

GEOLOGY

Isotopic Composition of Strontium in Carbonatites

IN a recent letter Hamilton and Deans¹ presented their results on the isotopic composition of strontium in carbonate rocks and strontium minerals, confirming the earlier discovery of Powell *et al.*² that the isotopic composition of strontium in accepted carbonatites, which have so far been analysed, falls within a restricted range. The results have led both groups of workers to conclude that the source of these carbonatites is below the sial, a conclusion which would certainly meet with the approval of many geologists who have examined such rocks: postulation of this source, however, provokes the question of how the carbonatite rises through tens of kilometres of sialic crust without contamination. Probably the most widely accepted answer would be that most carbonatites are emplaced through a conduit already lined with co-magmatic or co-eval metasomatic products, and hence are protected from sialic contamination. If this were a valid explanation then it would be expected that some carbonatite intrusions, not so protected, might incorporate sialic material in their uprise and, because of the volatile-rich nature of the system, the strontium from the two sources would be rapidly equilibrated. Such a possibility is envisaged by Hamilton and Deans¹ when they say that the atypical isotopic composition of the Keshya intrusive limestone might have resulted from "carbonatite assimilating granitic or sedimentary rocks". Unlike the other carbonatites analysed the Keshya intrusion³ is indeed full of granitic xenolith material, and it is difficult, therefore, to see the basis for the subsequent statement of Hamilton and Deans¹ that "Carbonatites show little evidence of assimilation on this scale . . .".

Obviously the Keshya problem will not be resolved with the present data and it would seem wise to postpone further speculation along such lines until we have knowledge of the isotopic composition of strontium in many more carbonate rocks, particularly those veins and vein-dykes not directly connected to any exposed alkaline complex.

D. K. BAILEY

Department of Geology,
Trinity College, Dublin,
and Geophysical Laboratory,
Washington, D.C.

¹ Hamilton, E. I., and Deans, T., *Nature*, **198**, 776 (1963).² Powell, J. L., Hurley, P. M., and Fairbairn, H. W., *Nature*, **196**, 1085 (1962).³ Bailey, D. K., *Quart. J. Geol. Soc. Lond.*, **117**, 423, Plates XVI and XVIII (1961).

BAILEY has inferred that Hamilton and Deans¹ have agreed with Powell *et al.*² that investigations of strontium isotopes show that the source of carbonatites is exclusively from below the sial. At present the isotopic composition of strontium has been examined in well-documented carbonatites and the results clearly show that they have been derived from a region that is identified by having a low ⁸⁷Sr/⁸⁶Sr ratio, similar to that found in basalts. The isotopic composition of strontium in carbonatites must be treated together with those from alkaline rocks in general. The ⁸⁷Sr/⁸⁶Sr for alkaline rocks has only been examined in a few cases while the isotopic composition of strontium in minor carbonate deposits, such as veins, pockets, breccia infillings, and that associated with ore mineralization have not been examined at all.

The characteristic trace element assemblage (for example, zirconium, niobium, rare-earths, lead, uranium and thorium) common to carbonatites and the alkaline rocks is more in keeping with a relation to a sialic origin rather than from the sima, unless extreme differentiation is invoked. Isotope studies have shown that the source

cannot be one of rubidium-rich sial, but the possibility that the sial shows a decrease in the Rb/Sr ratio with depth cannot be overlooked. Deeper parts of the sial having a low Rb/Sr ratio would constitute the source regions for the carbonatites and alkaline rocks. This zone of the crust would have vague limits, and unquestionably some material would be introduced from the underlying basic rocks through the combined process of differentiation, diffusion and gas transference. Many of the trace elements common to alkaline rocks could be removed from the lower areas of sial through the agency of anionic complex transfer, a process of some importance in the petrochemistry of the alkaline rocks.

The low ⁸⁷Sr/⁸⁶Sr ratio for the Bulawayan limestone is to be expected as the relatively thin limestone is associated with some 35,000 ft. of ironstones, spillites, and ultra-basic rocks. Of greater interest would be the finding of low strontium ratio in limestones preserved in ancient granitic basement rocks.

The trace element assemblage together with the mode of occurrence has often been used to 'recognize' a carbonatite. This approach must be treated with caution as processes of differentiation may lead to the depletion of some elements within parts of a carbonatite, or exchange with the surrounding rocks particularly if the carbonatite phase is small in volume.

E. I. HAMILTON

Geological Age Isotope Group,
University of Oxford.

¹ Hamilton, E. I., and Deans, T., *Nature*, **198**, 776 (1963).² Powell, J. L., Hurley, P. M., and Fairbairn, H. W., *Nature*, **196**, 1085 (1962).

IN view of Dr. Bailey's remarks it must be admitted that my phrase "carbonatites show little evidence of assimilation on this scale" was rather ill-chosen. Near the margins of carbonatite plugs inclusions of gneiss transformed into feldspathic or phlogopite rocks are common, and local enrichment of the carbonatite in ferromagnesian silicates is very suggestive of assimilation. The significant point, however, and the one I had intended to convey, is that this assimilation has surprisingly little effect on the carbonatite as a whole, apart from causing a modest increase in the silicate content. So far as strontium is concerned, the negligible effect of assimilation is witnessed by the very limited range of ⁸⁷Sr/⁸⁶Sr ratios in the 30 carbonatite specimens examined by Powell and Hamilton, as these could scarcely have failed to include some with sialic contamination. This may be largely due to the great abundance of strontium in carbonatites, which ranges from about 1,000 to more than 10,000 p.p.m., and may average perhaps 4,000 or 5,000 p.p.m., a value so high as to be little affected by assimilation of granite with probably less than 400 p.p.m. strontium, despite its higher ⁸⁷Sr/⁸⁶Sr ratio.

The Keshya limestone (No. 16) would certainly be more sensitive to contamination, as it contains only 230 p.p.m. strontium (a similar concentration to that in the Lusaka Limestone), but it would not appear to be a heavily contaminated rock, for it contains 86 per cent carbonates and only 8.4 per cent silica. Bailey mapped it as "limestone with scattered xenoliths", not as "breccia". As its strontium content and ⁸⁷Sr/⁸⁶Sr ratio are similar to those of many sedimentary limestones, there remains a strong case for regarding it as derived from the latter. In the case of the Keshya calcite (also strontium-poor, 110 p.p.m. strontium), there is certainly a need for more isotopic data on other vein calcites before sound conclusions can be drawn.

T. DEANS

Mineral Resources Division,
Overseas Geological Surveys,
London.