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Autor: Campbell Smith, Walter / Burri, Conrad

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The Igneous Rocks of Fernando Noronha

By *Walter Campbell Smith* in London and *Conrad Burri* in Zürich

CONTENTS

SUMMARY

Rocks collected in 1887 are described together with those collected by the Challenger Expedition in 1873. Five new chemical analyses have been made. The rocks are mainly phonolites (nosean-bearing), alkali-trachytes, nepheline-basalts and nepheline-basanites with dike-rocks represented by monchiquites and gauteites. Essexites occur but are not found in situ. Other kinds recorded are trachyandesite, limburgite, and tephritic trachybasalt. The series compares closely with the rocks of the Bohemian Mittelgebirge. Careful measurements made on the universal stage of the felspar phenocrysts in the phonolites show that although they have the crystal-habit of sanidine they have the optical orientation of orthoclase with, however, low values for the optic axial angle.

INTRODUCTION

The island of Fernando Noronha [1]) is situated off the north-east coast of Brazil (lat. 3° 50' 23" S., long. 32° 24' 46" W.). It is used as a convict settlement by the Brazilian Government, but landing places are few and many parts of the island are difficult of access.

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[1]) This is the spelling adopted in the Admiralty charts, the Challenger Reports, and the Year Book of Brazil (1932), but the name is given in the Proceedings of the Royal Geographical Society as Fernando *do* Noronha (1888)

The best account of the geology is that given by J. C. BRANNER who visited the island in 1876 [2]). This paper summarizes earlier accounts of the geology of which the most important is contained in the report of the Challenger Expedition which visited the island in 1873.

The rocks collected by BRANNER were described in detail by GEORGE H. WILLIAMS who recorded trachyte, andesite, phonolite, nepheline-basalt, nephe-

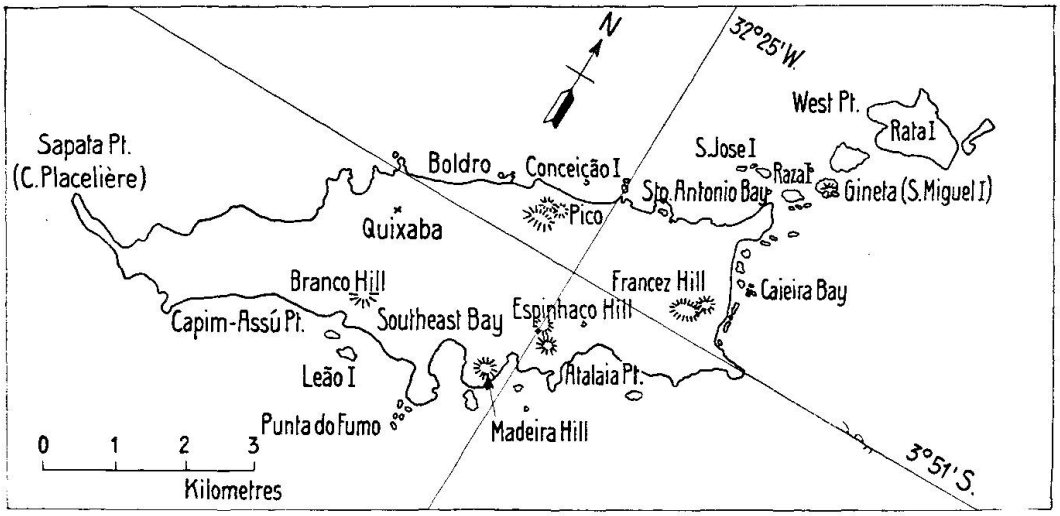

Fig. 1. Outline map of Fernando Noronha.

line-basanite, nepheline-dolerite, augitite, and limburgite. He gave a very full account of the phonolites which he divided according to texture into three groups referred to below. His paper summarizes earlier literature on the petrography.

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and in the American Journal of Science as Fernando *de* Noronha (1889). The „do" and „de" seem redundant. Alternative spellings are given as Fernam do Noronha (R. SOUTHEY, History of Brazil, London 1810—19) and Fernão de Noronha (*Encyclopaedia Britannica,* 14th ed. 1929).

[2]) JOHN C. BRANNER, The geology of Fernando de Noronha, Part. I. Am. J. Sc. (3) 37, 1889, pp. 145—161, 7 figs., map.

Cf. also by the same author, Geologia de Fernando de Noronha. Rev. Inst. Archeol. e Geogr. Pernambuco. 1890, p. 20.

BRANNER also contributed a short paper on „The Peak", apropos of the spine of Mont Pelée. Am. J. Sc. (4) 16, 1903, pp. 442—444.

GEORGE H. WILLIAMS, Geology of Fernando de Noronha. Part. II. Petrography. Am. J. Sc. (3) 37, 1889, pp. 178—189.

BRANNER's collection has been previously also examined by A. C. GILL. See: A. C. GILL, Petrographical Notes on a rock collection from Fernando de Noronha (A preliminary notice). John Hopkins Univ. Circulars, Baltimore, 7, 1888, No. 65, p. 71.

The only sedimentary rock met with in Fernando Noronha, an aeolian sandstone, has also been described by BRANNER:

J. C. BRANNER, The aeolian sandstone of Fernando de Noronha. Am. J. Sc. (3) 39, 1890, p. 247. Cf. also by the same author, Os grés eolios de Fernando de Noronha. Rev. Inst. Archeol. e Geogr. Pernambuco 1893, p. 161.

In 1887 the British Museum organized a small expedition to the island and a large number of rocks were collected by the botanist, Mr. H. N. RIDLEY, who in 1888, communicated a brief account of the geology based on petrological notes by THOMAS DAVIES, then an Assistant in the Mineral Department of the British Museum [3]). This paper was not published until 1891 [4]). Dr. G. T. PRIOR made a more thorough examination of this collection in 1896, and discovered rocks allied to monchiquite [5]). He was struck by the analogies which the rocks presented to the Tertiary volcanic rocks of the Bohemian Mittelgebirge and it was his intention to describe the collection fully supplementing the description by chemical analyses. Circumstances, however, prevented Dr. PRIOR from carrying out this work. The present authors are now endeavouring to complete the study which Dr. PRIOR commenced, supplementing the material with specimens from the Challenger collection and some three others kindly provided by Prof. A. LACROIX [6]). Chemical analyses of three of the specimens have been made by Prof. J. JAKOB and two by Mrs. S. PARKER in the Mineralogisch-Petrographisches Institut der Eidgenössischen Technischen Hochschule in Zürich. For another analysis we are indebted to Prof. A. LACROIX [7]).

Three maps of the island are readily available, one (based on the Admiralty chart of 1871) published with T. S. LEA's paper in 1888, another published with J. C. BRANNER's paper, and an Admiralty chart based on the Brazilian government plan of 1926, (last edition printed in 1931), from which the outline-map Fig. 1 has been drawn. Many place-names differ in the three maps. Where such differences occur we have given the names used by RIDLEY (as spelt in T. S. LEA's map) or by J. C. BRANNER, where necessary followed in parentheses by the name for the same place as given in the latest Admiralty chart.

PHONOLITE

Phonolite was recorded from Fernando Noronha in 1880 by C. W. GÜMBEL [8]) who gave a brief petrographical description and a chemical analysis of a specimen collected by a member of the CHALLENGER Expedition. A more complete account was given by A. F. RENARD in 1882 [9]).

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[3]) T. S. LEA, The island of Fernando do Noronha in 1887. Proc. R. Geogr. Soc. 10, 1888, pp. 424—435, map.

[4]) H. N. RIDLEY, in Journ. Linnean Soc. Botany, 27, 1891, pp. 86—94.

[5]) G. T. PRIOR, Note on the occurence of rocks allied to monchiquite in the island of Fernando Noronha. Min. Mag. 11, 1896, pp. 171—75.

[6]) The collections of the British Museum also contain two specimens (phonolite from The Peak, and an altered basaltic rock coated with siliceous sinter [B.M. 1911, 1633] which were sent to the Geological Society of London by J. PARKINSON, F. G. S., British Consul at Pernambuco, in 1828. They do not appear to have ever been described.

[7]) A. LACROIX, Minéralogie de Madagascar III, 1923, p. 63.

[8]) C. W. GÜMBEL, Tscherm, Min. Petr. Mitt., n. s., vol. 2, (for 1879), 1880, p. 188.

[9]) A. F. RENARD, Bull. Acad. Roy. Sci. Belg., (3) 3, 1882, p. 354.

The phonolites form the most prominent features of the island, The Peak (Pico) being regarded as „the most striking landmark in the South Atlantic Ocean“ [10]).

RIDLEY collected them from St. Michael's Mount (Gineta or S. Miguel Island), Tangle Rock (Madeira Hill or Atalainha in J. C. BRANNER's map), Morro Branco, and from the neighbourhood of The Peak. BRANNER records in addition Atalaia Grande, (the hill S. E. Espinhaço Hill), Conceição I., and between „the village“ and Sto. Antonio Bay.

Mr. RIDLEY's field notes indicate that some of them are later than basaltic lavas, and they appear to form some dikes [B. M. 67079] [11]) as well as the more prominent plugs [12]). CHARLES DARWIN had drawn attention to the similarity of these phonolitic obelisks with those of St. Helena, and others are of course well known in the Bohemian Mittelgebirge and in the Auvergne. BRANNER has also compared The Peak with the spine of Mt. Pelée. (op. cit. 1903.)

The varieties collected by Mr. RIDLEY are similar to those described by G. H. WILLIAMS from Branner's collection. They are all compact, with smooth platy fracture. Colour ranges from deep slate-green to mineral grey. Many are aphyric, others contain a few phenocrysts of tabular felspar and microphenocrysts of pyroxene and other minerals. Weathered surfaces show a uniform crust 1 to 3 mm thick of olive-buff colour, and at Morro Branco large masses of the rock have been altered to a very pale grey, almost white colour.

Material analysed

Part of a specimen from St. Michael's Mount (Gineta or S. Miguel I.) at the north-east end of the main island [B. M. 67056] has been analysed by Mrs. S. PARKER. See Table I. column 1. (Pl., fig. 1.)

Megascopic characters. Deep-slate green, compact, fracture smooth platy. Phenocrysts, few tabular felspars up to 7 mm long, with an average of 2—3 mm. Groundmass aphanitic.

Microscopic characters. These have been described fully by A. F. RENARD [13]). He recognized as phenocrysts nepheline, sanidine, augite,

[10]) J. C. BRANNER, Am. J. Sc. (3) 37, 1889, pp. 152—153.

For illustrations see: J. C. BRANNER, op. cit., p. 153 and ibid. (4) 16, 1903, p. 443.

Also CHALLENGER REPORT, Physics and Chemistry, vol. 2, part 4, 1889, p. 29.

[11]) Numbers in square brackets refer to specimens in the British Museum.

[12]) J. C. BRANNER, op. cit., p. 151.

[13]) A. F. RENARD, Report on the Rock specimens collected on oceanic is-

brown hornblende, magnetite, titanite (sphene) and nosean, and noticed irregular microliths of augite in the very fine-grained groundmass. He described the crystal form of the phenocrysts with great care. For the augites he records extinctions up to 30° and pleochroism n_α yellowish brown, n_β greenish yellow, n_γ green. This we can now identify as aegirine-augite.

Measurements on the universal stage gave:

$$n_\gamma - n_\alpha = 0.025_2 \qquad 2V_\gamma = 71°$$
$$n_\gamma - n_\beta = 0.016_7 \qquad c/n_\gamma = 54°$$
$$n_\beta - n_\alpha = 0.008_5 \qquad \text{(C. B.)}$$

There are also occasional crystals of titanaugite, with borders of green aegirine-augite, and some minute prisms appear to be true aegirine.

RENARD identified the felspar phenocrysts as sanidine with the optic axial plane in the plane of symmetry. The crystals have the sanidine habit with characteristic cross fracture. For the most part they are simple Carlsbad twins. Measurements on the universal stage of many crystals made independently by both of us show that the plane of the optic axes is normal to (010), or so nearly normal that the slight differences cannot be detected in the apparatus used. Values obtained for $2V_\alpha$ vary from 42° to 50° [14]). These values are low for orthoclase, but in view of the straight extinction we have called these felspars soda-orthoclase, bearing in mind, however, the possibility that they may be anorthoclase with a very low extinction angle on (001) with reference to (010), and showing no visible cross-hatching. The extinction on (010) with reference to the trace of (001) calculated from the measurements made on the universal stage averages 7½°. This is near the value obtained by E. D. MOUNTAIN on the anorthoclase from Mt. Kenya [15]).

The groundmass shows well-developed trachytic texture marked by parallel groups of orthoclase laths and of microliths of a

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lands during the voyage of H. M. S. Challenger during the years 1873—76. Challenger Report, Physics and Chemistry, vol. 2, part. 4, pp. 29—39. London 1889.

A. F. RENARD, Notice sur les roches de l'île de Fernando Noronha, recueillies pendant l'expédition du Challenger. Bull. Ac. R. Sc. de Belgique (3) 3, 1882, p. 352.

[14]) In another phonolite from Fernando Noronha [B.M. 67173] from the base of The Peak, one of us found $2V_\alpha = 31°$ or varying from 31° (border) to 18° (core). (C.B.)

[15]) E. D. MOUNTAIN, Min. Mag. 20, 1925, p. 336.

dark green pyroxene. Some minute nephelines can also be distinguished. The interstitial material is turbid and perhaps slightly altered. Patches showing higher birefringence than that general for the groundmass are probaly zeolitized.

The mineral identified by RENARD as nosean was referred by G. H. WILLIAMS to haüyne. Owing to the fact that the mineral is usually altered to a turbid aggregate of presumably zeolitic material it is really not possible to make any certain identification. WILLIAMS preferred to call it haüyne because some altered crystals contained patches of calcite; on the other hand the analysis of the rock from St. Michael's Mount shows 0.98 % SO_3 which points possibly to nosean, and the arrangement of inclusions in some crystals is also suggestive of that mineral. Both haüyne and nosean may be present, and some of the pseudomorphs may represent sodalite. Reference to nosean in these phonolites must therefore be understood to mean „a mineral of the sodalite group, possibly nosean". We shall only refer to „haüyne" when a blue colour is apparent in the thin sections.

Quite colourless isotropic sections are referred to simply as sodalite. They were not found in the analysed specimen but do occur in some of the phonolites.

Other material

The phonolites of The Peak are very similar to those of St. Michael's Mount and they have been fully described by G. H. WILLIAMS. The specimens collected by H. N. RIDLEY, with one exception, belong to WILLIAMS's third group (op. cit. p. 183), with „nepheline of the groundmass indistinct; green bisilicate not prominent". The only other variety found at this locality [B.M. 67166, 67175] occured at the base of The Peak on the main road and as a pebble on the shore. Both specimens belong to WILLIAMS's group II which he recorded only at Atalaia Grande. This group is characterized by having „nepheline of the groundmass moderately distinct; green bisilicate in more or less radiating ocellar sheaves". The ocellar tufts or sheaves consist of aegirine; they reach 1 mm in diameter. They are accompanied by a few phenocrysts of soda-orthoclase, 2 mm in length and very small nephelines, 0.3 mm in diameter. The groundmass is extremely fine-grained and contains much orthoclase, but is also crowded with minute (0.025 mm) sections of a mineral of the sodalite group [16]). Minute nephelines are present in the groundmass also but

[16]) These sections are colourless and too minute to be identified with

are much less abundant than „sodalite". In the hand specimen this rock is compact, aphanitic, greyish-green in colour, and has a smooth fracture.

WILLIAMS's first group, in which he finds „nepheline of the groundmass in distinct crystals; green bisilicate in compact stout crystalloids" is represented by a specimen from „north-east side, Tangle Bay", i. e. the base of the southern slopes of Atalaia Grande from which locality WILLIAMS described the same type of phonolite. Our specimen [B.M. 67122] shows a few good crystals of nosean with a central core, full of inclusions (and altered), surrounded by a clear isotropic zone. In one crystal, quite isotropic, the inclusions are dark red by strong transmitted light and appear to be hexagonal plates. Brown hornblende occurs as occasional phenocrysts.

The groundmass is similar to that of the rock described above and contains similar abundant little „sodalites".

Two sections of rocks in the Challenger Collection from St. Michael's Mount show exactly similar textures and only differ in the presence of felspar insets and the absence of hornblende.

Other examples of the same type of groundmass occur in [B. M. 67098] from near Morro do Chapeo [17]), with very rare phenocrysts of felspar and occasional microphenocrysts of brown hornblende [18]) and colourless sphene; and [B.M. 67192] with occasional nepheline and aegirine-augite as microphenocrysts, from near Cocoanut Tree Bay (?South-east Bay). In the latter the „sodalites" of the groundmass are beautifully developed and all show little central patches of inclusions strongly suggestive of nosean. Similar cores with inclusions are seen in very minute square and hexagonal sections in an extremely fine-grained, brown and green mottled specimen from Tangle Rock (Madeira Hill) [B.M. 67121].

Composition

In mineral composition these phonolites resemble the phonolites of the Bohemian Mittelgebirge described by J. E. HIBSCH as trachytic phonolite, or later as trachytic sodalite-phonolite [19]) and tra-

certainty. They are most simply referred to as „sodalite" implying a mineral of the sodalite group.

[17]) Mentioned in Mr. RIDLEY's notes as „the furthest east point of the main island" but shown on Mr. LEA's map as a very small islet just SW of Raza I.

[18]) The brown hornblende has $c/n_\gamma = 11^0$ and $2V_\gamma = 100^0$. It is mostly corroded or resorbed, aegirine-augite and opaque „ore" being developed. (C.B.)

[19]) Tscherm. Min. Petr. Mitt. 33, 1915, p. 319.

chytic nepheline-sodalite-phonolite [20]) in which sodalite refers to a member of the sodalite group frequently represented by nosean or sodalite [21]) or haüyne [22]). The rather well-known rock of the Teplitz Schlossberg is an example of one of these phonolites rich in a sodalite-mineral. Another is the trachytic phonolite of Donnersberg, Milleschau [23]), of which several specimens are available for comparison, some having been kindly presented to the British Museum by Prof. HIBSCH in 1927.

Table I.

	1)	a)	b)	c)	d)	e)	f)	g)
SiO_2	54.82	55.79	54.05	56.80	55.81	56.43	53.62	53.10
TiO_2	0.50	0.00	0.00	0.00	0.40	tr.	0.08	—
Al_2O_3	22.46	19.53	21.06	20.41	23.02	22.25	22.78	19.07
Fe_2O_3	1.84	2.07	0.41	0.00	2.04	2.66	2.62	5.57
FeO	0.72	2.13	3.90	3.62	0.83	0.97	0.72	0.00
MnO	0.12	0.51	1.91	0.46	0.18	—	0.05	—
MgO	0.07	0.40	0.86	0.29	0.13	tr.	0 42	0.17
CaO	1.42	3.68	2.80	1.75	2.73	1.41	0.68	1.33
Na_2O	10.22	7.39	9.67	9.42	10.02	11.12	10.40	9.41
K_2O	5.93	5.01	4.18	5.72	5.24	2.77	5.22	6.84
H_2O+	0.82	2.72	1.03	1.46	0.00	2.05	2.44	3.98
H_2O-	0.02	—	0.33	—	—	—	0.22	—
CO_2	0.00	0.43	0.04	0.26	—	—	0.07	0.10
P_2O_5	0.12	0.11	0.00	0.22	0.12	tr.	0.03	—
SO_3	0.98	0.00	0.48	0.00	0.28	—	0.05	—
Cl	0.28	0.12	0.25	0.00	0.13	—	0.19	—
ZrO_2	—	—	—	—	—	—	0.20	—
	100.32	99.89	100.97	100.41	100.73	99.66	99.79	99.57
— O for Cl	0.06	0.03	0.06		0.03		0.04	
	100.26	99.86	100.91		100.70		99.75	
Sp. gr.	2.58	2.53	2.63	—	—	2.54	2.58	—

Table Ia.

	si	al	fm	c	alk	k	mg	ti	p	c/fm
1)	179	43.5	7	5	44.5	.28	.06	1.2	0.2	0.71
a)	186	38	14.5	13	34.5	.42	.14	0.0	0.2	0.87
b)	159	36.5	19.5	9	35.5	.22	.20	0.0	0.0	0.46
c)	186	39.5	12.5	6	42	.28	.11	0.0	0.2	0.48
d)	175	42.5	8	9	40.5	.25	.07	0.9	0.2	1.12
e)	188	43.5	9.5	5	41.5	.14	tr.	—	tr.	0.53
f)	174	43.5	10.5	2.5	43.5	.25	.21	0.2	tr.	0.24
g)	177	37	14	4.5	44.5	.32	.28	—	—	0.32
	Normal foyaitic magma according to P. NIGGLI:									
	190	42	12	5	41	.28	.20	—	—	0.42

1. *Trachytic sodalite-phonolite (or Nosean-phonolite),* I. 6. 1. 4. St. Michael's Mount, (Gineta or S. Miguel I.) Fernando Noronha. Mrs. S. PARKER anal. [B.M. 67056].

[20]) Tscherm. Min. Petr. Mitt. 34, 1917, p. 152 and 154.

[21]) op. cit. 1915, p. 320, „zart bräunlich gefärbter Sodalith".

[22]) Tscherm. Min. Petr. Mitt. 24, 1905, p. 284.

[23]) Ibid., p. 287.

a) *Trachytic phonolite („Sodalite"-phonolite),* Donnersberg, Milleschau, Bohemian Mittelgebirge. F. HANUSCH anal. in J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 24, 1905, p. 287.

b) *Trachytic phonolite,* Hohe Riese, W. of Radelstein, Kostenblatt, Bohemian Mittelgebirge. F. HANUSCH anal. in J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 24, 1905, p. 287.

c) *Sodalite-tinguaite,* Flur Ratschin bei Saubernitz, Bohemian Mittelgebirge. F. HANUSCH anal. in J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 29, 1910, p. 432.

d) *Nepheline-phonolite,* Roter Berg bei Brüx, Bohemian Mittelgebirge. E. DITTLER anal. in J. E. HIBSCH, Erl. geol. Übers.-Karte böhm. Mittelgeb. 1926. Anal. No. 98.

e) *Phonolite (Nosean-phonolite),* Wolf Rock, near Lands End, Cornwall. J. A. PHILLIPS anal. (mean of two closely corresponding analyses) in J. J. H. TEALL, Brit. Petrography, London 1888, p. 368.

f) *Tinguaite,* Porcupine Mountain, Barigan, New South Wales. J. C. H. MINGAYE anal. H. S. WASHINGTON, U. S. Geol. Surv. Prof. Paper 99, 1917, p. 315, No. 67.

g) *Tinguaite,* Sta. Cruz R. R., Rio de Janeiro, Brazil. P. JANNASCH anal. in H. ROSENBUSCH, El. d. Gesteinslehre. Stuttgart 1898, p. 215.

Norm of 1 [24])

or	35.03	ne	26.70	wo	1.04	il	0.94
ab	26.72	hl	0.94	hy ($MgSiO_3$)	0.37	hm	0.96
an	3.34	th	1.70	mt	1.28	ap	0.27

The analyses quoted in Table I. Column a) and b) show the analysed phonolites from Donnersberg and Hohe Riese to be richer in lime and poorer in alkalies than the Fernando Noronha rock. A closer resemblance to the chemical analysis is shown by a sodalite-tinguaite from Flur Ratschin near Saubernitz (c) and a still better one by the phonolite of Roter Berg near Brüx (d). Another comparison may be made with the analysis of a tinguaite from Porcupine Mountain, near Barigan, New South Wales (f). It is interesting also, to compare the composition with the well-known „nosean-phonolite" of Wolf Rock off the coast of Cornwall, of which, however only a rather incomplete analysis by J. A. PHILLIPS, made in 1871, is available (e).

The tinguaites of the Brazilian mainland in the neighbourhood of Rio de Janeiro seem to be more potash-rich, though analyses of these rocks are very inadequate for a proper comparison. One, from ROSENBUSCH's Elemente der Gesteinslehre (g) is quoted in Table I.

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[24]) Norms have been calculated by W. CAMPBELL SMITH, NIGGLI-values by C. BURRI.

The only other varieties of the phonolites which need be mentioned particularly are those in which the phenocrysts of nepheline and of aegirine-augite and hornblende become much more abundant. Nosean and sanidine still occur as phenocrysts but are subordinate to the others. One of these, a greenish-grey rock with conspicuous dark patches [B.M. 67079] is from a dike in Sponge Bay (Caieira Bay) on the east coast. The others are from high rocks near Cocoanut Tree Bay above Sueste village [B.M. 67191] from Tobacco Point (Punta do Fumo) [B.M. 67185] and from Leão Bay [B.M. 67124] a little further to the west. Both show abundant insets of nepheline and sanidine set in the aphanitic groundmass which in both rocks has weathered greyish olive and not the usual green. Nosean, aegirine-augite and brown hornblende are all abundant as microphenocrysts, together with colourless sphene in well-formed crystals. The groundmass is extremely fine-grained but appears to agree with that of the St. Michael's Mount rocks.

In the rock from Leão Bay the brown hornblende gives $c/n_\gamma = 3°$ with measurements of $2V_\gamma$ varying from 116° to 126°. As in the phonolite from Morro do Chapeo it is undergoing resorption with formation of aegirine-augite and opaque „ore". The same rock contains a few microphenocrysts of common augite with conspicuous borders of aegirine-augite. Measurements of this augite gave:

	Core	Border	
$2V_\gamma$	58°	74°	
c/n_γ	48°	54°	(C. B.)

ALKALI-TRACHYTE

Trachytes were described by G. H. Williams (loc. cit. p. 180) and we can compare with his amphibole-trachyte from the east base of Morro Francez (Francez Hill S. end Sto. Antonio Bay, near the fort) a rock from the end of Chaloupe Bay [B.M. 67099]. Mr. Ridley does not record whether it is a flow or a dike, but the strong flow structure shown by the specimen suggests the former. It is compact, grey, with very few phenocrysts of felspar. (Pl., fig. 2.)

The felspar of the phenocrysts is plagioclase (andesine An_{40-45}) showing Carlsbad and albite twinning, and mantles of orthoclase. $2V_\alpha$ for this orthoclase = 70° (C. B.). There are very small phenocrysts of aegirine-augite, with microphenocrysts of magnetite, colourless sphene and occasional crystals of altered sodalite or nosean, like that occurring in the phonolites. The groundmass is very fine-grained and consists of abundant, closely-packed, simple Carlsbad

twins of orthoclase in long laths ($2V_\alpha = 65^0—70^0$), with prisms of pale green pyroxene, magnetite grains and accessory apatite. One patch of magnetite and pyroxene probably represents resorbed hornblende. This mineral was only occasionally observed by WILLIAMS in his amphibole-trachyte.

Measurements of the pyroxene on the universal stage gave: for a phenocryst $2V_\gamma = 54^0$ (core) to 66^0 (border), for small prisms of aegirine-augite $2V_\gamma = 72^0$ and $c/n_\alpha = 25^0$. (C. B.)

A chemical analysis of this rock (Table II, column 2), kindly made by Prof. J. JAKOB, shows a high content of alkalis with soda in excess over potash. In composition, the rock is comparable with some trachytes from the Auvergne, for example those from the Mont Dore neighbourhood (Table II a) or the Puy de Dome (b). Compared with the trachyte from Algersdorf in the Bohemian Mittelgebirge it is much less rich in SiO_2 and contains more CaO and Na_2O and less K_2O. This accords with the mineralogical composition, the Algersdorf trachyte having orthoclase in excess of plagioclase, and the pyroxene being a diopside.

A rather similar rock, but containing fairly abundant crystals of altered nosean was collected at Morro Branco (Branco Hill) [B.M. 67181, B.M. 67193]. The plagioclase is andesine (An_{35} with $2V_\gamma = 92^0$) and borders of orthoclase which gave $2V_\alpha = 55^0$. (C. B.) These rocks are intermediate in composition between the alkali-trachyte and the phonolites.

The only other trachytes collected in situ occurred in Sponge Bay (Caieira Bay) where they are cut by monchiquite dikes. [B.M. 67071, 67076, 67084]. These are compact, fine-grained, pale brownish drab to pale olive-grey, with very few small phenocrysts of felspar, and rare hornblende. The thin section shows the felspar to be basic andesine or labradorite, the microphenocrysts and minute laths of the groundmass, andesine to oligoclase with borders of orthoclase. Microphenocrysts of aegirine-augite and grains of sphene are rare. Some black patches may represent resorbed hornblende. The groundmass is colourless, somewhat turbid and probably consists of orthoclase, strewn with microliths of pyroxene, plagioclase, and minute cubes of magnetite.

The texture is trachytic, the fabric seriate in the sense of IDDINGS. There is every gradation between the small phenocrysts of plagioclase and the most minute laths in the groundmass. This rock may perhaps be classified as trachyandesite, but compared with the well-known trachyandesites ot the Siebengebirge it is very much poorer

Table II.

	2)	a)	b)	c)
SiO_2	59.13	60.20	60.10	64.70
TiO_2	1.01	0.51	0.46	0.31
Al_2O_3	19.62	20.50	17.96	18.34
Fe_2O_3	1.57	1.58	1.34	—
FeO	0.72	1.01	1.53	3.44
MnO	0.02	—	—	—
MgO	0.41	0.39	0.26	0.50
CaO	2.71	1.96	2.20	1.72
Na_2O	5.94	4.77	6.25	4.61
K_2O	4.65	5.57	3.80	6.46
H_2O+	3.81	3.00	5.62	0.24
H_2O-	0.27	—	—	—
P_2O_5	0.02	—	0.05	0.18
CO_2	0.00	—	—	—
Cl	0.07	—	—	—
SO_3	0.00	—	—	—
BaO	—	—	—	0.08
	99.95	99.47	99.56	100.58
Sp. gr.	2.48	—	—	2.57

2. *Alkali-trachyte,* Chaloupe Bay, Fernando Noronha, J. Jakob anal. [B.M. 67099] I. 5. 2''. 4.

a) *Phonolite-trachyte,* Lusclade, Mont Dore, Auvergne. Pisani anal. in A. Michel-Lévy et A. Lacroix, C. R. Ac. Sc. Paris 148, 1909, p. 1723.

b) *Domite* (Pumice), Puy de Dôme, Auvergne. Pisani anal. in A. Lacroix, C. R. Ac. Sc. Paris 147, 1908, p. 830.

c) *Trachyte,* Algersdorf, Bohemian Mittelgebirge. F. Ullik anal. in J. E. Hibsch, Tscherm. Min. Petr. Mitt. 9, 1888, p. 247.

Norm of 2):	Q	1.14	hl	0.12	hm	1.60
	or	27.24	C	0.31	ap	0.07
	ab	49.78	hy	1.00	tn	0.34
	an	12.51	il	1.59		

Table Ia.

	si	al	fm	c	alk	k	mg	ti	p	c/fm
1)	232	45.5	9.5	11	34	.34	.24	3.1	tr.	1.16
a)	241	48	10.5	8.5	33	.44	.22	1.4	—	0.81
b)	250	44	11	10	35	.36	.16	1.5	tr.	0.91
c)	261	43.5	14.5	7.5	34.5	.48	.20	1.0	0.2	0.52
	Nordmarkitic-pulaskitic Magma according to P. Niggli:									
	250	41	15	5	39	.35	.28	—	—	0.33

in ferromagnesian minerals. This is also true, but to a less extent, of the only trachyandesite described by J. E. Hibsch from Lieben in the Bohemian Mittelgebirge[25]). A very fair resemblance to this

[25]) J. E. Hibsch, Tscherm. Min. Petr. Mitt. 23, 1915, p. 154.

rock is shown by a dike from below Pico Sidrão, Gran Curral, Madeira, described by L. FINCKH, 1914, as trachyandesite, though previously recorded by C. GAGEL as gauteite [26]).

TRACHYANDESITE

More truly representative of a trachyandesite, possibly trachybasalt, is a dike from Caieira Bay [B.M. 67082], which is porphyritic with abundant small (< 2 mm) phenocrysts of felspar in a dark olive-grey aphanitic groundmass. The phenocrysts of felspar are acid labradorite (An_{50-55}) showing Albite, Carlsbad, Roc Tourné and Pericline twins. The pyroxene is augite, feebly pleochroic, with $c/n_\gamma = 44^0$ and $2V_\gamma = 60^0$. Accessory constituents are magnetite and apatite as very small cubes and prisms. The groundmass consists of abundant laths of oligoclase (near An_{25}), with pale green pyroxene, magnetite, and minute flakes of brown hornblende (or biotite), and interstitial orthoclase. The rock is richer in ferromagnesian minerals than the trachyandesite of Lieben, Bohemian Mittelgebirge, and differs from it also in the absence of hornblende phenocrysts and the character of the pyroxene which is therein diopsidic. It shows a fairly close resemblance to some latites described from California.

GAUTEITE

A specimen from a stream in the central plateau seems to correspond to the gauteites of J. E. HIBSCH [27]). This [B.M. 67 165] is a porphyritic rock, rather rough to the touch, containing in a light greyish olive groundmass, small phenocrysts of brown hornblende, aegirine-augite, and anorthoclase, showing extremely fine cross-hatching. (Pl., fig. 3.)

The hornblende has the following properties:

n_α Naples yellow $n_\beta = n_\gamma$ russet (brown) $n_\alpha < n_\beta \leqq n_\gamma$
$c/n_\gamma = 12^0$ $2V_\gamma = 114^0$ (border) to 98^0 (core).

A few patches with hexagonal outlines may represent a mineral of the sodalite-group. Accessory constituents as small crystals are magnetite, apatite, and rarely sphene. The groundmass consists of minute sheaves of felspar, and very minute needles of brown hornblende in a feebly birefringent matrix, which shows traces of spherulitic structure.

[26]) FINCKH, L., Zeitschr. d. d. geol. Ges. 65, 1914, p. 487.
GAGEL, C., ibid. 64, 1912, p. 412.
[27]) J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 24, 1905, p. 300.

A rock [B.M. 67114] from between Cotton Tree Bay and „the hill" (Lookout Hill, Atalaia Grande, SE of Espinhaço Hill) is similar, but has an isotropic (glassy) groundmass containing only a few very minute microliths of felspar, and some of the phenocrysts of felspar are of acid plagioclase with borders of alkali-felspar showing only Carlsbad twinning. The plagioclase is andesine (An_{35}) with $2V_\gamma = 94°$. They show very fine albite-twin lamellae, and also Carlsbad and Roc Tourné twins. The outer border gives uneven extinction and $2V_\alpha = 70°$, and in one crystal $2V_\alpha = 52°$. Some phenocrysts measured appear to be anorthoclase (as in the specimen described above), with $2V_\alpha = 51°$.

G. H. WILLIAMS described a rather similar rock from the base of Atalaia Grande as amphibole-trachyte. (op. cit. p. 181. No. 10.)

Table III.

	3)	a)	b)	c)	d)	e)
SiO_2	52.70	54.15	54.71	55.23	55.52	55.52
TiO_2	2.13	tr.	0.73	0.42	0.70	0.81
Al_2O_3	19.14	18.25	19.42	18.31	20.05	17.98
Fe_2O_3	3.17	3.62	3.21	4.90	2,52	3.82
FeO	1.28	2.09	1.50	2.06	2.40	3.74
MnO	0.03	—	0.42	tr.	—	0.10
MgO	2.71	2.56	2.08	1.85	2.10	1.90
CaO	3.19	4.89	4.45	3.62	3.15	5.28
Na_2O	3.54	4.43	4.53	4.02	3.44	3.86
K_2O	6.66	6.56	6.47	6.43	7.49	5.90
H_2O+	3.30	3.69	2.62	1.84	1.42	0.77
H_2O-	2.27	—	—	—	—	—
CO_2	0.00	—	0.53	0.00	—	—
P_2O_5	0.06	0.41	0.32	0.58	0.51	0.34
SO_3	0.00	—	—	0.23	—	—
Cl	0.01	—	—	0.32	—	—
BaO	—	—	—	0.46	—	—
SrO	—	—	—	tr.	—	—
	100.19	100.65	100.99	100.27	99.30	100.02
Sp. gr.	2.43	2.63	—	—	—	—

3. *Gauteite,* from a stream in the central plateau, Fernando Noronha. [B.M. 67 165] J. JAKOB anal. (I) II. 5. 2. 3.

a) *Gauteite,* Mühlörzen, Bohemian Mittelgebirge. PFOHL anal. in J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 17, 1898, p. 87.

b) *Gauteite,* Pihlberg, Polzengebiet, Bohemia. K. H. SCHEUMANN anal. in Abh. K. Sächs. Ges. d. Wiss. 32, 1913, p. 757.

c) *Gauteite,* Aspen Creek, Highwood Mts. Mo. U. S. A. H. W. FOOTE anal. in L. V. PIRSSON, U. S. Geol. Surv. Bull. 237, 1905, p. 134.

d) *Gauteite,* Pic de Maros, Celebes. F. HINDEN anal. in C. SCHMIDT in F. und P. SARASIN, Ins. Celebes 4, 1901, p. 20.

e) *Gauteite,* La Forcella, Predazzo, Venezia Tridentina. Italy. M. DITTRICH anal. in J. ROMBERG, Anh. Abh. Pr. Ak. d. Wiss. 1904, p. 78.

Norm of 3):	or	39.48	C	1.22	ap	0.13
	ab	27.51	ol	4.76	pf	1.22
	an	13.07	il	2.74		
	ne	1.28	hm	3.20		

Table IIIa.

	si	al	fm	c	alk	k	mg	ti	p	c/fm
3)	177	37.5	25.5	11.5	25.5	.56	.54	5.25	tr.	0.45
a)	165	32.5	25.5	16	26	.50	.46	tr.	0.55	0.63
b)	172	35.5	22.5	15	26.5	.49	.44	1.7	0.4	0.67
c)	178	34.5	26.5	13	26	.51	.34	1.0	0.8	0.49
d)	183	39	23.5	11	26.5	.59	.45	1.8	0.8	0.47
e)	170	32 5	27	17.5	23	.50	.32	1.8	0.4	0.65
	Monzonite-syenitic Magma according to P. NIGGLI:									
	190	37	23	14	26	.50	.35	—	—	0.61
	Essexite-dioritic (tönsbergitic) Magma:									
	180	38	20	17	25	.30	.30	—	—	0.85

The identification of these rocks as gauteite assumes their occurrence as dikes. Unfortunately field-notes give no evidence on this point, but the texture strongly suggests a dike rock. The identification is confirmed by a chemical analysis (Table III, 3) kindly made for us by Prof. J. JAKOB. The high content of water indicates that the rock is perhaps not quite fresh, although no trace of alteration can be seen in the section and no CO_2 has been recorded in the analysis. Apart from a high content of TiO_2 the analysis shows close agreement with that of the gauteite from Gaute near Mühlörzen in the Bohemian Mittelgebirge described by J. E. HIBSCH[28]) and with one from Pihlberg in the Polzen district, Northern Bohemia, described by K. H. SCHEUMANN. Other fairly closely comparable gauteites of which the analyses are tabulated in Table III and III a are known from the Highwood Mts, Montana, U. S. A., from the Pic de Maros in the Celebes and from Predazzo. They are all relatively high in potash and belong to the monzonite-syenitic Magma of P. NIGGLI.

From the essexite-dioritic magma, to which it shows also some affinities, the rock differs especially by being lower in lime and higher in k.

It is a matter for some satisfaction that the identification of the rock as gauteite by comparison with the Bohemian specimens was made quite independently of the analytical work.

[28]) J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 17, 1898, p. 84.

MONCHIQUITE

Several Monchiquites were fully described by G. T. PRIOR in 1896[29]). The most common type found in the neighbourhood of Cotton Tree Bay and Atalaia Grande (near Atalaia Point) is represented by several specimens [B.M. 67106, 67112, 67116, 67117]. They are porphyritic with prismatic crystals of hornblende and augite in a dense greyish groundmass. Olivine is absent, and colourless nosean (or a mineral of the sodalite group) occurs sparingly. The hornblende gives pleochroism $n_\gamma = n_\beta$ chestnut, n_α pale yellow-orange, $c/n_\gamma = 13°$. The augite, which is strongly zoned, gave $c/n_\gamma = 47°$ (core), 51° (border), and weak pleochroism in the outer zones from n_γ olive-buff to n_α pale purple drab. Under the microscope the groundmass is seen to consist of a colourless base (mainly isotropic) densely crowded with microliths of augite and brown hornblende, and minute magnetite grains and accessory apatite.

PRIOR described from the same locality another variety apparently only differing from the above in the entirely glassy groundmass crowded with extremely minute hair-like crystals believed to be hornblende and augite showing well marked flow-structure. (Pl., fig. 4). The glass in thin section is cinnamon buff in colour and entirely isotropic. The phenocrysts are quite similar to those described above.

This rock [B.M. 67113] was the only one of the monchiquites that could possibly be considered fresh enough to provide material for chemical analysis. Prof. J. JAKOB kindly undertook to analyse it, and his results are given in Table IV, 4.

The high H_2O content might suggest some alteration and L. HAWKES has shown that glassy rocks may suffer alteration without showing its effects in the thin section[30]), on the other hand the absence of Fe_2O_3 might suggest that the material was unaltered. The analysis differs rather notably from the published analyses of monchiquites, especially in the high Al_2O_3 and TiO_2 and low iron and lime, and it has not been found possible to make close comparisons with other rocks. The nearest approaches are perhaps some of the tahitites or haüynophyres described by A. LACROIX[31]) and P. MARSHALL[32]) from Tahiti in the Society Islands, and allied to haüyne-

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[29]) G. T. PRIOR, Min. Mag. 11, 1896, pp. 171—75.

[30]) L. HAWKES, Min. Mag. 23, 1932, p. 172.

[31]) A. LACROIX, Minéralogie de Madagascar 3, 1923, p. 286.

[32]) P. MARSHALL, Trans. N. Zealand Inst. 47, 1915, pp. 368—369 and Rep. Austr. Ass. Adv. Sc. 13, 1912, p. 196.

tephrites, but the groundmass, when crystallized, in these rocks contains much felspar as well as augite-microliths.

Table IV.

	4)	a)	b)	c)	d)
SiO_2	46.15	48.70	50.64	50.72	51.40
TiO_2	5.29	2.37	2.50	1.76	0.55
Al_2O_3	19.62	19.12	21.75	19.18	18.54
Fe_2O_3	0.00	2.40	0.19	4.29	4.69
FeO	3.49	4.77	5.93	3.31	4.69
MnO	0.09	—	0.07	—	0.46
MgO	2.61	1.54	2.56	1.68	1.35
CaO	5.54	6.25	6.88	5.92	7.25
Na_2O	5.20	7.83	5.27	6.22	6.72
K_2O	4.46	3.45	3.73	4.56	4.40
H_2O+	6.04	2.80	0.44	1.92	0.68
H_2O-	0.94	—	0.31	0.58	0.12
CO_2	0.00	—	—	—	0.20
P_2O_5	0.10	—	—	0.13	0.69
SO_3	0.39	0.83	—	—	0.30
Cl	0.20	0.13	—	—	
	100.12	100.19	100.27	100.27	100.20
Sp. gr.	2.81	—	—	—	2.74

4. *„Monchiquite"* (?), Near Atalaia Pt., Fernando Noronha. J. Jakob anal. [B.M. 67113] "II." 6. 2". (3) 4.

a) *Haüynophyre,* Vairao, Tahiti, Society Islands. Pisani anal. in A. Lacroix, Bull. Soc. géol. de France (4), 10, 1910, p. 115 and Min. Madagascar, 3, 1923, p. 286.

b) *Trachybasalt,* dike, Middle Island, Tristan da Cunha. E. D. Mountain anal. in W. Campbell Smith, Report Geol. Coll. made during the voyage of the „Quest"... 1921—22. London, British Museum, 1930, p. 83.

c) *Nepheline-monzonite,* João de Gales, Barranco S. of Foia, Serra de Monchique, Portugal. Raoult anal. in F. Pereira de Sousa, Bull. Soc. géol. de France (4), 26, 1926, p. 329.

d) *Haüyne-tephrite,* Schlossberg, Grosspriessen, Bohemian Mittelgebirge. F. Hanusch anal. in J. E. Hibsch, Tscherm. Min. Petr. Mitt. 21, 1902, p. 167.

Table IVa.

	si	al	fm	c	alk	k	mg	ti	p	c/fm
4)	143	36	21.5	18	24.5	.36	.56	1.23	0.2	0.84
a)	136	31.5	22.5	18.5	27.5	.23	.29	5.0	—	0.84
b)	139	35	24.5	20	20	.31	.43	5.1	—	0.82
c)	145	32	24.5	18	25.5	.33	.30	3.9	0.17	0.74
d)	141	30	23.5	21.5	25.5	.30	.48	1.1	0.8	0.93
Ijolitic Magma according to P. Niggli:										
	100	25	25	25	25	.20	.50	—	—	1.00
Essexite-dioritic Magma according to P. Niggli:										
	180	38	20	17	25	.30	.30	—	—	0.85

Norm of 4):							
	or	26.69	hl	0.35	il	7.60	
	ab	18.86	th	0.71	ap	0.34	
	an	18.90	di	2.59	pf	2.18	
	ne	11.36	ol	3.64			

A fairly close comparison with the analysis is also found in that of a trachybasalt dike from Middle Island, Tristan da Cunha, described by one of us, but the rocks show no resemblance in mineral composition. Amongst other rocks of similar chemical composition a nepheline-monzonite from João de Gales, Serra de Monchique and a haüyne-tephrite from Grosspriessen, Bohemian Mittelgebirge may be mentioned and are tabulated in Table IV, c) and d). All these rocks can also be compared in chemical composition with the ijolites which are however lower in si. It may be mentioned in this connection, that the haüynophyre (Tahitite) from Vairao, Tahiti, has been included by P. NIGGLI [33]) as „Übergang" amongst his ijolitic magma-type.

An olivine-bearing porphyritic dike-rock [B.M. 67111] from the base of Atalaia Grande was also described by PRIOR as a variety of monchiquite. It contains in a black glassy-looking groundmass abundant small phenocrysts of augite and olivine up to 5 mm in length. Augite is much more abundant than olivine. A few small magnetite microphenocrysts are present and there are occasional colourless sections of a mineral of the sodalite group. The groundmass though very dense is not wholly glassy, but is crowded with very minute microliths of pyroxene and brown hornblende. In their high olivine-content these rocks resemble some of the monchiquites from Serra de Tingua, Brazil, originally described by H. ROSENBUSCH and M. HUNTER [34]).

The habit and relative proportions of phenocrysts to each other and to the groundmass are similar to those in „magma-basalts" described by E. BOŘICKY from Sauberg near Svindschitz, south of Bilin and from Zinkenstein near Kosel in Bohemia [35]). The interstices between the augite microlithes in the groundmass of these rocks are however, filled with brown glass, and the minute hornblendes recorded by PRIOR do not appear.

Other monchiquites [B.M. 67063, 67081] described by PRIOR from Caieira Bay (op. cit. p. 4), containing small amounts of altered olivine, are dense, black, glassy-looking rocks with abundant small phenocrysts of augite and some large brown hornblendes. Under the microscope there are also distinguished numerous hexagonal sections

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[33]) P. NIGGLI, Gesteins- und Mineralprovinzen I, 1923, p. 158.

[34]) H. ROSENBUSCH and M. HUNTER, Tscherm. Min. Petr. Mitt. 11, 1890, p. 445.

[35]) E. BOŘICKÝ, Petrographische Studien an den Basaltgesteinen Böhmens. Prag 1874, pp. 50—51.

of haüyne, often (in thick slides) showing blue colour. The groundmass is very dense and similar to that of rocks decribed above.

The augite in these rocks is strongly zoned, with pale-green centres and, in thin section almost colourless borders, though in thick sections they sometimes show purplish drab borders. Extinction $c/n_\gamma = 53^0$ (core), 44^0 (border). The brown hornblende phenocrysts are partly resorbed and form crystals up to 1 cm in length, and are frequently in crystal aggregates with rather large augites.

PRIOR considered that the limburgite No. 14 described by G. H. WILLIAMS (op. cit. p. 188) from Atalaia Grande was a monchiquite of this kind.

These rocks are somewhat similar to the haüyne-monchiquites described by J. E. HIBSCH as „haüynophyr" or „sodalithophyr" from the Bohemian Mittelgebirge [36]) and by K. BUSZ as heptorite [37]) from the Siebengebirge, but both of these contain much less hornblende and very much more augite and less groundmass than the ones described by PRIOR.

Another haüyne-monchiquite closely resembling the best crystallized specimen in RIDLEY's collection [B.M. 67085 A] was collected by J. W. JUDD at Hermesdorf, Duppau, Bohemia and presented to the British Museum in 1887.

ESSEXITE

On the hill above Cotton Tree Bay (near Atalaia Point) and between that and Atalaia Grande two specimens [B.M. 67109, 67115] were collected which prove on examination to resemble closely some of the so-called essexites.

Idiomorphic pale-purple augites and some serpentinized olivines lie in a mesh of long laths of plagioclase with interstitial orthoclase and small grains of pyroxene and magnetite. For the augite $c/n_\gamma = 49^0$; the dispersion is strong. The plagioclase is zoned and varies from labradorite (An_{55}) at the centre to andesine (An_{30}) at the edge.

The rock closely resembles the „essexite" of Löwenburg, Siebengebirge. Another close comparison can be made with an „essexite" found loose by A. C. de Noronha on Pico Sidrão, Gran Curral, Madeira, which probably resembles the fine-grained essexite of Lombo dos Porteas, Gran Curral, figured and described by C. GAGEL and L. FINCKH [38]).

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[36]) J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 21, 1902, pp. 526—529.

[37]) K. BUSZ, N. Jb. f. Min. etc. 1904, vol. 2, pp. 86—92.

[38]) C. GAGEL, Zeitschr. d. d. geol. Ges. 64, 1912, p. 390 and fig. 12.
L. FINCKH, ibid. 65, 1913, p. 467.

NEPHELINE-BASALT

(Basalte néphélinique, RENARD 1882; Ankaratrite, LACROIX 1923)

A compact black rock with a few small olivines in an aphanitic groundmass [B.M. 64646] was collected by the Challenger Expedition in the west of Rat Island (Rata I.) and was figured and described by A. F. RENARD as „basalte néphélinique", and an analysis, probably inaccurate, was given [39]). Later a slightly fuller account was published in the Challenger Report [40]), but no name was there assigned to the rock. RENARD recognized the absence of plagioclase, and the presence of nepheline and augite, with microphenocrysts of olivine, fairly abundant magnetite, and accessory biotite, perovskite, and apatite.

Similar material was collected by Mr. RIDLEY on Rata Island. The olivine of these rocks and in the slightly better crystallized material from Pedras Petras, has an optic axial angle varying from 89°—91°, corresponding to about 10 % fayalite. The birefringence is rather low. In the actual specimen examined by RENARD [B.M. 64 646] measurements of the olivine gave:

$$n_\gamma - n_\alpha = 0.030_7$$
$$n_\gamma - n_\beta = 0.015_8 \qquad 2V_\gamma = 88^\circ.$$
$$n_\beta - n_\alpha = 0.014_9$$

Low birefringence of this kind seems to be typical for olivines with a slight content of lime [41]). (C. B.)

Nepheline-basalts are also described by G. H. WILLIAMS (op. cit. pp. 187—188) from Morro Francez (Francez Hill) and from the western point of Rata I. „about the Espigão" (West Point, probably the same place as that from which RENARD's figured specimen was collected), and from a point on the south side of the main island. To judge from the descriptions these rocks are similar to the one described by RENARD.

Material analysed

Professor A. LACROIX has published an analysis by F. RAOULT

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[39]) A. F. RENARD, Bull. Ac. R. Sc. de Belgique (3) 3, 1882, pp. 358—359, fig. 2.

[40]) CHALLENGER REPORT, Physics and Chemistry, vol. 2. pt. 4, 1889, pp. 35—36.

[41]) C. BURRI und I. PARGA-PONDAL, Schweiz. Min. Petr. Mitt. 13, 1933, p. 39, esp. pp. 47—50.

of an „ankaratrite" from Fernando Noronha but the exact locality is not stated [42]). (Pl., fig. 5.)

A specimen of this rock has been kindly presented by Prof. LACROIX. In mineral composition it is very similar to RENARD's figured „basalte néphélinique" but it is slightly better crystallized. The following is a brief description of the section:

Phenocrysts. Olivine, very small, up to 0.8 mm long, colourless. Pale green serpentine developed at edges. Birefringence low. Augite, pale purplish, very small, rare [43]). Biotite, very small (0.2 mm) brown flakes, pleochroic colourless to raw sienna. Magnetite forms patches up to 0.15 mm across but these seem to be aggregates of the minute cubes so abundant in the groundmass.

Groundmass. Nepheline forms clear rounded patches (0.03 mm in diameter), framed in masses of minute prisms of augite with abundant minute cubes of magnetite (0.006—0.02 mm across). See Pl., Fig. 5. The nephelines frequently contain minute inclusions which sometimes cluster round the centre. Perovskite was not found.

RAOULT's analysis of this rock is quoted in Table V. 5. The composition of the normative olivine is forsterite 10.92, fayalite 1.53, corresponding to 12 % fayalite. This is in fair agreement with the values for $2V_\gamma$, 89° to 91°, obtained on the material from Rata I. and Pedras Pretas.

Table V.

	5)	a)	b)	c)	d)	e)
SiO_2	39.96	40.90	40.20	40.03	38.74	39.66
TiO_2	3.03	0.70	3.20	5.79	3.30	1.79
Al_2O_3	9.75	10.47	11.44	9.61	11.30	12.22
Fe_2O_3	5.98	3.43	2.12	2.90	4.28	6.57
FeO	7.61	9.99	7.84	7.60	7.71	6.90
MnO	—	0.42	0.19	0 19	—	0.17
MgO	12.95	14.61	13.16	12.65	11.97	12.13
CaO	14.04	12.63	13.10	13.18	14.43	12.54
Na_2O	2.86	3.22	3.61	2.53	3.02	3.60
K_2O	0.94	1.11	0.88	1.08	1.92	1.51
H_2O+	1.78	0.68	3.50	2.45	1.28	1.79
H_2O-	0.35	0.49	0.36	1.33	0.60	
CO_2	—	0.23	—	—	—	0.14
P_2O_5	0.79	0.92	0.63	0.95	1.77	0.82
SO_3	0.05	tr.	—	—	—	0.03
Cl	0.07	0.22	—	—	—	0.04
						incl. 0.11
	100.16	100.02	100.04	100.29	100.32	100.06
Sp. gr.	3.12	3.14	—	—	—	—

[42]) A. LACROIX, Minéralogie de Madagascar 3, 1923, p. 63.

[43]) In a better crystallized specimen from Boldro [B.M. 67171] the augite showed strong zonal structure with optic axial angle varying from 62° (core) to 34° (shell). (C.B.)

5. *Nepheline-basalt* (Ankaratrite LACROIX), Fernando Noronha. RAOULT anal. in A. LACROIX, Min. de Madagascar 3, 1923, p. 63. IV. [7. (2). 3. 4.] 2. 2. 2". 2.

a) *Nepheline-basalt,* Schanzberg near Aussig, Bohemian Mittelgebirge. F. HANUSCH anal. in J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 23, 1904, p. 342.

b) *Ankaratrite,* Puy de Barneire, Puy de Dôme, Auvergne. RAOULT anal. in A. LACROIX, loc. cit., p. 59.

c) *Ankaratrite* (with glassy matrix), Piedra Buena, Campos de Calatrava, Ciudad Real, Spain. I. PARGA anal. in C. BURRI u. I. PARGA-PONDAL, Schweiz. Min. Petr. Mitt. 13, 1933, p. 55.

e) *Mean of 38 Nepheline-basalts.* W. C. BRÖGGER, Eruptivgest. Krist. Geb. IV. Fengebiet. 1920, p. 52 a.

Norm of 5):	an	11.68	th	0.08	mt	8.68
	ne	12.35	di	39.61	il	5.75
	lc	4.36	ol	12.45	ap	1.84
	hl	0.23	cs	0.77		

Table Va.

	si	al	fm	c	alk	k	mg	ti	p	c/fm
5)	73	10.5	55.5	27.5	6.5	.18	.64	4.2	0.7	0.50
a)	72	11	58.5	24	7	.19	.69	0.9	0.6	0.41
b)	76	13	53	26.5	7.5	.15	.71	4.6	0.5	0.50
c)	79	11	54.5	28	6	.23	.68	8.6	0.7	0.51
d)	72	12.5	51.5	28.5	7.5	.29	.65	4.6	1.5	0.55
e)	73	13	54	25	8	.21	.63	—	—	0.46
Theralite-gabbroic magma according to P. NIGGLI:										
	90	20	46	23	11	.25	.50	—	—	0.50

The analysis shows that the rock is of a common type and it would be quite easy to quote a great number of closely corresponding analyses from many volcanic regions over the whole world. In Table V. there are given some examples from Bohemia, France, Spain and Madagascar. In column e) W. C. BRÖGGER's mean of 38 nepheline-basalts is given which shows also a close resemblance. This mean value is tabulated by P. NIGGLI amongst the basic members of his theralite-gabbroic magma type[44]) of which the type values with higher content in Al_2O_3 and alkalis are also given for comparison in Table V a.

Other material

Rocks almost exactly similar in thin section to LACROIX's analysed specimen were collected by RIDLEY from Pedras Pretas (Capim Assú Pt., Pontal in BRANNER's map) [B.M. 67131, 67133, 67134]. In one of these, slightly coarser in grain than the others, the ne-

[44]) P. NIGGLI, Gesteins- und Mineralprovinzen I, 1923, p. 168.

phelines reach 0.15 mm in diameter, minute grains of perovskite occur (sometimes abundantly), and there are small, yellow, almost isotropic pseudomorphs of ? deeckeite after melilite. Some of these pseudomorphs show „hour-glass" shapes recalling the melilite with „hour-glass structure" in the nepheline-melilite-basalt of Rabenstein, east of Sebusein, Bohemian Mittelgebirge [45]). In another specimen from Boldro [B.M. 67153] altered melilite forms plates about 0.25 mm across) enclosing grains of magnetite and very minute pyroxenes.

RIDLEY also collected nepheline-basalts from the east side of Atalaia Grande [B.M. 67110], north side of Rata I. near the isthmus, near Morro Francez, around Sto. Antonio Bay [B.M. 67066, 67068, 67097, 67198], Boldro [B.M. 67154, 67155, 67168, 67171], Sambaquixaba [B.M. 67169], Cape Placelière (Sapata Pt.) [B.M. 67143] and from Tobacco or South Point (Punta do Fumo) [B.M. 67182, 67189] where the rock vesicles are lined with zeolites and, in the larger ones, with calcite. He describes it as the commonest rock on Rata I. and „forming the hills near Cape Placelière".

Many of these specimens resemble RENARD's figured section both in texture and composition, but some are more fine-grained and seem to correspond in texture to the „nephelinitoid" of E. BOŘICKÝ from the Bohemian Mittelgebirge [46]). Others like those of Pedras Pretas are slightly coarser in grain and the minerals of the groundmass are well crystallized. The augite in some specimens e. g. [B.M. 67110] forms well crystallized microliths, often with parallel alinement. Such types, by decrease in the proportions of olivine lead to augitites [47]) such as described by G. H. WILLIAMS from Morro Francez (op. cit. p. 188).

Among the nepheline-basalts described from the Bohemian Mittelgebirge it is possible to find many closely similar to those from Fernando Noronha. Especially closely resembling RENARD's type

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[45]) J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 34, 1917, p. 127.

[46]) E. BOŘICKÝ, Petrographische Studien an den Basaltgesteinen Böhmens. Prag 1874, p. 61.

[47]) The only example collected by RIDLEY is from the shore at the base of the Peak [B.M. 67 159]. In this specimen the augite forms idiomorphic phenocrysts, tabular parallel (100), and 1 cm in length, as well as the main constituent of the groundmass. Olivine occurs as small phenocrysts, and the groundmass consists of a mesh of augite microliths, with minute cubes of magnetite, and colourless interstitial material. A similar rock [B.M. 67 085 B] with fewer phenocrysts of augite shows recognizable nepheline in the groundmass and can be described as a nephelinite. It forms a dike in Caieira Bay.

rock from Rata I. is a nepheline-basalt from Wacholderberg, 2.5 km SW of Teplitz, but it contains less magnetite. Another, not quite so good a match in texture, is the nepheline-basalt of Schanzberg, NE of Schreckenstein, near Aussig. An analysis of this rock is quoted in Table V. column a.

Among the many nepheline-basalts of the Rhöngebirge the closest similarity is shown by BÜCKING's specimens from Kreutzberg, SW of Bischofsheim, of which he quotes three analyses, the earliest made in 1883, the latest in 1887 and perhaps not very trustworthy [48]). They show remarkably low figures for MgO.

Comparison with the rocks of the Mittelgebirge and the Rhöngebirge would therefore lead us to name these rocks simply nepheline-basalt. Professor A. LACROIX has, however, referred his analysed specimen to the ankaratrites, a group first defined by him as a result of the study of specimens from Madagascar, and intended to take the place of the nepheline-basalts, including the melilite-bearing ones, in his classification.

Professor A. LACROIX has kindly sent to the British Museum typical specimens of his ankaratrites. Comparison shows that his analysed specimen from Fernando Noronha, and many of RIDLEY's nepheline-basalts agree very closely indeed with the „ankaratrite néphélinique" (Type Tsiafajavona) from Madagascar [49]) so that if it is desired to retain LACROIX's name of ankaratrite in use, the nepheline-basalts of Fernando Noronha can be described as ankaratrite LACROIX. Perhaps, however, it will suffice to call them nepheline-basalt (Ankaratra type).

„NEPHELINE-DOLERITE"

WILLIAMS records „nepheline-dolerite" from the north-east part of the island, but nowhere in situ. RIDLEY collected an olivine-free type on the north side of the Sto. Antonio Bay [B.M. 67050]. In appearance it resembles the nepheline-dolerite (nephelinite) of Löbauer Berg, Zittau, Saxony from which it differs little in mineral composition. Another coarse-grained type, found as a pebble on the shore at the base of the Peak [B.M. 67160], is olivine-bearing and corresponds closely with the description given by WILLIAMS. Augite, olivine, and nepheline with abundant magnetite and apatite needles are the main constituents, and there is much turbid, isotropic groundmass penetrated by laths of orthoclase and enclosing the smaller

[48]) H. BÜCKING, Sitzungsber. K. Preuss. Akad. Wiss. Berlin 1910, I, p. 497.
[49]) A. LACROIX, op. cit., p. 60 and C. R. Ac. Sc. Paris 163, 1916, p. 253.

(0.1—0.25 mm) crystals of augite, olivine, and magnetite. The isotropic groundmass may be analcime or sodalite. The specimen is much weathered.

NEPHELINE-BASANITE
(Nepheline-basanite, G. H. WILLIAMS 1889;
Felspathic basalt, A. F. RENARD 1882)

RENARD gave a detailed description of the columnar basalt of Platform Island (S. José I.) and determined it as felspathic basalt (op. cit. 1882, p. 361, and 1889, pp. 37—39). A selected specimen of this rock from the Challenger Collection [B.M. 64648] was analysed by Mrs. S. PARKER, whose results are given in Table VI. 6. (Pl., fig. 6.)

Megascopic characters. Iron-grey, somewhat vesicular, aphanitic. Contains occasional nodules of „olivine" up to 1 cm in diameter.

Microscopic characters. The phenocrysts are augite and olivine, the former predominating. The augites are small, (0.3—0.4 mm), idiomorphic, zoned; core nearly colourless, outer zone light ochraceous buff. The central parts of the crystals contain abundant minute inclusions which are fully described by RENARD. Measurements of the augite gave:

Core		Border
$n_\gamma - n_\alpha = 0.023_7$	$2V_\gamma = 57^0$	$2V_\gamma$ slightly greater
$n_\gamma - n_\beta = 0.018_3$	$c/n_\gamma = 39^0$	$c/n_\gamma = 50^0$.
$n_\beta - n_\alpha = 0.005_4$		(C. B.)

The olivines are small, colourless, and partly altered to a brown substance referred by RENARD to pilite (op. cit. 1889, p. 39). Some of the olivines show good idiomorphic forms. They are optically neutral or slightly negative. Measurements gave:

$n_\gamma - n_\alpha = 0.036_8$
$n_\gamma - n_\beta = 0.018_3$
$n_\beta - n_\alpha = 0.018_5$

$2V_\gamma = 90\frac{1}{2}^0$
corresponding to 15% Fe_2SiO_4. (C. B.)

The groundmass consists of augite prisms similar to the phenocrysts, and laths of basic labradorite (An_{65-70}), and magnetite cubes and grains. Thickness of felspar laths and diameter of magnetite grains about 0.03 mm, the augite prisms somewhat thicker. There is a small amount of isotropic interstitial material, partly colourless, but in some patches pale green or yellow. Microchemical tests confirm the presence of a small amount of nepheline.

G. H. WILLIAMS described a nepheline-basanite containing only small amounts of nepheline from S. José I. (op. cit. p. 186). This also

carried inclusions of olivine and enstatite and was probably the same rock as the one described by RENARD.

A similar rock was collected by RIDLEY from Morro do Chapeo, south of S. José I.[50]). This contains „olivine nodules" up to 2 cm across [B.M. 67095], containing both olivine and enstatite, with small amounts of plagioclase (An_{15-50}) in an isotropic yellowish base. Measurements on a thin section of one of these [B.M. 67 092] gave:

Olivine		Enstatite	
$n_\gamma - n_\alpha = 0.034_8$		$n_\gamma - n_\alpha = 0.009_5$	
$n_\gamma - n_\beta = 0.017_6$	$2V_\gamma = 89^0$	$n_\gamma - n_\beta = 0.005_2$	$2V_\gamma = 85^0$
$n_\beta - n_\alpha = 0.017_2$		$n_\beta - n_\alpha = 0.004_3$	
corresponding to 5—10 % Fe_2SiO_4		corresponding to 11 % $FeSiO_3$	

It may be a matter for discussion whether the small amount of nepheline present (only 6.25 % appears in the norm) is sufficient to warrant the name nepheline-basanite. The rock is probably referable to the „basanitoids" of H. BÜCKING and A. LACROIX. In the classification of H. ROSENBUSCH it might fall with the „alkali-basalts".

Table VI.

	6)	a)	b)	c)	d)	e)
SiO_2	44.23	44.29	46.04	41.72	43.26	43 10
TiO_2	4.33	4.92	1.14	3.41	2.43	1.88
Al_2O_3	10.12	12.62	14.84	11.47	11.84	11.71
Fe_2O_3	3.50	3.61	3.89	4.04	3.97	4.43
FeO	6.58	8.84	5 18	10.58	7.65	8.82
MnO	0.18	—	0.21	—	—	—
MgO	11.70	10.06	7.27	12.55	11.78	13.20
CaO	11.45	9.23	17.92	10.82	11.36	10.84
Na_2O	3.20	3.25	1.66	2.28	2.85	2.78
K_2O	1.12	1.82	0.64	1.22	1.95	1.27
H_2O+	2.04	0.21	0.64	1.11	2.97	1.71
H_2O-	0.50	0.09	0.11	—	0.25	—
CO_2	0.31	0.00	—	—	—	—
ZrO_2	—	0.02	—	—	—	—
P_2O_5	0.78	0.57	0.12	0.66	—	0.49
SO_3	—	0.05	—	—	—	0.09
S	—	—	—	0.04	—	—
BaO	—	0.06	—	—	—	—
SrO	—	0.04	—	—	—	—
	100.04	99.68	100.16	99.90	100.31	99.78
Sp. gr.	3.02	—	—	—	—	—

6. *Nepheline-basanite,* Platform Island (S. José I.), Fernando Noronha. [B.M. 64648]. S. PARKER anal. III. (IV). 6". (2) 3. 4.

a) *Nepheline-basanite,* Las Planas near Olot, Spain. H. S. WASHINGTON anal. in Am. J. Sc. (4) 24, 1907, p. 239.

b) *Basanitoid basalt,* Fonte Moreira, Algarve, Portugal. RAOULT anal. in F. PEREIRA DE SOUSA, C. R. Ac. Sc. Paris 185, 1927, p. 546.

[50]) See footnote [17]), p. 411.

c) *Trachydolerite,* Pico Serrado, Madeira. EYME anal. in C. GAGEL, Zeitschr. d. d. geol. Ges. 64, 1912, p. 429.

d) *Basalt,* Hohe Warte near Giessen, Hesse, Germany. A. STRENG anal. in W. SCHOTTLER, Abh. geol. L. A. Darmstadt 4, 1908, p. 458.

e) *Basalt,* Ilmenberg, Rhöngebirge, Germany. KLÜSS anal. in H. PRÖSCHOLDT, Jahrb. preuss. geol. L. A. 14, 1894, p. 12.

Norm of 6):	or	6.67	ne	6.25	mt	5.10
	ab	15.72	di	31.58	il	8.44
	an	9.45	ol	11.63	ap	1.85

Table VIa.

	si	al	fm	c	alk	k	mg	ti	p	c/fm
6)	92	12.5	54	25.5	8	.19	.68	6.8	0.75	0.47
a)	93	15.5	54.5	20.5	9	.27	.58	7.8	0.5	0.38
b)	95	13	52	27	7.5	.18	.60	1.7	0.1	0.52
c)	80	13	59.5	22.5	5.5	.26	.61	5.0	0.6	0.38
d)	86	14	54	24.5	8	.31	.69	3.6	—	0.45
e)	83	13	57.5	22	7	.24	.66	2.7	0.5	0.38
Theralite-gabbroic magma according to P. NIGGLI:										
	90	20	46	23	11	.25	.50	—	—	0.50

The chemical analysis (Table VI. 6) may be compared with that of a nepheline-basanite from Olot described by H. S. WASHINGTON (a) with 6 % calculated modal nepheline. Very close in chemical composition is also a „basanitoid basalt" from the Algarve in southern Portugal (b). Another rock very similar in texture, but lower in alkalis, and much richer in FeO, which appears in the rock as olivine, is a lava from Pico Serrado, Madeira (c), described by C. GAGEL as trachydolerite and by L. FINCKH as felspar-basalt (essexite-basalt) [51]). Such rocks were previously described by L. FINCKH as nepheline-basanite. Basalts with rather similar chemical composition but low TiO_2 are from Hohe Warte near Giessen (d), and Ilmenberg in the Rhöngebirge (e).

LIMBURGITE

Between Morro do Chapeo and „North-east Point". RIDLEY collected several boulders of basaltic rocks [B.M. 67093, 67094, 67096] containing angular „olivine nodules" up to 10 cm across, and apparently very plentiful. The rocks are compact and aphanitic. They consist of very numerous, very small phenocrysts of colourless olivine and fewer augites (0.35 mm) in a very dense groundmass of minute prisms of augite, abundant minute cubes of magnetite, with a small amount of colourless interstitial material, and very rare extremely thin laths of felspar. So far as it can be determined the interstitial

[51]) C. GAGEL, Zeitschr. d. d. geol. Ges. 64, 1912, p. 429.
L. FINCKH, ibid, 65, 1914, pp. 507—08.

material appears to be isotropic, but it would be difficult to tell whether it were nepheline or not.

Measurements of the phenocrysts in [B.M. 67 094] on the universal stage gave:

Olivine		Augite	
$n_\gamma - n_\gamma = 0.036_7$		$n_\gamma - n_\alpha = 0.025_0$	$2V_\gamma = 63\frac{1}{2}^0$
$n_\gamma - n_\beta = 0.018_1$	$2V_\gamma = 91^0$	$n_\gamma - n_\beta = 0.018_0$	$c/n_\gamma = 44^0$
$n_\beta - n_\alpha = 0.018_6$		$n_\beta - n_\alpha = 0.007_6$	

corresponding to 15 % Fe_2SiO_4.

These rocks are here described as limburgite but they are very closely related on the one hand to the nepheline-basalts, and on the other to the nepheline-basanite just described.

G. H. Williams described as limburgite a rock from Atalaia Grande (op. cit. p. 188, No. 14) but it is almost certainly one of the olivine-bearing monchiquites described above (p. 422).

TEPHRITIC TRACHYBASALTS

Basaltic rocks carrying numerous large crystals of black hornblende and augite (up to 1 cm in length) in a dark mouse grey, aphanitic groundmass were collected by Mr. Ridley at Caieira Bay [B.M. 67077, 67083] and Morro Branco [B.M. 67125].

The hornblende in thin section is dark brown. Pleochroism: n_γ and n_β chestnut brown, n_α buff-yellow $n_\gamma \geqq n_\beta > n_\alpha$ $c/n_\gamma = 15^0$, $2V_\gamma = 100^0$.

The augite is basaltic augite, pale greenish with pale violet borders, pleochroism weak $n_\gamma = n_\beta$ pale green to pale violet, n_α = pale buff-yellow. Extinction $c/n_\gamma = 39^0$, $2V_\gamma = 62^0$. Both minerals are idiomorphic.

Magnetite occurs as very small phenocrysts (0.4—0.1 mm) or microphenocrysts. The groundmass consists of minute augites, laths of plagioclase (andesine An_{25-30}) 0.01 mm thick, and abundant minute cubes of magnetite (0.01—0.03 mm), with small amounts of some colourless interstitial material. Nepheline is only identifiable under the microscope in very thin sections and is confirmed by microchemical tests. It seems to be present in relatively greater amount than in the „nepheline-basanite".

The rocks may be described as hornblende-bearing tephritic trachybasalts. In the system of Rosenbusch they are classified as trachydolerites or alkali-basalts [52]).

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[52]) H. Rosenbusch, Elemente der Gesteinslehre. Stuttgart 1923, p. 456.

Rocks of the same type are known from the Rhöngebirge and the Bohemian Mittelgebirge though many of the „hornblende-basalts" from those regions can be classified definitely as tephrite or basanite. A hornblende-bearing „felspar-basalt" is recorded by H. BÜCKING from Kirschberg near Rasdorf (Rhöngebirge) associated with a phonolitoid nepheline-tephrite [53]).

In the Bohemian Mittelgebirge E. BOŘICKÝ describes a hornblendic „phonolitähnlicher Basalt" from Dubitz, near Salesel [54]).

J. E. HIBSCH describes a hornblende-bearing alkali-basalt from Morwan near the same place [55]).

CONCLUSIONS

As is to be seen from the description of the various rock types in the preceding chapters, the igneous rocks of Fernando Noronha form an association of typically atlantic character. Like all the other volcanic islands of the middle and southern Atlantic ocean, Fernando Noronha is a part of that great, petrographical province, so often mentioned in the literature but still insufficiently studied, which gave the name to the atlantic suite of igneous rocks. The similarity to another well known atlantic province, that of the Bohemian Mittelgebirge, has already been pointed out by showing that to most of the rocks described from Fernando Noronha a close match in chemical and mineralogical composition from this region can be quoted.

P. ESENWEIN [56]) has discussed the relations of the igneous rocks of the Atlantic islands on the basis of those chemical analyses which were available in 1928. He distinguishes several types of differentiation within the province of the Atlantic islands, showing that the atlantic tendency for instance in the Canary Islands is much more pronounced than in the Azores or in Madeira, both of which show pacific affinities. For Fernando Noronha, the relations seem to be somewhat more complex and its rocks cannot be attributed simply to one of these types, as the chemical analyses show that a more and a less pronounced atlantic tendency has been at work in the same place. The first is represented by the nepheline-basalt and the phonolite, the second by the series nepheline - basanite - monchiquite-gauteite - trachyte. The essexites and trachyandesites which have not

[53]) H. BÜCKING, Sitzungsber. K. Preuss. Akad. Wiss. Berlin 1910, I, p. 503.

[54]) E. BOŘICKÝ, Petrographische Studien an Basaltgesteinen Böhmens. Prag 1874, p. 148.

[55]) J. E. HIBSCH, Tscherm. Min. Petr. Mitt. 34, 1917, p. 104.

[56]) P. ESENWEIN, Zur Petrographie der Azoren. Diss. Univ. Zürich. Z. f. Vulk. 1928 esp., pp. 195—225.

been analysed would also belong to the latter series. For the gauteite analysed it may also be mentioned, that it is one of the most potassic rocks known from the Atlantic islands ($k = 0.56$). In the present state of knowledge it is not possible to discuss these interesting relations in more detail. (C. B.)

London, British Museum (Natural History), Mineral Department.

Zürich, Mineralogisch-Petrographisches Institut der Eidg. Technischen Hochschule.

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Explanation of Plate

Fig. 1. Phonolite, [B.M. 67056]. S. Miguel I, Fernando Noronha. Phenocrysts of aegirine-augite, brown hornblende, and nosean. × 22. (see p. 408.)

Fig. 2. Alkali-trachyte, [B.M. 67099]. From south end of S. Antonio Bay, Fernando Noronha. Small phenocrysts of andesine, aegirine-augite, sphene and magnetite. × 22. (see p. 414.)

Fig. 3. Gauteite, [B.M. 67165]. From the central plateau, Fernando Noronha. Phenocrysts of anorthoclase, and of aegirine-augite, and small phenocrysts of brown hornblende, with curved microliths of felspar and needles of brown hornblende in the groundmass. × 22. (see p. 417.)

Fig. 4. Monchiquite, [B.M. 67113]. Between Cotton Tree Bay and Atalaia Grande, Fernando Noronha. Phenocrysts of aegirine-augite and brown hornblende in a glassy groundmass with abundant crystalites of hornblende showing flow-structure. × 22. (see p. 420.)

Fig. 5. Nepheline-basalt, (Ankaratrite), (Lacroix, Nr. N 40), Fernando Noronha. Phenocrysts of olivine in a groundmass of nepheline, augite, and magnetite. × 22. (see p. 425.)

Fig. 6. Nepheline-basanite, [B.M. 64648]. S. José I., Fernando Noronha. Idiomorphic augites and small olivines (altered) in groundmass of augite and labradorite, etc. × 22. (see p. 429.)

We are greatly indebted to Mr. F. N. Ashcroft for the photomicrographs reproduced on the plate and take this opportunity of thanking him for the pains he has taken to secure the best results from the material and apparatus available in the Mineral Department of the British Museum.

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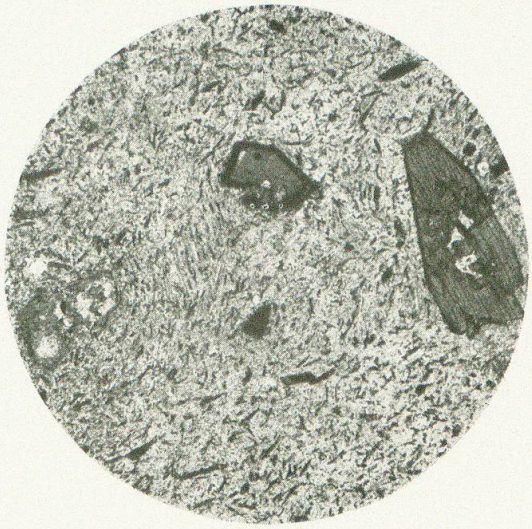

Fig. 1

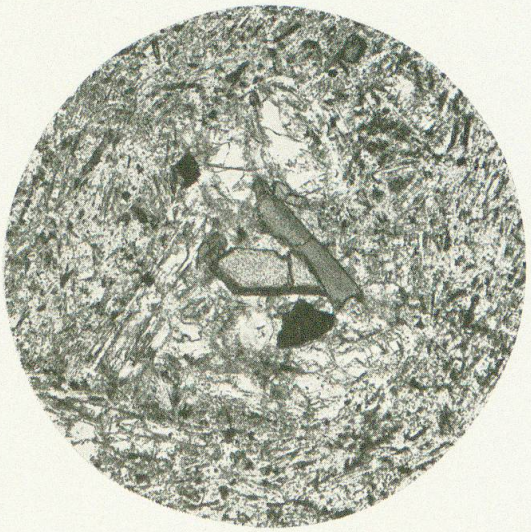

Fig. 2

Fig. 3

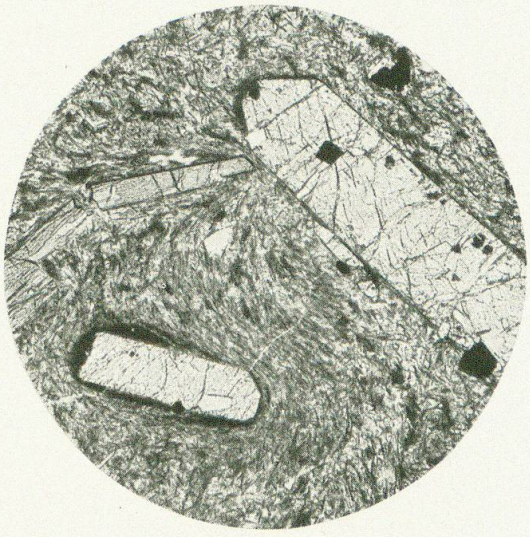

Fig. 4

Fig. 5

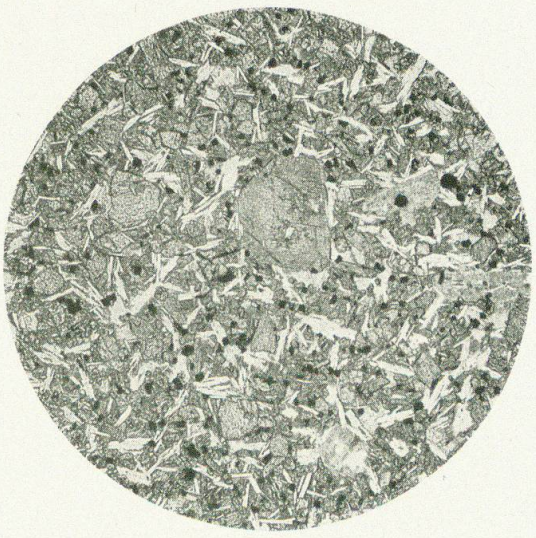

Fig. 6

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