Jōhachidōlite—A New Mineral of Hydrous Fluoborate of Sodium, Calcium and Aluminium.

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[With Plates VI–VII.]

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Abstract.

We have found a new mineral species in the nephelite blocks from Jōhachidō at Kankyohokudō in Chosen. We call it johachidolite after the name of the locality, from where the mineral comes. Under the ultra-violet excitation it shows remarkably intense blue fluorescence, which gives us a clue to this new finding. The spectra of ultra-violet-fluorescence as well as of cathodo-luminescence were investigated. Its chemical constitution may be regarded as a hydrous fluoborate of sodium, calcium and aluminium. Moreover, some explanations are given as to the mode of occurrence of jōhachidōlite.

1. At Jōhachidō district, Kisshu County, Kankyhokudō Prefecture in Chosen, light brownish transparent nephelite dykes are found penetrating the limestone of the Matenrei system, and accompanied by phlogopite and plagioclase.(1) While engaged in a fluorescence investigation of the nephelite specimens from this locality, we have discovered a peculiar mineral occurrence, which exhibits intense blue fluorescence by the stimulus of ultra-violet radiation. In the nephelite it occurs as a colourless transparent mass, hardly discriminable from the nephelite in the ordinary diffuse daylight. Usually it is lamellar, 1 mm in thickness, and often granular amounting to 1 cm in length. The crystals in the latter case are somewhat more opaque and the rounded edges show their easy fusibility. Fig. 1 A gives an ordinary photogram of a specimen of nephelite taken in diffuse sunlight and Fig. 1 B its luminogram taken by the fluorescence. By the ultra-violet light of quartz-mercury lamp filtered through Wood's glass, nephelite itself remains non-fluorescent, whilst the mineral in question shows bright blue fluorescence as seen in Fig. 1 B.

When heated the mineral melts readily at red glow. Its specific gravity is slightly smaller than 3·4, hardness 6·5∼7, optically biaxial (rhombic), negative, dispersion strong ($\rho > v$), axial angle 2 V

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(1) Y. KINOSAKI: *Geological Atlas of Chosen*, No. 14 (1932), 10.

(calculated) 72°. Indices of refraction are $\alpha_D = 1{\cdot}715$, $\beta_D = 1{\cdot}720$, and $\gamma_D = 1{\cdot}729$ as determined by the immersion method.

Fig. 1 A—Ordinary photogram.

Fig. 1 B—Fluorescence photogram through Riken ultrazin filter No. 5.

Fig 1.—Prismatic occurrence of fluorescent jōhachidōlite in a specimen of the nephelite from Jōhachidō.

2. The result of chemical analysis for this mineral is indicated in Table I. Potassium could not be detected by means of the usual flame test as well as by the cobaltinitrite reaction. As chinalizarin colour reaction was found to be negative, the absence of magnesium will be certain. For the quantitative measurement of boron oxide,(2) fluorine,(3) silica(4) and water(5) special attentions were paid. In addition to boron oxide, alumina and calcium oxide which altogether amounts to 77·32%, it contains fluorine, sodium and water. Empirical formula derived from the analytical data may be described as $H_6Na_2Ca_3Al_4F_5B_6O_{20}$, and this mineral is reasonably regarded as

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(2) H. Schöfer und A. Sierents: *Zeitschr. Analyt. Chem.*, **121** (1941), 161, 170.

(3) F. Nölke: *Ibid.*, **121** (1941), 81.

(4) A. J. Weinig and W. P. Schoder: "*Technical Methods of Ore Analysis*," (1939), 228.

(5) A. Classen: "*Handbuch der Quantitativen Chemischen Analyse,*" *Siebente vermehrtə Auflage* (1920), Stuttgart, 240, 243.

hydrous fluoborate of sodium, calcium and aluminium. As regards the naturally occurring mineral composed of boron, uni-, di-, and trivalent metals, only one species, has hitherto been known i. e. rhodizite, a hydrous borate of alkalies, beryllium and aluminium. On the other hand it is to be noted that in the natural halogenoborate minerals reported up to the present the metal combining with halogen and boron is always one and the same, as in the cases of teepleite, boracite, hilgardite, bandylite and fluoborate.

Investigation on chemical composition and determination of some physical constants convincingly demonstrate that the blue fluorescent mineral here studied is a new mineral species for which we would like to present the name jōhachidōlite after Jōhachidō district, where we have come across it.

TABLE I.

Chemical analysis of jōhachidōlite.

SiO_2	0·34%
Al_2O_3	28·34
Fe_2O_3	0·09
FeO	—
MnO	0·23
CaO	24·77
Na_2O	8·27
P_2O_5	0·03
B_2O_3	24·21
Cl	—
F	12·21
$H_2O(+)$	6·52
$H_2O(-)$	0·07
SO_3	—
	105·08
$-O=F_2$	5·14
Total	99·94%

TABLE II.

Composition and property of some borate minerals.

Mineral	Chemical composition	Specific gravity	Hardness
Fluoborate(6)	$3MgO \cdot B_2O_3 \cdot 3Mg(F, OH)_2$	2·89	3·5
Teepleite(7)	$Na_4B_2Cl_2O_4 \cdot 4H_2O$	2·076	3∼3·5
Boracite(8)	$Mg_7Cl_2B_{16}O_{30}$	2·9	7
Hilgardite(9)	$Ca_8Cl_4B_{18}O_{33} \cdot 4H_2O$	2·71	5
Bandylite(10)	$CuB_2O_4 \cdot CuCl_2 \cdot 4H_2O$	2·81	2·5
Rhodizite(11)	$4BeO \cdot 4(K, Na, Li, H)_2O\ 6B_2O_3 \cdot 3Al_2O_3$	3·4	8
Jōhachidōlite	$H_6Na_2Ca_3Al_4F_5B_6O_{20}$	5·4	6·5∼7

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(6) Dana's Textbook of Mineralogy, Fourth Edition (1932), 742.

(7) W. A. GALE, W. F. FOSHAG, and M. VOUSEN: *Amer. Miner.*, **24** (1939), 48.

(8) C. DOELTER and H. LEITMEIER: *Handbuch der Mineralchemie*, III (2), 419.

(9) C. S. HURLBUT and R. E. TAYLOR: *Amer. Miner.*, **22** (1937), 1052.

(10) C. PALACHE and N. F. FOSHAG: *Amer. Miner.*, **23** (1938) 85.

(11) C. DOELTER and H. LEITMEIER: *Handbuch der Mineralchemie*, III. (2), 428.

More opaque, white specimen which is almost similar to jōhachidōlite in appearance, but seems to be lacking in fluorine, is found in the nephelite block from the same locality. We will carry out detailed investigation on such a specimen in the near future when it comes into our hands in sufficient amount.

3. The lamellar occurrence of jōhachidōlite in a fissure of the nephelite was cut longitudinally and investigated in thin section. As is evident from Fig. 2 A and B, microphotograms under parallel and crossed nicols respectively, jōhachidōlite does not occur in immediate contact with the nephelite, but it is always found sandwiched by plagioclase.

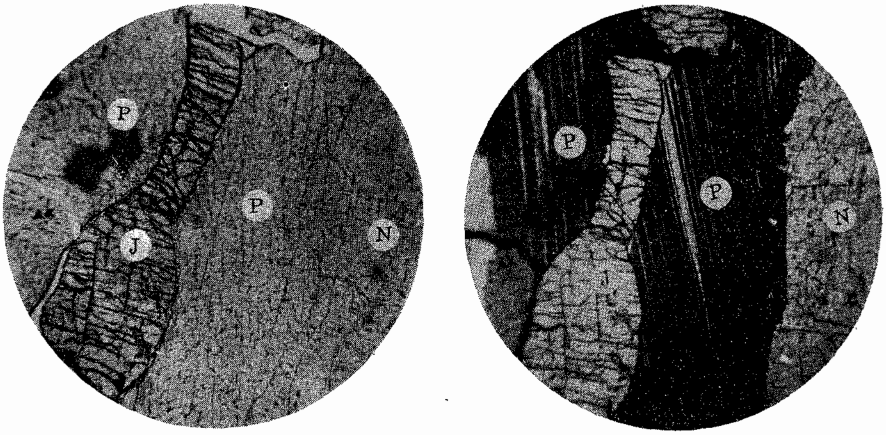

Fig. 2 A—In the ordinary light. Fig. 2 B—Under crossed nicols.

J: Jōhachidōlite. P: Plagioclase. N: Nephelite.

Fig. 2—Photomicrographs of Jōhachidōlite-bearing nephelite in thin section.

In the series nephelite, plagioclase and jōhachidōlite, there is a progressive increase of calcium content; boron, fluorine and water being found only in jōhachidōlite. Whilst nephelite and plagioclase have silica as one of their main constituent, in jōhachidōlite it may be regarded as only an impurity.

Judging from these facts a following conclusion may probably be drawn concerning the mode of formation of jōhachidōlite. When nephelite occurs, calcium, boron and fluorine are squeezed out and in the fissures of the nephelite, plagioclase is formed by taking up calcium and thus the last silica present in the ore solution is consumed. Boron, fluorine and water, which have been utterly left out of the reaction up to that time, will then begin to take part in constituting the jōhachidōlite.

4. As already mentioned, fluorescence of jōhachidōlite under ultra-violet light is blue and intense, this fact have attracted our attention first and have lead to the noteworthy finding described above. We will now investigate the spectrum of fluorescence given by this new mineral. For taking the spectrogram of fluorescence a small glass-prism Fuess spectrograph and Agfa Isopan I. S. S. plate are used, the time of exposure being 17 hours and the relative width of slit of the spectrograph, 2. In Fig. 3 the fluorescence spectrogram thus obtained is reproduced which consists of a broad continuous band extending from 490 *mμ* to 380 *mμ* and several weak line-like bands in the spectral region of 560～620 *mμ* as well.*

Under the excitation by cathode-ray bombardment the feature of these luminescence bands becomes more sharply defined (Fig. 4). Excepting a broad diffuse band covering the spectral region of 496～372 *mμ* with its intensity-maximum at 430～420 *mμ*, we can now clearly see a number of sharp bands, which came out quite obscurely in the case of the fluorescence provoked by the ultra-violet light. Arranged in the order of their intensity, the wave-lengths of these sharp bands are 558, 596, 575, 590, 570, and 604 *mμ*, the band at 558 *mμ* being the most intense. In addition to the comparatively intense bands here cited several other weak sharp bands are visible. So far as the present state of our knowledge on luminescence of inorganic substances is concerned, these sharp line-like bands are probably to be ascribed to minute presence of trivalent rare earths and the broad blue band to that of divalent europium in jōhachidōlite.

In conclusion we wish to express our cordial thanks to Prof. K. Kimura, Tokyo Imperial University for his valuable advices and to Prof. T. Sueno, Technical College of Tokyo for his kindness in measuring optical constants. In the preparation of thin section photograms, we received aid from Mr. T. Miyazawa, a member of Geological Survey of Chosen, to whom thanks are due.

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* In the reproduced photogram these Weak line-like bands are not visible.

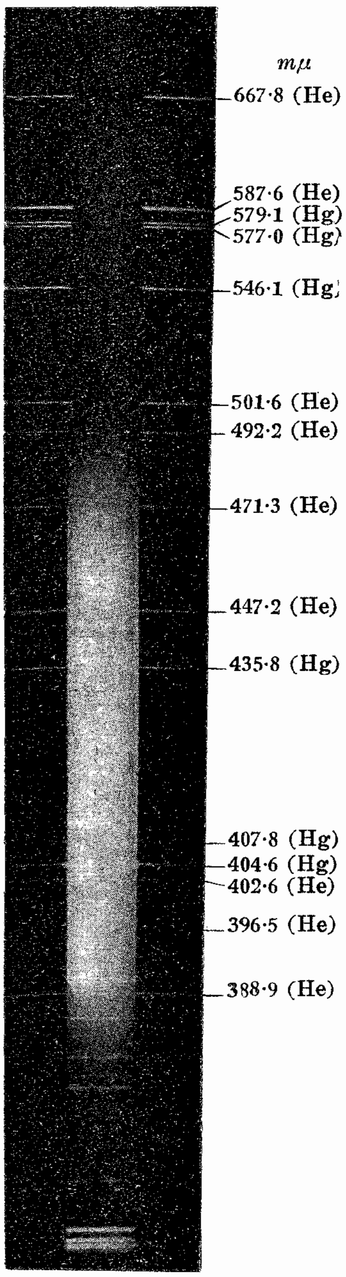

Fig. 3.—Fluorescence spectrum of jōhachidōlite under the excitation of ultra-violet light.

Agfa Isopan I. S. S. plate, time of exposure 17 hours, relative width of slit of the Fuess spectrograph, 2.

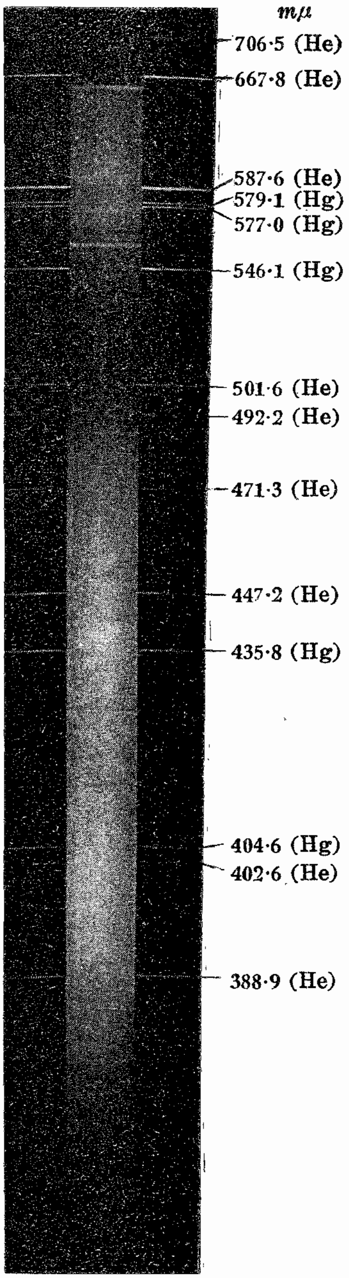

Fig. 4.—Cathodo-luminescence spectrum of jōhachidōlite.

Ilford Hypersensitive Panchromatic plate, time of exposure 6 min., relative width of slit of the Fuess spectrograph, 10.

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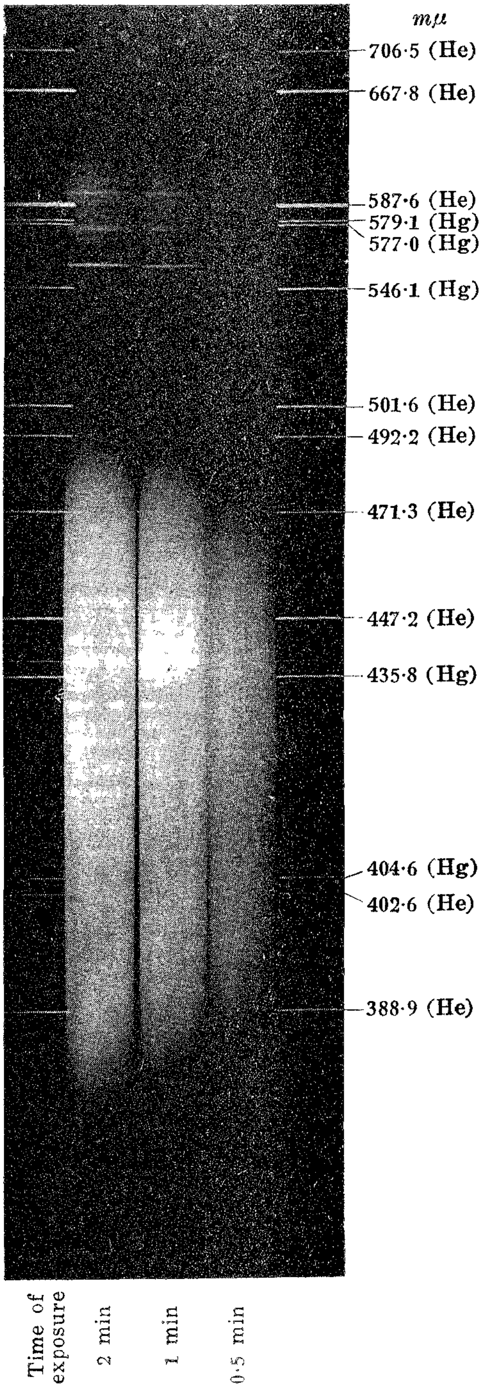

Ilford Hypersensitive Panchromatic plate, relative width of slit of the Fuess spectrograph, 5.

Fig. 5.—Mode of appearance of cathodo-luminescence bands given by jōhachidōlite on a photographic plate after various length of exposure.

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