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11. *DATA REPORT:* GEOCHEMISTRY OF BASALTS AND GLASSES FROM THE EAST PACIFIC RISE AXIS ZONE AT 9°30.45′N, LEG 142[1]

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ABSTRACT

Petrographic and geochemical data from East Pacific Rise basalts cored at Ocean Drilling Program Site 864 show that the rocks are practically unaltered normal mid-ocean-ridge basalts (N-MORB). The analyzed glasses from four samples were practically identical in composition, suggesting a common source for corresponding lava flows.

INTRODUCTION

During Ocean Drilling Program Leg 142, Site 864 was drilled at the East Pacific Rise (EPR) axial zone, 9°30.85′, 104°14.66′. The site is south of the Clipperton transform fault and north of an overlapping spreading center. Three holes were drilled at Site 864 and cores were recovered from two holes.

METHODS

Igneous whole rocks and glasses were studied in thin sections to determine mineralogy and texture.

Rare earth elements (REE) in the basalts were determined by radiochemical neutron activation in the Analytical Center of the Geological Institute, Russian Academy of Sciences. 100-mg samples were irradiated together with a standard by a thermal neutron flux of 1.2×10^{13} n/cm^2 $\times$ s during 20 hr. REE fractions were separated by radiochemical method. Gamma-spectrometry determination REE was done with a coaxial Ge(Li)-detector. The accuracy of the analyses (1σ errors) for individual elements is: ±3%–5% for La, Sm, Eu, and Yb and ±5%–7% for Ce, Tb, and ±10% for Nd. The accuracy of the determination has been checked against USGS BHVO-1 standard (Gladney and Roelandts, 1988).

All analyses of major and trace elements in the glasses were made at the Central Analytical Laboratory of the Geochemistry and Analytical Chemistry Institute, Russian Academy of Science.

The glass compositions were determined by microprobe analysis with a Camebax-Microbeam analyzer and four vertical spectrometers (X-ray angle of emergence 40°; probe diameter, ~1 µm). The error was not more than ±1.5% relative, sensitivity 0.01 mass percent.

Fragments of pure glass (0.5–0.25 mm) separated under the binocular microscope were used for the analyses. A special method was developed to determine the glass compositions. Silicate analysis for 10 elements was perfomed with an accelerating potential of 15 kV and probe current of 30 nA (the automatic parameter adjustment and monitoring enabled us to reproduce the analysis conditions with necessary accuracy). We recorded the corresponding K series for the elements.

To reduce the beam damage, all the measurements were made with scanning over an area of 5 × 5 µm (scan time per frame 0.2 sec). The X-ray intensities were measured at three arbitrarily selected points in each of three grains. The composition was thus determined at the mean of nine measurements. The reproducibility was ±2% relative on the major elements having contents over 5 mass percent. To check the accuracy, a control measurement was made on a reference standard after every 10–15 measurements, from which we corrected the deviations in the element contents from the recommended values. That standard for the major elements was chosen as the international standard VG-2 (USNM-111240/52) for natural basalt glass (Melson et al., 1977).

Analyses of V, Cr, Ni, Cu, Zn, Sc, Sr, Y, Zr, and Ba in the glasses were performed by atomic emission spectrometry with inductively coupled plasma (ICP AES). Conditions were found for determination of trace elements by ICP AES in solution containing high concentrations of metal cations (3–6 mg/ml). To reduce matrix interferences, the reference solutions were prepared using a synthetic matrix with a composition of average rock. Optimal plasma zones were selected for determining trace elements. Programs were obtained for the analysis of 16 elements in rocks on an multichannel atomic emission spectrometer ICAP-9000 (Termo Jarrell ASP Corp. USA). A method is proposed for the analysis of rocks by ICP AES which, in combination with atomic absorption spectrometry (AAS) and flame AES. The metrical characteristics were estimated by analysis of standard reference samples of rocks. The relative standard deviation values were 0.005–0.03 for major constituents and 0.01-0.1 for trace elements.

Analyses of As, Ag, and Au in the glasses were performed by AAS with atomic absorption electrotermic atomization (AAS ETA). Method detection limits for As, Au, and Ag are 0.5×10^{-7}%. Relative standard deviation values were 0.02–0.05.

Determination of REE in the glasses was performed by Neutron Activation Analysis. Two types of sample irradiation were employed. In the first case samples were irradiated with fast and thermal neutrons at a flux of 1.6×10^{13} n/cm^2 $\times$ s for 15 hr, and in the second case the samples were irradiated in cadmium filter for period of 80–100 hr. The sample masses were in the ranges 15–20 mg and 50–60 mg, respectively.

Irradiated samples were analyzed at different time intervals to avoid interferences of radionuclides. Measurements were carried out using a Ge (Li)- and Ge-detector, multichannel analyzer coupled with microprocessor. The gamma-spectra and elemental concentrations were evaluated using a special computer program. The accuracy of

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Table 1. Brief petrographic description of basalts (Unit 1), Site 864.

Core, section, interval (cm)	Description
142-864A- 1M-2, 0–35	Hyalobasalt, aphyric, practically noncrystallized, with sparse microphenocrysts of plagioclase. Volcanic glass contains section of dark, oxidized, partially devitrified glass with crystallites of plagioclase and clinopyroxene. Single olivine quench crystals and small drop-like inclusions of pyrite occur. Hyalobasalt is fresh.
142-864A- 1M-3, 0–35	Hyalobasalt, aphyric, weakly crystallized with vitrophyric (subvariolitic in separate parts) texture. Groundmass consists of isotropic brown partially devitrified volcanic glass, crystallites of clinopyroxene, and isolated microlite of plagioclase. Crystallites of clinopyroxene form radial-radiant aggregates. Isolated prismatic microphenocrysts of plagioclase (<1 mm) occur. Hyalobasalt is fresh.
142-864A- 1M-3, 100–150	First thin section: Basalt, aphyric, weakly crystallized with pilotaxitic texture. Microlites and laths of plagioclase and clinopyroxene are 80% and dark isotropic glass composes 20% of the rock. Microlites and laths are not oriented. Small rounded forms of pyrite occur. The rock is almost fresh. In the XRD there is a weak diffraction peak of smectite. Second thin section: Basalt, aphyric, weakly crystallized with isolated microphenocrysts of plagioclase. Texture of rock is hyalopilitic. Plagioclase (up to 0.5 mm) is labradorite (An_{62}). Partially devitrifed volcanic glass consists of bunch-like aggregates of microlites of clinopyroxene, laths of plagioclase, ore dust, and isolated rhomboid olivine quench crystals.
142-864A- 1M-5, 0–100	Hyalobasalt, aphyric, with practically isolated prismatic microphenocrysts of plagioclase (up to 0.5 mm). Texture of rock is vitrophyric. Isolated vesicles occur. Volcanic glass partially devitrified. Original isotropic glass has light-yellow color. Devitrified glass occurring in same parts of rock has black-brown color and consists of crystallites of plagioclase, pyroxene, and sparse olivine quench crystals. In same parts of the rock sparse glomerophyric aggregates of plagioclase occur. Plagioclase is labradorite (An_{55}). Hyalobasalt is fresh.
142-864A- 1M-6, 0–75	First thin section: Basalt, sparsely microplagiophyric, weakly crystallized, weakly vesicular. Texture of groundmass vitrophyric-variolitic. Groundmass is devitrified and is represented by varioles (up to 0.1 mm) filled by radially radiant aggregates of clinopyroxene and plagioclase. In same parts of the rock, original isotropic glass occurs. Sections of devitrified glass include sparse phenocrysts of plagioclase. Basalt is fresh. Second thin section: Hyalobasalt, aphyric, weakly crystallized with isolated microcrysts of plagioclase. Texture of rock is vitrophyric. Primary isotropic light-yellow volcanic glass contains a part of partially devitrified, weakly anisotropic glass with radially radiant aggregates of clinopyroxene and plagioclase, and isolated olivine quench crystals.

the determination has been checked against interlaboratory standard (basalt 396B-15-2, 120-133 cm; Kirkpatrick et al., 1979).

RESULTS

On the ship, two lithologic units were identified based on geochemical and petrographic features. Unit 1 rocks are glassy, aphyric basalt. Unit 2 basalt occurs lower in the section and has more phenocrysts and crystalline groundmass. All rocks are practically fresh.

Table 3. Composition of glasses from Site 864.

Core, section: Interval (cm):	1M-2 0–35	1M-3 0–35	1M-5 0–100	1M-6 0–75	STND
Major element (wt%)					
SiO_2	50.63	50.21	50.20	50.28	
TiO_2	1.60	1.67	1.67	1.65	
Al_2O_3	15.02	14.39	14.35	14.09	
FeO*	10.53	10.33	10.37	10.52	
MnO	0.20	0.18	0.18	0.17	
MgO	7.25	7.39	7.37	7.42	
CaO	11.64	11.54	11.55	11.60	
Na_2O	2.88	3.07	3.03	3.14	
K_2O	0.14	0.14	0.15	0.15	
P_2O_5	0.20	0.19	0.14	0.17	
Total	100.09	99.11	99.01	99.19	
Trace element (ppm)					
V	328	330	341	332	
Cr	198	193	209	196	
Ni	71	73	74	71	
Cu	67	88	74	74	
Zn	99	98	104	97	
Sc	42	42	41	39	
Sr	122	125	128	125	
Y	48	48	49	46	
Zr	94	100	102	107	
Ba	14	18	22	18	
As	0.053	0.44	0.28	0.43	
Ag (ppb)	12	30	70	11	
Au (ppb)	4.4	5.4	6.1	3.4	
La	4.50	4.70	4.30	4.20	3.90
Ce	13.10	13.20	11.60	11.50	12.50
Pr	2.08	2.10	1.80	1.78	2.05
Nd	10.10	10.20	9.20	9.10	10.60
Sm	3.30	3.20	3.20	3.10	3.60
Eu	1.41	1.41	1.19	1.17	1.42
Gd	5.90	5.90	5.00	4.90	6.00
Tb	0.92	0.93	0.82	0.81	0.95
Dy	5.70	5.80	5.10	5.00	6.00
Ho	1.30	1.33	1.28	1.24	1.40
Er	3.90	3.80	3.80	3.70	4.20
Tm	0.58	0.57	0.59	0.56	0.62
Yb	3.45	3.40	3.50	3.25	3.80
Lu	0.55	0.54	0.58	0.54	0.64

Notes: FeO* = total iron as FeO; STND = basalt 396B-15-2, 120–133 cm (this work).

A brief petrographic description of Unit 1 basalts is given in Table 1. Units 1 and 2 are compositionally very similar. Rare earth element concentrations of basalts are given in Table 2.

Compositions of four analyzed glasses are very similar (Table 3), indicating that corresponding lava flows have a common source.

The chemical analyses of rocks and glasses lying in the tholeiitic field on the alkali-silica diagram (Fig. 1) and in mid-ocean-ridge basalts (MORB) field on the AFM diagram (Fig. 2). REE distribution in basalts (Fig. 3) and the spidogram for glasses (Fig. 4) show that these rocks belong to the series of normal mid-ocean-ridge basalts (N-MORB).

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Table 2. Rare earth element concentrations (ppm) of basalts from Site 864.

Hole: Core, section: Interval (cm):	864A 1M-3 0–35	864A 1M-3 100–150	864A 1M-5 0–100	864A 1M-6 0–75	864A 1M-4 0–9	864A 1M-2 0–35	864B 2W-1 16–18	864A 5Z-1 24–30	864A 4-Z1 pic2	STND
La	4.1	4.5	4.0	3.7	3.6	4.3	4.1	4.2	4.0	16
Ce	12	12	11	11	11	11	12	12	11	40
Nd	9.6	11	9.6	9.6	9.6	10	11	11	11	24
Sm	3.5	4.0	3.7	3.5	3.4	3.8	3.9	4.0	3.8	6.0
Eu	1.3	1.4	1.4	1.4	1.3	1.3	1.4	1.5	1.4	2.0
Tb	0.96	1.0	0.95	1.1	0.89	1.0	0.90	1.1	0.92	1.0
Yb	3.1	3.9	3.4	3.3	3.1	3.7	3.7	3.8	3.6	1.95
Lu	0.46	0.57	0.51	0.51	0.47	0.54	0.58	0.57	0.54	0.28

Note: STND = standard sample USGS BHVO-1 (this work).

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*Abbreviations for names of organizations and publications in ODP reference lists follow the style given in *Chemical Abstracts Service Source Index* (published by American Chemical Society).

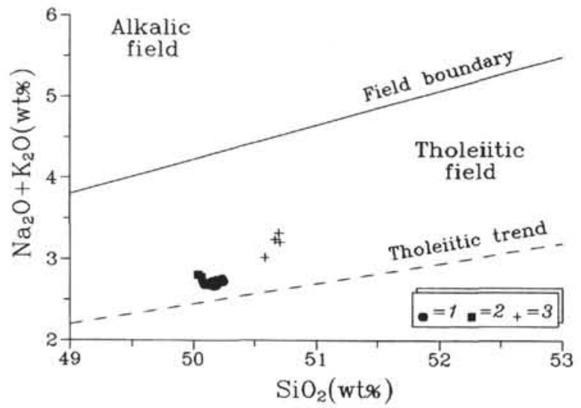

Figure 1. Alkali-silica variation diagram (Macdonald, 1968) of basalts and glasses from Site 864. 1 = Unit 1 basalts and glasses (Storms et al., 1993); 2 = Unit 2 basalts (Storms et al., 1993); 3 = new data on Unit 1 glasses.

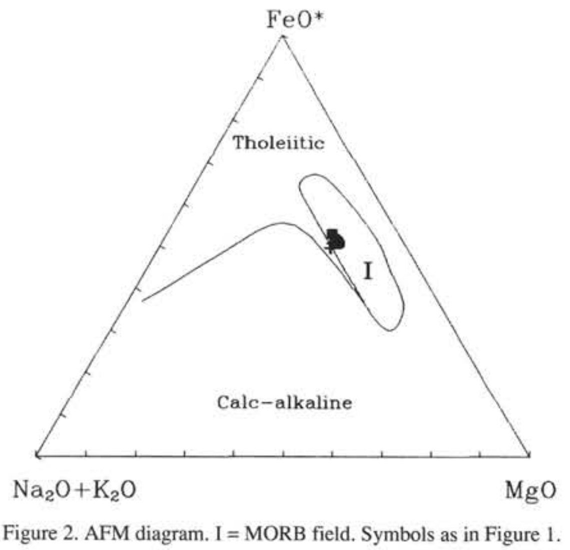

Figure 2. AFM diagram. I = MORB field. Symbols as in Figure 1.

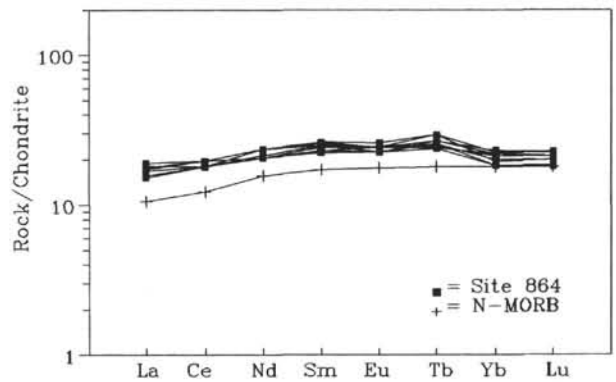

Figure 3. Rare earth elements of the basalts, normalized to chondrite. Average composition of N-MORB (Sun and MacDonough, 1989) is also plotted.

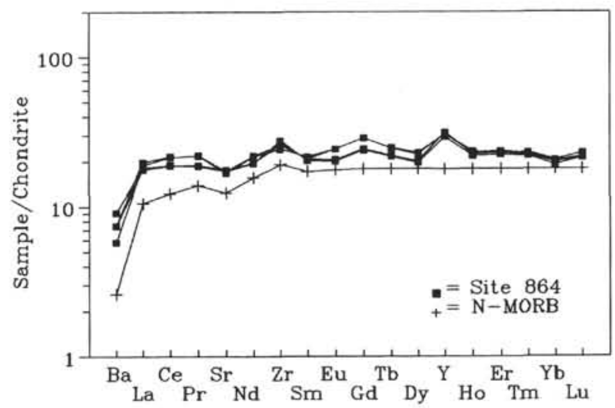

Figure 4. Trace elements of glasses (normalized to chondrite). Average composition of N-MORB (Sun and MacDonough, 1989) is also plotted.