

# THE HISTORIC ERUPTIONS OF LA PALMA ISLAND (CANARIES)

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## ABSTRACT

From the first contacts of the European navigators who first visited the Canary Islands, around the middle of the XIV century, 18 eruptions have taken place of which seven occurred on the island of La Palma.

A historic-bibliographic study as well as a detailed field work have enabled us to accurately determine the places, dates, duration and volcanological patterns as well as the petrology and geochemistry of this historic eruptive cycle.

In every instance, alkaline basaltic lavas were emitted: true basalts, basanitoids and/or ankaramites. A differentiation process always took place in the magma chamber and a sequence from amphibole to olivine-bearing lavas was erupted. These variations of the chemistry and mineralogy of the lavas were related to the different stages of the eruption and the

height over sea level, where the corresponding eruptive vents opened.

The two main structural trends of the historic subhistoric volcanism of La Palma are N 5° W and N 35° W. Both trends correspond to the predominant ones of the dike swarms of the Basal Complex of the island. The secondary trends, N 80° E and N 15° E, likewise coincide with the corresponding main directions of the dike swarms of the Basal complexes of La Gomera and Fuerteventura.

The duration of these historic eruptions was between 1 to 3 months and the area covered with lava and pyroclasts was 37 km<sup>2</sup>, 5 % of the total surface of the island.

#### THE HISTORIC ERUPTIONS OF THE CANARIAN ARCHIPELAGO

From the first contacts of the European navigators who visited the Canary Islands around the middle of the XIVth century, 18 eruptions have taken place (Table 1).

Of the 18 eruptions, 7 occurred on the island of La Palma. A new historic-bibliographic study as well as a detailed field-work have enabled us to accurately determine the places, dates and duration of these eruptions as well as their volcanological, petrological and geochemical features. The detailed study of all these aspects will be published separately; here we will give only a brief summary.

Nearly all historic eruptions on the Canary Islands, were relatively moderate, restricted to local areas of limited extension and their duration ranged only from a few days to 3 months. Notwithstanding, some of the eruptions were of a bigger magnitude, specially the Timanfaya eruption of Lanzarote island in the XVIII century, that lasted six years practically without interruption, covered with lava and tephra

a third of the island and obliged most of its inhabitants to emigrate. In other instances, as in the eruption of Montaña Negra, Tenerife, in 1706, the volcanic outburst, that lasted 9 days only, completely destroyed the town of Garachico.

#### THE HISTORIC ERUPTIONS OF LA PALMA

The seven historic eruptions of La Palma (Table 2) have taken place in the southern half of the island, in the mountain spine known as Cumbre Vieja, from its beginning in the El Paso valley till the southern point of the island, in Fuenca-liente, near the sea (Fig. 1).

All the eruptions began after a more or less prolonged period of earth tremors, whose magnitude never exceeded No. 6 of the Richter scale. These tremors were always restricted to some zones of the island, increased their intensity and frequency on the days and hours preceeding the eruptions, restricting to the area where the eruption took place thereafter. The eruption s.s. starts with the opening of little fissures of the ground following directions prefixed by the main structural patterns of the island. From the first moments, these fissuration is accompanied by the emission of gases and little lava fountains from several points along the whole extension of the main fissure that can attain several kilometers in length. Within a short time during the first hours of the event, these multiple incipient volcanic vents remain restricted to a few ones, more and more active, where the construction of heaps of tephra grow little by little and coalesce to the typical volcanic cones with their corresponding craters.

When the fissure opens in a terrain with a considerable slope and in its direction, high pressure lava fountains, pyroclastic materials and gases are emitted from the higher volcanic vents, while from the lower vents only more or less degasified lava pours out with a much lower explosivity.



Fig. 1 — Location of the historic eruptions of La Palma. 1. — Tacande (1470-92). 2. — Tahuya (1585). 3. — Tegalate (1646). 4. — San Antonio (1677). 5. — El Charco (1712). 6. — San Juan (1949). 7. — Teneguía (1971).

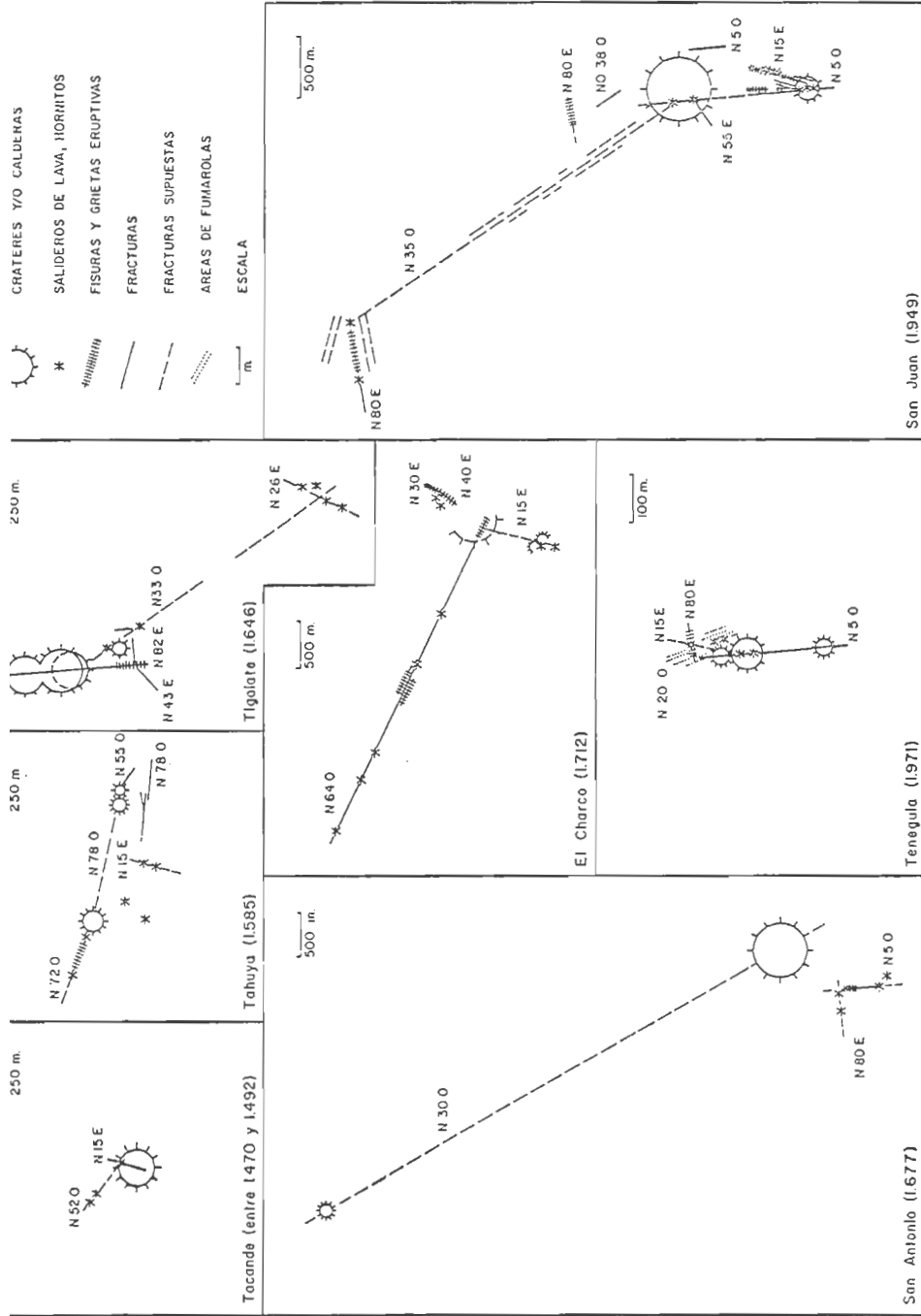


Fig. 2—Structural patterns of the historic eruptions. Legend from top to bottom : craters and/or Calderas. Lava vents, hornitos. Eruptive fissures and fractures. Supposed fractures. Fumaroles. Scale.

This pattern is more noticeable when the difference in height of the extreme volcanic vents is greater, and the duration of the eruption is longer. In the most typical instances the higher vents grow to volcanic cones of a couple of hundreds of meters, while in the lower ones there only remain some eruptive fissures outpouring lava. This pattern is very clearly exposed in the eruptions of the volcanoes Tigalate, El Charco or San Juan, where the difference in height of the different vents is very noticeable.

During the course of the eruption it is also frequent that secondary cracks and fissures develop near the main volcanic vents, following also the main structural trends of the island. (Fig. 2 and 3).

The eruption continues with changes in the activity of the several vents, until suddenly and without a marked and gradual diminution of the explosivity and lava outpour, the activity practically stops. Subsequently, all the eruptive area suffers a period of slow degasification, becoming weaker and weaker, that lasts for 2 or 3 years. After this period, all volcanic manifestations cease, starting a new eruption, after an irregular period of time that normally lasts for several years, in other part of the same island or in other island of the Archipelago. (Table 1).

#### STRUCTURAL PATTERNS OF THE VOLCANIC ERUPTIONS

All these historic eruptions and in general all the recent eruptions of the island are conditioned in its geometric patterns by the directions that rule the whole of the Archipelago and La Palma in particular.

The main structural trends that rule the several eruptive areas (Fig. 2 and 3) are N 5° W and N 35° W. Both are the

SYMPOSIUM ON THE ACTIVITY OF OCEANIC VOLCANOES

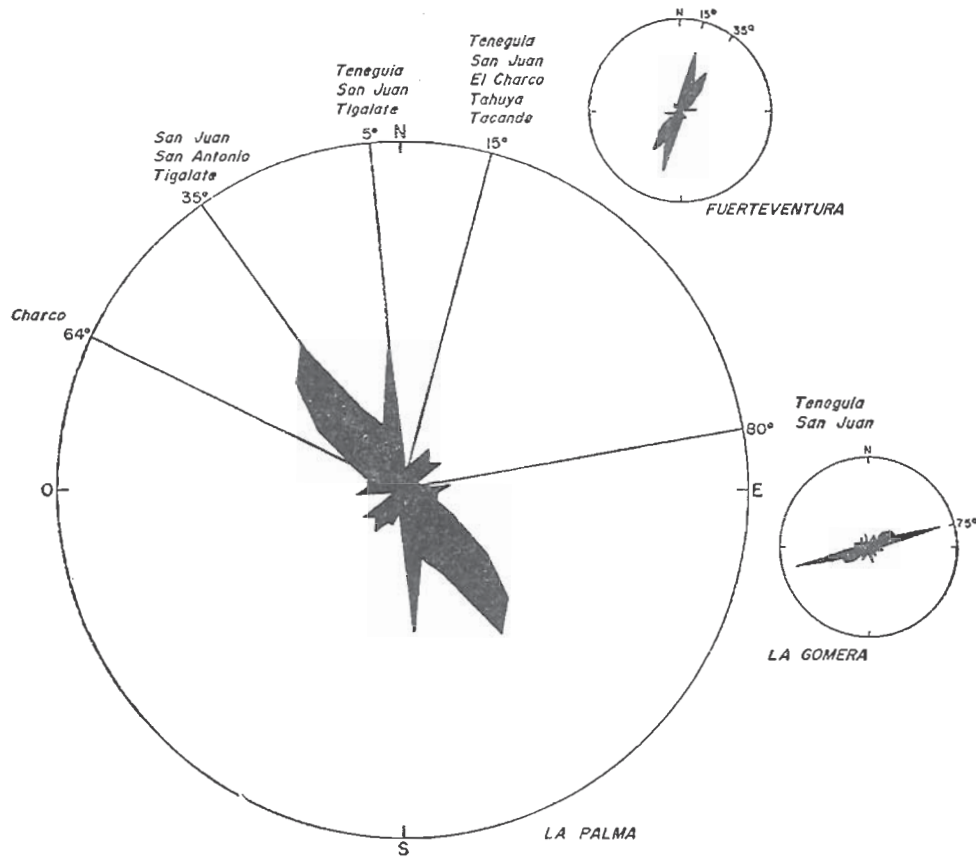


Fig. 3— Main directions of historic eruptions of La Palma related to the dike-swarms of the Basal Complex of the Island. The orientation diagrams corresponding to the Basal Complexes of Fuerteventura and La Gomera Islands are also drawn. (Data of Basal Complex of La Palma from NUEZ, J. de la (pers. communication) and data of the basal complexes of Fuerteventura and La Gomera from HERNANDEZ-PACHECO, A., 1979).

predominant ones in the eruptions of Tegalate, San Antonio, San Juan and Teneguía volcanoes. Both coincide with the maxima for the trends of the dike swarms of the Basal Complex of the island that appears in the Caldera de Taburiente.

Other trend, N 15° E, of secondary magnitude, appears in the eruptions of Tacande, Tahuya, El Charco and also San Juan and Teneguía volcanoes. It coincides with a maximum of the dike swarms of the Basal Complex of Fuerteventura. Lastly, the approximate direction N 75-80° E, fundamental in San Juan eruptions but also existing in San Antonio, Tegalate and Teneguía volcanoes, coincides with the corresponding maximum of the dike swarms of the Basal Complex of La Gomera. Special consideration deserves the fracture originated by the fissural eruption of El Charco. Its direction follows a N 64° W trend that could be likened to the direction of the Atlantic fracture system that exists to the W of the island. It marks the alignment of the volcanic edifices of Gran Canaria, Tenerife and La Palma.

The fact that these directions are the same that control the volcanic phenomena is logical, but the important point is that they do not follow a simple, unique pattern NE-SW or NNE-SSW as it was previously said. The above mentioned directions predominate in the whole extent of the Archipelago and exist at least from the Lower Miocene, age of the magmatic episodes of the Basal Complexes until the present time. It can be said that, for the whole Archipelago in general and for La Palma in particular, the recent vulcanism is ruled by complex structural lineaments, of regional extent, that come from about 30 M.a. ago and are periodically reactivated in connection with volcanic eruptions dependent from one or other of these structural trends.

PETROLOGY AN GEOCHEMISTRY  
OF HISTORIC LAVAS

The materials emitted by the historic volcanoes of La Palma belong to the group of alkaline basalts with porphyritic texture with pyroxene and/or olivine and/or plagioclase and/or amphibole phenocrysts in a dark cryptocrystalline to microcrystalline matrix.

Following the criteria of IBARROLA, E. (1970) and according to the abundance of CIPW normative feldspar (Feld.) and nepheline (Ne), only a few percentage of the samples are basalts ( $> 45\%$  Feld,  $< 10\%$  Ne). Most of them are basanitoids ( $< 45\%$  Feld,  $> 10\%$  Ne) and ankaramites ( $< 45\%$  Feld,  $< 10\%$  Ne), as it can be seen in Table 2.

Generally each volcano has two or more types of basalts depending on their existing minerals as phenocrysts. At Tene-guía volcano, the two types of basalts, pyroxene amphibole basalts and pyroxene olivine basalts, correspond to two eruptive phases, delimited in time.

In the other volcanoes it is not always possible to establish this correspondence but in general terms, it can be said that the crystallization has taken place at three stages. In a first stage of magma consolidation, amphibole (kaersutite type), greenish pyroxene (ferrisalite type), acidic plagioclase and h aüyne were formed. These minerals were mainly preserved in the scorias and pyroclastic materials, while in compact lavas they appear corroded and with resorption phenomena. H aüyne is only found as inclusions in the very scarce and corroded plagioclase crystals. The main crystallization stage follows and olivine, augite and plagioclase are then formed. Lastly, there is a final consolidation stage, only observed in rather few samples and formed by interstitial analcime, alkaline feldspar and biotite or by glass.

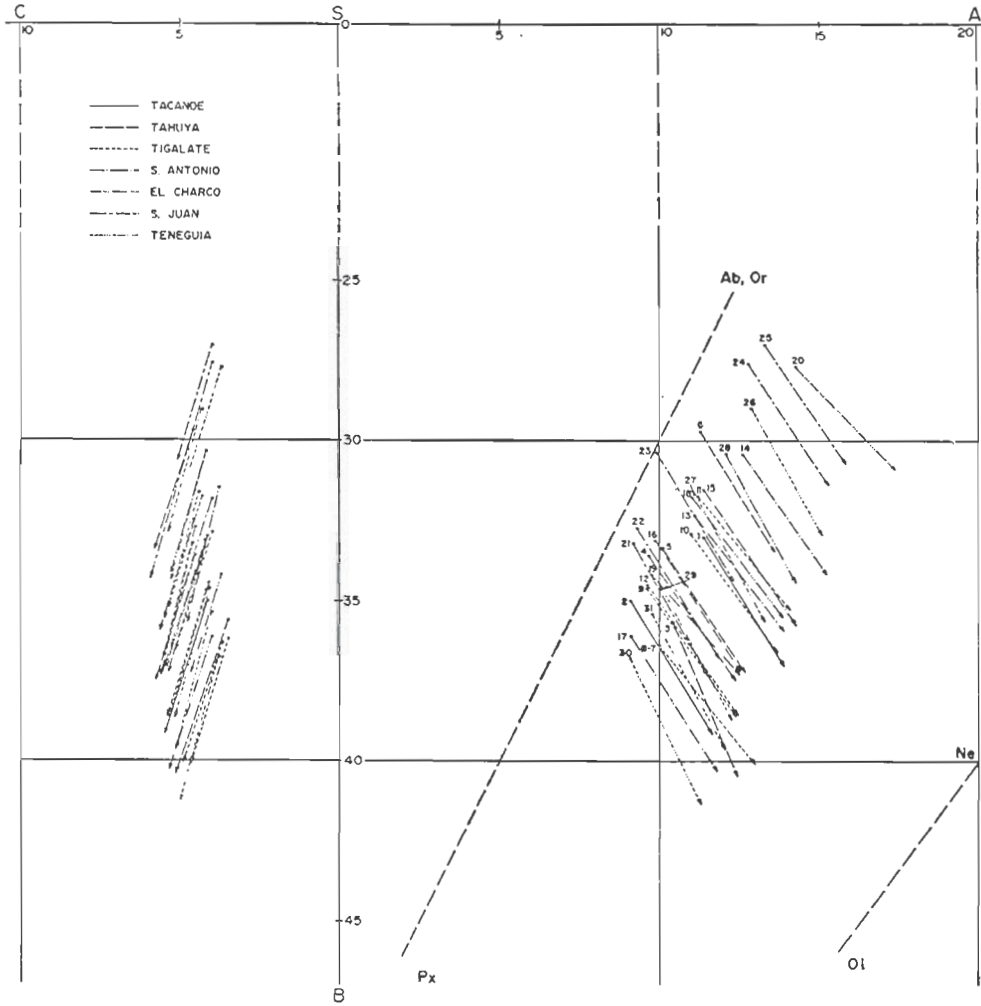


Fig. 4 — Zavaritzkii diagram of the historic lavas of La Palma.

TABLE 1

## HISTORICAL ERUPTIONS OF THE CANARIAN ARCHIPELAGO

Year	Start-up	End	Island	Site and name	Main References	Observations
1341	—	—	Tenerife	Not located	RECCO's report, according to BRAVO, T., pers. com.	It is doubtful.
1393-1394	—	—	Tenerife	Not located	Report of Biscayan seamen. BRAVO, T., pers. com.	It is doubtful.
1430	—	—	Tenerife	Taoro eruption (Orotava valley) : Mña de las Arenas or Horca Mña de los Frailes, Mña de Gañanías.	Aboriginal guanche tradition. BRAVO, T., pers. com.	
between 1470 & 1492	—	—	La Palma	Tacande Volcano (Montaña Quemada)	Aboriginal guanche tradition SANTIAGO, M. (1960) HERNANDEZ-PACHECO, A.	Corroborated by C <sup>14</sup> dating 1530 ± 60 years
1492	Aug. 24 volcanic activity existed.	—	Tenerife	SW slopes of Pico Viejo : Montaña Reventada ?, near Montaña Bilma : Montañetas Negras ?	« Historias del Almirante » by Fernando Colon and Summary of Fray Bartolomé de las Casas according to BRAVO, T., pers. com.	The volcano has not been localized with absolute certainty.
1585	May 20	July ?	La Palma	Tahuya Eruption (Roques de Jedey)	Historical researches, by SANTIAGO, M. (1960) Geolog. researches by BRAVO, T. pers. com. & HERNANDEZ-PACHECO, A.	The Roques de Jedey made extrusion during this eruption
1646	Oct. 2	Dec. 18 or 21 st.	La Palma	Tigalate or Martin Volcano	SANTIAGO, M. (1960) and later geological researches by HERNANDEZ-PACHECO, A.	Some volcanic vents opened at the Eastern coast between the Puertito and La Baja del Agua.
1677-1678	Nov. 17	Jan. 21	La Palma	San Antonio or Montaña de las Cabras volcano, near Fuencaliente. La Caldereta Volcano ?	SANTIAGO, M. (1960) and later geological researches by HERNANDEZ-PACHECO, A.	
1704-1705	Dec. 31 Jan. 5 Febr. 2	Jan. ? Jan. 13 Febr. 26	Tenerife	Siete Fuentes or Llano de los Infantes volcano Fasnía, Almarchiga or Dos Roques volcano Montaña Arenas or Güimar volcano	FRITSCH, K. v. & REISS, W. (1868) BRAVO, T., pers. com.	The distance between the furthest vents is about 12 Km.
1706	May 5	May 14	Tenerife	Montaña Negra or Garachico volcano	FRITSCH, K. v. & REISS, W. (1868). BRAVO, T., pers. com.	Garachico village was destroyed.
1712	Oct. 9	Dec. 2	La Palma	El Charco or Montaña Lajiones eruption	SANTIAGO, M. (1960). AFONSO, A. (1974) and later geolog. researches by HERNANDEZ-PACHECO, A.	
1730-1735	Sept. 1	April 16	Lanzarote	Timanfaya eruption	HERNANDEZ-PACHECO, E. (1910, 1960)	Large number of vents opened. One third of the surface of the island was covered with lavas & pyroclasts.
1793	March ?	July ?	El Hierro	At El Golfo, near the N. coast	DARIAS & PADRON, D. V. (1929) BRAVO, T., pers. com.	The eruption was probably submarine. Many earthquakes affected the island.
1798	June 9	Sept. 8	Tenerife	Chahorra or Narices del Teide volcano	FRITSCH, K. v. & REISS, W. (1868). BRAVO, T., pers. com.	
1824	July 31 Sept. 29 Oct. 16	Oct. 16 Oct. 4 Oct. 24	Lanzarote	Tao or Clerigo Duarte volcano Volcán Nuevo del Fuego Tinguaton volcano	HERNANDEZ-PACHECO, E. (1910, 1960)	During the last stages of the eruption, sea water was emitted by Tinguaton volcano.
1909	Nov. 18	Nov. 27	Tenerife	Chinyero volcano	FERNANDEZ NAVARRO, L. (1911)	
1949	June 24 July 8 July 12	Aug. 9 July 26 July 31	La Palma	San Juan or Duraznero volcano Llano del Banco or Las Manchas volcano Hoyo Negro volcano	ROMERO ORTIZ, J. (1951) MARTEL, M. (1960) and geolog. researches of HERNANDEZ-PACHECO, A.	Also named « Eruption del Nambroque ».
1971	Oct. 26	Nov. 18	La Palma	Teneguía volcano	Teneguía Volume. Est. geol. 1974 unpublished Journal of the eruption by HERNANDEZ-PACHECO, A.	Several vents named Teneguía I to Teneguía VI.

TABLE 2

Historic eruptions of La Palma	— Type of eruption — Number of eruptive vents — Maximum distance between them	— Days of eruption — Surface covered with lava & tephra (Km <sup>2</sup> )	— Morphology of the lavas — Type of material	— Proportion of ankaramites/basaltoids/basalts, according to CIPW normative minerals (number of analysis)
TACANDE (between 1470 & 1492)	— Eruptive vent — 3 — —	— ? — 5.6	Aa, blocky lava Oliv. — px. basalt.	1/1/— (2)
TAHUYA (1585)	— Eruptive fracture — 9 — 1100 m	— 50 at least — 4.8	Aa Px-Oliv. basalt Px-Amphib. basalt	2/1/1 (4)
TIGALATE or MARTIN (1646)	— Eruptive fracture — 7 (9 ?) — 4900 m	— 79 or 82 — 7.5	Aa Px-Oliv. basalt Px-Amphib. basalt	1/5/— (6)
SAN ANTONIO (1677)	— Eruptive fracture — 5 — 3700 m	— 66 — 6.5	Aa, dalles Px-Oliv-Amphib. basalt	1/3/— (4)
EL CHARCO (1712)	— Eruptive fracture — 9 (12 ?) — 2600 m	— 55 — 4.9	Aa, ropy Px-Amphib. basalt Px-Oliv. basalt	1/3/— (4)
SAN JUAN (1949)	— Eruptive fracture — 5 — 3450 m	— 47 — 4.5	Aa, pahoe-hoe, ropy Px-Oliv-plag. basalt Px-Oliv. basalt Px-plag. basalt	2/—/3 (5)
TENEGUIA (1971)	— Eruptive fracture — 6 — 730 m	— 24 — 3.1	Aa, Blocky lava Px-Amphib. basalt Px-Oliv. basalt	2/3/1 (6)

TABLE 3

## CHEMICAL ANALYSIS OF HISTORIC LAVAS OF LA PALMA ISLAND

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SiO <sub>2</sub>	43.49	44.54	43.69	43.69	44.76	45.67	42.99	43.49	43.94	43.95	44.39	44.60	43.09	43.90	45.04	45.47
Al <sub>2</sub> O <sub>3</sub>	14.63	13.42	14.19	13.65	14.19	15.48	13.39	12.98	13.81	14.58	14.96	13.81	15.03	15.73	14.58	14.06
Fe <sub>2</sub> O <sub>3</sub>	4.00	3.65	4.10	6.72	5.04	6.11	4.62	4.10	4.46	4.58	5.85	3.85	4.47	4.79	5.43	4.06
FeO	8.33	9.04	8.42	5.74	7.51	6.25	8.15	8.18	7.61	8.03	6.66	8.17	7.81	6.99	4.81	7.56
MnO	0.21	0.21	0.08	0.22	0.22	0.22	0.20	0.22	0.21	0.22	0.23	0.21	0.22	0.33	0.23	0.21
MgO	8.06	8.83	10.68	7.92	8.08	6.67	8.27	8.50	8.43	7.48	6.67	8.42	6.95	6.77	8.02	8.28
CaO	10.24	11.27	9.25	11.36	10.91	9.79	12.76	12.65	11.84	10.91	11.19	11.84	11.22	10.07	10.72	11.19
Na <sub>2</sub> O	3.94	3.21	3.70	3.41	3.56	3.91	3.50	3.54	3.40	3.91	3.94	3.50	3.81	4.42	4.26	3.50
K <sub>2</sub> O	1.97	1.64	1.89	1.61	1.74	1.95	1.76	1.66	1.61	1.83	1.84	1.58	1.84	2.02	1.58	1.73
TiO <sub>2</sub>	3.51	3.66	3.57	3.70	3.55	3.55	3.60	3.64	3.66	3.75	3.76	3.68	3.72	3.68	3.70	3.57
P <sub>2</sub> O <sub>5</sub>	0.87	0.95	0.85	0.81	0.83	0.82	0.95	1.19	1.26	1.01	1.11	1.02	1.06	1.03	0.96	0.91
H <sub>2</sub> O	0.27	0.27	0.37	0.19	0.16	0.33	0.29	0.05	0.32	0.19	0.30	0.21	0.14	0.19	0.29	0.24
Total	99.72	100.69	100.25	99.58	100.55	100.75	100.48	100.20	100.17	100.44	100.90	100.89	99.36	99.92	99.62	100.78

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SiO <sub>2</sub>	43.84	44.99	45.11	45.40	45.55	46.12	46.79	46.79	47.02	44.80	44.30	44.49	43.20	43.50	43.27
Al <sub>2</sub> O <sub>3</sub>	13.29	14.56	13.42	16.12	14.19	14.24	14.96	15.73	16.12	16.06	15.09	15.44	13.59	12.99	13.68
Fe <sub>2</sub> O <sub>3</sub>	3.86	3.56	4.04	4.39	3.38	2.69	2.74	2.82	3.95	5.10	4.31	4.38	4.73	3.36	3.92
FeO	8.14	8.23	7.89	6.55	9.15	9.08	8.73	8.01	7.17	7.08	8.55	7.96	8.85	9.76	9.39
MnO	0.22	0.24	0.21	0.23	0.21	0.20	0.21	0.22	0.21	0.21	0.22	0.22	0.22	0.22	0.22
MgO	9.39	7.19	8.69	5.26	8.44	8.22	7.46	6.18	5.91	6.68	7.63	7.18	8.70	10.19	9.22
CaO	12.03	10.97	11.19	10.07	10.55	11.08	10.24	9.23	9.04	8.77	9.52	9.19	10.07	10.37	10.28
Na <sub>2</sub> O	3.23	3.91	3.50	4.91	3.46	3.50	3.56	4.53	4.70	4.58	3.99	4.33	3.71	3.42	3.60
K <sub>2</sub> O	1.61	1.91	1.71	2.38	1.30	1.35	1.58	2.02	2.15	1.90	1.68	1.80	1.50	1.37	1.47
TiO <sub>2</sub>	3.57	3.70	3.79	3.36	3.34	3.36	3.50	3.47	3.49	3.30	3.88	3.61	3.90	3.54	3.71
P <sub>2</sub> O <sub>5</sub>	0.91	0.94	0.93	1.07	0.73	0.71	0.78	0.85	0.88	0.98	0.89	0.98	0.89	0.84	0.88
H <sub>2</sub> O	0.25	0.22	0.23	0.35	0.18	0.29	0.18	0.10	0.14	0.13	0.04	0.25	0.17	0.18	0.18
Total	100.34	100.42	100.71	100.09	100.48	100.84	100.75	99.95	100.75	99.59	100.10	99.83	99.93	99.74	99.82

1. — Oliv. px. basalt. Tacande
2. — Oliv. px. basalt. Tacande
3. — Px-oliv. basalt. Tahuya
4. — Px-oliv. basalt. Tahuya
5. — Px-oliv. basalt. Tahuya
6. — Px-amphib. basalt. Tahuya
7. — Px-oliv. basalt. Tigalate
8. — Px-oliv. basalt. Tigalate
9. — Px-amphib. basalt. Tigalate
10. — Px-amphib. basalt. Tigalate
11. — Px-amphib. basalt. Tigalate
12. — Px-oliv. basalt. Tigalate
13. — Px-oliv. amphib. basalt. San Antonio
14. — Px-oliv. amphib. basalt. San Antonio
15. — Px-oliv. amphib. basalt. San Antonio
16. — Px-oliv. amphib. basalt. San Antonio

17. — Px-oliv. basalt. El Charco.
18. — Px-oliv. basalt. El Charco
19. — Px-oliv. basalt. El Charco
20. — Px-amphib. basalt. El Charco
21. — Px-oliv. plag. basalt. San Juan
22. — Px-oliv. plag. basalt. San Juan
23. — Px-oliv. plag. basalt. San Juan
24. — Px-plag. basalt. San Juan
25. — Px-oliv. plag. basalt. San Juan
26. — Px-amphib. basalt. Teneguía
27. — Px-amphib. basalt. Teneguía
28. — Mean of 15 analysis of px-amphib. basalts. Teneguía
29. — Px-oliv. basalt. Teneguía
30. — Px-oliv. basalt. Teneguía
31. — Mean of 13 analysis of Px-oliv. basalts. Teneguía

Analysts : No. 1 to 25 : M. C. VALLS and A. HERNANDEZ-PACHECO.  
Nos. 26 to 31 : E. Ibarrola (IBARROLA, E., 1974).

SYMPOSIUM ON THE ACTIVITY OF OCEANIC VOLCANOES

Comagmatic or xenolithic inclusions are common in the historic volcanoes. The comagmatic inclusions are pyroxenic and amphibolic cumulates and the xenolithic ones are not only peridotites and gabbros pulled out from great depths but also syenites, phonolites and basalts corresponding to more superficial substratum of the island. Some of these inclusions show partial fusion phenomena and metasomatic transformations such as alkanization and haüynization.

The geochemical characteristics can be appreciated in Table 3 and Figure 4. The alkaline and subsaturated character is strong. All the samples consolidated from a basic melt scarcely differentiated. However, a differentiation process always happened in the magmatic chamber and the emission of a sequence from amphibolic to olivine types can be related to the different stages of the eruption and the height over the sea level where the corresponding eruptive vents opened.

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