



# THE STRONTIUM ISOTOPIC COMPOSITION IN CARBONATE ROCKS OF CAPE VERDE ISLANDS

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By carbonatites we understand the eruptive rocks rich in carbonates, usually calcitic, dolomitic or ankeritic, in most cases associated, directly or indirectly, with subsilicic alkaline igneous rocks, as ijolites, peridotites, pyroxenites, nepheline syenites, etc.

Carbonatites typically occur at the centre of ring structures, surrounded by country rocks, which often exhibit evident metasomatic alterations; carbonatite dykes frequently cut those country rocks.

Some carbonatites also form dykes and sills unrelated to the structures mentioned before.

Carbonatites occur not only as plutonic or hypabyssal rocks but also as extrusive volcanic rocks, forming lava flows and pyroclastics.

These elements permit to establish a geological basis for the field study of these rocks.

The minerals most frequently associated with carbonatites are: apatite, pyrochlore, phlogopite, biotite, melilite, aegirine, sphene, perovskite, etc.

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From a geochemical point of view, the carbonatites present, as an important characteristic, an exceptional concentration of some rare elements, which give to these rocks a high economical value. Those elements are: Ba, Sr, Ti, Nb, Zr, Rare Earths, P, F and Th.

Owing to the development of isotopic geology, the carbonatites can now be identified by the isotopic compositions of the three elements Sr, O and C. In fact, the experiments have shown that Sr present in carbonatites has a very low  $^{87}\text{Sr}/^{86}\text{Sr}$  isotopic ratio compared to that of other rocks, although very close to the ratio in basalts. Significant ratios can also be obtained for the isotopes of O and C.

So, it seems important to have the isotopic composition of those elements in order to characterize the carbonatites.

We had the opportunity of determining the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios and this paper will describe the process used, the results obtained and the conclusions reached.

## EXPERIMENTAL METHOD

The three samples chosen by F. MACHADO, C. TORRE DE ASSUNÇÃO and others (1965 b), and C. TORRE DE ASSUNÇÃO and M. H. CANILHO (1965 a), had been considered as carbonatites. The samples were first ground, then Sr was extracted as a nitrate, and afterwards subjected to the isotopic analysis. The technique used was the one adopted in the Geological Department of Clermont-Ferrand University (1961).

We took approximately 0,5 gram in a crucible, and dissolved with 3 ml of  $\text{HClO}_4$  and 15 ml of HF. Next, the crucible was put in the sand, warmed to about  $65^\circ\text{C}$  until the remainder was consolidated. Afterwards, the remainder was treated with  $\text{HCl/N}$  and the solution was put into a pyrex ballon and further  $\text{HCl/N}$  was added to make 50 ml. Then a volume of 20 ml was taken and completely evaporated.

The residue was treated with some drops of  $\text{HCl}/2,5 \text{ N}$  cooled in a mixture of water and ice, and centrifuged with a

speed of 3000 r. p. m. Next, the mixture was decanted for about 48 h.

Then, the solution traversed a cylindrical column of ion exchange resin, with 9 mm internal diameter and 250 mm height, and was filtrated through a fibre glass plug.

A portion of Sr was taken and put in sand for complete evaporation. The evaporation should be slow, and only by trials we could choose the suitable temperature.

The remainder was dissolved with 5 or 6 drops of  $\text{HNO}_3/0,1 \text{ N}$  and the solution kept in a pyrex flask and labelled. Afterwards this solution was analysed in a MS10 mass spectrometer (for solid samples) and evaporated over a hot tungsten filament to obtain a strontium nitrate residue. From this residue we separated and analysed the isotopes in a vacuum below  $10^{-5}$  mmHg and with suitable temperature for the thermoionic emission.

The spectrometer was provided with a system for scanning in both directions the spectral interval of the four Sr natural isotopes.

The four peaks corresponding to the four isotopes were observed in 25 to 30 scans.

The height of the peaks was measured with a rule divided in 0.5 mm and the readings were estimated to 0.1 mm. The average value of each peak was obtained in a first approximation from all the observed values and in a second approximation considering only the values falling within twice the standard deviation.

In this way, we obtained a new set of values with 95 % confidence, all values being between

$$(\bar{x} + 2 \sigma_x) \quad \text{and} \quad (\bar{x} - 2 \sigma_x),$$

where

$$\sigma_x = \sqrt{\sum (x - \bar{x})^2 / (n - 1)}.$$

The error is given by

$$E = \sqrt{\sum (x - \bar{x})^2 / n(n - 1)}$$

In Table I we present the obtained values.

TABLE I

Location	Sample n.º	$Rb_{N}/Sr_{N}$	Sr (ppm)	$^{87}Sr/^{86}Sr$	$^{87}Sr/^{86}Sr$ Normalized
<i>Ilha Brava</i>					
Ribeira da Aguada					
$\lambda = 14^{\circ} 50', 4 N$	1819	0.0020	9031	0.7095	0.7095
$\mu = 24^{\circ} 41', 3 W$	(Br-19)				
<i>Ilha do Fogo</i>					
Ribeira do Pico					
$\lambda = 14^{\circ} 55', 4 N$	1820	0.0025	9806	0.7097	0.7091
$\mu = 24^{\circ} 30', 0 W$	(F-210)				
<i>Ilha de S. Vicente</i>					
Monte Julião					
$\lambda = 16^{\circ} 51', 6 N$	1821	0.0008	3756	0.7095	0.7113
$\mu = 25^{\circ} 00', 2 W$	(V-13)				

The  $^{87}Sr/^{86}Sr$  ratios reported in the last column in Table I are normalized to a value of 0.1194 for the  $^{86}Sr/^{88}Sr$  ratio.

To check against possible changes in machine characteristics analyses of the interlaboratory Sr standard have been made.

## DISCUSSION

The values that we found for the  $^{87}Sr/^{86}Sr$  ratio are relatively high when compared with the values from POWELL, J. L. *et al.* (1965) for carbonatites, which lie between 0.702 and 0.705 with an average value of  $0.7035 \pm 0.0003$ . For limestones POWELL *et al.* (1962 a) found values between 0.709 and 0.713.

Based on this criterion we could conclude that our samples were not carbonatites but some other kind of carbonate rocks, probably a limestone, because for plutonic or hypabyssal carbonatites the  $^{87}Sr/^{86}Sr$  ratio would be certainly lower.

On the other hand, from geological, petrological and geochemical considerations, TORRE DE ASSUNÇÃO *et al.* (1965 b), and TORRE DE ASSUNÇÃO and CANILHO, M. H. (1965 a), considered those rocks as carbonatites.

From conflicting results, we arrive at one of the following conclusions:

- 1) The samples are not carbonatites, but other carbonate rocks with characteristics very close to carbonatites.
- 2) They are carbonatites but have a Sr isotopic composition very different from that of the continental carbonatites.

The possibility of these being very old carbonatites has probably to be excluded because the  $^{87}\text{Sr}/^{86}\text{Sr}$  isotopic ratio seems to be too high.

For the three rocks studied, the Rb/Sr ratio are very low. In an environment so poor in Rb, no radiogenic process could produce so high an enrichment in  $^{87}\text{Sr}$ . So we do not admit that the rocks could be very old.

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