28. PETROLOGY AND GEOCHEMISTRY OF THE VALENCIA TROUGH VOLCANIC ROCKS

PREFACE

Volcanic rocks were sampled at two sites during DSDP Leg 13. Both are located in Valencia Trough: Site 122, 40° 26.86'N, 2° 37.46'E, at 2146 meters water depth; Site 123, 40° 37.83'N, 2° 50.27'E at 2290 meters water depth. The volcanic samples from Site 122 are not autochthonous; they consist of bean-sized particles from a gravel (Figure 1). Associated with the volcanics are clasts of selenite crystals, pelagic limestones, and shallow-water fossils. Neither quartz, feldspar, nor lithic rock fragments from a continental provenance is present as detritus. We believe, therefore, that this gravel was deposited during the late Miocene when the Mediterranean was dessicated. The source of the clasts was an oceanic province, underlain by the Mediterranean evaporites, older pelagic limestones, and a volcanic basement. The volcanic clasts were derived from the acoustic basement responsible for the observed magnetic anomalies (see Chapter 4). At Site 123, we drilled some 140 meters into the flank of a volcano and sampled a very thick pyroclastic ash-deposit (see Chapter 5).

Volcanic rocks were sent for chemical analysis to M. Weibel at the Swiss Federal Institute of Technology, Zurich; for trace-element analysis to J. Cann at the University of East Anglia, Norwich, England; and for radiometric dating to G. Ferrarra and his co-workers at the University of Pisa, Italy. This chapter reports their findings.

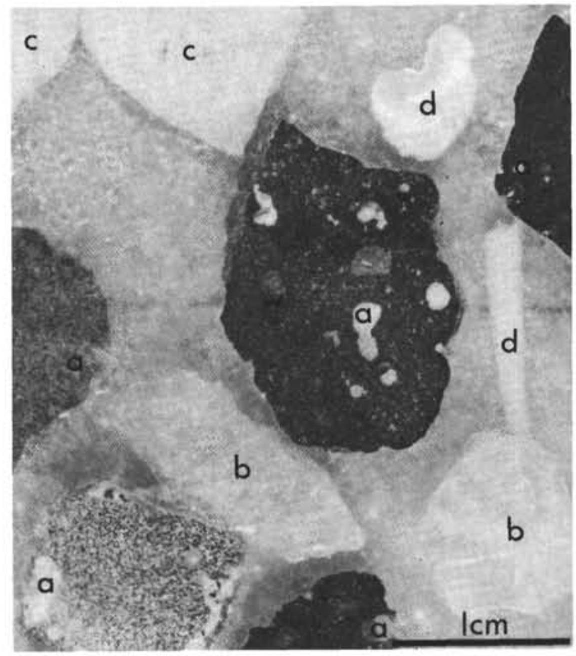

Figure 1. *Loose gravel from the drillbit sample of Site 122. The components include vesicular and aphanitic basalt (a), selenite (b), pelagic limestone (c), and shell debris (d).*

28.1. PETROGRAPHY OF THE VALENCIA TROUGH VOLCANIC ROCKS

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The volcanic clasts from the gravel in Hole 122 are mainly vesicular basalt and andesite. Three fragments, each about 1 cm long, were sectioned and studied petrographically. One is a vesicular basalt, another is a basaltic or andesitic tuff, and the third is an aphanitic basalt. In addition, a sample of the volcanic ash from Hole 123 was also examined microscopically. The petrographic descriptions are contained in the following sections.

Sample 13-122-DB-1 – Vesicular Basalt

The thin section includes a basalt and a tuffaceous sediment in cracks of the basalt (Figure 1).

The basalt consists of plagioclase phenocrysts in a vesicular glassy matrix. The plagioclase laths range from less than 0.1 to 0.3 mm and constitute about 10 per cent of the bulk volume. The subparallel orientation of the laths gives the rock a flow structure. The glassy matrix is dark brown in color. Scattered in the matrix are a few grains of opaque iron minerals and hematite. The vesicles are abundant, constituting 25 per cent of the bulk volume. They range up to 1 mm long and are flattened, and are in part parallel to the flow banding. The insides of the vesicular cavities are lined with cryptocrystalline aggregates, which include chlorite and clinozoisite. Some large vesicles have been converted into amygdules; the cavities have been filled by carbonates and by zeolitic aggregates.

Within the basalt is a tuffaceous sediment. The pyroclastic grains include pyroxene, plagioclase, and tiny basalt fragments. Grains of sedimentary origin are also present. These grains are mainly pelagic oozes, and foraminiferal

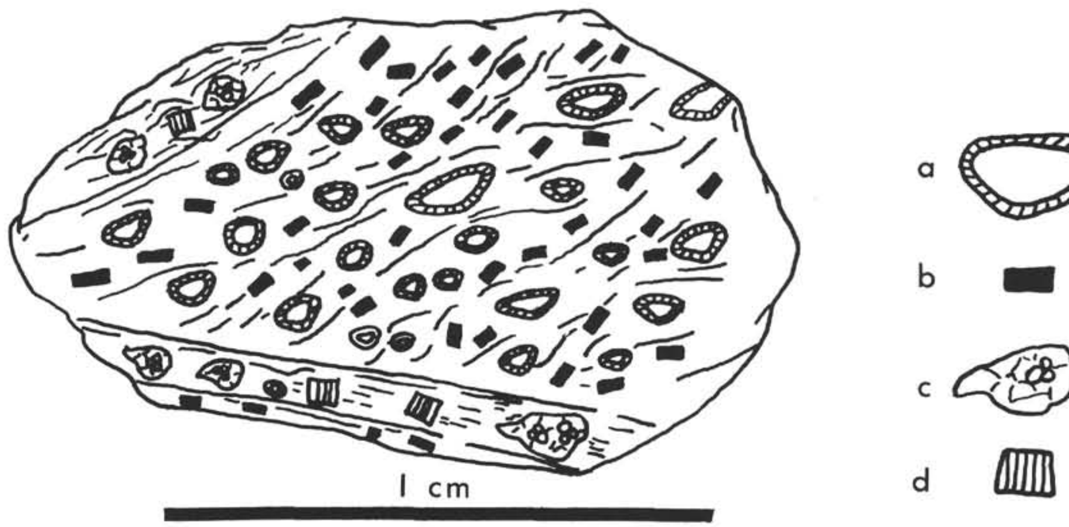

Figure 1. *A sketch of the vesicular basalt and tuff of Sample 13-122-DB-1. a = vesicles; b = feldspar laths; c = carbonate ooze with foraminifera; d = crystal fragments.*

tests are clearly recognizable in some of them. The tuffaceous matrix is altered to a very fine-grained zeolitic aggregate. The tuff is only 0.6 mm "thick" and is bounded sharply by basalt. The contacts are inclined to the flow banding of the basalt (Figure 1). Such a contact relation suggests that the tuff may have been squeezed into the cracks of the basalt. Alternatively, the basalt could have been clasts in a tuffaceous breccia (the tuff being the matrix of the breccia) for we observe another tuffaceous sediment at another corner of the section fringing the basalt. There the contact is more or less parallel to flow-banding of the basalt.

Sample 13-122-DB-2 – Andesitic or Basaltic Tuff

The thin section is an andesitic or basaltic tuff. Nearly equant or slightly elongated plagioclase constitute the bulk of the crystal fragments. They range from 0.1 to 2 mm in size. Some of them show signs of having been shattered. A few basalt fragments are present (block); they consist of lath-shaped plagioclase crystals in a dark glassy matrix (Figure 2). The crystal and lithic fragments constitute about 50 per cent of bulk volume. The other half is a glassy tuffaceous matrix which includes scattered grains of opaque iron minerals.

Sample 13-122-DB-3 – Aphanitic Basalt

The thin section is a basalt. The phenocrysts are mainly lath-shaped plagioclase ranging up to 0.5 mm in length (Figure 3). A few larger, zoned and more nearly equant plagioclase grains are also present. The laths show some preferred orientation. The matrix is glassy and dark brown in color. A few small vesicles, less than 5 per cent by volume, are present.

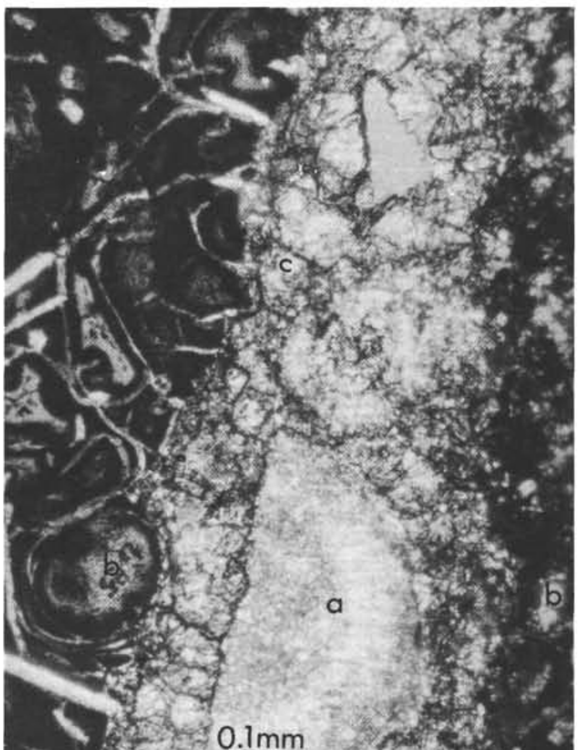

Figure 2. *Vesicular basalt of Sample 13-122-DB-1. The vesicles (a) are often flattened parallel to the flow banding in the glassy basalt (b). The inside of the cavities are lined with cryptocrystalline aggregates (c) including chlorite and clinozoisite. Plane-polarized light.*

Sample 13-123-C-1, 6 cm – Vitric Tuff

The thin section consists almost exclusively of colorless glass shards (R.I. = 1.50), and a fused glassy tuff (Figure 4). A few crystal fragments are present, including plagioclase, olivine, biotite; all are less than 0.1 mm in size. Neither lithic fragments nor microfossils are present. One or two coccoliths were observed. However, the possibility cannot be ruled out that the nannofossils are contaminants.

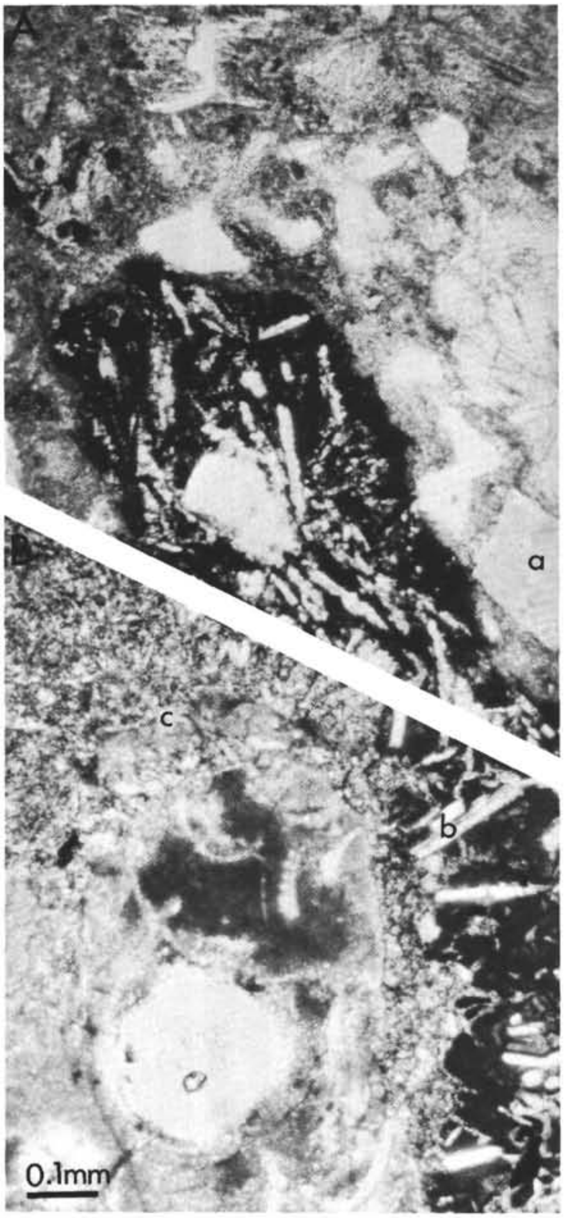

Figure 3. *Basaltic tuff of Sample 13-122-DB-2. The basalt fragments (dark) are welded (e.g. lower right of B) with the glassy tuffaceous matrix. The basalt fragment consists of lath shaped plagioclase crystals. Plane-polarized light.*

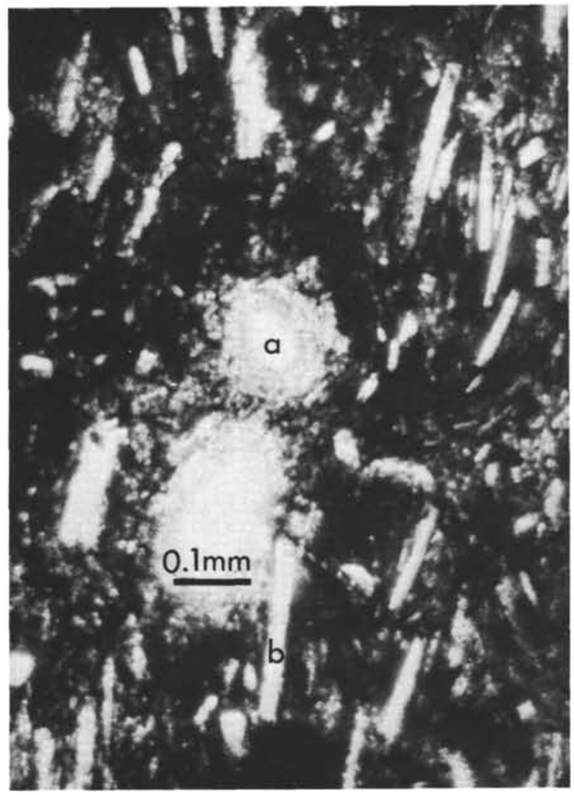

Figure 4. *Aphanitic basalt of sample 13-122-DB-3. Note the small vesicles (a) and the laths of plagioclase (b). The matrix (dark) is glassy and dark brown in color. Plane-polarized light.*

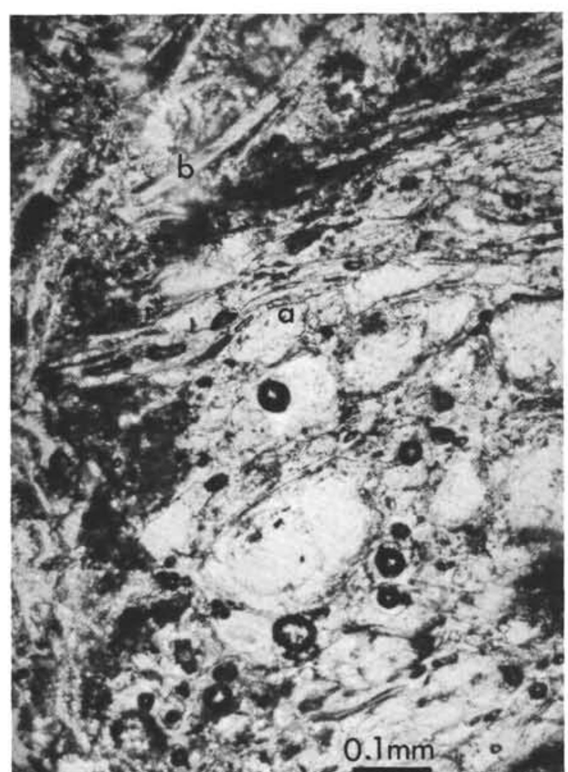

Figure 5. *Vitric tuff of Sample 123-8-1-6 cm. Note the frozen welded texture of the colorless glass (a) and the few crystal fragments of plagioclase (b). Plane-polarized light.*

Sample 13-123-6-1, 75 to 80 cm – Volcanic Ash

This level of fine-grained ash consists of (a) small acidic glass shards (up to 0.45 mm long) in which relicts of vesicle walls (but no pumice) were commonly observed; the low refractive index of the glass (definitely lower than 1.54) indicates a minimum of 60 per cent SiO_2 content; and (b) frequent small ($<$0.2 mm) and subangular fragments of volcanic minerals (plagioclase and sanidine).

These clastic components are cemented by a montmorillonitic matrix which contains a little dolomitic material and opal. The presence of plagioclase, dolomite (or ankerite), and montmorillonitic material was checked by X-ray diffraction. No stratification or organic structures could be observed in the thin sections.

Sample 13-123-8-1, 98 cm – Volcanic Ash

The sample is composed of coarse ash formed by acidic glass shards and pumice (up to 1.6 mm long) and angular fragments (up to 0.3 mm long) of volcanic minerals (plagioclase, sanidine and a few unidentified grains); all are cemented by dolomite or ankerite, opal, and some montmorillonitic material.

The presence of dolomite or ankerite, sanidine, plagioclase, opal, and montmorillonitic material was checked by X-ray diffraction.

Lenticular layering is emphasized by an opaque material probably formed by a clay mineral (montmorillonite?) along with Fe-Mn oxides. No organic structures were observed.

Sample 13-123-8-1, 120 cm – Volcanic Ash

The sample is composed of a coarse ash layer formed of acid glass shards and pumice (up to 5 mm long), and a few angular fragments and rounded phenocrysts (up to 1.2 mm long) of igneous minerals (sanidine, plagioclase, and micropegmatite); all are cemented by dolomite-ankerite, opal, and montmorillonitic material. The presence of dolomite or ankerite, plagioclase, sanidine, opal, and montmorillonitic material was checked by X-ray diffraction. Neither stratification nor organic structures was observed.

Comments on the Site 123 – Volcanic Ash Layers

The four ash layers studied by petrographic microscopy and X-ray diffraction seem to be closely related to the same volcanic source. This could be some explosive volcano(es) generating trachytic or latitic ash and pumice. Taking into account the explosiveness of such volcanoes, it is very difficult to estimate, with only one core, how far the craters were from Site 123. Nevertheless, the large fragments of pumice, the great thickness of the volcanic unit, and the welded nature of some of the levels all suggest a rather local source; perhaps the very same basement high on which the site is located.

28.2. CHEMISTRY OF THE VALENCIA TROUGH VOLCANIC ROCKS

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Two samples of volcanic rocks from the gravel in Hole 122 and one ash sample from Hole 123 were analyzed, using the improved rapid wet-chemical method devised by Weibel (1961). The results are shown in Table 1.

Unfortunately, the samples were so small that sections could not be made before the samples were pulverized for chemical analyses. Apparently, all the samples have undergone secondary alteration. Therefore, the water content is very high, from 5.7 to 8.8 per cent. Also noteworthy is the unusually low magnesium content, and rather high alkali content.

Results of the chemical analyses show that the samples from Hole 122 are basalt and that the sample from Hole 123 is dacite.

Cenozoic extrusive rocks are common in southern and eastern Spain, in Almeria (Cabo de Gata), Cartagena, Ciudad Real (Campos de Calatrava), Murcia, Cofrentes, Tarragona, Gerona, Isla de Alboran, Islas de Columbretes, etc. (Figure 1). Those occurrences were investigated by Osann (1889, 1891 a,b), by Burri and Parga-Pondal (1933, 1935, 1936, 1937), and by others. Two volcanic provinces have been recognized:

(1) "Pacific Suite" in the Betic Cordillera Province. The volcanic rocks there include hypersthene basalts (on Isla de Alboran), andesites, and dacites.

(2) "Atlantic Suite" in the Iberian Foreland Province. These include mainly olivine basalts, nephelinite, and ankaratrites.

Also listed in Table 1 are the chemical analyses of these Spanish volcanics. Columns 4 to 7 give the composition of dacite, andesite, and basalts from the Betic Cordillera, and columns 8 and 9 show the composition of the Iberian Foreland rocks. The rocks from the Valencia Trough obviously belong to the first group.

Of particular interest is the eruptive series in Cabo de Gata described by Ossan in (1891 a,b). There he recognized a series of andesites and dacites older than the Pliocene limestone and demonstrated that these rocks are the product of subaerial volcanism. This volcanic formation is correlative to the cacitic tuff we sampled from Hole 123. Osann (1891b) gave several analyses of the dacite from his area, one of which is shown in column 7, Table 1. A comparison shows that our dacite is richer in H_2O and poorer in alumina and iron oxide (Cf. Columns 3 and 7, Table 1).

Genetically related to the Cabo de Gata volcanics are the hypersthene basalts on the Island of Alboran (Burri and Parg-Pondal, 1937, p. 262). These basalts were named hypersthene andesites or "alboranites" by Becke (1899) because they have a composition range between that of a

TABLE 1
Chemical Analyses of Volcanic Rocks from Valencia Trough and Spain

	1	2	3	4	5	6	7	8	9
SiO_2	50.1	49.9	63.5	52.28	56.32	61.08	62.21	64.78	40.03
Al_2O_3	17.2	17.4	10.5	15.33	16.05	17.25	15.60	17.81	9.61
Fe_2O_3	6.65	6.25	1.25	3.03	3.68	3.16	5.26	2.91	2.90
FeO	2.75	2.4	0.7	5.77	5.35	3.10	1.36	0.24	7.60
MnO	0.08	0.07	0.06	0.06	0.10	0.06	–	0.10	0.19
MgO	2.6	2.4	3.1	6.26	4.45	2.82	2.61	0.08	12.65
CaO	6.2	5.9	4.2	11.44	9.25	3.14	6.55	0.54	13.18
Na_2O	3.6	3.8	3.2	1.71	2.35	1.75	2.50	8.28	2.53
K_2O	2.4	2.4	2.9	1.22	0.55	3.33	1.63	4.16	1.08
H_2O^+	5.7	7.2	8.8	1.36	0.81	2.63	2.25	0.22	2.45
H_2O^-				0.78	0.40	0.05		0.13	1.33
TiO_2	1.98	1.76	0.15	0.77	0.48	0.79	–	0.44	5.79
P_2O_5	0.64	0.58	0.07	0.28	0.22	0.12	–	0.12	0.95
Others	–	–	–	–	–	0.80	–	–	–
Total	99.90	100.06	98.43	95.29	100.01	100.08	99.97	99.81	100.29

Legend:

Column

1 Basalt, DSDP Hole 122, Sample 13-122-4A-2, Analyst, M. Weibel.
2 Basalt, DSDP Hole 122, Sample 13-122-4A-B, Analyst, M. Weibel.
3 Dacite ash, DSDP Hole 123, Sample 13-123-8A, Analyst, M. Weibel.
4 Hypersthene basalt from Alboran, from Burri and Parga-Pondal, 1937.
5 Hypersthene basalt from Alboran, from Burri and Parga-Pondal, 1937.
6 Garnet-bearing cordierite-andesite from Alboran, Burri and Parga-Pondal, 1936.
7 Dacite, Cabo de Gata, Almeria, Osann (1891b).
8 Trachyite, Gerona, Burri and Parga-Pondal, 1935.
9 Ankaratrite, Campos de Calatrava, Burri and Parga-Pondal, 1933.

typical andesite and that of a typical basalt. Burri and Parga-Pondal (1937) found a remarkable similarity between the "alboranites" and the basalt-andesite series of the Fuji-Bonin province of Japan. Such a similarity may be more than coincidental when we recognize that both the Alboran-Cabo de Gata and the Fuji-Bonin volcanic rocks were products of andesitic volcanism behind island arcs. The Valencia Trough basalts are chemically similar to the alboranites, but the former seemed to be poorer in silica and richer in H_2O.

Mineralogically and chemically the Valencia Trough volcanics had little in common with the volcanic suite of the Iberian Foreland Province.

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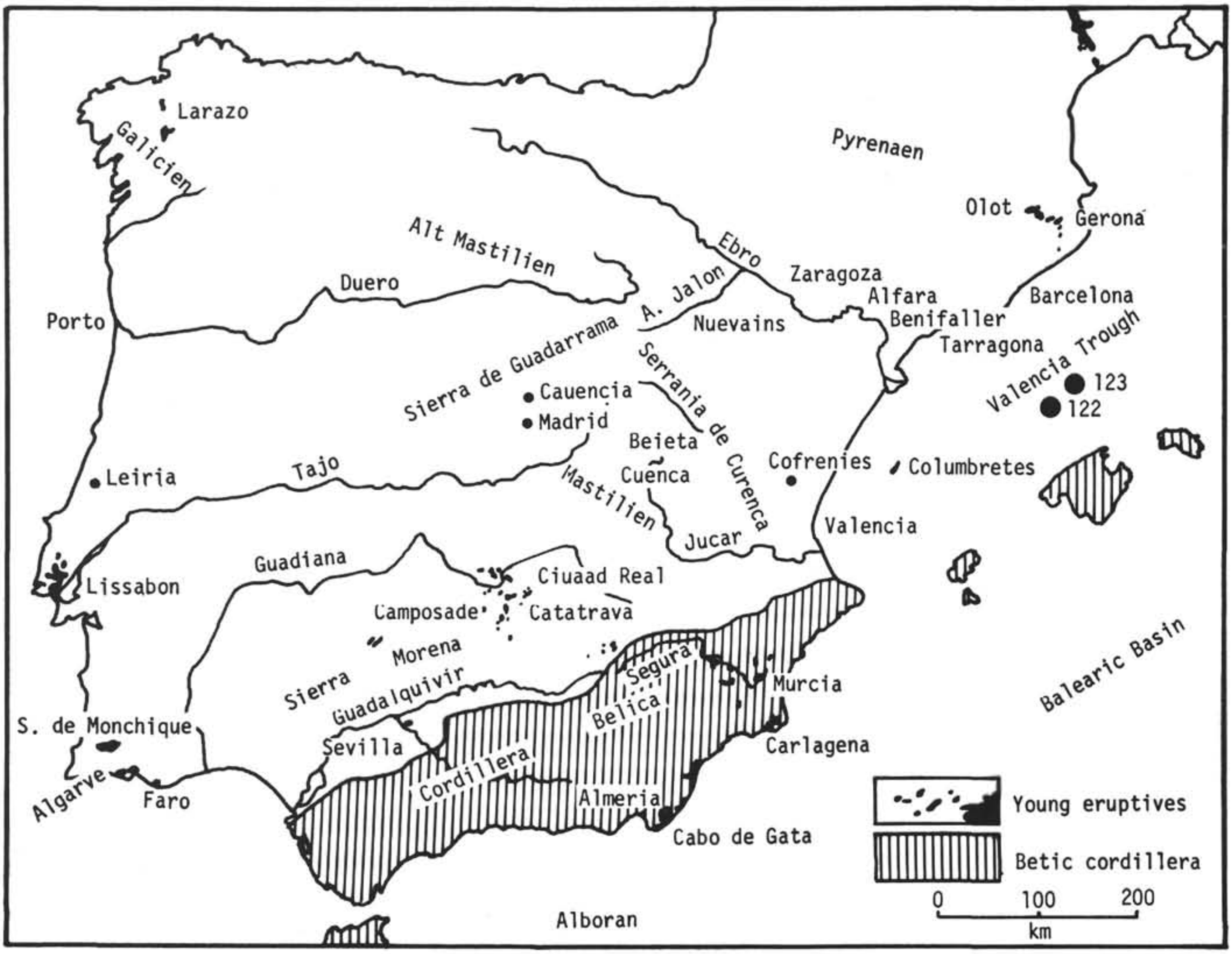

Figure 1. *Distribution of volcanic rocks of Cenozoic age in Spain and Portugal and the locations of Sites 122 and 123 in the Valencia Trough. (After Burri and Parga-Pondal, 1935).*

28.3. TRACE ELEMENTS IN THE VALENCIA TROUGH VOLCANIC ROCKS

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and
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Three samples of the Valencia Trough volcanics were analysed for Rb, Sr, Y, Zr, and Nb. These samples were the pulverized powders from Weibel after his wet-chemical analyses. One of the samples contained too little material to yield any meaningful data. The results of the other two analyses are shown in Table 1.

Sample 13-122-4A-2 shows strong affinities to alkali basalt; our present stage of knowledge does not yet permit us to determine if such an alkali basalt is continental or marine. Sample 13-123-8-CC, being a dacite, cannot yet be typed on the basis of trace-element analysis. Obviously, considerably more investigation will be needed before definitive conclusions can be drawn. Nevertheless, it is noteworthy that neither of the rocks analysed show any affinity in their trace-element composition to the ocean-floor basalts.

TABLE 1
Trace-Element Composition of Two Valencia Trough Volcanic Rocks

	Sample 13-122-4A-2	Sample 13-123-8-CC
Rb	45 ppm	215 ppm
Sr	850 ppm	42 ppm
Y	65 ppm	50 ppm
Zr	300 ppm	215 ppm
Nb	60 ppm	25 ppm

Analyst: J. R. Cann.

28.4. RADIOMETRIC DATING OF THE VALENCIA VOLCANIC ROCKS

G. Ferrara, G. Bigazzi, F. P. Bonadonna and O. Giuliani, Laboratorio per Ricerche RAdiometriche Applicate all Geocronologia e alla Paleoecologia, CNR, Pisa, Italy

A dacite ash from Site 123 in the Valencia Trough was sent to Professor Ferrara, Laboratorio per Ricerche Radiometriche Applicate, Pisa, for radiometric dating. Both whole-rock K/Ar and fission-track methods have been used. The results are as indicated below.

FISSION TRACKS RESULTS

The sample studied consists of very small fragments of glass, either transparent or opaque. The sample was mounted in epoxy and a polished section was made. This allowed us to count the track density on the interior surface alone. In this way it was also possible to minimize uranium contamination.

Two separate portions of the sample were used for the counting of induced and natural fission tracks because the size of the glass fragments does not allow two subsequent polishings on the same section. The track density uniformity favored use of this technique. The samples were etched with hydrofluoric acid (40% by volume) for 1 minute at 20°C.

K-Ar MEASUREMENTS

Ar was extracted and measured using the standard methods routinely employed in this laboratory. A continuous spike system is used. The mass spectrometric measurement was performed by means of a Reynolds type glass mass spectrometer running at static conditions. K was determined by flame photometry using a Perkin-Elmer photometer with Li as internal standard.

Two different fractions of the sample were measured, and the results are shown in Table 2.

TABLE 1

Sample	Natural Tracks Density F	Induced Tracks Density I	Thermal Neutron Dose	Age m.y.
Leg 13 Station 123 Barrel 6 Section CC Sample CT	28×10^3	140×10^3	1.8×10^{15}	22.4 ± 2.2

TABLE 2

Sample Fraction	K%	$\frac{\text{rd Ar}^{40}\text{ ccSTP}}{\text{gr K}}$	% rd Ar^{40}	Age m.y.
0.27 mm	3.12	8.58×10^{-5}	32	21.4 ± 0.6
0.16	2.77	8.13×10^{-5}	11	19.3 ± 0.7

Measurements performed at the Laboratorio per Ricerche RAdiometriche applicate all Geocronologia e alla Paleoecologia, CNR, Pisa (directed by Prof. Giorgio Ferrara) by G. Bigazzi and F. P. Bonadonna (fission tracks) and O. Giuliana (K/Ar).