

sulfur-oxygen tetrahedron, the  $y$ -coordinates of S, O(1), and O(2) are fixed by the mirror plane at either  $\frac{1}{4}$  or  $\frac{3}{4}$ ; whereas, O(3) is in a general position on either side of the plane. The mean interatomic distance for this tetrahedron is 1.472(3) Å (see Table 2): the average bond angle is 109.5(2) degrees. Barium is in a special position at  $(x, \frac{1}{4}, z)$  and  $(x, \frac{3}{4}, z)$  and is surrounded by a total of 12 oxygen atoms; however, in view of the range of interatomic distances, we have arbitrarily grouped six oxygen atoms as nearest neighbors. These have a mean distance of 2.80 Å. The other six oxygen atoms are in pairs at progressively longer distances.

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## CALZIRTITE FROM CARBONATITES OF NORTHERN SIBERIA

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## INTRODUCTION

Calzirtite, a complex oxide of calcium, zirconium, and titanium, is one the rare accessory minerals of carbonatites and alkaline rocks. In 1956

this mineral was reported by G. F. Anastasenko in carbonatites of the Meimecha-Kotui petrographical province, at the northern border of Siberian platform, where it was discovered in alluvial deposits in the Kugda and Odichinch massifs. In 1958 it was reported by L. M. Dakhiya in the carbonatites of the Guly intrusive. Later calzirtite from this massif was described by E. M. Epstein and also by A. G. Zhabin and others (1962). Besides, calzirtite was noted by N. Z. Evzikova in the Magan intrusive. The first published descriptions were by Bulakh and Abakumova (1960) from carbonatites of Kola peninsula and by Zdorik and others (1961) from alkalic-ultrabasic rocks of Eastern Siberia.

The description of the mineral from these new occurrences is given below. The geological and petrographical characteristics of the plutons can be found in the article by E. L. Butakova and L. S. Egorov (1962).

#### OCCURRENCE

In the Guly massif calzirtite was observed in calcitic and dolomite-calcitic carbonatites. It exists here in extremely small quantities and is associated with phlogopite, rarely with diopside-augite, with forsterite, baddeleyite and anastase, and sometimes forms intergrowths with dysanalyte and apatite. In considerably larger quantities, calzirtite was observed in the same associations in the alluvial placers of carbonatites in the Bezimyani and Zayachi streams. In the Kugda, Magan, and Odikhinch massifs, calzirtite was found in placers of the streams that erode carbonatites and alkaline rocks. Here the minerals associated with calzirtite are olivine, apatite, perovskite, pyrochlore, diopside, *etc.*

#### MORPHOLOGY

The symmetry of calzirtite is tetragonal,  $4/mmm$ ;  $a:c=1.06648$ ; its single crystals have prismatic habit and are formed with faces of (100), (121) and also (110), (231), (123), (112) as reported by Bulakh and Shevalevskii (1962). At all the above-mentioned places calzirtite exists in the form of small (not more than 0.5 mm) isometric grains with many faces. All grains are characterized by the presence of a large number of re-entrant angles and are always twinned intergrowths of two or three crystallographic individuals. From the point of view of their crystal habit and crystallographic forms they are almost complete analogues of the twins of calzirtite from placers of the river Kotui, described by Bulakh and Shevalevskii (1962).

Among the grains of calzirtite from the massifs of Magan, Guly, Kugda, Odikhinch, twinned growths of the so-called Type IV of A. G. Bulakh (1962) sharply predominate. Usually they have hexahedral habit (Fig. 1 f, g) and are also characterized by the presence of original four-

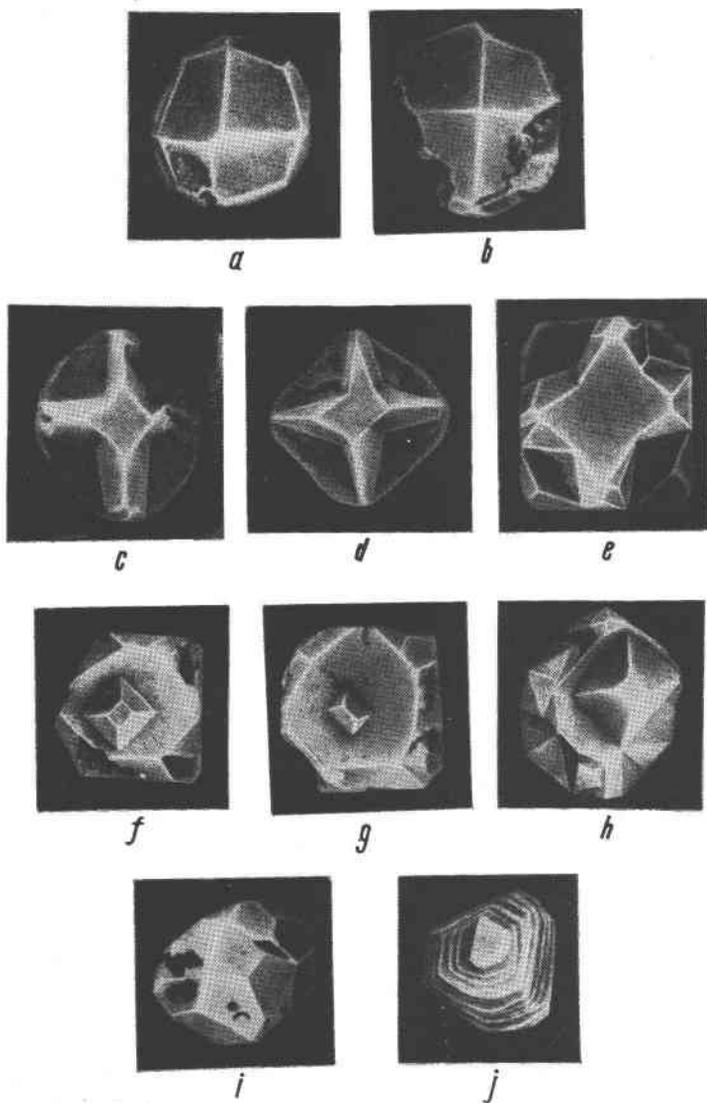


FIG. 1. Forms of crystals and grains of calzirtite (photograph by A. P. Reus, size of crystals 0.3 mm): a, b—twins, having dipyramidal habit; c, d, e—twinned growths of Type III; f, g, h—twinned growths of Type IV; i—pseudocubic twinned growths; j—sculptured surface on grains.

faced pyramids on strongly developed faces of the "hexahedron". The external shape of these growths sometimes remind one of single crystals. That is why the grains of calzirtite from the carbonatites of the Guly

massif were wrongly described by A. G. Zhabin as single crystals. Besides the hexahedral habit, the twinned growths of Type IV can have spheroidal habit. Crystals of such shape are characterized by a strong growth of four-faced pyramids on the faces of the hexahedron (Fig. 1h.). In other cases they have external pseudocubic symmetry (Fig. 1i).

In the above mentioned massifs, twinned growths of the so-called Type III of A. G. Bulakh are less common. In those the reentrant angles are distinctly developed (Fig. 1c, d, e). The growths themselves appear to consist of three individuals, oriented mutually perpendicularly.

Finally in isolated cases growths of Type II have been observed. Externally they are characterized by a set of elements of symmetry  $4/m\bar{3}m$  and look like ideal single crystals. They have flattened, dipyramidal habit (Fig. 1a, b).

However for many grains of calzirtite only partial idiomorphism is common. In these cases most of the grains have proper crystallographic boundaries and the rest of the grains are characterized by complexly sculptured surfaces, with a large number of closed and spirally mounting fine steps (Fig. 1j.). Probably they are the surfaces of contact of calzirtite with calcite.

#### PHYSICAL PROPERTIES

The color of calzirtite as a rule varies for different grains from light brown to dark brown. In the samples from Kugda and Odikhinch, calzirtite of light green or brownish green color is quite common. The luster on crystal faces is adamantine, and in the fractures it is greasy.

Specific gravity of the brown grains of calzirtite from the Guly intrusive is  $5.01 \pm 0.01$ .

In thin sections the mineral is transparent, has a light brown or greenish-brown tinge. Not pleochroic. Optically the mineral is uniaxial, positive (+). For calzirtite from all the studied samples, refractive indices were the same (within the limits of the probable errors in the measurements):  $\omega = 2.22 \pm 0.01$ ;  $\epsilon = 2.26 \pm 0.01$ .

#### CHEMICAL COMPOSITION

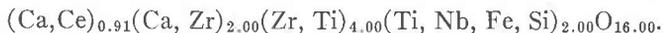
The brown calzirtite from the Kugda intrusive was chemically analyzed by A. G. Shpindler on a 0.6 gm sample, with the following results: Nb<sub>2</sub>O<sub>5</sub> 1.58, SiO<sub>2</sub> 0.80, TiO<sub>2</sub> 17.62, Fe<sub>2</sub>O<sub>3</sub> and FeO 0.75, Cr<sub>2</sub>O<sub>3</sub> traces, RE and ThO<sub>2</sub> 0.15, ZrO<sub>2</sub> and HfO<sub>2</sub> 66.09, CaO 12.22, MgO traces, P<sub>2</sub>O<sub>5</sub> 0.05, loss of weight on ignition 0.65, Sum—99.91%.

The material which was analyzed has almost the usual calzirtite composition. Only the amounts of ZrO<sub>2</sub> and HfO<sub>2</sub> are slightly less and that of TiO<sub>2</sub> and SiO<sub>2</sub> are slightly more than the usual amounts shown in

previous analyses. The presence of  $P_2O_5$  and the loss of weight on ignition is most probably due to the contamination of the sample by apatite and calcite. Calculations from the results of the analysis to the formula, suggested by Yu. A. Pyatenko and Z. V. Pudovkina (1961) for this mineral, gives the following results:



or



Here, in order to retain the coefficient of the group (Ti, Nb, Fe, Si) as 2.00, we have to assume the possibility of distribution of titanium in the crystal structure of the mineral in two systems of equivalent positions, as suggested by Yu. A. Pyatenko and Z. V. Pudovkina for calcium and zirconium.

#### CONCLUSIONS

In general, according to chemical composition, physical properties, and conditions of occurrence calzirtite from Magan, Kugda, Odikhinch, Guly massifs are very similar to calzirtite from other deposits (Zdorik and others, 1961; Bulakh and Shevaleevskii, 1962). Its discovery in four new geological units in similar paragenetic associations once again confirms our earlier assumption that this mineral is a usual accessory of carbonatites and alkaline rocks, and previously was either missed or wrongly determined as some other mineral. Just recently calzirtite was discovered in Tapira, Brazil (Veen, 1965). Obviously, many more such findings may be expected. In particular, one can assume the presence of calzirtite in the carbonatites of the Mbeya complex (Africa), in the composition of which accessory cassiterite—a mineral, which is unusual for carbonatites but sometimes difficult to distinguish from calzirtite—has been noticed.

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AN OCCURRENCE OF CYMRITE IN THE  
FRANCISCAN FORMATION, CALIFORNIA

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The mineral cymrite,  $BaAl_2Si_2O_8 \cdot H_2O$ , heretofore found only in Wales and Alaska,<sup>2</sup> was discovered by the writer with W. S. Fyfe near the only serpentinite body exposed on the Pacheco Pass Road (San Benito County, Calif.) about  $2\frac{3}{4}$  miles west of the summit. It is found at the west end of the serpentinite in a jadeite metagraywacke at the well-exposed contact with the ultramafic rock. The metagraywacke is bleached and desilicated at the contact, and is shot through with calcite, albite, lawsonite, and more rarely cymrite veins. The cymrite is seen in hand specimen as coarse platelets easily confused with the common albite. In thin section the rock is laced with laths of lawsonite and cymrite, and albitized jadeite relicts remain. Veinlets of cymrite-lawsonite may be found, although the coarsely disseminated cymrite is often penetrated by fine lawsonite. The lawsonite, albite and cymrite show no signs of reaction. Optical properties of the cymrite closely match those described for material from the type locality (Smith *et al.*, 1949), and its powder pattern is similar to that published by Smith *et al.*, and Seki and Kennedy (1964a). The cymrite is often partially altered to a cloudy brown material, and with the inclusions of lawsonite, the alteration would make it difficult to obtain perfectly pure material for wet chemical analysis. Relatively pure splits were obtained by magnetic separation.

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<sup>2</sup> Two cymrite occurrences have been recorded in Alaska, one at Bonanza Creek by Brosge (1960) and Carron *et al.*, (1964), and one at Ruby Creek by Runnells (1964).