Duncan, R. A., Backman, J., Peterson, L. C., et al., 1990
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 115

44. CHEMISTRY OF BASALT ALTERATION FROM LEG 115[1]

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INTRODUCTION

Basalts recovered along the Réunion hotspot track on Ocean Drilling Program (ODP) Leg 115 range in age from 34 Ma at Site 706 to 64 Ma at Site 707. They have undergone various degrees of secondary alteration. Within single holes the amount of alteration can vary from a few percent to near complete replacement of phenocrysts and groundmass by secondary minerals. Olivine appears to be the most susceptible to alteration and in some sections it is the only mineral altered. In other sections, olivine, pyroxene and plagioclase phenocrysts, and groundmass have been completely replaced by secondary minerals.

Clays are the predominant form of secondary mineralization. In addition to replacing olivine, pyroxene, glass, and groundmass, clays have filled veins, vesicles, and voids. Minor amounts of calcite, zeolites, and K-feldspar were also detected. The clays that filled vesicles and veins often show color zonations of dark, opaque bands near the edges that grade into tan or green transparent regions in the centers of the veins. The electron microprobe was used to obtain chemical analyses of these veins as well as to characterize isolated clays that replaced specific minerals and filled voids and vesicles.

METHODS AND SAMPLE DESCRIPTIONS

Microprobe analyses were obtained for a few selected alteration minerals, mostly in areas where fresh glass was also present. These analyses were done with an ARL/EDX microprobe at an accelerating voltage of 15 kV and an absorbed current of 0.15 μA. The details of the analytical procedure are given in Fisk and Howard (this volume). A standard chlorite (SS-3) was used as an internal standard.

Four thin sections from Hole 706C were examined, two from within the upper meter of the basalt and two from about 40 m below the sediment-basalt interface. All thin sections come from basalts that are chemically similar, but the lower units have slightly higher MgO abundance. All four samples contain fresh glass. (A discussion of the division of the lithologic units into chemical units based on bulk-rock chemistry can be found in Fisk and Howard, this volume.)

In the upper two samples, clays have replaced the 1%–5% olivine that was originally present and have also filled vesicles and replaced some of the glass. These clays are brown to green in color. The two samples from 40-m depth were also originally predominantly glass (about 80%), but this has been replaced by green or brown to pale brown clay. Veins within the glass and vesicles have also been filled with clay.

Two thin sections from Hole 707C were analyzed, one from 20 m below the sediment-basalt interface, and one from about 80 m below the interface. The basalts at these two depths are chemically distinct, in that the upper basalt has a lower TiO_2 and FeO, and a higher MgO. In the upper unit the clays have replaced 50% of the plagioclase and pyroxene in the groundmass, and carbonate has filled the vesicles and voids. In the lower unit, alteration appears to be as extensive (50%), but it has primarily replaced augite, groundmass, and any glass that was present. Calcite and clay are also found filling vesicles.

One thin section from Hole 713A (Unit 3) was analyzed. This unit is a fine-grained, olivine-plagioclase-augite basalt that is between two sedimentary units and is about 20 m below the sediment-basalt interface. Clays replace olivine and fill fractures and vesicles, but the amount of alteration is only about 10%.

RESULTS

Brief descriptions of the alteration materials are given in Table 1, and these descriptions are keyed to the analyses in Table 2. The relative concentrations of Al_2O_3, FeO, and MgO of the clays are illustrated in Figures 1 and 2. The analyses show that there is no systematic change in clay chemistry with depth at

Table 1. Description of analyses.

Analysis no.	Description
31-6	Tan clay in interior of vesicle
31-8	Tan clay replacing olivine in glass
31-9	Clay replacing olivine in glass
31-10	Reddish brown clay at edge of vesicle
31-11	Additional analysis in above vesicle
29-6	Tan clay replacing olivine
29-7	Tan clay replacing olivine
41-14	Dark brown, nearly opaque clay at edge of vein through glass
41-15	Dark clay at center of vein
41-16	Tan clay at center of vein through clear brown glass
41-17	Edge of second vein, tan
41-18	Edge of second vein, tan to green yellow
41-19	Edge of vesicle fill near glass, dark brown-opaque
41-20	Center of vesicle fill, tan-green
41-21	Center of vein, same vein as 41-14 to 41-16
55-26	Tan clay next to glass at edge of vesicle
55-27	Next layer in from above, hard, highly reflective zone
55-28	Center of vesicle, green
55-29	Tan edge of grain
55-30	Half distance to center of vein (next zone in)
55-31	Center of vein, green
58-14	Dark tan altered glass at edge of vesicle
58-15	100 μm from edge of vesicle near iddingsite
86-2	Clay at edge of vesicle containing calcite
86-4	Altered groundmass at edge of vesicle
86-5	Gray clay in vesicle
86-6	Gray clay near edge of void
86-7	Clay replacing groundmass
86-8	Clay replacing groundmass
85-11	Edge of calcite-filled vesicle
103-6	Clay replacing olivine
103-7	Clay replacing olivine
103-8	Clay replacing olivine
101-8	Clay replacing groundmass
101-9	Clay replacing groundmass
101-10	Clay replacing groundmass
119-1	Clay in thin dark-brown vein through glass
119-2	Dark brown clay at center of vein through glass
119-3	Opaque clay at edge of vein through glass

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Table 2. Microprobe analyses of secondary minerals from Leg 115.

Sample	115-706C-2R-1, 76–80							115-706C-2R-2, 2–4							
Analysis no.	31-6	31-8	31-9	31-10	31-11	29-6	29-7	41-14	41-15	41-16	41-17	41-18	41-19	41-20	41-21
SiO_2	47.95	49.29	50.16	40.23	47.41	46.68	47.69	38.10	47.20	44.56	45.19	49.44	45.02	45.39	47.07
TiO_2	0.22	0.72	0.97	9.96	0.12	0.88	0.16	14.96	0.97	2.04	0.88	0.64	2.59	0.26	0.50
Al_2O_3	11.09	12.63	11.97	9.03	10.48	7.39	11.28	11.97	8.83	8.21	11.35	10.87	10.30	9.71	11.64
FeO	12.52	9.89	9.66	12.08	13.58	21.75	12.64	9.00	13.90	26.16	8.96	10.39	8.13	11.57	9.34
MnO	0.05	0.05	0.05	0.12	0.05	0.09	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.05
MgO	8.65	7.17	6.97	4.67	9.65	6.61	8.98	5.37	5.43	6.78	6.39	5.62	6.23	8.00	6.83
CaO	0.84	0.71	0.72	1.10	0.67	1.00	0.65	0.51	0.58	4.90	3.23	0.54	0.91	0.53	0.46
Na_2O	0.26	0.22	0.21	0.68	0.24	0.40	0.31	0.37	0.24	0.52	0.23	0.19	0.21	0.23	0.27
K_2O	1.45	1.68	1.78	1.43	1.49	2.02	1.68	2.01	3.89	2.44	1.63	2.99	1.82	1.98	2.00
Cr_2O_3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sum	83.06	82.41	82.53	79.35	83.74	86.86	83.49	82.38	81.14	95.86	77.95	80.77	75.32	77.77	78.21

Sample	115-706C-5R-2, 102–105						115-706C-5R-3, 44–48		115-707C-23R-1, 65–66						
Analysis no.	55-26	55-27	55-28	55-29	55-30	55-31	58-14	58-15	86-2	86-4	86-5	86-6	86-7	86-8	85-11
SiO_2	44.78	53.72	48.57	49.99	43.32	54.23	44.73	45.95	47.50	44.55	46.12	48.55	48.66	47.55	46.75
TiO_2	11.12	0.10	0.04	5.12	7.76	0.06	5.69	2.00	0.04	0.06	0.04	0.09	0.04	0.04	0.04
Al_2O_3	11.89	9.71	7.13	10.33	9.74	9.14	19.09	13.11	2.95	4.09	3.21	3.86	2.79	2.25	3.29
FeO	11.63	22.34	18.88	11.90	12.64	18.28	11.42	11.94	11.64	12.28	12.56	15.68	12.97	12.52	14.98
MnO	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.17	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MgO	5.64	5.91	11.27	5.10	4.92	5.58	15.83	12.68	18.09	19.13	19.01	17.87	18.45	18.64	17.48
CaO	0.49	0.33	0.46	0.89	0.81	0.37	0.94	1.79	1.05	0.79	1.12	1.99	0.97	1.00	0.93
Na_2O	0.56	0.15	0.09	0.58	0.24	0.17	0.32	0.16	0.37	0.24	0.39	0.41	0.22	0.25	0.23
K_2O	2.26	4.87	2.01	2.26	2.75	5.09	1.85	2.59	0.63	0.45	0.38	0.43	0.52	0.48	0.43
Cr_2O_3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sum	88.46	97.23	88.54	86.26	82.27	93.00	99.98	90.42	82.37	81.69	82.93	88.98	84.72	82.83	84.22

Sample	115-707C-28R-3, 48–50						115-713A-15R-5, 3–7		
Analysis no.	103-6	103-7	103-8	101-8	101-9	101-10	119-1	119-2	119-3
SiO_2	40.40	45.67	34.90	31.24	24.35	36.92	53.75	43.55	53.11
TiO_2	0.04	0.04	0.05	0.12	0.04	0.32	1.17	0.22	2.80
Al_2O_3	6.90	3.96	6.90	4.80	0.87	8.83	15.06	4.83	15.20
FeO	15.39	11.00	11.43	16.73	28.25	13.05	5.77	11.88	4.96
MnO	0.05	0.05	0.09	0.05	0.60	0.05	0.05	0.11	0.05
MgO	13.79	18.64	14.08	14.91	3.71	12.32	8.49	16.12	10.00
CaO	1.57	1.10	1.59	1.20	14.72	2.06	4.43	0.46	3.51
Na_2O	0.57	0.52	0.19	0.06	0.07	0.27	3.63	0.13	3.32
K_2O	0.39	0.41	0.23	0.44	0.26	0.59	1.22	2.14	1.02
Cr_2O_3	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04
Sum	79.15	81.46	69.50	69.59	72.92	74.45	93.60	79.49	94.01

Site 706. Most of the clays can be described as Fe-beidellite on the basis of chemistry alone, and they are similar to those found in the upper 100 m at Hole 417A (Alt and Honnorez, 1984). Some of the clays have high iron contents, which implies that they are a mixture of Fe-beidellite and iron oxy-hydroxides.

Some clays that replace olivine and fill vesicles can be classified as Al-saponites, based on chemistry. The unusually high TiO_2 abundance of some of the clays that fill veins and vesicles (Table 2, analyses 41-14, 55-26, 55-29, 55-30, and 58-14) is puzzling because there are no iron-titanium oxides within these veins and TiO_2 is generally immobile during alteration of basalt (Howard and Fisk, 1988).

At Site 707 the clays are low in alumina and appear to be chemically similar to saponites (Fig. 2). Some of the saponites have high iron abundances, indicating a mixture of an iron-rich clay or FeOOH and saponite. The clays from the upper chemical unit of the site have higher MgO abundance than the lower chemical unit (Fig. 2), which may be a reflection of the MgO content of these units.

In one sample from Site 713, the clay compositions range from saponite to Al-saponite (Fig. 2). Alt and Honnorez (1984) have proposed that Al-saponite is the result of less extensive alteration than beidellite. This is consistent with the extent of alteration of the Site 713 sample (about 10%) compared with the extensive (50%–80%) alteration of the samples from Sites 706 and 707 (Backman, Duncan, et al., 1988).

CONCLUSIONS

The secondary minerals from three sites of Leg 115 have a range of compositions. Hole 706C clays are primarily Fe-beidellite, similar to those found in the upper 100 m of Deep Sea Drilling Project (DSDP) Hole 417A. Hole 707C clays are primarily saponites. In the upper high-MgO unit at Hole 707C, the clays have a higher MgO content than in the underlying low-MgO unit, possibly reflecting these chemical differences in the parent rocks. At Site 713 the few analyses that were obtained show that the clays are saponites and Al-saponites.

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Date of initial receipt: 25 September 1989
Date of acceptance: 8 January 1990
Ms 115B-125

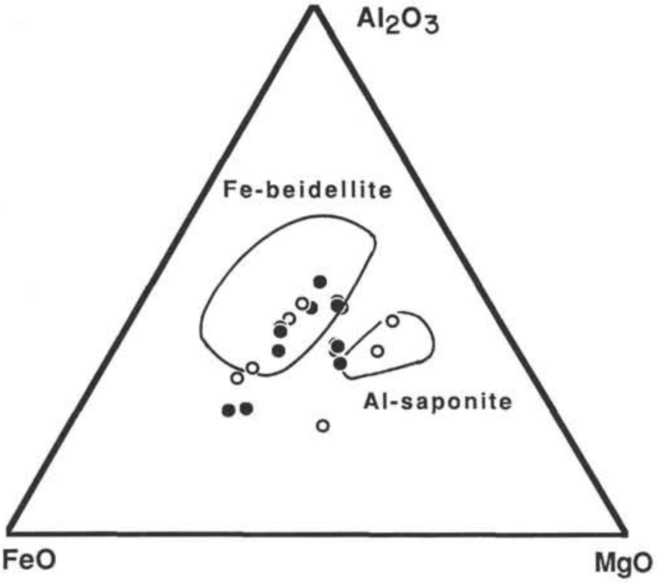

Figure 1. Microprobe analyses of clays from Hole 706C. The solid circles are from the top meter of the basalt, and the open circles are from about 40 m depth below the sediment-basalt interface. The triangular diagram coordinates are molar amounts. Fields of Fe-beidellite and Al-saponite are from Alt and Honnorez (1984).

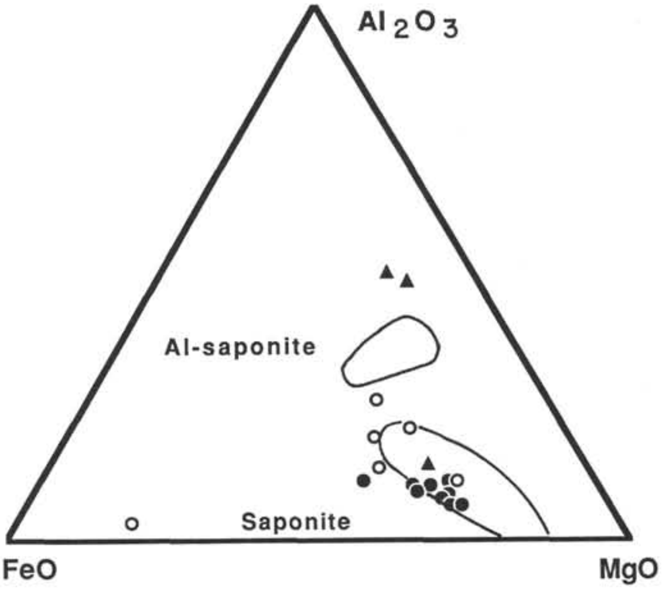

Figure 2. Microprobe analyses of clays from Holes 707C (circles) and 713A (triangles). Solid circles are from the upper chemical unit, which is high in MgO and low in FeO, and open circles are from the underlying low MgO unit. The fields of Al-saponite and saponite are from DSDP Hole 417A (Alt and Honnorez, 1984).