Fryer, P., Pearce, J. A., Stokking, L. B., et al., 1992
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 125

40. *DATA REPORT:* SEDIMENTARY PETROLOGY AND PROVENANCE OF THE IZU-BONIN FOREARC SEQUENCE, LEG 125[1]

Catherine A. Rigsby[2] and Josef Kekula[2]

INTRODUCTION

This report presents petrographic data that will be used to characterize spatial and temporal changes in the provenance of Izu-Bonin forearc sediments recovered during Ocean Drilling Program Leg 125. These data document the history of the Izu-Bonin arc system as reflected in the framework mineralogy of supra-subduction zone sediments. Subsequent analysis will reveal the record of arc-splitting events as well as the spatial and temporal episodes in forearc volcanism, in source type, and in source area that are preserved in these sediments.

METHODOLOGY

Uncovered, polished, unstained, blue-dye-impregnated thin sections of 172 samples from Leg 125 (Holes 782A, 783A, 784A, and 786A) were grain counted using six major framework-grain categories: glass (six subspecies, as discussed subsequently), pyroxene, amphibole, plagioclase, olivine, and opaque materials. Because the sample size was small and the ratio of grains to matrix was low, the maximum possible number of grains was counted in each thin section. Grains counted per section ranged from one (where the sample consisted of one clast of vitric mud) to 356. Only samples for which 50 or more grains were counted are included in this report (141 of the 172 samples). Note that these data have not yet been analyzed statistically and, thus, that the validity of comparisons among point counts is uncertain. Statistical analysis of these data will permit valid comparison and trend analysis.

Categories of Volcanic Glass

Although several scientists (for example, Tomkeiff, 1983; Heiken, 1985) have characterized volcanic glass in thin section, there is little agreement as to nomenclature for glass-rich sediments and no comprehensive classification scheme appropriate to forearc basin sediments has been published. Thus, it was necessary to devise a method of classification for this project. Our aim was to keep the number of grain categories to a minimum (thereby reducing operator error) while obtaining as much information as possible from each sample. A reconnaissance examination of the Izu-Bonin samples led to the delineation of six categories of glass: sideromelane, tachylyte, pumice, shards, vitric-ash, and vitric-mud. Each of these are described herein and illustrated in Plates 1 and 2.

Sideromelane

Sideromelane (Pl. 1, Fig. 1) is an anhydrous, fresh, homogeneous basaltic glass (Bates and Jackson, 1980). This glass is pale green, dark brown, or yellow in thin section and has a refractive index of 1.58 to 1.62. It commonly displays a blocky morphology, is more massive, and has thicker wall chambers and septa than pumice. The shape of the sideromelane vesicles varies; although usually round, the vesicles in sideromelane may be oblate or, locally, elliptical. Sideromelane is vitric; microlaths are visible only under crossed nicols. The laths are smaller and less abundant than those in tachylyte.

Tachylyte

This basaltic glass (Pl. 1, Fig. 2) is typically dark brown to nearly opaque in thin section; alteration may give it a greenish or yellowish orange cast. Tachylyte has a more pronounced vitrophyric texture than sideromelane; the laths are usually larger and more abundant and are visible under plane light. Tachylyte is vesicular and has a blocky morphology similar to sideromelane, though the grains may be oblate or slightly elliptical. The vesicles, which are generally not visible without the aid of the light condenser, are round or slightly oblate. These are larger than the vesicles in sideromelane, but less abundant.

Pumice

Pumice (Pl. 1, Fig. 3) is a general term applied to pyroclastic lava that is so vesicular that it resembles froth (Tomkeiff, 1983). The term is usually associated with light-colored rocks of acidic to intermediate composition. The pumice in these samples is colorless in thin section and varies in shape from equant to elongate or blocky with jagged edges. Its most prominent feature is an abundance of vesicles. The vesicles have thin, fragile-appearing wall chambers and septa; they vary in shape depending on the viscosity of the magma and the angle of the cut of the section.

Pumice also may have a vitrophyric texture, though not to the same extent as tachylyte or sideromelane. The laths are usually smaller than in the other types and are barely visible under crossed nicols. Under high magnification, the laths appear cloudy because they are intertwined within a fine network of weblike glass.

Shards

A shard is a vitric fragment in a pyroclast. Shards are bubble-wall fragments produced by the physical breakdown of pumice (Tomkeiff, 1983). As such, many shards have a characteristic curved fracture surface. They are typically colorless in thin section and Y-shaped, but also exhibit sickle, blocky, equant, or platy morphologies (Pl. 1, Fig. 4).

Vitric-ash

Vitric-ash clasts (Pl. 2, Fig. 2) are defined here as clasts composed of glass shards, glass fragments (including any or all of the preceding), and varying amounts of mineral grains and microfossils randomly oriented and scattered within a fine matrix of clay or silt. In thin section, vitric-ash may be colorless, light brown to tan, or yellow to ochre yellow, depending on the amount of matrix present. Clasts of vitric-ash are circular to oval and generally have smooth edges. Vitric-ash may resemble siltstone or mudstone clasts, but examination under high magnification reveals the presence of abundant glass shards. The minimum amount of glass required for classification as vitric-ash is 50%.

[1] Fryer, P., Pearce, J. A., Stokking, L. B., et al., 1992. *Proc. ODP, Sci. Results,* 125: College Station, TX (Ocean Drilling Program).
[2] Department of Geological Sciences, California State University, Long Beach, CA 98040, U.S.A.

Vitric-mud

Vitric-mud clasts (Pl. 2, Figs. 1 and 2) are defined here as clasts composed of silt and mud with varying amounts of mineral grains and microfossils and less than 50% glass. These clasts differ from vitric-ash in glass content only.

RESULTS

Summaries of the framework-grain composition of the Leg 125 sediments are presented in Table 1. Vitric-mud is by far the most abundant framework constituent in these sediments and makes up 36.1% of the total. Sideromelane is the most abundant glass type (20% of total grains, 46.2% of the individual glass grains), followed by pumice (12% of total grains, 27.8% of glass grains), tachylyte (6.7% of total grains, 15.4% of glass grains), and shards (4.6% of total grains, 10.6% of glass grains). Silt- to sand-size glass shards are less common than vitric-ash (which contains abundant, but unidentifiable, glass grains and makes up 6% of the grains counted). All other glass types occur commonly as silt- to sand-size grains and are more abundant than the vitric-ash. Ratios of basaltic to acidic glass (sideromelane plus tachylyte to all other types) vary among the sampled drill holes. The highest ratios are found in Holes 782A and 786A (ratios of 3.2 and 2.7, respectively). The lowest basaltic:acidic ratios are found in Holes 783A and 784A (ratios of 1.6 and 1.1, respectively).

With the exception of plagioclase, nonglass framework constituents are rare. Plagioclase, which accounts for 11.6% of the total grains counted, is present in abundances rivaling that of pumice; amphibole (1.4% of total) is rare, and pyroxene (0.04% of total) and olivine (0.15% of total) also are rare. Opaque materials make up 1.2% of the counted grains.

DISCUSSION

Analysis of vertical variations in framework-grain composition within single holes and of lateral variations between holes is under way. These analyses will provide a record of the tectonic, erosional, and depositional history of the region, as reflected in the framework mineralogy of forearc sediments. We are compiling a set of time-slice provenance maps (using biostratigraphic and paleomagnetic data obtained aboard ship and during the post-cruise work of other researchers), as well as a set of stratigraphic/petrographic cross sections. These will graphically illustrate all spatial and temporal variations in the basin history that are recorded in the framework mineralogy of these sediments.

REFERENCES

Bates, R. L., and Jackson, J. A. (Eds.), 1980. *Glossary of Geology:* Alexandria, VA (American Geological Institute).

Heiken, G., 1985. *Volcanic Ash:* Los Angeles (Univ. of California Press).

Tomkeiff, S. I., 1983. *Dictionary of Petrography:* New York (John Wiley).

Date of initial receipt: 1 October 1990
Date of acceptance: 6 May 1991
Ms 125B-148

Table 1. Framework-grain composition of sediments, Leg 125.

Sample Number	(mbsf)	Si	Ta	Pu	Sh	VA	VM	Py	Am	Pl	Ol	Op	Total
125-782A-1H-3, 22-24	3.22	30	77	0	0	0	107	0	1	14	0	0	229
2H-3, 84-86	13.64	0	1	1	1	105	0	0	0	3	0	7	118
2H-4,112-115	15.42	4	4	15	6	22	34	0	10	91	0	1	187
2H-6, 84-87	18.14	224	23	6	0	0	86	0	2	10	0	1	352
5H-4, 31-33	42.80	0	0	1	50	47	8	0	0	1	0	0	107
5H-7, 53-56	47.83	26	30	0	0	0	196	0	0	23	0	0	275
6H-3, 52-56	51.32	1	0	40	0	0	94	0	0	5	0	0	140
6H-4, 74-78	53.04	14	2	0	0	0	103	0	1	2	0	0	122
8R-1, 60-62	67.40	0	0	0	0	0	118	0	0	0	0	0	118
10X-CC, 12-15	88.92	70	24	19	0	0	52	0	4	40	4	2	215
11X-1, 55-57	96.25	48	77	3	0	0	61	0	3	20	0	0	212
11X-1, 115-118	96.85	20	11	99	1	0	34	0	2	58	0	5	230
13X-2, 104-106	117.54	42	1	18	7	5	173	0	0	3	0	0	249
13X-3, 52-54	118.52	152	1	7	0	0	58	0	0	7	0	1	226
14X-2, 141-143	127.51	150	1	2	0	2	5	0	0	3	0	0	163
14X-5, 14-16	130.74	143	9	0	0	3	86	0	3	15	0	1	260
15X-2 ,113-115	136.93	21	4	0	0	0	189	0	0	4	0	3	221
15X-4, 15-17	138.95	87	20	3	0	0	67	0	13	117	0	14	321
16X-1, 90-92	144.80	5	4	0	0	0	113	0	0	0	0	0	122
17X-2, 3-5	155.13	76	1	1	0	5	107	0	3	1	0	1	195
17X-2, 123-125	156.33	127	45	9	0	0	111	0	2	10	0	3	307
17X-4, 1-3	158.11	224	9	5	0	0	57	0	1	15	0	3	314
17X-5, 140-142	161.00	41	49	89	0	0	48	0	10	66	0	2	305
18X-1, 14-15	161.00	28	109	2	0	0	166	0	3	36	0	7	351
19X-1, 52-54	163.34	20	3	0	5	0	101	0	0	2	0	0	131
19X-1, 145-147	173.42	65	26	0	0	0	79	0	1	14	0	0	185
19X-2, 23-25	174.35	155	41	0	0	2	46	0	13	99	0	0	356
19X-3, 52-53	174.63	1	0	0	0	0	0	0	7	44	0	13	65
21X-2, 50-51	176.42	101	48	0	0	0	71	0	1	37	0	0	258
21X-2, 85-86	194.10	171	51	9	0	0	5	0	1	11	1	0	249
21X-2, 96-97	194.45	103	30	0	0	0	157	0	5	14	0	12	321
21X-5, 43-44	194.56	146	60	9	0	0	51	0	6	39	0	2	313
23X-2, 14-1	202.27	51	40	0	0	0	61	0	2	39	0	12	205
23X- 3, 22-23	213.14	81	18	2	0	0	172	0	3	8	0	9	293
23X-3, 92-93	214.72	48	9	1	0	0	181	0	1	12	0	1	253
23X-5, 41-42	215.42	179	27	7	0	0	22	0	6	46	0	4	291
23X-6, 134-135	217.91	63	15	0	0	0	156	0	3	37	0	0	274
24X-1, 105-107	220.34	18	9	16	0	0	8	0	10	63	0	2	126
25X-4 , 110-112	235.44	18	1	122	7	0	24	0	3	31	0	1	207
26X-4, 11-13	236.30	3	0	58	6	0	102	0	3	45	0	2	219
26X-4, 16-18	244.91	2	1	30	3	0	0	0	1	20	0	0	57
6X-4, 51-53	244.96	20	16	80	10	0	31	0	4	17	0	0	178
26X-4, 67-72	245.47	24	6	134	12	4	49	0	2	29	0	1	261
27X-1, 121-122	251.21	21	3	32	5	2	80	0	2	52	0	2	199
27X-2, 30-33	251.80	18	1	96	15	0	39	0	1	33	0	4	207
28X-2, 32-35	261.42	8	4	2	0	0	166	0	0	6	0	1	187
28X-5, 55-57	266.15	10	4	40	2	0	114	0	2	3	0	2	177
29X-CC , 12-14	278.67	4	9	9	0	0	6	0	6	18	0	2	54
29X-2, 81-83	271.51	35	16	16	0	1	58	0	0	19	0	0	145
29X-3, 9-11	272.29	31	25	0	0	0	123	0	0	29	0	0	208
29X-5, 15-17	275.35	48	8	46	7	3	27	0	6	35	0	2	182
29X-6, 39-41	277.09	38	81	0	0	0	51	0	1	65	9	0	245
29X-6, 121-123	277.91	133	32	20	0	1	45	0	3	13	0	0	247
32X-2, 25-29	295.75	71	11	32	0	0	49	0	1	4	0	0	168
32X-4, 121-126	299.71	147	16	0	0	0	13	0	10	34	0	0	220
33X-2, 39-42	305.39	119	12	0	0	1	120	0	2	18	0	2	274
33X-3, 80-83	307.3	25	24	73	0	0	100	0	3	21	0	0	246
33X-5, 86-90	310.36	46	13	1	0	0	17	0	4	18	0	4	103
33X-6, 123-127	312.23	24	11	4	1	0	1	0	5	23	0	0	69
34X-4 , 2-4	317.62	1	19	0	0	0	177	0	0	3	0	0	200
35X-2, 102-104	325.02	7	3	60	0	6	91	0	3	10	0	1	181
35X-4, 74-76	327.74	12	1	27	0	0	71	0	2	6	0	2	121
35X-6, 29-31	330.29	1	6	1	2	0	3	0	19	225	0	23	280
35X-8C, 8-10	333.08	0	0	0	0	0	0	2	3	117	0	10	132
37X-4, 45-48	346.55	0	0	8	0	0	0	0	12	67	0	5	92
37X-5, 86-88	348.46	7	4	22	6	2	4	0	2	8	0	3	58
37X-7, 41-44	351.01	12	0	40	4	6	101	0	2	10	0	2	177
41X-2, 28-31	381.98	2	0	0	0	0	0	0	13	133	0	8	156
41X-3, 124-127	384.44	6	13	0	0	0	98	0	5	42	0	0	164
41X-4 , 137-140	386.07	5	7	0	0	0	149	0	1	12	0	5	179
41X-5, 65-68	386.85	6	4	2	0	0	174	0	0	9	0	3	198
41X-6, 97-100	388.67	0	1	0	0	0	1	0	0	129	0	23	154
41X-6, 34-39	388.04	3	5	0	4	0	0	0	0	58	0	4	74
42X-CC, 10-12	392.90	2	1	0	0	0	3	0	12	62	0	1	81
42X-1, 34-36	390.14	2	0	1	0	0	62	0	1	36	0	2	104
42X-2, 66-67	391.96	50	4	42	0	16	0	0	11	62	0	1	186

Table 1 (continued).

Sample Number	(mbsf)	Si	Ta	Pu	Sh	VA	VM	Py	Am	Pl	Ol	Op	Total
125-783A-1R-2, 3-4	1.53	10	7	65	19	5	13	0	4	27	0	1	151
1R-4, 61-66	5.11	9	8	102	5	18	29	0	2	12	0	0	185
1R-6, 107-109	8.57	4	7	143	3	5	0	0	9	15	0	0	188
2R-1, 147-149	11.17	1	0	7	23	34	59	0	0	4	0	0	128
4R-4, 25-2	30.75	6	1	15	71	16	43	0	0	15	0	2	169
5R-1, 33-34	36.03	10	0	92	30	4	40	0	0	4	0	1	181
5R-2, 36-37	37.56	102	4	55	13	3	9	0	0	10	0	4	200
5R-2, 137-138	38.57	40	0	4	30	8	20	0	0	3	0	4	109
7R-1, 37-38	52.77	3	0	18	19	8	93	0	0	1	0	0	142
8R-2, 138-139	64.98	47	4	2	1	99	0	3	2	14	0	1	173
10R-1, 36-38	81.66	60	12	0	0	9	67	0	0	4	0	2	154
10R-2, 11-13	82.91	29	0	1	2	4	84	0	0	2	0	4	126
11R-1, 13-14	91.03	104	12	22	0	26	16	1	3	16	0	0	200
11R-1, 13-14	91.03	1	2	74	8	3	14	0	2	6	0	3	113
12R-1, 4-6	100.64	66	1	20	1	5	100	0	2	14	0	0	209
125-784A-4R-2, 56-57	22.46	2	0	0	78	7	8	0	1	0	0	0	96
6R-4, 8-9	44.08	3	0	1	1	2	194	0	0	2	0	0	203
6R-4, 56-57	44.56	14	2	0	12	34	115	0	0	6	0	2	185
6R-6, 18-20	47.18	11	0	1	0	8	162	0	0	0	0	1	183
6R-6, 30-31	47.30	20	0	3	36	49	125	0	0	2	0	1	236
8R-2,5 32-3	60.62	23	0	11	17	0	0	0	0	1	0	0	52
8R-5, 35-37	65.15	188	3	10	36	10	24	0	2	7	0	4	284
9R-1, 20-22	68.7	28	6	3	4	18	59	0	0	2	0	2	122
9R-1, 69-71	69.19	1	0	6	17	74	80	0	0	2	0	0	180
9R-4, 64-65	73.64	5	0	1	1	0	188	0	0	1	0	0	196
10R-3, 29-31	81.39	54	3	36	13	28	46	1	1	11	0	6	199
10R-4, 16-18	82.76	54	4	13	26	10	65	0	1	3	0	1	177
12R-1, 79-81	98.19	13	0	5	3	24	88	0	0	3	0	0	136
14R-2, 18-20	116.88	4	0	0	0	13	107	0	0	0	0	0	124
14R-2, 32-34	118.52	26	1	9	11	19	111	0	1	11	0	2	191
14R-5, 48-50	123.18	27	0	1	19	44	24	0	0	1	0	0	116
14R-5, 94-96	123.64	53	0	103	49	2	25	0	0	9	0	0	241
15R-5, 16-18	132.56	2	0	1	9	43	75	0	0	0	0	0	130
17R-3, 80-82	149.40	58	1	6	3	3	72	0	0	0	0	0	143
17R-4, 139-141	151.49	9	1	67	31	34	89	0	1	18	1	1	252
18R-1, 35-39	155.65	44	7	3	0	0	0	0	1	13	0	3	71
18R-2, 102-104	157.82	76	25	3	1	5	152	0	0	14	2	5	283
19R-1, 7-9	165.07	26	9	64	25	23	49	0	2	14	0	1	213
19R-1, 75-76	165.75	22	47	7	10	0	0	0	0	25	0	1	112
20R-1, 18-20	174.88	46	28	0	0	0	0	0	2	23	0	0	99
20R-3, 67-69	178.37	8	1	0	0	44	138	0	0	0	0	1	192
20R-4, 14-16	179.34	60	58	17	9	73	0	0	1	20	1	2	241
20R-5 , 65-67	181.35	2	1	102	33	26	10	0	4	9	0	2	189
21R-3, 45-48	187.85	8	8	0	0	11	195	0	1	0	0	2	225
21R-3, 82-84	188.22	70	7	41	0	1	18	0	0	10	0	0	147
21R-6, 21-24	192.11	16	1	28	7	24	79	0	1	4	0	4	164
21R-6, 51-53	192.41	20	11	4	0	19	141	1	2	5	1	0	204
22R-3, 40-43	197.40	23	10	14	0	0	76	0	0	11	0	0	134
25R-1, 86-88	223.76	6	2	18	25	0	57	0	6	115	4	2	235
26R-1, 31-33	232.81	2	0	0	6	18	44	0	0	0	0	0	70
27R-2, 78-80	244.38	5	23	0	0	0	0	0	1	19	0	10	58
28R-1, 55-57	252.35	4	0	0	0	0	0	0	0	8	0	0	12
29R-1, 11-13	261.51	6	8	17	3	0	57	0	2	22	0	4	119
29R-1, 27-29	261.67	1	0	99	1	1	24	0	0	1	0	1	128
30R-5, 32-34	277.72	12	22	3	0	0	0	0	1	22	0	2	62
31R-2, 31-34	282.61	23	12	49	1	0	37	0	1	14	1	0	138
32R-1, 128-131	291.68	8	18	9	0	0	108	0	0	4	0	1	148
125-786A-5R-3, 114-116	42.34	20	24	0	4	10	78	0	1	13	2	10	162
6X-4 , 122-124	53.32	50	43	6	0	4	25	0	1	10	0	4	143
7X-2, 99-100	59.59	45	23	0	2	1	118	0	3	11	0	5	208
7X-2, 127-128	59.87	29	68	0	0	7	27	0	0	20	0	1	152
9X-3, 129-131	81.09	4	7	48	22	9	22	0	6	37	6	1	162
11X-3, 134-137	100.34	10	1	0	4	6	49	0	6	10	0	3	89
12X-1, 68-71	106.38	0	0	0	0	0	0	0	32	5	0	0	37
34R-1, 43-45		6	32	50	0	4	30	1	6	62	2	4	197
22R-1, 45-48	363.05	0	0	0	0	0	0	0	2	49	0	0	51

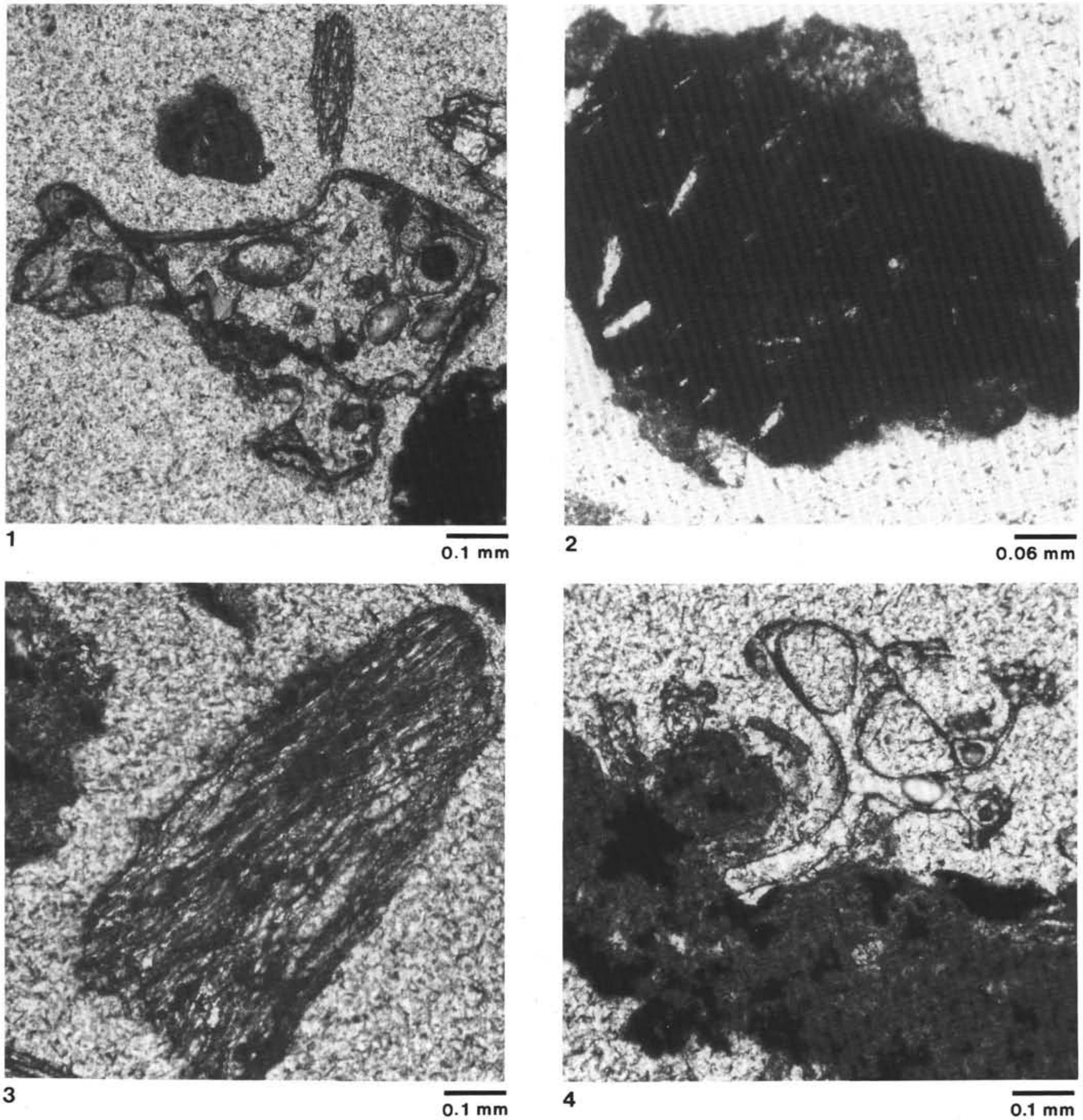
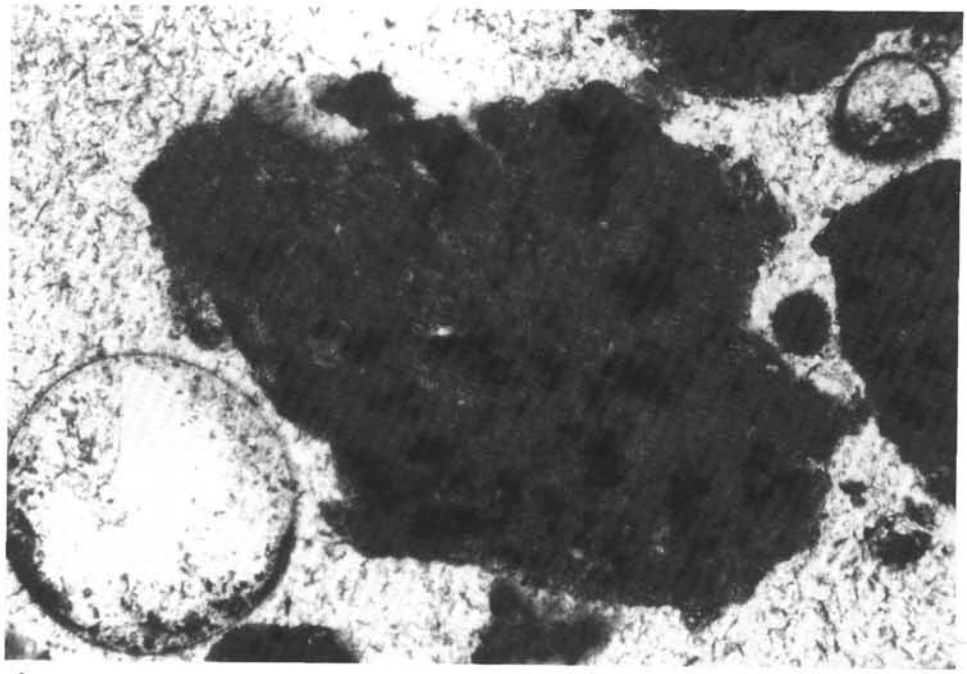
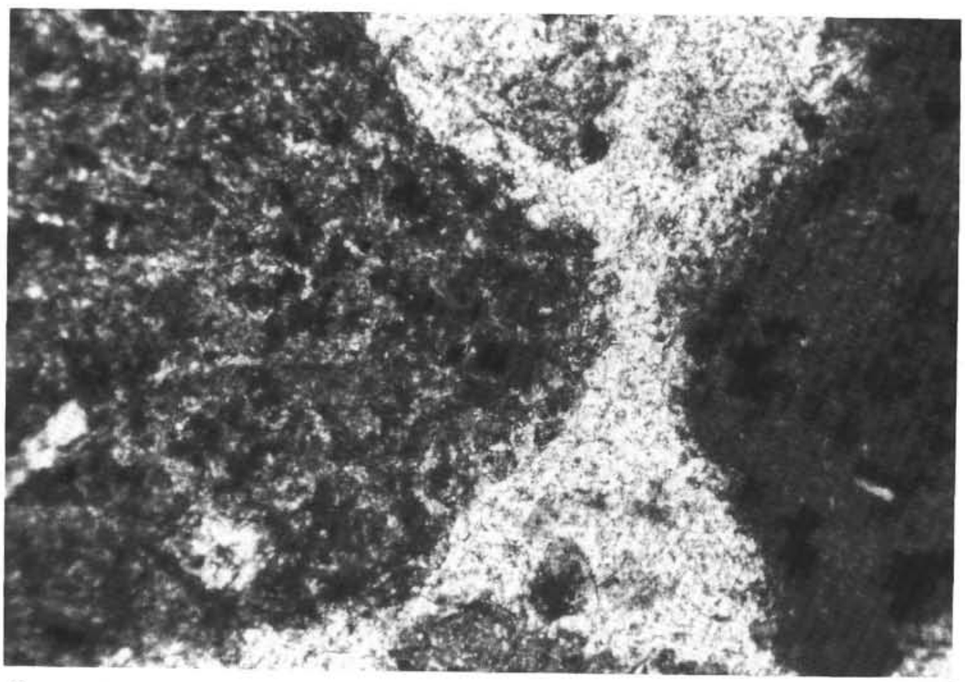


Plate 1. Thin-section photomicrographs of glass categories used in this study. **1.** Sideromelane grain. Note thick wall structure and widely spaced vesicles (Sample 125-783A-5R-2, 36–37 cm). **2.** Tachylyte grain with pronounced vitrophyric texture in Sample 125-783A-45R-9, 45–47 cm. **3.** Large pumice grain in Sample 125-783A-1R-2, 3–4 cm. **4.** Well-preserved glass shard partially encased in vitric-mud (Sample 125-783A-1R-2, 3–4 cm).



1

0.1 mm



2

0.03 mm

Plate 2. Thin-section photomicrographs of glass categories used in this study. **1.** Vitric-mud. The matrix in this sample contains less than 20% visible glass fragments (Sample 125-782A-32X-2, 25–29 cm). **2.** Adjacent grains of vitric-mud (grain on the right) and vitric-ash (grain on the left). These grain types are distinguished primarily on the basis of glass content (Sample 125-783A-2R-1, 147–149 cm).