The determination of *in situ* cosmogenic radionuclides in olivine

A. SHIMAOKA[1], P. KONG[1], R. C. FINKEL[2],
M. W. CAFFEE[2] AND K. NISHIIZUMI[1]

[1]Space Sciences Laboratory, University of California,
Berkeley, CA 94720-7450 (akiko@ssl.berkeley.edu)
[2]Geoscience & Environmental Technology Div., Lawrence
Livermore National Laboratory, Livermore, CA 94550

Introduction

In situ cosmogenic radionuclide dating of terrestrial samples mainly relies on the use of ^{10}Be ($t_{1/2}$=1.5 Myr) and ^{26}Al (0.7 Myr) in quartz and/or ^{36}Cl in whole rocks or mineral separates. Although quartz is an ideal mineral, it is not available in many geological settings. We are therefore exploring the possibility of measuring cosmogenic radionuclides produced in olivine. Olivine is an attractive choice because it is present in many geologic settings in which quartz is not present, e.g. basaltic environments. From the perspective of cosmogenic nuclides, olivine $(Mg,Fe)_2SiO_4$ is nearly an ideal composition, because of the range of cosmogenic radiounuclides, ^{10}Be, ^{14}C, ^{26}Al, ^{36}Cl, ^{41}Ca, and ^{53}Mn, and cosmogenic stable nuclides, ^{3}He, ^{21}Ne, and ^{38}Ar, that can be produced from its constituents. By measuring multiple cosmogenic nuclides in aliquots of the sample it may be possible to reconstruct even complex exposure histories for samples having multiple stages of exposure to cosmic rays on Earth's surface.

Experimental Procedure and Results

^{10}Be and ^{26}Al produced *in situ* in olivines have only been measured successfully in a sample from a Hawaiian basalt. The successful measurement of ^{10}Be and ^{26}Al requires the removal of all meteoric ^{10}Be and the minimization of the olivine Al concentration. To accomplish these objectives we are developing a new chemical leaching method. To validate this new method, we measured ^{10}Be and ^{26}Al extracted from olivines subjected to this leaching procedure. The olivines were physically separated from the ground mass of volcanic lavas having known exposure ages.

The ^{10}Be and ^{26}Al concentrations in olivines taken from continental lava samples (Clear Lake, Oregon and Bluewater, New Mexico) are $4x10^4$-$1x10^6$ atom/g and $5x10^4$-$3x10^6$ atom/g, respectively. Exposure ages based on these concentrations are consistent with those based on cosmogenic ^{3}He. However, in a few instances we measured ^{10}Be/^{26}Al ratios higher than expected, evidently the result of residual meteoric ^{10}Be.

The olivines collected from recent flows at Kilauea, Hawaii (1840 eruption) and Hekla, Iceland (flow age of 1-2 days) have surprisingly high concentrations of ^{10}Be ($5x10^3$-$1x10^5$ atom/g). The high ^{10}Be concentration in olivines from both volcanoes suggests that unexpected reactions between basaltic magma and hydrothermally altered oceanic crust may occur, effectively contaminating the entire lattice structure with meteoric ^{10}Be.

The evolution of the Belingwe greenstone belt, Zimbabwe

K. SHIMIZU[1], E. NAKAMURA[1], S. MARUYAMA[2], AND
K. KOBAYASHI[1]

[1] Okayama University, Institute for Study of the Earth's
Interior (shimmy@pheasant.misasa.okayama-u.ac.jp)
[2] Tokyo Institute of Technology, Dept. Earth Planet. Sci.

The Belingwe greenstone belt, one of the best-studied areas, is controversial on its tectonic setting, whether it is autochthonous or allochthonous. As most Archean greenstone belts are, the Belingwe greenstone belt is composed of mainly tholeiitic basalt and komatiites occur small amount only near the basement of the sequence. Studying these basalts is significant to discuss the origin of komatiites. The least altered samples were selected from 2.7 Ga volcanic sequences, and major and trace element compositions and isotopic ratios of Nd and Pb were determined for bulk rock, clinopyroxene and plagioclase.

<100 µm garnet xenocrysts were discovered in a komatiite. Their major element compositions (Grs_{20} Pyp_{35} Alm_{45}) and trace element ratios $[(Sm/Yb)_N \sim 0.2]$ suggest that they are lower crust origin. This discovery indicates that komatiite was erupted through a continental basement and that the 2.7 Ga volcanic sequence is autochthonous.

Volcanics in this region were divided into four types, petrologically and geochemically. $(La/Sm)_N$ of komatiites, komatiitic basalt, D-basalt and E-basalt are ~0.7, ~1.5, ~0.8 and 1.2-1.6, respectively. Trace element compositions of clinopyroxenes are equilibrium with those of whole rocks, suggesting that the variations of these volcanics have been formed before pyroxene crystallized, but not after the alterations. Since komatiitic basalts and E-basalts have high µ1 values (~8.5 and 9.0, respectively) and low initial Nd isotopic ratios [εNd(2650Ma) ~1 and –1, respectively], and komatiites and D-basalts have low µ1 values (~8) and high initial Nd isotopic ratios [εNd(2650Ma) ~3], the chemical variations are produced by different degree of contaminations of an older crustal materials. The REE patterns and contents of D-basalt can be reproduced by melting the same source for komatiite; it needs ~8-26% degree of partial melting, while they can be also obtained by ~45-80 % crystallization of primary komatiitic magma. Major element variations of the D-basalts show that it is more reasonable to be formed by crystallization of komatiitic magma at 1 to 5 kbar. Degrees of crystallizations and contaminations of basalts increase stratigraphically upward, indicating that more evolved and more contaminated basalts erupted at the later stage.

Belingwe komatiite may immediately erupt through continental crust without major contaminations and fractionations at the early stage when the plume activity is high enough for komatiite to be erupted to the surface. Some of komatiitic and basaltic magmas may be contaminated with an older crustal material, and komatiitic basalt and E-basalt were formed. Large amount of komatiitic magma may pond at a magma chamber and may crystallize to form voluminous D-basalts.