61. OPAQUE MINERALOGY OF ALTERED BASALTS FROM HOLE 417A OF IPOD LEG 51

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ABSTRACT

A detailed opaque mineralogical investigation of five samples from IPOD Leg 51, Hole 417A, shows that characteristic hydrothermal alteration textures are not present in the titanomaghemites. This evidence supports an earlier suggestion that the high degree of alteration observed in Hole 417A basalts is due to intensive weathering (halmyrolysis) and not to hydrothermal alteration at temperatures approaching 150°C. The high magnetic intensity of the Site 417 basalts may be related in part to a high abundance of magnetic minerals (1.4% average volume), but more samples are required to verify this suggestion.

INTRODUCTION

The combination of ore microscopy and rock magnetism has proven to be an effective way of characterizing secondary alteration processes which occur in upper oceanic Layer 2 (Irving, 1970; Ade-Hall et al., 1976a; Hall and Ryall, 1977). An optical examination of the magnetic mineralogy defines the type of oxidation which has taken place (low temperatures, hydrothermal, or deuteric), while Curie temperature measurements provide a quantitative estimate of the degree of oxidation.

With rare exceptions, sea-floor weathering at no more than a few tens of degrees centigrade is by far the dominant alteration process to act on Layer 2 as a whole (Hall and Ryall, 1977). Evidence for zeolite facies metamorphism and high temperature (initial cooling) alteration is rare (Hall and Ryall, 1977).

The 108-m.y.-old basalts recovered during IPOD Leg 51 from Hole 417A (located at about 25.1°N, 68°W in the North Atlantic) are interesting because they are reported to be both highly altered and to have an unusually strong remanent magnetization (Donnelly et al., 1977). The main purpose of this investigation was to perform a routine opaque mineralogical examination on a small number of samples of the altered basalts from Hole 417A in the hope that it would tell something about their alteration history. At the same time, the opaque mineralogy data could be compared with results from DSDP Legs 34 and 37 to see if there were any abnormalities in the abundance or type of magnetic phases present at Site 417 which might be related to the strong magnetization.

METHODS

Microscopic observations were performed on a Zeiss Universal microscope using an oil-immersion objective at a total magnification of 1375 diameters. All of the magnetic measurements were conducted at Dalhousie University using equipment and techniques described elsewhere (Ade-Hall et al., 1976b; Hall and Ryall, 1977).

OPAQUE MINERALOGY

The magnetic minerals of the basalts from Hole 417A are titanomaghemites (cation-deficient titanomagnetites) with an off-white color and high reflectivity. The titanomaghemite grains occur as microlitic phases in the basalt groundmass (Plate 1, Figure 1). Phenocrysts of titanomaghemite are absent but chains of interlocking microlites are common (Plate 1, Figure 2). Granulation, the typical hydrothermal alteration texture of a titanomagnetite (Ade-Hall et al., 1971; Abdel-Aal, 1977) was not observed in any of the samples from Hole 417A. Other textures were observed, such as patchy color lightening, cracking, and occasional corrosion and partial replacement of titanomaghemite by a yellow phase.

The titanomaghemites of the Hole 417A basalts are rather fine-grained and moderately abundant. The average grain diameter is about 5 μm at Hole 417A, in contrast with 14.4 μm for Leg 34 and 3.5 μm for Leg 37 basalts. The average volume percentage of titanomaghemite for the Hole 417A basalts is 1.4, in contrast with 2.35 in Leg 34 and 0.4 in Leg 37.

MAGNETIC PROPERTIES

Values of J_{NRM} and susceptibility of the Hole 417A basalts tend to be higher than those observed in basalts from Legs 34 and 37 (Table 1). The five basalts studied here from Hole 417A had an average magnetization of 63.6×10^{-4}

TABLE 1
Summary of Magnetic and Opaque Mineralogical Data for Five Samples From IPOD Leg 51, Hole 417A, Altered Basalts

Sample (Interval in cm)	1	2	3	4	5	6	7	8	9	10	11
25-1, 57	20	3.56	58.8	350	0.31	6.8	8.6	200	1.4	3.5	0.90
26-2, 10	30	1.36	52.9	300	0.57	9.8	5.4	160	1.2	4.5	0.77
27-2, 15	35	1.83	20.7	347	0.40	7.6	2.7	185	0.8	2.8	0.88
28-3, 119	55	1.79	111.8	290	0.37	3.2	34.9	300	1.7	4.1	0.74
29-1, 86	65	0.46	73.6	355	0.41	11.5	6.4	80	1.8	12.4	0.91
Average	–	–	63.6	328	0.41	7.8	11.6	185	1.4	5.5	0.81

Note: 1 = Sub-basement depth (m); 2 = K_2O wt. % in rock; 3 = J_{NRM} ($\times 10^{-4}$ emu/cm^3); 4 = Curie temperature (°C); 5 = Saturation magnetization (emu/g); 6 = Susceptibility (emu/cm^3); 7 = Q ratio; 8 = Median demagnetizing field (Oe); 9 = Volume per cent titanomaghemite; 10 = Average titanomaghemite grain diameter (μm); 11 = Degree of cation deficiency ($\bar{z}$).

emu/cm^3 (vs. 41×10^{-4} emu/cm^3 for Leg 34 and 36.6×10^{-4} emu/cm^3 for Leg 37; Ade-Hall et al., 1976b; Ryall et al., 1977; p. 692), a value somewhat lower than the average value obtained from shipboard measurements. Keeping in mind that only five samples were measured in this study, and one of them (Sample 417A-28-3, 119 cm) had a very high magnetization of 111×10^{-4} emu/cm^3, little significance should be attached to the difference in average magnetic intensities reported here and for the results of the shipboard study (Donnelly et al., 1977).

The average Curie temperature for the five Hole 417A basalts is 328°C, implying that the titanomagnetites are highly cation deficient ($\bar{z} = 0.84$). There is no obvious correlation between secondary oxidation and basement depth or K_2O content. All of the strong field heating curves for the Hole 417A basalts are highly irreversible, further evidence for the high oxidation state of the magnetic minerals.

Values of J_{sat}, median destructive field, and Q ratio are all similar to those observed for the Leg 37 basalts. In the case of saturation magnetization, this is quite interesting because one would expect a high J_{sat} to accompany the high J_{NRM} and high susceptibility observed at Hole 417A. This apparent discrepancy in the magnetic data might be examined more closely in further magnetic investigations of the Hole 417A basalts.

There is no obvious connection between the high remanent and induced magnetizations and the type of magnetic minerals present in Site 417 basalts. There is a hint of a direct correlation between magnetic intensity and titanomagnetite abundance (Table 1) but more than five samples are needed to be able to state this with confidence. In addition, many Leg 34 samples (Ade-Hall et al., 1976b; Table 1) have titanomagnetite volume percentages greater than or equal to that observed for the Hole 417A basalts without exhibiting high magnetic intensities. During further investigations into the origin of the high magnetic intensity of basalts from Hole 417A, other investigators should allow for differences in titanomagnetite volume percentages as well as other possible causes.

CONCLUSIONS

The absence of characteristic hydrothermal alteration textures in the opaque oxides of Hole 417A basalts suggests that secondary alteration took place at temperatures well below 150°C and at probably only a few tens of degrees centigrade. These results are consistent with the suggestion of Donnelly et al. (1977) that the high degree of alteration observed in Hole 417A was primarily due to an intense halmyrolysis of basalts during a long period of direct exposure to sea water.

ACKNOWLEDGMENTS

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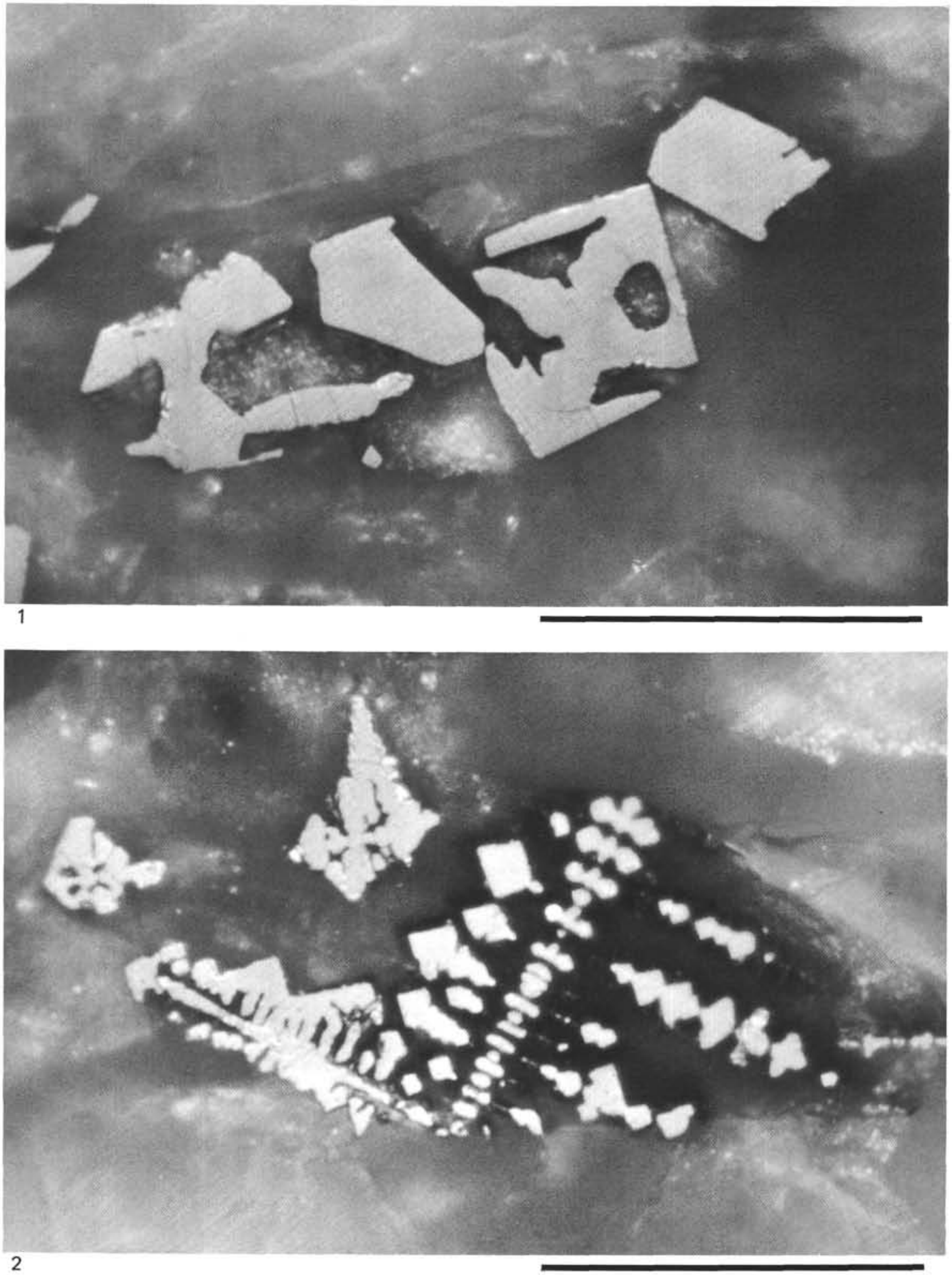
PLATE 1



1

2

Skeletal Titanomaghemites From Hole 417A
(bar width in both paragraphs = 15 μm)

Figure 1	Typical skeletal grain, Sample 417A-29-1, 86 cm.
Figure 2	Chains of interlocking microlites showing slight corrosion and partial replacement of the titanomaghemite by a yellow phase (i.e., the light areas in the plate), Sample 417A-28-3, 119 cm.