Trace element and Nd, Sr, Pb isotope geochemistry of Kīlauea Volcano, Hawai‘i, near-vent eruptive products: 1983 - 2001

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Open File Report 03-493

2003

U.S. GEOLOGICAL SURVEY
U.S. DEPARTMENT OF INTERIOR

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Introduction

This open-file report serves as a repository for geochemical data referred to in U.S. Geological Survey Professional Paper 1676 (Heliker, Swanson, and Takahashi, eds., 2003) which includes multidisciplinary research papers pertaining to the first twenty years of Pu‘u ‘Ō‘ō-Kūpaianaha eruption activity. Details of eruption characteristics and nomenclature are provided in the introductory chapter of that volume (Heliker and Mattox, 2003). Geochemical relations of this data are depicted and interpreted by Thornber (2003), Thornber and others (2003a) and Thornber (2001).

This report supplements Thornber and others (2003b) in which whole-rock and glass major-element data on ~1000 near-vent lava samples collected during the 1983 to 2001 eruptive interval of Kīlauea Volcano, Hawai‘i, are presented. Herein, we present whole-rock trace element compositions of 85 representative samples collected from January 1983 to May 2001; glass trace-element compositions of 39 Pele’s Tear (tephra) samples collected from September 1995 to September 1996, and whole-rock Nd, Sr and Pb isotopic analyses of 10 representative samples collected from September 1983 to September 1993. Thornber and others (2003b) provide a specific record of sample characteristics, location, etc., for each of the samples reported here. Spreadsheets of both reports may be integrated and sorted based upon time of formation or sample numbers. General information pertaining to the selectivity and petrologic significance of this sample suite is presented by Thornber and others (2003b). As justified in that report, this select suite of time-constrained geochemical data is suitable for constructing petrologic models of pre-eruptive magmatic processes associated with prolonged rift zone eruption of Hawaiian shield volcanoes.

Acknowledgments

We gratefully acknowledge the efforts of all the HVO staff, volunteers, student interns, and visiting scientists who collected samples for geochemical analysis between January 1983 and October 2001. In addition to the senior author, other HVO geologists that have enabled petrologic monitoring of this eruption include Edward Wolfe, Tina Neal, George Ulrich, Ken Hon, Christina Heliker, Margaret Mangan, Tari Mattox, Dave Sherrod and Rick Hoblitt.

Analytical Methods

Whole-Rock Trace-Element Analysis

The whole-rock abundances of trace elements reported here were determined by instrumental neutron activation analysis (INAA) long-count at the USGS-Denver laboratory. A summary of the procedures used is provided by Budahn and Wandless (2002), who estimate precision and accuracy for most elements as 1-5% based upon replicate analyses of USGS standard reference materials, including Kilauean basalt standard, BHVO-1.

Glass Trace-Element Analysis

Glass trace-element concentrations in small (1mm – 1cm) episode 53 Pele’s tear samples were conducted by Laser Ablation, Induction Coupled, Mass Spectrometry (LA-ICP-MS) at USGS, Denver, with a Sciex 6000 mass spectrometer and Cetac LSX-200 ultraviolet laser. Analyses were performed in spot mode using a 25um diameter beam to ablate clean glass from the interior of broken tears. The instrumental system incorporates a solution nebulizer device that

simultaneously introduces a dry aerosol of Li, Rh, and Ir to monitor instrument drift as a function of mass (Ridley and Lichte, 1998). USGS standard glasses of GSE and GSD were used as primary standards and BCR-1, BIR-1 and BHVO-1, and ENDV were used as normalization standards. Counting statistics (detection rates per ppm) for all analyzed elements indicate that counting errors were less than 0.2%. Data were corrected using the program QUANTLASER (Ridley, 2000). Repeated analyses of standard ENDV (a MOR basalt) indicates precision for most elements of 1 to 1.6% and accuracy between 3-5%.

Whole-Rock Isotopic Analysis

Isotopic analyses for $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$ ratios and ratios of ^{206}Pb, ^{207}Pb and ^{208}Pb versus 204Pb were performed at USGS-Denver on powder splits of 10 samples that were also analyzed by INAA. Analytical procedures were similar to those reported by Budahn and others (2002). All samples were run on a Micromass model 54R single-collector mass spectromenter. Lead data were corrected for mass fractionation of 0.13 ±0.03% per mass based on analyses of NBS standard SRM-982. Five analyses of NBS strontium standard, SRM987, produced a mean value of $^{87}Sr/^{86}Sr = 0.710248 \pm .000013$. Four analyses of the La Jolla Neodymium standard yielded $^{143}Nd/^{144}Nd = 0.511851 \pm .000013$

Explanation of the Data Spreadsheets

Trace-element data for whole-rocks and glasses and Sr, Nd, Pb isotopic data are presented in chronological order in three separate worksheets (Tables 1, 2 and 3). Explanations for the categories of sample information provided are as follows:

Sample Number: The sample number prefix (for example, "KE53-") designates the Kīlauea episode number (see Heliker and Mattox, 2003). Each sample number is followed by a "T", "S," "F," or "P" suffix, which denotes a lava sample as tephra, spatter, flow, or pond respectively.

Deposit Type: Tephra samples of fountain-generated reticulite or "Pele's tears" are categorized as "vent tephra". Samples of spatter from vents are listed as "vent spatter". Lava-flow samples in the table are categorized as "tube flow" for tube-contained flow, or "surface flow" for near-vent surface flows and "pond dip" for samples of near-vent ponded lava.

Geochemical Type: "Hybrid" samples (episodes 1 -30, 54 and early 55) have petrologic characteristics suggesting mixing with fractionated rift-stored magma bodies (Garcia and Wolfe,1988; Garcia and others, 1989 and 1992; Thornber and others, 2003). Samples of "Open System" type are typically olivine-phyric and most were collected during intervals of prolonged near-continuous eruption (episodes 48-53 and 55).

Date Collected, Date Formed: Dates are in mm/dd/yy format. Many flow samples were collected from active lava flows, and some spatter samples were collected immediately after impact. These samples were water quenched by the collector, and the date collected is the same as the date formed. For most tephra samples, which were deposited as fallout on collection trays and gathered roughly once a week, the date formed is assigned as the midpoint date of each collection interval.

Decimal Time: Decimal equivalents to the year, month, day and hour of sample formation are provided to facilitate temporal data plots of eruption chemistry.

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