24. VOLCANISM

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INTRODUCTION

Volcanism has played a prominent role both in the creation of the ocean basins and in the formation of the topographic features of the sea floors. In parts of the Pacific Ocean Basin, notably near volcanic island groups along the western edge, volcanic sediments are important contributors to the sediment column. However, within the terrigenous sequences of the northeastern Pacific Basin, volcanism has contributed only a small part to the total sediment volume.

This chapter deals with the major volcanic materials which were cored during the Leg 5 cruise. Depths and probable ages are given for ash beds and pumice fragments. Modal analyses of five basalts are presented. Ages of the basalts were determined from the magnetic anomalies and from the paleontologic ages of the sediments that directly overlie the basalts. Some basalts may be intrusive, so more accurate age assignments must await radiometric age dating.

Many questions arise during preliminary studies of this nature, some of which cannot be answered with the available data. For instance, the acidic ashes in deep water far from land present a perplexing problem. Were they erupted on the mainland and carried to the deep ocean by wind transport or by density currents? Do they represent highly fractionated magma which was erupted from a normally basaltic volcano? Can explosive volcanism occur at depths greater than 5000 meters (see Menard, 1964)? Was the Mendocino Escarpment a chain of volcanic islands during parts of the Tertiary where volcanic explosive eruptions occurred periodically? The origins of abyssal hills are still not adequately explained. Some of the basalts indicate a probable intrusive origin, whereas others were probably extruded and then covered by sediment. Pumice fragments far from land masses do not arouse questions because of the ease with which pumice can be transported by surface currents.

VOLCANIC ASH

Volcanic ash, predominantly made up of glass fragments, occurs in twenty-three distinct beds and has contributed to the sediment content in the form of pods or as scattered shards in six other beds. Only four of the 23 beds were altered; the remaining beds contained unaltered glass. Occurrences, depths and probable ages are given in Table 1.

Fresh volcanic glass is characterized by fragments or shards with sharp angles and conchoidal fractures. Some shards contain gas bubbles. Bedding contacts of ash beds generally are sharp and many are graded.

Altered glasses occur in the older Tertiary sediments at Sites 32, 37 and 38. Glass alters to clay and/or phillipsite. Possibly, most of the phillipsite in the "red" clays was derived from glass. White beds of phillipsite in the "red" clay suggest that the zeolite deposit represents a former ash fall. The ages and depths of the phillipsite beds are not given in this chapter. One altered ash from Core 4, Site 38, contains abundant phillipsite, biotite and hornblende. Even some of the plagioclase feldspars may be partly albitized. A dacite or andesite magma seems to be the most probable source for this ash.

Some ash beds in the Miocene at Sites 32, 33 and 34 may be correlative. However, because of the spot coring at these sites, absolute correlation will have to wait on shore studies, where chemical compositions and refractive indices can be compared or where radiometric dating can be applied to determine ages.

PUMICE

Nine pumice fragments were observed in cores from Sites 40 and 42. The origin of the pumice is not known. Alternative derivations might be from nearby seamounts, from the Hawaiian volcanoes, or from a continental source. A thin-section of pumice from Site 40 is very similar to pumice from continental localities. Because of their ease of transport, pumice fragments should be common in cores from the deep part of the central Pacific Ocean Basin.

BASALT

The petrography of five basalts from Leg 5 cores allows some conclusions to be drawn concerning the nature of the basement rocks. Thin-sections were studied, and point counts were made for modal analyses. According to the terminology of Williams, Turner and Gilbert (1955), the textures of the basalts are intersertal, porphyritic intersertal, variolitic and hyalo-ophitic. Compositions of the plagioclase feldspars were determined by studies of twin extinctions and may be modified by later studies.

TABLE 1
Major Volcanic Contributors in the Northeast Pacific

Site	Type	Core	Section	Depth (m)	Probable Age	Remarks
32	Ash pocket	1	4	4763	Pleistocene	
	Ashy sediment	8	1&3	4924-4928	Upper Miocene	Scattered pockets of volcanic ash.
	Ash bed	8	6	4933	Upper Miocene	Somewhat muddy.
	Ash beds	11	6	4959-4960	Lower Miocene/ Upper Oligocene, undiff.	Five ash beds in a 1-meter interval.
	Ash beds	12	6	4969	Lower Miocene/ Upper Oligocene, undiff.	Altered or devitrified ash.
	Basalt	14	1	4975	Lower Oligocene- Upper Eocene	Anomaly 13 (38×10^6 years). Oldest sediment overlying the basalt is younger than this.
33	Ash bed	1	6	4292	Pleistocene	
	Ashy sediment	8	6	4529	Upper Miocene	Glass equals approximately 5% of the sediment.
	Ash bed	12	6	4568	Middle Miocene	Bed is 5 centimeters thick.
	Ash bed	13	6	4577	Middle Miocene	White ash in core catcher.
34	Ash beds	5	1&2	4338-4340	Lower Pliocene	Glass also scattered throughout sediment.
	Ash pod	5	5	4345	Lower Pliocene	Probably a thin bed before coring deformation.
	Ash bed	7	6	4464	Upper Miocene	
	Ash beds	8	6	4495	Upper Miocene	Three ash beds in 60-centimeter zone.
	Ash beds	13	2	4627-4628	Middle Miocene	Two thick ash beds.
	Basalt	18	1	4706	Upper Oligocene	Between Anomaly 9 and 10; oldest sediment is Upper Oligocene. May be intrusive.
35	Scattered glass				Pleistocene	Rare glass shards in some silts.
36	Ash bed	1	5	3279	Pleistocene	
	Ash bed	4	6	3308	Pleistocene	
	Ash bed	10	2	3358	Lower Pliocene	
	Ash bed	12	5	3383	Upper Miocene	10 centimeters thick; graded.
	Basalt	14	1	3388	Upper Miocene	Between Anomaly 4 and 5; anomaly age is younger than the oldest sediment.
37	Ash bed	4	3	4710	?	Altered glass. No paleontologic control.
	Ash bed	4	5	4712	?	Altered glass. No paleontologic control.
	Basalt	4	5	4712	Lower Oligocene	Anomaly 10 (32×10^6 years).
38	Ash pod	4	6	5172	?	Altered ash with hornblende, biotite, and phillipsite.
	Basalt	6	6	5191	Paleocene (?)	Anomaly 23 (oldest sediments are Lower Eocene).

TABLE 1 – *Continued*

Site	Type	Core	Section	Depth (m)	Probable Age	Remarks
39	Basalt	2	6	4946	Paleocene	Between Anomaly 24 and 25 (sediments are Lower Eocene).
40	Pumice	7	6	5242	Middle Eocene	Core catcher.
	Pumice	12	1	5278	Lower Eocene	Scattered fragments.
	Pumice	15	2	5308	Lower Eocene	Fragment.
	Pumice	15	3	5309	Lower Eocene	Fragments.
41	Basalt	5		5371	Middle Eocene (?)	Fragments recovered in the drill bit (dating by oldest sediment).
42	Pumice	6	3	4894	Upper Eocene	Fragments.
	Pumice	8	5	4915	Middle Eocene	Altering to zeolites.
	Pumice	9	4	4923	Middle Eocene	Altering to zeolites.
	Pumice	10	3	4929	Middle Eocene	Altering to zeolites.
	Pumice	11	1	4936	Middle Eocene	Fragments.

Major minerals are labradorite ($An_{62\text{-}55}$) and clinopyroxene (augite). Glass, as sideromelane and palagonite, comprises more than one-half of two specimens. Olivine is a rare constituent of one basalt, and is pseudomorphed by a serpentine mineral in one basalt and by chlorite in another. Alteration of glass forms chlorite, chlorophaeite and montmorillonitic clay. Other major secondary minerals are calcite and hematite. Modal analyses, based on 600 to 700 point counts, are given in Table 2. Major characteristics of the basalts are described in the paragraphs below.

Specimen 5-32-13 is a black, fine-grained basalt. Microamygdules are notable in an intersertal texture. Labradorite ($An_{58\text{-}55}$) and clinopyroxene are set in a mesotasis of iron-rich sideromelane and palagonite. Most labradorite occurs as laths but a few phenocrysts, in which zoning is common, are present. Small rods, spheres and octahedrons of magnetite are scattered throughout the glass. Chlorophaeite, the orange highly birefringent mineral, either occupies spaces between feldspar laths or occurs in thin veins. Chlorite fills some microvesicles.

The glassy basalt recovered at Site 34 (Core 18) is altered near the wide chlorite-calcite veins, but shipboard studies of a fresher specimen give some indication of the original nature of the rock. The modal analysis was made on an altered specimen. The fresher specimen is a variolitic basalt, characterized by small laths and microphenocrysts of clinopyroxene set in a groundmass of glass which has radial, sheaf-like structures. In the altered specimen, the glass has changed to chlorite, except around some feldspar laths where it has changed to clayey palagonite. Feldspar laths can be observed only under high magnifications, and pyroxene is rare.

Specimen 5-36-14 has a porphyritic intersertal texture. Labradorite ($An_{60\text{-}58}$) phenocrysts and laths occur here in a groundmass of clinopyroxene, which forms sheaf-like aggregates; bow-tie structures of the clinopyroxene are present. Magnetite octahedrons and small rods occur along the cleavage planes in the sheaf-like aggregates of clinopyroxene. Secondary minerals are chlorite, chlorophaeite, calcite and sphene.

A glassy basalt from Site 37 (Core 4) has a texture which might best be described as hyalo-ophitic. Labradorite ($An_{62\text{-}60}$) and fresh phenocrysts of olivine (1.5 per cent) are set in a groundmass composed of sideromelane and palagonite. The magnetite occurs as fine grains in the glassy groundmass. This specimen has the only unaltered olivines, and it also contains a labradorite with the highest anorthite content.

The basalt cored at Site 39 (Core 2) has a porphyritic intersertal texture. Labradorite ($An_{60\text{-}58}$) laths and

TABLE 2
Modal Analyses of Basalts From Leg 5
(600 to 700 points counted)

Minerals	Site 32	Site 34	Site 36	Site 37	Site 39
Labradorite	36.3	5.1	52.7	17.7	45.9
Augite	30.7	0.5	41.2	–	32.9
Olivine	–	–	–	1.5	Trace
Magnetite	14.1	–	2.2	–	3.8
Sideromelane	15.0	52.6	–	80.6	–
Palagonite	–	–	–	–	–
Chlorite	3.1	38.9	1.1	0.2	0.3
Calcite	–	2.9	0.2	–	–
Chlorophaeite	0.8	–	2.6	–	11.1
Sphene	Trace	–	Trace	–	–
Serpentine	–	–	–	–	Trace
Hematite	–	–	–	–	6.0
Total	100.0	100.0	100.0	100.0	100.0

phenocrysts occur with clinopyroxene microphenocrysts in a groundmass of sheaf-like clinopyroxene. Pseudomorphs of olivine, now chlorite and a serpentine mineral, are rare. Iron ore, both as magnetite and hematite, comprises nearly 10 per cent of the specimen. Chlorophaeite is the dominant secondary mineral, and it occurs not only in microamygdules but also between laths of feldspar. Some of the microamygdules contain chlorite.

On the basis of thin-section studies, all five specimens can be classified as tholeiites (Wilkinson, 1967). These tholeiites are characteristic of basalts dredged from other parts of the deep ocean basins.

Dating by magnetic anomalies gives the basalts the approximate ages found in Table 3.

Ages based on magnetic anomalies may not be accurate for all of the basalts. For instance, the basalts cored at Site 32 are probably intrusive, as the sediment which overlies the basalt is baked and is altered to a dolomitic clay. The basalt at Site 34 is partly metamorphosed; here, the sideromelane is altered to chlorite and wide veins of chlorite and calcite cut the basalt. These secondary minerals also occur in the overlying sediment. This metamorphism does not suggest intrusion, but it does seem anomalous because the site is far from a known fracture zone or other tectonic feature.

TABLE 3
Approximate Ages of Basalts Dated by Magnetic Anomalies

Specimen	Anomaly	Approximate Age
5-32-13	13	38×10^6 years
5-34-18	between 9 and 10	31×10^6 years
5-36-14	between 4 and 5	8×10^6 years
5-37-4	10	32×10^6 years
5-39-2	24	60×10^6 years

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