

At 1200° C. photographs are obtained of preferentially oriented mullite and randomly oriented cristobalite. The morphology of the fibers is preserved. Mullite fibers are arranged with their [110], [010] and [120] directions parallel to the fiber axis. The (110) spacing of mullite is very similar to the a axis spacing of pyrophyllite anhydride. The first of the three arrangements thus appears to be favored. In all cases the mullite c axis, which corresponds to the direction of the chains of octahedral groups, is perpendicular to the fiber axis and the (001) reflections consequently appear as spots on the zero layer.

The photographs obtained are complex and have not, as yet, been completely interpreted. However, the salient point emerges that the thermal transformation of pyrophyllite to mullite involves an intermediate crystalline phase. It is evident that while extensive breakup of the structure occurs in the direction perpendicular to the sheets, within the sheets order is preserved and only relatively minor rearrangements take place, as envisaged by Bradley and Grim. Crystallization of mullite proceeds gradually over a range of temperature and the associated energy changes are small.

Studies of thermal transformations of clay and other minerals have shown that rearrangement of existing structures commonly occurs in preference to complete disintegration followed by crystallization of a new phase. Only rarely, however, can the successive changes be so readily observed. Detailed analysis of the structures of pyrophyllite anhydride, mullite and the intermediate phase would, no doubt, give valuable information on the type of mechanism involved.

REFERENCES

- BRADLEY, W. F. AND GRIM, R. E. (1951), High temperature thermal effects of clay and related materials. *Am. Mineral.*, **36**, 182.
BRAGG, W. L. (1937), *Atomic Structure of Minerals*, Cornell University, p. 170.

THE AMERICAN MINERALOGIST, VOL. 47, JANUARY-FEBRUARY, 1962

LAZULITE FROM YUKON, CANADA

FINLEY A. CAMPBELL, *Department of Geology, University of Alberta, Edmonton, Alberta, Canada.*

LOCATION

Lazulite, a relatively rare phosphate mineral, was collected from along the Blow River near Mt. Fitton in the Yukon Territory. This location is 80 miles W.N.W. of Aklavik at 68°30' N. Lat., 138°45' W. Long. The mineral was discovered and collected by B. Cameron in the summer of 1959 while employed by Triad Oil Company.

MODE OF OCCURRENCE

The lazulite is found as open space fillings and veinlets in quartzitic Jurassic sediments. Clusters of well-terminated deep blue clear crystals have developed on a base of light blue massive lazulite. The largest crystal faces are 3–4 mm across and show both curved and planar surfaces that are in places striated.

Associated with the lazulite are euhedral quartz crystals up to 2 mm in length and goethite in grains with 7 mm maximum dimension.

CHEMICAL COMPOSITION

A sample of 0.65 gm. of lazulite was hand picked under a binocular microscope. Evidently some quartz contamination was present in the

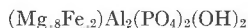
TABLE 1. CHEMICAL ANALYSIS OF LAZULITE FROM YUKON¹

MgO	11.10%
FeO	4.74
Al ₂ O ₃	32.05
MnO	0.06
CaO	Tr.
P ₂ O ₅	45.61
TiO ₂	0.06
H ₂ O ⁺	6.38
	100.00

¹ A. Stelmach, Analyst, University of Alberta Rock Analysis Laboratory.

sample as the analysis gave 0.42 per cent SiO₂. Table 1 gives the analysis of this sample recalculated to 100 per cent after the removal of the SiO₂.

On the basis of the analysis the composition of this lazulite is given by the following formula:



OPTICAL PROPERTIES

In plane polarized light, grains of lazulite show marked pleochroism from prussian blue to colorless with $\gamma > \beta > \alpha$. The following optical properties were determined for the mineral.

$$\begin{aligned} \alpha &= 1.614 & \beta &= 1.633 & \gamma &= 1.642 \\ 2V_\alpha (\text{obs}) &= 68.9^\circ & 2V_\alpha (\text{calc}) &= 68.6^\circ \\ & & r &< v \text{ distinct.} \end{aligned}$$

These data indicate a composition of 80 mole per cent $\text{MgAl}_2(\text{PO}_4)_2(\text{OH})_2$ (Winchell, 1956, p. 203) and this agrees with the chemical analysis.

TABLE 2. POWDER DATA FOR LAZULITE

$a=7.15 \text{ \AA}$ $b=7.28 \text{ \AA}$ $c=7.25 \text{ \AA}$ $\beta=120^{\circ}35'$					
I	$d \text{ \AA}$	hkl	I	$d \text{ \AA}$	hkl
75	6.146	100	10	1.961	$\bar{3}21$
15	4.726	011	8	1.959	221
16	4.711	110	14	1.819	040
3	3.627	$\bar{1}02$	10	1.814	$\bar{2}04$
		020	16	1.804	023
75	3.234	$\bar{1}12$	7	1.787	$\bar{4}02$
65	3.197	111			320
95	3.136	120	6	1.781	202
		021	6	1.662	$\bar{4}11$
		$\bar{2}02$	11	1.619	141
100	3.072	200	11	1.601	222
25	2.546	121	7	1.578	033
4	2.342	102	20	1.572	042
11	2.254	130	24	1.567	330
8	2.217	211			240
10	2.051	300	5	1.548	$\bar{4}21$
12	2.004	131	4	1.544	322
10	2.000	013	15	1.538	400
12	1.982	$\bar{1}23$	7	1.410	$\bar{2}15$
21	1.974	$\bar{3}22$	5	1.389	312
		122	16	1.274	242
		310			

X-RAY DIFFRACTION DATA

Considerable interest has been shown in the diffraction data of lazulite and related minerals in recent years. Berry (1948) presented data from single crystal work that showed the close similarity between the cells of lazulite and scorzalite. Pecora and Fahey (1949, 1950) established that an isomorphous series exists between lazulite and scorzalite. Lindberg and Christ (1959) presented single crystal data for the isostructural minerals lazulite, scorzalite and barbosalite.

With the single crystal data available the powder data for lazulite has been indexed (Table 2). This task was complicated by the fact that the cell of the mineral is close to hexagonal and a large number of planes apparently can satisfy the requirements of a given spacing.

The comparison of cell parameter for lazulite is shown in Table 3. The results are in good agreement within the limits of experimental error. By

TABLE 3. UNIT CELL DATA FOR LAZULITE

Parameter	Berry (1948)	Lindberg (1959)	This Study
$a(\text{\AA})$	7.14	7.16	7.15
$b(\text{\AA})$	7.27	7.26	7.28
$c(\text{\AA})$	7.16	7.24	7.25
β	119°18'	120°40'	120°35'

employing Q_{102} and Q_{102} from the powder data the calculated β would be 120°40' but as the angle is $\pm 5'$ at best and the Q_{102} value involves some of the 020 reflection this value is not considered better than 120°35'.

The space group for lazulite as determined by Lindberg and Christ (1959) is $P2_1/c$. The indices determined from the powder data are permissible for a mineral in this group (*i.e.* for *oko*, $k = 2n$ and for *hol*, $l = 2n$).

REFERENCES

- BERRY, L. G. (1948), Structural crystallography of lazulite, scorzalite and veszelyite. *Am. Mineral.*, **33**, 750.
- LINDBERG, MARIE L. AND C. L. CHRIST (1959), Crystal structures of the isostructural mineral lazulite, scorzalite and barbosalite. *Acta Cryst.*, **12**, 695-696.
- PECORA, W. T. AND J. J. FAHEY (1949), The Corrego Frio Pegmatite, Minas Gerais: Scorzalite and souzalite, two new phosphate minerals. *Am. Mineral.*, **34**, 83-93.
- (1950), The lazulite-scorzalite isomorphous series. *Am. Mineral.*, **35**, 1-18.
- WINCHELL, A. N., AND H. WINCHELL (1956), Elements of Optical Mineralogy, Pt. 2. Descriptions of Minerals, 4th ed., John Wiley & Sons, Inc., New York.

THE AMERICAN MINERALOGIST, VOL. 47, JANUARY-FEBRUARY, 1952

HORNBLENDE-CUMMINGTONITE INTERGROWTHS¹

B. ASKLUND², WILLIAM L. BROWN³ AND J. V. SMITH⁴

It is commonly considered that a gap exists in nature between the cummingtonite-grunerite (or anthophyllite) series of amphiboles and the tremolite-hornblende series. Basic metamorphic rocks, which from their composition might be expected to contain a single amphibole of composition between these two groups, always appear to contain two (or three) amphiboles (Eskola, 1914; Asklund, 1923; Seitsaari, 1952; Pirani, 1952;

¹ Contribution number 60-43. College of Mineral Industries, Pennsylvania State University.

² Geological Survey of Sweden, Stockholm, Sweden.

³ Dept. of Mineralogy, Pennsylvania State University. Now at Institut für Kristallographie, Eidg. Techn. Hochschule, Zürich, Switzerland.

⁴ Dept. of Mineralogy, Pennsylvania State University. Now at Dept. of Geophysical Sciences, University of Chicago.