41. MIOCENE VOLCANIC GLASS FROM DSDP SITES 368, 369, AND 370

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ABSTRACT

Seventeen samples of Miocene volcanic glass were selected from sediments from Sites 368 and 369. The index of refraction of samples from Site 368 varies from 1.514-1.516 to 1.552-1.554 whereas volcanic glass from Site 369 shows variations of 1.516-1.518 to 1.552-1.524.

Microprobe analysis of glass samples from Site 369 reveal 67.43% and 77.09% silica, respectively.

Both age and chemical composition suggest the glass from Site 369 originated from Gran Canaria, where abundant pyroclastic material erupted during the Miocene. The origin of the glass from Site 368 (56.63%, 64% SiO_2) remains less certain because almost no high silica volcanics are reported from the Cape Verde archipelago nor from the adjacent African continent. The data indicate that the transport mechanism was ash falls rather than reworking.

INTRODUCTION

DSDP Leg 41 drilled in the eastern North Atlantic off northwest Africa, and three of the sites are located close to the volcanic archipelagos of the Canary and Cape Verde islands. According to both limited paleontological evidence (Rothpletz and Simonelli, 1890; Rothe, 1966; Fuster et al., 1968a) and absolute age data (Abdel-Monem et al., 1971, 1972), the Canary Islands originated during the Miocene, and a similar age may reasonably be suggested for the Cape Verdes. Volcanism was mostly basaltic, but from the central part of the Canary group and particularly from Gran Canaria, rocks of higher silica content (trachyrhyolites) are known (Hausen, 1962; Schmincke, 1967).

Miocene sediments or rocks from nearby DSDP sites should thus reflect at least some of the volcanic events on the islands, especially because a large mid-Miocene caldera and associated high-silica pyroclasts have been reported from Gran Canaria (Schmincke and Swanson, 1966, 1967; Schmincke, 1967, 1969). Volcanic glass was found within the sediments of lower, middle, and upper Miocene age from Sites 368 and 369.

ANALYTICAL PROCEDURE

Two series of samples were investigated:

One set of samples are the bulk samples obtained from shipboard sampling. These were analyzed for mineralogical composition by X-ray diffraction methods and carbonate content was measured gasometrically with the "carbonate bomb" (Müller and Gastner, 1971). Volcanic glass was selected by hand picking, and index of refraction was determined by the immersion method.

The other set of samples are sieve-fraction samples with abundant glass obtained from investigations on foraminifers (Pflaumann, this volume).

Scanning-electron microscopy was used to determine shape and appearance of volcanic glass. Single grains were picked and index of refraction was determined as above. Selected glass particles from the two sites with different index of refraction were then analyzed for chemical composition by electron microprobe (ARL-EMX-II).

RESULTS (See Tables 1 through 3)

Sediments from which the glass was isolated are "nanno marls and clay" at Site 368, and "nanno marl and ooze with minor volcanic ash" at Site 369. Total carbonate content was measured and semiquantitative X-ray analysis was run from the bulk samples where glass has been described by the shipboard scientific party, hence, these samples are not representative of the dominant lithology as indicated by the term "nanno marl." The results are given below (Table 1).

Three different types of glass can be distinguished using color: brown, greenish yellow, and almost white. Most of the glass is of the greenish yellow type.

The index of refraction is slightly different between the three sites (Table 2). High values (1.552-1.554) are found only in samples from Site 368, but low refracting glass (1.514-1.518) occurs at all three sites. Most values range between 1.522-1.528 at Site 368 and 1.516 and 1.522 at Site 369. On the average, the glass from Site 368 has a slightly higher index of refraction than does glass from Site 369. The single sample from Site 370 is within the lower extreme (1.516-1.518).

Chemical composition of four glass samples was studied by microprobe analysis (Table 3). These samples were selected from Sites 368 and 369, and attention was paid to analyze samples with rather different index of refraction. A good correlation (four samples only) was found between silica content and

TABLE 1
Gross Mineralogical Composition of Sediments Containing Volcanic Glass; Semiquantitative X-Ray Determinations; Carbonate Content by "Bomb" (Muller and Gastner 1971)

	368-13-4, 125-126cm	368-13-4, 128-129cm	368-14-2, 41-42cm	368-37-2, 57-58cm	369A-4-5, 114-115cm	369A-5-5, 26-27cm	370-19-1, 131-132cm
Total carbonate	6	7	33	–	7	20	2
Total clay minerals	30	65-75	30-40	50-60	8	–	60
Feldspar + quartz	10	5+2	2+5	5+30	10	10	10+25
Heavy minerals (hornblende?, pyroxene?, biotite?)	4	–	–	–	–	5	–
Volcanic glass	50	20-25	20-30	tr.	70	60	<5
Palygorskite	–	–	–	10	–	–	–
Radiolaria	–	–	–	–	5	5	–

TABLE 2
Index of Refraction of Volcanic Glass From Sites 368, 369A, and 370

Sample (Interval in cm)	Index of Refraction
Site 368	
13-1, 134-136	1.522-1.524
13-4, 44-46	1.522-1.524
13-4, 125-126	1.514-1.516
13-4, 128-129	1.524-1.526
	1.526-1.528
14-2, 41-42	1.528-1.530
15-3, 64-66	1.552-1.554
37-2, 57-58	1.524-1.528
Hole 369A	
2-1, 63-66	1.522-1.524
3-3, 64-66	1.522-1.524
3-6, 64-66	1.516-1.518
4-4, 64-66	1.516-1.518
4-5, 114-115	1.520-1.522
4, CC	1.516-1.518
5-5, 26-27	1.518-1.520
	1.520-1.522
5, CC	1.516-1.518
Site 370	
19-1, 131-132	1.516-1.518

TABLE 3
Chemical Composition of Volcanic Glass From Sites 368 and 369A[a]

	368-13-4, 125-126 cm	368-15-3, 64-66 cm	369A-3-3, 64-66 cm	369A-4-4, 64-66 cm
SiO_2	64.00	56.63	67.43	77.09
TiO_2	0.91	1.81	1.08	0.34
Al_2O_3	18.71	18.18	17.45	12.92
FeO[b]	2.71	5.49	4.54	2.71
MnO	0.21	0.20	n.d.	0.27
MgO	0.42	1.95	0.64	0.18
CaO	1.07	5.42	0.57	0.23
Na_2O	5.41	5.85	3.09	1.55
K_2O	6.53	4.44	5.16	4.66
	99.97	99.97	99.96	99.95

[a] Microprobe analysis (ARL - EMX - TI) by V. Stihle (Heidelberg), recalculated H_2O-free. [b] Total Fe as FeO.

index of refraction, as shown by George (1924) (Figure 1). The most striking result was the high silica content of the volcanic glass from Site 369. Silica was calculated on an H_2O-free basis for the uppermost sample as 77.09% (see Table 3) and for the lower sample as 67.43%.

The two samples from Site 368 show lower silica contents. The upper sample has 64% SiO_2 and the lower sample has 56.63% (both values H_2O-free). The silica content of volcanic glass from both sites, however, is considerably greater than that for the basalts.

DISCUSSION

The Miocene glass from Sites 368, 369, and 370 must be regarded as exceptional because volcanism around the Atlantic Ocean is essentially of basaltic composition. The fact that silica-rich magmas produce more pyroclastic material makes it possible that the glass found in the sites represents some kind of late differentiates of basaltic magmas. It seems reasonable to correlate the volcanic glass within the sediments of the sites to the adjacent volcanic archipelagos of the Canary and Cape Verde islands. This correlation is supported by high silica contents of the Site 369 samples. It is probable that this glass originated from the large caldera in Gran Canaria (Central part of the Canary archipelago) described by Schmincke (1967). The origin of the glass from Site 368, however, remains more speculative although the most reasonable assumption would still be an origin from the eastern Cape Verde Islands.

The composition of the volcanic glass from Site 368 changes with age (Figure 2). Except for the lowermost sample, a decrease of the index of refraction was found from 1.552-1.554 to 1.522-1.524 with an exceptional low value of 1.514-1.516 within the upper part. This decrease seems continuous (only eight samples) and might possibly reflect a magmatic differentiation trend from the lower to the middle Miocene. The lower Miocene glass has a chemical compositon of a trachybasalt whereas the middle Miocene glass has a trachyphonolitic affinity. Little can be said as to whether this trend is also found on the islands because

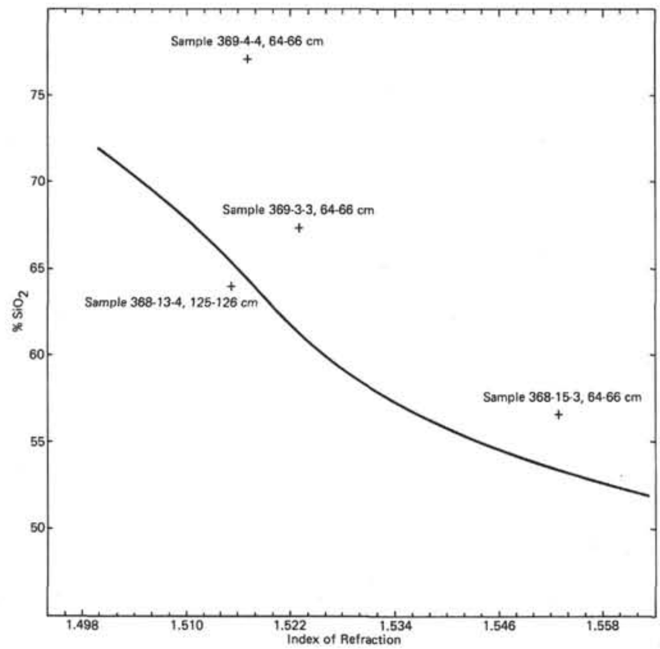

Figure 1. *Relation of the index of refraction of volcanic glass from Site 368 and Hole 369A to the silica content. Massive line from George (1924).*

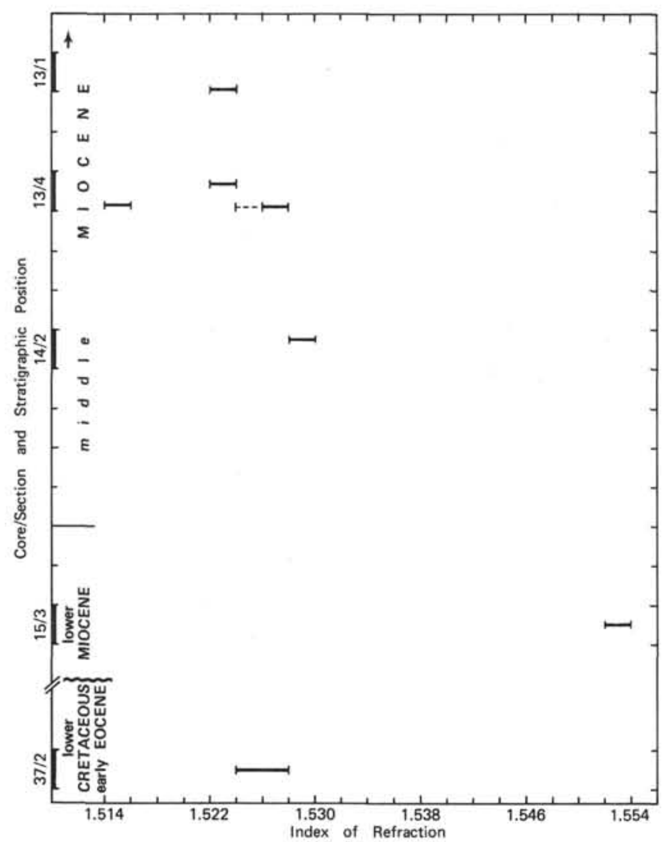

Figure 2. *Index of refraction of volcanic glass from Site 368.*

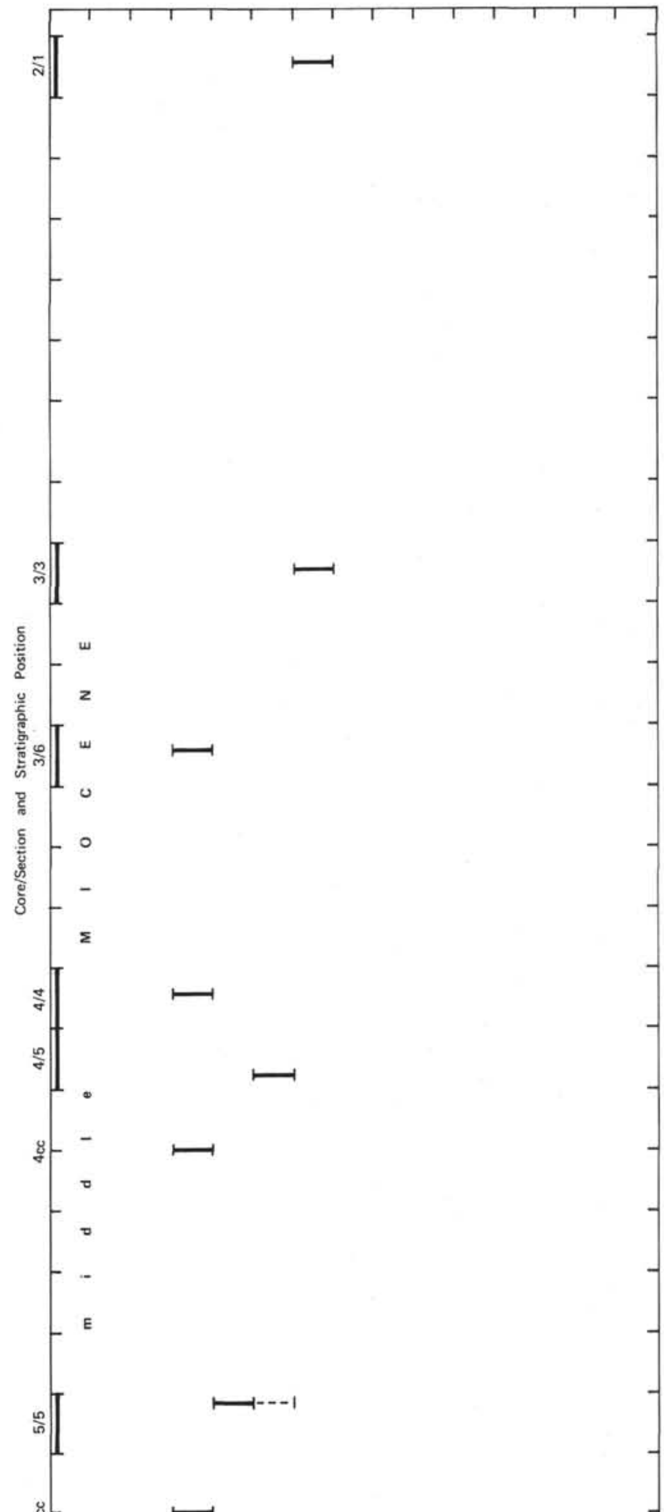

Figure 3. *Index of refraction of volcanic glass from Hole 369A.*

of the scarce analytical data so far published from the Cape Verde Islands.

Igneous rocks of the Cape Verde Islands (Mitchell-Thomé, 1972) are essentially basaltic with very scarce trachytes and trachyandesites but phonolites do occur on all of the major islands. The rock with the highest silica percentage analyzed so far (59.16%) is from Boa Vista, one of the eastern Cape Verde Islands (Mitchell-Thomé, 1972; Part, 1950).

Volcanism is known from the Dakar area on the neighboring African continent mainly during the Miocene (Spengler et al., 1966). The samples studied from Site 368 may thus eventually have their origin there as well.

The composition of volcanic glass from Site 369 off Cape Bojador reveals only a small change with vertical distribution (Figure 3). The Site 369 samples, however, are stratigraphically younger, ranging from middle to late Miocene, whereas the Site 368 samples are lower and middle Miocene in age. This age difference might account for the different composition of the glass.

The two samples analyzed from Site 369 have a probable origin on the Canary Islands. High silica igneous rocks are known from Gran Canaria (Bourcart and Jérémine, 1937; Hausen, 1962; Fuster et al., 1968b; Schmincke, 1967, 1969; Schmincke and Swanson, 1967; Ibarrola Muñoz, 1970).

There is a resemblance between these rocks except that the glass from Site 369 has a somewhat higher silica content, the percentage of Na_2O is lower by a factor of 2 in the glass from both samples from Site 369 as compared to the Gran Canaria volcanics, and also CAO and K_2O differs. Some of the Gran Canaria rocks have been termed alkali-trachytic to soda rhyolitic (Schmincke, 1967).

Whitish volcanic glass from Site 370 with a low index of refraction may also correspond to rather high silica content, but the origin of this single sample remains an open question.

Possible source areas for the volcanic glass from Sites 368 and 369 are the Cape Verde and Canary islands, respectively. However, a continental source area cannot be entirely ruled out for the glass from Site 368.

The presence of tonly high silica glass suggests two possibilities: either no basaltic glass was present at all in the sediments or the silica glass was concentrated because it is much more resistant to alteration than basaltic glass. It seems more probable to assume that only silicic glass was deposited because the glass studied is still completely vitric without alteration. Its occurrence within nanno marls and oozes makes reworking and redeposition as detrital sediments less probable. Ash falls and possibly subsequent drift seems the most probable mechanism of transport for the volcanic glass analyzed here.

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