of 40 µm, 10 Hz, with 50% power output, and a dwell time of 30 secs per point. The amount of material ablated is approx. 100 ng. The synthetic NIST SRM 612 glass was used for calibration, with Si as an internal standard. A systematic uncertainty of 10% is assigned to the NIST values.

Results and Discussion

A set of six glasses prepared from natural samples (MPI-DING) for ISO certification as standards for microanalysis were analyzed for 20 elements, including W, Re, Pt and Au. Rhenium was not detected (limit <2 ng/g) in any of the glasses. The other elements were measured with a detection limit of <2 ng/g for W and Pt, and <10 ng/g for Au. The data are shown in the table below together with data from the literature (Jochum et al., 2000). The microanalytical method employed here was both more sensitive and more precise than previous measurements, particularly for W where only upper limits were previously available for half of the glasses. Only one discrepancy (Pt in ATHO-G) exists. Humayun and Campbell (2002) developed techniques for analysis of W in meteoritic metal where the abundances of W are higher than in silicates. The new method is suitable for the measurement of W in meteoritic silicates to determine the fidelity of isotope-based chronometers.

Table: Microanalysis of MPI-DING glasses (errors apply to the last place of decimal); literature values in parentheses.

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<thead>
<tr>
<th></th>
<th>GOR128-G</th>
<th>KL2-G</th>
<th>ML3B-G</th>
<th>T1-G</th>
<th>StHs6/80-G</th>
<th>ATHO-G</th>
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<tbody>
<tr>
<td>W  (µg/g)</td>
<td>16.1±2  (14)</td>
<td>0.49±3 (&lt;0.4)</td>
<td>0.38±3 (&lt;0.3)</td>
<td>0.70±3 (0.9)</td>
<td>0.38±9 (&lt;0.5)</td>
<td>9.6±3 (9±1)</td>
</tr>
<tr>
<td>Pt (µg/g)</td>
<td>11.0±4  (9.6)</td>
<td>9.5±4 (10)</td>
<td>9.3±3 (8)</td>
<td>5.2±6 (&lt;7)</td>
<td>1.7±6 (&lt;1)</td>
<td>0.12±1 (12)</td>
</tr>
<tr>
<td>Au  (ng/g)</td>
<td>25±1  (28)</td>
<td>98±21 (118)</td>
<td>81±5 (70)</td>
<td>94±18 (100)</td>
<td>48±8 (42)</td>
<td>26±4 (25)</td>
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References