ON THE OCCURRENCE OF CARBONATITES IN THE CAPE VERDE ISLANDS

BY

C. TORRE DE ASSUNÇÃO *, F. MACHADO **
and R. A. DAVID GOMES **

ABSTRACT

Samples of crystalline carbonate rocks from Fogo and Brava (Cape Verde Islands) have been studied. In addition to calcite the rocks contain accessory apatite, biotite and several other minerals. Quantitative spectrographic analyses have shown considerable amounts of Ba and Sr (up to 6000 and 13400 p.p.m., respectively), which are characteristic of carbonatites. These carbonatites, associated with alkaline rocks, appear to belong to a large structure, forming a common basement to Fogo, Brava and the neighbouring islets.

RESUMO

O estudo de rochas carbonatadas do Fogo e da Brava (ilhas de Cabo Verde) mostrou que, além de calcite, as rochas contêm, como acessórios, apatite, biotite e outros minerais. Por análise espectrográfica foram determinados teores elevados de Ba e Sr (que atingem 6 000 e 13 400 p.p.m., respectivamente); estes teores de oligo-elementos são característicos de carbonatitos. As rochas carbonatadas estão associadas a rochas alcalinas; o conjunto constitui possìvelmente um vasto soco comum às ilhas do Fogo, Brava e ilhéus vizinhos.

1 — INTRODUCTION

In addition to fossiliferous limestone, there are in the Cape Verde Islands some bodies of crystalline carbonate rock, which were mentioned by several writers.

FRIEDLAENDER and BERGT (1913) drew attention to what they assumed to be a Mesozoic basement (with igneous plutonic rocks

* Prof. of the University of Lisbon.

** Researchers of «Junta de Investigações do Ultramar» — Lisbon.

and metamorphic limestone), occurring in some of the islands, namely in Fogo and Brava.

Later on, BEBIANO (1932) mentioned «calcareous» dykes in San Vicente and in the small islets, off Brava; he thought that these rocks must have had an igneous origin, but did not exclude the possibility of mineral replacement.

PART (1950) considered the Fogo «basement» complex as a metamorphosed Tertiary limestone; ASSUNÇÃO (1954) also described the crystaline carbonate rock of Fogo, accepting the same interpretation.

The recent development of the study of carbonatite intrusions, usually associated with alkaline (partly ultrabasic) igneous rocks, in other parts of the world, pointed to the possibility that some of the calcite rich rocks of the Cape Verde Islands be true carbonatites, especially because the igneous environment (nepheline syenites, ijolites, etc.) is typical of most carbonatite associations (PECORA, 1956; CAMPBELL SMITH, 1956).

The study of all these rocks is still under way, but, as there is presently considerable interest on the subject, it has seemed advisable to publish immediately this preliminary note.

2 — THE BASEMENT OF FOGO AND BRAVA

In 1964, during the geological survey of Fogo, the following small exposures of the basement complex were found:

— Ribeira do Pico (northern slope of Monte Almada),
— Montinho de Oiro (southern slope of Monte Almada),
— Ribeira da Trindade (near Monte Barro).

At the first two places the rock (carbonatite) consists mainly of calcite with small amounts of black mica, pyroxene and other minerals.

At Ribeira da Trindade there is a greenish silicate rock (much altered) with discrete minor bodies of carbonatite. Everywhere the complex is intruded by numerous thin dykes of volcanic (or plutonic) rocks (see MACHADO and ASSUNÇÃO, in press).

A rapid survey of Brava Island, made in 1965, showed that the «calcareous» inclusions in the syenites described by BEBIANO (1932) are fairly common. In the basement exposures, on the eastern side of the island, the carbonatite is probably dominant.

No evidence could be found for Bebiano's suggestion that the various outcrops of plutonic rocks are independent intrusions; all appear to belong to the same basement, which is also exposed in Fogo and at the small islets, to the north of Brava. However, a detailed survey of Brava and the islets is planned for the near future.

Recently, in either island, magma rose through fractures in the basement, and lavas were poured, which concealed most of the older rocks.

In Fogo these lavas are essentially nephelinitic (sensu lato) and basanitic, whereas in Brava they are mostly phonolitic.

As far as is presently known, the carbonatite of the basement of both islands appears to form a central stock (?) with an outer ring of alkaline rocks, consisting of nepheline syenite, ijolite, etc. with minor carbonatite inclusions (fig. 1). Interpolation through

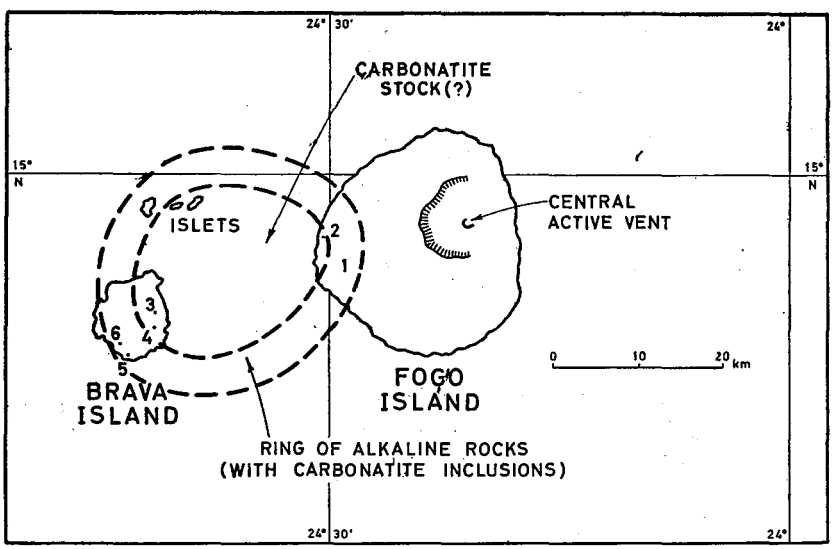

Fig. 1 — Possible structure of the carbonatite complex of Fogo and Brava (1. Ribeira da Trindade; 2. Ribeira do Pico; 3. Soghi; 4. Aguada; 5. Porto Ancião; 6. Chão de Oiro).

the sea is of course speculative, other intepretations being certainly, possible.

The carbonatite could well represent the extreme diferentiate of an alkaline magma, as suggested by BAILEY and SCHAIRER (1966).

3 — MINERALOGICAL STUDY

The rocks were first studied in thin sections.

— *Carbonatite* of Ribeira do Pico, Fogo (samples F-15, F-200, F-202, F-207, F-210 and F-211):

> Most of the rock is calcite; as accessory minerals there are biotite (or phlogopite), apatite, magnetite, hematite, and, in one case, pyrochlore; in some samples aegirine--augite, a sodium-amphibole (imerinite?), sphene and vermiculite have been recognized (partly by X-ray diffraction). Scapolite was mentioned in previous papers (FRIEDLAENDER and BERGT, 1913, p. 104; ASSUNÇÃO, 1954, p. 88), but it appears to be a rare accessory.

— *Carbonatite* of Soghi and Aguada, Brava (samples BR-14 and BR-19):

> The rock presents a calcite mosaic with a few crystals of aerigine-augite and magnetite: a clay mineral was identified as halloysite, by X-ray diffraction.

— *Carbonatite inclusions* of Ribeira da Trindade, Fogo (samples F-4, F-5 and F- 222):

Calcite is by far the predominant mineral. As accessories, the rock contains apatite, iron ores, ilmenite, nepheline and zeolites (probably derived from the nepheline).

— *Carbonatite inclusions* of Porto Ancião, Brava (sample BR-7):

In addition to calcite, there are some feldspathoids (especially analcite) and brown ores (hematite and goethite, according to the X-ray analysis).

As refers to the environing silicate rocks the following samples were studied:

— *Nepheline syenite* of Porto Ancião, Brava (sample BR-8):

It is a light coloured granular rock, consisting of nepheline, sanidine, some plagioclase, a mafic mineral (pyroxene?) with calcite inclusions and a little biotite and magnetite. To the north, at Chão de Oiro, conspicuous segregations of black mica (BR-21; biotite, as shown by X-ray diffraction), are found within a similar rock.

— *Ijolite* (urtite) of Aguada, Brava (sample BR-16):

The dominant minerals are nepheline and aegirine; in addition accessory augite, ores and sphene can be found.

The much altered greenish rock (sample F-221) of Ribeira da Trindade (Fogo) is an alkaline undersaturated (probably plutonic) rock; it contains biotite, apatite, some zeolites and traces of plagioclase. A sodium amphibole (imerinite?) and ilmenite were identified on X-ray powder photographs.

The thin dykes (samples F-6, F-19, F-225, F-226 and F-227), which intrude the basement (on the Fogo exposures) are also alkaline, highly undersaturated rocks; in most cases they have a microlitic groundmas formed by mafic minerals.

4 — CHEMICAL STUDY OF THE CARBONATITES

Some samples from Fogo Island were chemically analysed (for the routine elements). The results are given in Table 1.

These rocks are fundamentally formed by $CaCO_3$ with variable amounts of silicates, phosphates, etc. In fact the variability of the accessory minerals appears to be characteristic of these carbonatites.

TABLE 1

Sample	F-4	F-5	F-15
Location	Rib. Trindade, Fogo	Rib. Trindade, Fogo	Rib. Pico, Fogo
SiO_2	0.04	3.36	3.27
Al_2O_3	0.04	0.15	0.09
Fe_2O_3	0 83	2.15	2.37
Fe O	0.50	0.21	0.64
Mg O	1.44	0.56	0.98
Ca O (1)	52.85	50.53	50.88
Na_2O	0.43	0.38	0.51
K_2O	0.07	0.05	0.27
H_2O^+	0.19	0.43	0.44
H_2O^-	0.15	0.18	0.17
CO_2	41.49	39.42	36.34
Ti O_2	0.12	0.04	0.30
P_2O_5	0.93	1.77	3.19
Mn O	0.46	0.40	0.13
	99.56	99.63	99.58

Analyst: L. Conceição Silva

Spectrographic determination of some trace elements was also carried out, as shown in Table 2.

The abundance of Ba and Sr is decisive to classify all these rocks among the carbonatites (HIGAZY, 1954; WAMBEKE and others

(1) Includes BaO and SrO.

1964; see also TURNER and VERHOOGEN, 1960, p. 400; BARTH, 1962, p. 212).

As said before, samples F-4, F-5, F-222 and BR-7 are relatively small inclusions in silicate roks; the remaining samples repre-

TABLE 2

Sample	F-4	F-5	F-15	F-200	F-202	F-207
Location	Rib. Trind., Fogo	Rib. Trind., Fogo	Rib. Pico, Fogo	Rib. Pico, Fogo	Rib. Pico, Fogo	Rib. Pico, Fogo
Ba	1 800	2 000	520	860	570	Not studied quantitativety
Sr	13 400	9 600	9 500	8 400	9 800	
Nb (1)	*	*	*	*	2 000	
La (2)	1 300	600?	600?	600?	600?	
Y (3)	200?	200?	200?	200?	200?	

Sample	F-210	F-211	F-222	BR-7	BR-14	BR-19
Location	Rib. Pico, Fogo	Rib. Pico, Fogo	Rib. Trind., Fogo	Porto Ancião, Brava	Soghi, Brava	Aguada, Brava
Ba	660	790	>6 000	1 470	490	770
Sr	10 600	11 800	4 700	4 400	9 600	11 200
Nb (1)	*	*	*	*	*	*
La (2)	600?	600?	2 500	600?	600?	600?
Y (3)	200?	200?	200?	200?	200?	200?

Analyst: R. A. David Gomes

Notes: Contents in p.p.m. (* means a value below the limit of sensitivity).

(1) Limit of sensitivity: about 600 p.p.m.

(2) Limit of sensitivity: about 600 p.p.m.

(3) Limit of sensitivity: about 200 p.p.m.

sent the bulk rock of the outcrops. In the latter samples the trace elements (with the exception of Nb) show a fairly constant distribution, whereas in the former the contents are more variable.

Carbonatites appear to form also the calcite dykes of San Vicente. In a geological survey carried out by A. Serralheiro, a few samples were collected which are being studied and have already shown high Ba and Sr contents. Similar dykes were found during a preliminary survey of Sal, in the summer of 1966.

Sr isotopic analyses of the Fogo carbonatites (as well as age determinations) are presently under way.

These carbonatites of the Cape Verde Islands are indeed remarkable; they seem to be the only ones known in oceanic islands.

AKNOWLEDGEMENTS

The chemical analyses are due to L. CONCEIÇÃO SILVA. The writers are also indebted to Dr. J. LIMA DE FARIA who made some X-ray mineral identifications. Dr. C. MATOS ALVES and L. CELESTINO SILVA kindly separated the minerals for the X-ray work.

LOCATION OF THE SAMPLES

F - 4 — Ribeira da Trindade, near Monte Barro, Fogo Island.
F - 5 — Ribeira da Trindade, near Monte Barro, Fogo Island.
F - 6 — Ribeira da Trindade, near Monte Barro, Fogo Island.
F - 15 — Ribeira do Pico, near Monte Almada, Fogo Island.
F - 19 — Ribeira do Pico, near Monte Almada, Fogo Island.
F -200 — Ribeira do Pico, near Monte Almada, Fogo Island.
F -202 — Ribeira do Pico, near Monte Almada, Fogo Island.
F -207 — Ribeira do Pico, near Monte Almada, Fogo Island.
F -210 — Ribeira do Pico, near Monte Almada, Fogo Island.
F -211 — Ribeira do Pico, near Monte Almada, Fogo Island.
F -221 — Ribeira da Trindade, near Monte Barro, Fogo Island.
F -222 — Ribeira da Trindade, near Monte Barro, Fogo Island.
F -225 — Ribeira da Trindade, near Monte Barro, Fogo Island.
F -226 — Ribeira da Trindade, near Monte Barro, Fogo Island.
F -227 — Ribeira da Trindade, near Monte Barro, Fogo Island.

BR- 7 — Porto Ancião, Brava Island.
BR- 8 — Porto Ancião, Brava Island.
BR- 14 — Soghi, Brava Islanda.
BR- 16 — Aguada, Brava Island.
BR- 19 — Aguada, Brava Island.
BR- 21 — Chão de Oiro, Brava Island.

REFERENCES

ASSUNÇÃO, C. F. TORRE de
(1954) — *Expedição Científica à Ilha do Fogo — Estudos Petrográficos,* J. Inv. Ultramar, Lisboa.

BARTH, T. F. W.,
(1952) — *Theoretical Petrology* (2nd ed.), Wiley, New York.

BAILEY D. K. and SCHAIRER, J. F.
(1966) — The System Na_2O — Al_2O_3 — Fe_2O_3 — Si O_2 at 1 atmosphere, and the petrogenesis of alkaline rocks, *J. Petrology,* v. 7, 114-170.

BEBIANO, J.B.
(1932) — A geologia do arquipélago de Cabo Verde, *Com. Serv. Geol. Port.,* t. 18, 1-275.

FRIEDLAENDER, I. and BERGT, W.
(1913) — *Beiträge zur Kenntnis der Kapverdischen Inseln,* Reimer, Berlin.

HIGAZY, R. A.
(1954) — Trace elements of volcanic ultrabasic potassic rocks of southwestern Uganda and adjoining part of the Belgian Congo, *Bull. Geol. Soc. Amer.,* v. 65, 39-70.

MACHADO F. e ASSUNÇÃO, C. TORRE de
Carta geológica de Cabo Verde — Notícia explicativa da folha da ilha do Fogo (in press).

PART, G. M.
(1950) — Volcanic rocks from the Cape Verde Islands, *Bull. Brit. Mus. (Nat. Hist.), Miner.,* v. 1, 27-72.

PECORA, W. T.,
(1956) — Carbonatites: a review, *Bull. Geol. Soc. Amer.,* v. 67, 1537-1555.

SMITH, W. CAMPBELL,
(1956) — A review of some problems of African carbonatites, *Quart. J. Geol. Soc. London*, v. 112, 189-219.

TURNER F. J., and VERHOOGEN, J.
(1960) — *Igneous and Metamorphic Petrology* (2nd ed.), Mc Graw Hill, New York.

WAMBEKE L. VAN and others,
(1964) — *Les Roches Alcalines et les Carbonatites du Kaisertuhl*, Euratom, Bruxelles.

Agrupamento Cient. de Geologia da Universidade de Lisboa, J. Inv. do Ultramar.

Lab. Est. Petrológicos e Paleontológicos do Ultramar, J. Inv. Ultramar, Lisbon.

Lab. Técn. Físico-Químicas Aplicadas à Mineralogia e Petrologia, J. Inv. Ultramar, Lisbon.