

## LETTERS TO THE EDITOR

## GEOPHYSICS

**Radioactivity of Sodium Carbonate Lava from Oldoinyo Lengai, Tanganyika**

Two papers on the chemical composition of the Oldoinyo Lengai sodium carbonate lavas have recently appeared in *Nature*<sup>1,2</sup>. Oldoinyo Lengai is an active volcano situated about ten miles south of Lake Natron in the eastern or Gregory Rift Valley of Northern Tanganyika. It is the only active volcano in East Africa. The most significant feature of the chemistry of its carbonate lava is the virtual absence of silica and the very small amounts of alumina and iron combined with the very high amounts of alkaline and volatile substances.

I became interested in the uranium and thorium contents of the lava, since the very low silica content of the lava suggested that the radioactive content of the lava should be very low, as it has been generally found that the more basic a rock the smaller its radioactive content. Through the kindness of the Commissioner, Geological Survey, Dodoma, Tanganyika, I obtained about 150 g of the lava. This amount was amply sufficient to measure the  $\alpha$ -ray emission from the rock, but a larger amount would have been better for finding its thorium content. The lava, however, is difficult to collect, and I am very grateful to the Geological Survey, Tanganyika, for sending me nearly 10 per cent of its stock.

The uranium and thorium contents were determined from the  $\alpha$ -ray emission of a powdered specimen of the lava and the  $\gamma$ -ray emission of the 2.62 MeV  $\gamma$ -ray produced in the decay of Th<sup>232</sup> (ref.3). The results obtained were: thorium content, 4.3 parts per million;  $\alpha$ -ray emission, 19.8/cm<sup>2</sup>/h; uranium content, 34.5 parts per million.

These results are quite unexpected. The uranium content is very high, corresponding to that of a very radioactive granite, while the thorium content as compared with the uranium content is very low. A similar result holds for some phosphatic deposits, which may be quite rich in uranium but contain very little thorium. This fact would, however, seem to have no bearing on the present problem, since the probable modes of production of the lava and the phosphatic deposits are so very different. In calculating the uranium content from the  $\alpha$ -ray emission and the thorium content, it is assumed that both the radioactive families in question are in radioactive equilibrium. The lava contains about 1 per cent of barium oxide, and it seemed possible that preferential deposition of radium might have occurred, radium and barium being chemically very similar. Since the half-life of radium is only about 1,600 yr., it would mean that the preferential deposition of radium must have taken place very recently geologically speaking. It was found possible to check whether the uranium family was in equilibrium by comparing the low-energy  $\gamma$ -ray spectrum of the lava with the spectrum of a specimen of uraninite, which was undoubtedly in equilibrium. UX<sub>1</sub> gives a  $\gamma$ -ray of energy 0.091 MeV and RaB one of 0.35 MeV. From the short half-lives involved, UX<sub>1</sub> must be in equilibrium with its parent uranium and RaB in equilibrium with radium. The peaks in the  $\gamma$ -ray spectrum due to the two  $\gamma$ -rays showed up well in both the spectrum of the lava and in that of the uraninite, and the ratio of the heights of the two peaks was practically identical in both cases. This fact would seem to show that the uranium and radium in the lava are in radioactive equilibrium. To obtain the spectra a large sodium iodide crystal, a 5-in. E.M.I. photomultiplier, and a 50-channel Société d'Applications Industrielles de la Physique analyser were used.

In conclusion, no satisfactory explanation of why the lava is so rich in uranium can be offered, although the fact that a readily soluble complex uranyl carbonate, Na<sub>4</sub>UO<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>, is produced when uranium compounds are leached with sodium carbonate solution may have some bearing on the problem.

J. H. J. POOLE

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<sup>1</sup> Dawson, J. B., *Nature*, **195**, 1075 (1962).

<sup>2</sup> Du Bois, C. G. B., *et al.*, *Nature*, **197**, 445 (1963).

<sup>3</sup> Poole, J. H. J., and Byrne, F. N., *Nature*, **191**, 62 (1961).

## GEOCHEMISTRY

**Synthesis of Uvarovite**

In previous investigations of the synthesis of the garnet, uvarovite (Ca<sub>3</sub>Cr<sub>2</sub>Si<sub>3</sub>O<sub>12</sub>), various temperatures have been given for the synthetic product to be obtained. These temperatures range from 855° to 1,490° C (ref. 1), with Glasser and Osborn<sup>2</sup> reporting the optimum temperature as 1,370° ± 10° C. In all cases, however, this mineral was not the sole reaction product, but was accompanied by the formation of  $\alpha$ -CaSiO<sub>3</sub> and Cr<sub>2</sub>O<sub>3</sub>.

The geochemistry of uvarovite is at present being studied and its synthesis was therefore undertaken. Experimental temperatures were varied between 1,200° and 1,460° C, and the best results were obtained in the range 1,360°–1,400° C, at one atmosphere pressure. Once again, in none of these experiments was uvarovite the only product;  $\alpha$ -CaSiO<sub>3</sub> and Cr<sub>2</sub>O<sub>3</sub> always were present. The X-ray powder patterns also indicated that there were structural distortions in the uvarovite, and it is entirely possible that a stoichiometric (3 : 1 : 3 = CaO : Cr<sub>2</sub>O<sub>3</sub> : SiO<sub>2</sub>) garnet was not obtained.

An examination of the solid solution series between uvarovite and its germanium analogue showed that substitution of between 1 and 2 per cent germanium in the silicon position stabilized the garnet structure and resulted in the formation of garnet as the only phase. The same result was obtained when approximately 5 per cent Al<sub>2</sub>O<sub>3</sub> was substituted for Cr<sub>2</sub>O<sub>3</sub>. Non-random substitutions in the lattice positions is the probable explanation for these results, and crystallographic studies on single crystals should show where these atoms enter the structure, and also enable us to understand the bonding forces affecting these substitutions.

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<sup>1</sup> Hummel, F. A., *Amer. Mineral.*, **35**, 324 (1950).

<sup>2</sup> Glasser, F. P., and Osborn, E. F., *J. Amer. Ceram. Soc.*, **41**, 358 (1950).

## PHYSICS

**A Spectroscopic Method of measuring Electron Temperatures in Plasmas**

THE measurement of electron temperature in high-temperature plasmas is an important but somewhat difficult problem particularly for temperatures above about 10 eV. Spectroscopic methods which have been used or suggested<sup>1-4</sup> are subject to certain limitations and have been reviewed by Thonemann<sup>5</sup>. This communication presents a new method, based on the relative intensities