

*Note on the plumbiferous Barytes from Shibukuro,
prefecture of Akita, Japan.*¹

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1. *Introduction.*

DURING 1907, a plumbiferous barytes, deposited by a hot spring at Hokuto in Taiwan (Formosa), was discovered by Mr. Y. Okamoto.² This mineral, although a special name 'hokutolite' was proposed for it by Professor K. Jimbō in 1912, is a variety of barytes. It shows a slight difference in its chemical composition as well as its physical properties from ordinary barytes.

The occurrence of a mineral, closely resembling that from Hokuto, has also been discovered later at Shibukuro near Akita.

2. *Occurrences.*

Shibukuro is situated on the western flank of the Yakeyama volcano in the Ōu Range, and is a spa well known among the Japanese for its many hot springs and solfataras. The barytes is in process of deposition from spring water, which contains the following constituents:—

Analysis of hot spring water at Shibukuro. Sp. gr. = 1.0080 (at 19° C.).
(Analysed at the Imperial Hygienic Laboratory of Tōkyō.) Parts per thousand :

H . . .	0.07500	Mg . . .	0.01483	SO ₄ . . .	0.93776
K . . .	0.02491	Fe . . .	0.24846	HBO ₂ . . .	0.04244
Na . . .	0.04415	Al . . .	0.09622	H ₂ SiO ₃ . . .	0.37022
NH ₄ . . .	0.00011	Cl . . .	2.69729		
Ca . . .	0.04870	H ₂ SO ₄ . . .	0.42034	Total	5.02043

¹ The substance of this paper has already been published in Japanese (1918) in the College Magazine 'Hokkō' of the Akita Mining College, with illustrations of photographs and radiographs. Radioactive barytes, but free from lead, from this locality (occurrence 1 mentioned below) has also been described by the author, Journ. Geol. Soc. Tōkyō, 1916, vol. 23, p. 477 (Min. Abstr., 1920, no. 3, p. 63).

² Y. Okamoto, Minerals of Taiwan. Beiträge zur Mineralogie von Japan, 1912, no. 4, p. 178. M. Hayakawa and T. Nakano, Zeits. Anorg. Chem., 1912, vol. 78, p. 183. R. Ishizu, Mineral springs of Japan, 1915, p. 42. Y. Okamoto, Report on hokutolite, 1915 (in Japanese).

Barytes is found here in three different modes of occurrences, viz. (1) well-defined crystals¹ on the walls of fissures from which the hot water issues, (2) as a crust on the wall of the orifice of a small geyser, and (3) as a crust on the pebbles and rocks in the stream of hot water. In the first two cases, the temperature of the water is nearly 100° C., while in the last it is between 40° and 50° C. It is in the last that the barytes contains a notable amount of lead and constitutes the variety known as 'hokutolite'. Minerals associated with the barytes are sulphur, siliceous sinter, ferric oxide, realgar, and orpiment.

3. *Forms and structures.*

Plumbiferous barytes of the third occurrence is an aggregate of slender prismatic crystals of which the diameter attains rarely more than 1 mm. Radiated as well as concentric structures are very common. The elongation of the crystals is generally in a direction between the crystallographic axes *c* and *b*. The concentric structure is marked by the alternating bands of white and brownish-yellow colours. These colour-bands run through crystal-columns transversely without interrupting their crystallographic continuity.

The surface of the crust, where the crystal-columns terminate, shows an assemblage of minute crystal-faces. Though these faces are curved and oscillatory, (111) and (001) are usually observed. This very simple combination of faces is, in some cases, modified by the addition of (110) and oscillatory faces of (*hhl*). The basal pinacoid is the smoothest face; but it often shows stepped depressions or elevations.

The accurate measurement of the angles is difficult because of the curvature, striation, dullness, and minuteness of the faces. However, the author obtained the following results by means of a reflection goniometer: angle between prism-faces, 78° 12½'; prismatic cleavage-angle, 78° 31'.

4. *Physical properties.*

Specific gravity = 4.62. Hardness = 3. Cleavage, (001) and (110). Colour, brownish-yellow, light brownish-yellow, or white, sometimes reddish-brown. Lustre, vitreous, resinous, or silky, sometimes dull.

Optical properties can be determined only under the microscope because of the minuteness of the crystals. Indices of refraction are between 1.650 and 1.700. The measurement was done in sodium-light

¹ H. Yoshida, Beiträge zur Mineralogie von Japan, 1915, no. 5, p. 301. R. Ōhashi, Journ. Geol. Soc. Tōkyō, 1916, vol. 23, p. 477 (in Japanese).

on the powdered mineral immersed in liquid. Birefringence, $\gamma - a = 0.0119 - 0.0138$, measured by means of Wright's combination wedge. Optic axial plane (010); acute bisectrix $\perp(100)$. Optical character (+). 2E, different in different individuals; the writer obtained, by means of Mallard's method, $2E = 67^\circ, 76^\circ, 83^\circ, 85^\circ, 86^\circ$. The measurement of the axial angle is difficult because of the zonal structure, abundance of inclusions, and undulatory extinction. Dispersion of the optic axes, $\rho > v$ strong.

Minute solid inclusions are exceedingly abundant in the white zones. The nature of the inclusion is not quite certain, but for several reasons it is inferred to be barytes.

That the mineral is an isomorphous mixture of barytes and anglesite may be suggested, not only by reason of the chemical composition, but from the following physical properties:—

- (1) Zonal structure, the layers showing different indices of refraction.
- (2) The indices of refraction lie between those of the two minerals.
- (3) Optic axial angle, intermediate between those of the two minerals.

Chemical analysis, specific gravity, angles of crystals, amount of birefringence, &c., cannot be relied upon as criteria for the mineral being an isomorphous mixture.

5. Chemical composition.

Chemical analyses of this barytes are not yet so detailed as those of the mineral from Hokuto.

Chemical analyses of the plumbiferous barytes from Shibukuro.

	(1) Analysed by T. Shiomi.	(2) Analysed at the Yoshioka mine.
BaO	59.96	48.95
PbO	4.67	17.78
SO ₃	32.77	32.24
Fe	—	trace
Ign. loss	—	0.60
	97.40	99.57

According to the analyses, the mineral has compositions very near that of barytes and always contains lead in different amounts in different parts. As pointed out by the present writer in 1912,¹ the lead is present in greater amount in the yellow zones than in the white zones. This is probably due to the exceedingly abundant inclusions of barytes in the white zones.

Based on the chemical composition, the mineral from Shibukuro

¹ See R. Ishizu, Mineral Springs of Japan, 1915, p. 42.

corresponds to the mixtures $A_1B_{14}-A_1B_3$, and that from Hokuto to the mixtures $A_1B_3-A_3B_3$, in which A represents anglesite and B barytes molecules. Although not yet proved, the existence at Shibukuro of all intermediate varieties between pure barytes and the plumbiferous barytes mentioned here may be inferred. We have now representatives of about one-third of the isomorphous series.

6. Radioactivity, &c.

It is worthy of note that all the barytes found at Shibukuro, whether it contains lead or not, is radioactive. The radioactivity is ascertained by the ionizing and scintillating effects, and by the photographic effect through metal foil, such as tin or aluminium. Some reliable results, measured with the Schmidt electrometer, are given below.

Radioactivity of barytes from Shibukuro (and Hokuto).
(Determined by G. Sugimoto of the Akita Mining College.)

		Radioactivity in Curie units for one gram of mineral.
Shibukuro, occurrence (1), colourless	. . . . .	1.06×10^{-10}
" " (1), "	. . . . .	1.37
" " (1), red	. . . . .	0.68
" " (2), colourless	. . . . .	0.79
" " (2), brownish-yellow	. . . . .	0.57
" " (3), brownish-yellow, } plumbiferous }	. . . . .	0.32
" " (3), yellow, plumbiferous	. . . . .	0.90
" " (3), " " "	. . . . .	1.15
Hokuto, brownish-yellow, plumbiferous	. . . . .	2.06

Concerning only the barytes containing lead, the ionizing power and the photographic effect of the white zones are remarkably stronger than those of the yellow zones; and also, generally speaking, those of outer parts of the crust are stronger than those of inner layers.

The peculiarity of the photographic effect of the mineral is that it gives but a slight effect upon a dry plate through an opaque object such as black paper, aluminium foil, tin foil, or even semi-transparent red paper, while it gives a remarkable effect on a plate through transparent objects such as glass, celluloid, selenite, mica, transparent paper, animal membrane, &c. It is inferred, therefore, based on this peculiar effect, that the mineral has a self-luminescent property in addition to the radioactivity. Mr. G. Sugimoto proved, by several experiments, that sunlight, ultra-violet rays, or X-rays produce no change in the luminescent power of the mineral. When heated, however, it glows brilliantly (thermo-luminescence).