

Lithia Mica Deposits in Korea with Special Reference to Spodumene and Amblygonite

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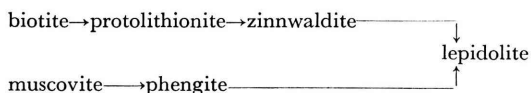
1. Introduction

The author surveyed lithia mica deposits of the Munch'ŏn Mine, Hamgyŏng-pukto, and the Ch'ŏngp'yŏng Mine, Kangwŏn-do, in the autumn of 1944. He was kindly given a few specimens from the collections of Hideki IMAI and of Shinji SATŌ, and after analyzing the specimens, found spodumene and amblygonite. In addition, large blocks of spodumene were found at the Munch'ŏn Mine; the deposit was a large one missed by other surveyors. Lithia micas are found in a pegmatite deposit which resembles the one in Japan.

2. Lithia micas and associated minerals

Varieties of lithia micas include lepidolite, protolithionite, zinnwaldite and lithia phengite. Lepidolite contains much manganese and is pink. Zinnwaldite is commonly pale-brown. Protolithionite is dark-green, pale-green and pale-brown like biotite, and contains little lithia. Lithia phengite is silver-white, like muscovite, and microscopically uniaxial.

There are two series of micas in pegmatites: the biotite series and the muscovite series. Both evolve to lepidolite by parallel growth as follows:



Lithium pegmatite, without exception, contains tourmaline. The tourmaline is colored by the lithia content as follows; black, dark-green, green, indigo, pink and white. One variety contains more than 3% Li_2O . Lithia-tourmaline is found in cleavelandite (lamellar albite) aggregates, and with increase in lithia content goes from black to green and pink. From the Munch'ŏn Mine, beautiful crystals of green tourmaline, which had been mistaken for beryl, were found.

The spodumene is white to grey, and is found near the central quartz. Amblygonite greatly resembles microcline, and is apt to be missed in rock waste. It is found in the Munch'ön and Ulchin Mines in portions rich in lepidolite. From the Ulchin Mine, an altered product of spodumene was found. The analyses of these minerals are shown in Table 1.

3. Types of deposits

The ore consists of lithium minerals occurring in pegmatites.

The granite is two mica-granite or biotite-granite, partially porphyritic. It intrudes gneiss and is cut by porphyrite and quartz-porphyry dikes which belong to the Bukkokuji (Pulguksa) Series. Therefore this granite may have formed during the igneous activity of the Bukkokuji Era, or earlier.

Lithium pegmatite may belong to the same age as the one in which columbite was produced, and a small amount of columbite is found in the Tanyang and Munch'ön Mines.

Localities in Korea where lithium occurs are shown in Table 2, compiled in December, 1944.

Table 1. Chemical Composition of Lithium Minerals in Korea.

	Amblygonite		Spodumene	Lepidolite		Phengite		Muscovite
	Ulchin Mine	Munch'ön Mine	Munch'ön Mine	Munch'ön Mine	Ulchin Mine	Ulchin Mine	Munch'ön Mine	Munch'ön Mine
SiO ₂	1.89%	1.14%	64.16%	49.18%	49.14%	47.44%	43.24%	41.52%
TiO ₂	—	—	—	0.12	0.08	—	0.24	0.28
P ₂ O ₅	46.80	46.77	—	—	—	—	—	—
Al ₂ O ₃	32.31	32.13	26.42	18.85	21.90	25.98	33.90	32.58
Fe ₂ O ₃	—	—	0.22	0.42	0.44	0.56	0.55	0.88
FeO	0.13	0.21	0.12	0.16	0.24	1.31	1.38	0.94
MgO	0.48	0.18	0.09	1.24	0.88	1.41	0.90	0.68
MnO	0.00	none	none	1.77	1.41	0.56	none	none
CaO	2.54	0.18	0.80	0.26	0.96	1.42	0.26	0.10
Na ₂ O	0.51	1.13	0.52	0.06	0.52	0.86	0.12	0.30
K ₂ O	0.41	1.33	0.13	10.37	9.82	10.25	10.21	9.60
Li ₂ O	7.21	9.64	7.48	5.67	5.41	3.02	1.53	1.51
H ₂ O ⁺	5.32	5.38	} 0.76	3.94	3.25	5.02	5.96	6.50
H ₂ O ⁻	0.50	0.20		3.86	3.51	2.90	2.36	4.86
F	3.20	3.13	—	5.93	4.61	0.56	0.04	1.02
Total	101.20	101.44	100.70	102.23	102.17	10.022	100.65	100.77
—F=½O	1.34	1.32		2.49	2.16	0.24	0.02	0.43
	99.86	100.12		99.74	100.01	99.98	100.43	100.34

Analysed by SHIBATA

Table 2. Localities of Lithium Pegmatites and Lithium Minerals.

No.	Locality	Surveyor	Lepidolite	Zinnwaldite	Spodumene	Amblygonite	Lithia tourmaline
1	Öbok-tong, Haksö-myön, Haksöng-gun, Hamgyöng-pukto	KINOSAKI, YOSHIZAWA, HARADA	-	+	-	-	-
2	Wönp'yöng-dong, Haksö-myön, Haksöng-gun, Hamgyöng-pukto	"	-	+	-	-	-
3	Sin-dong, Changbaeng-myön, Kilchu-gun, Hamgyöng-pukto	KINOSAKI	-	+	-	-	-
4	Chikchön-dong, Sangp'al-dong, Kilchu-gun, Hamgyöng-pukto	"	-	+	-	-	-
5	Ch'önggye-ri, P'ungha-myön, Munch'on-gun, Hamgyöng-namdo	ASANO, HARADA, SHIBATA	+	+	+	+	+
6	Pagam-ni, Nam-myön, Ch'unch'on-gun, Kangwön-do	TAKAYAMA	-	-	-	-	+
7	Sangul-li, Só-myön, Ulchin-gun, Kangwön-do	IMAI, MIYAMOTO	+	-	+	+	+
8	Ch'öngp'yöng Mine, Homyöng-ni, Nam-myön, Kapy'öng-gun, Kyönggi-do	HATANI HARADA, YAGYÜ, SHIBATA	+	+	-	-	+

9	Onjông-ni, Chôgam-myôn, P'yôngsan-gun, Hwanghae-do	KINOSAKI, HATANI	+	-	-	-	-
10	Namch'ô-li, Posan-myôn, P'yôngsan-gun, Hwanghae-do	KINOSAKI, YAMAGUCHI	+	-	-	-	-
11	Oejungbang-ni, Tanyang-myôn, Tanyang-gun, Ch'ungch'ông-pukto	TATEIWA, KINOSAKI, SHIMAMURA, HARADA	+	+	-	-	+
12	Puksang-ni, Tanyang-myôn, Tanyang-gun, Ch'ungch'ông-pukto	KINOSAKI, YAMAGUCHI	+	+	-	-	-
13	Hoesal-li, Tanyang-myôn, Tanyang-gun, Ch'ungch'ông-pukto		-	+	-	-	-
14	Koep'yông-ni, Taegang-myôn, Tanyang-gun, Ch'ungch'ông-pukto		+	+	-	-	-
15	Songgye-ri, Hansu-myôn, Chech'ôn-gun, Ch'ungch'ông-pukto	KINOSAKI, YAMAGUCHI	+	+	-	-	+
16	Sayang-ni, Sô-myôn, Okch'ôn-gun, Ch'ungch'ông-pukto	HATANI TSUDA	+	-	-	-	+
17	Taesal-li, Taesan-myôn, Sôsan-gun, Ch'ungch'ông-namdo	YAMAGUCHI, ISHIKAWA	+	+	-	-	-

These pegmatites have unusual characteristics due to cleavelandite. This mineral replaced the potash feldspar which formed most of the pegmatite. At the Munch'ön Mine, potash feldspar stands perpendicular to the walls and gives the aspect of a ladder structure. However, in the part rich in lithium minerals, structure parallel to the walls as the result of replacement is evident on the weathered surface. Amblygonite, the earliest lithium mineral, is cut by lepidolite-and albite-veins; spodumene, however, was the last lithium mineral formed.

In Korea, zinnwaldite from the Tanyang Mine had been worked and, with lepidolite from the Ulchin Mine, was exported to Japan during the later part of the war. Other mines were being prospected, and exploration had been started.

4. Distribution

As shown in Table 2, pegmatites are distributed from Hamgyöng-pukto to Ch'ungch'öng-namdo. These dikes or veins of pegmatites intrude gneiss of the Matenrei and Rensen Series and limestone of the Chosen System.

The granite in contact with the rocks of these Systems is biotite-granite intruded by porphyrite and quartz-porphyry.

5. Mines and reserves

a. Öbok-tong, Haksöng-gun, Hamgyöng-pukto (HARADA & ISHIKAWA, 1944)

Location: 2.5 km northwest of the Öbok-tong Station on the Hamgyöng Line. The deposit is located 1.5 km north along the highway and 4 km along the road to Onch'ön-dong.

Geology: Granite, pegmatite and aplite intruding mica-gneiss, amphibolite and magnesite of the Matenrei System.

Ore: Zinnwaldite crystals, small to 4 cm in size with a Li_2O content of 0.39–3.17 percent. They are thought to be a variety intermediate between protolithionite and lepidolite.

Reserves: The richer portions of the ore contain 10–20 percent zinnwaldite; the average is 2 percent. The reserves of the two main bodies is estimated at 488 tons.

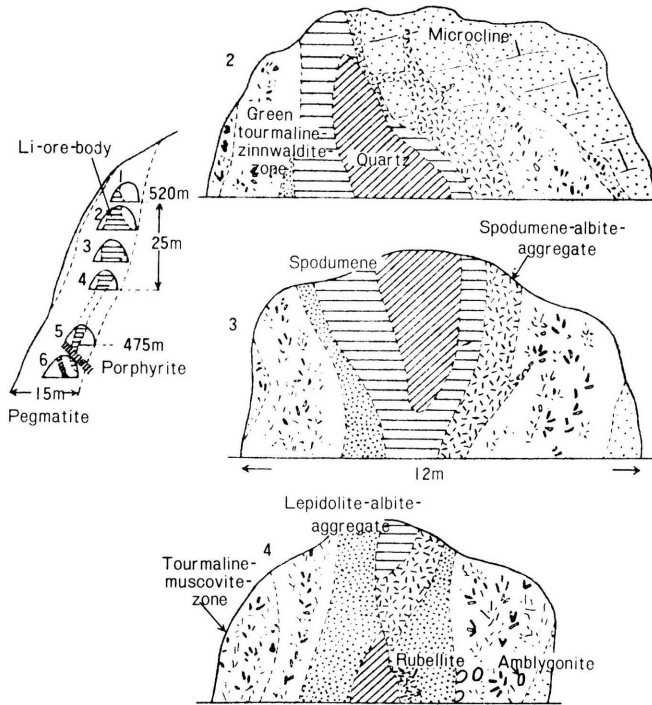
b. Munch'ön Mine, P'ungha-myön, Munch'ön-gun, Hamgyöng-namdo

Location: 92 km east from Pokkye Station of the Kyöngsöng—Wönsan Line, through Ich'ön, 100 km from Wönsan, through Majöl-lyöng. The deposit is east of the Ch'önggye-ri Hot Spring.

Geology and deposit: A pegmatite dike starting from the periphery of the granite intrudes biotite-gneiss, augen-gneiss and amphibolite of the Matenrei (Mach'öl-lyöng) System. The dike extends 6 km to the east. The granite is intruded by wolframite-quartz-veins.

The pegmatite is rich in microcline, replaced by albite and is associated with

tourmaline and lithia mica. Tourmaline changes its color from black to green and pink with increase in Li_2O content. Partial replacement has taken place. Spodumene occurs along the margin of the central quartz zone of the replaced portion.



Openings of the West no. 4 Quarry of the Munch'on Mine.

Ore: Micas are muscovite, zinnwaldite, lepidolite and phengite. Li_2O is contained in all the micas.

Spodumene crystals, with a maximum size of 20 cm, are found between the lepidolite zone and the central quartz zone. Also, large blocks of spodumene are found in rock waste and detritus. Fifty tons of ore were to be collected at the time.

Amblygonite crystals up to 5 cm in size are found in the lepidolite albite mass the first lithium mineral. The amount is less than that contained in spodumene, but the deposit should be prospected again. It is produced from West No. 4 and East No. 2 Quarries.

Table 3. Li_2O contents of Micas.

	Muscovite	Zinnwaldite	Phengite	Lepidolite
	Associated with black tourmaline	Associated with green tourmaline		
Li_2O	1.51%	1.53%	4.19%	4.90%

Rubellite crystals are slender prisms in a radial arrangement in the quartz mass, and attain a length of 20 cm. Green tourmaline contains a large amount of Li_2O , which crystallizes as thick prisms like those of beryl.

Table 4. Li_2O Content of Tourmalines.

	Schorl	Green tourmaline	Rubellite
Li_2O	0.05%	0.82%	1.89%

Reserves: The distribution of ores in six quarries along 6 km of a pegmatite dike is shown in Table 5.

Table 5. Ores and Reserves of the Munch'ön Mine

Ore mineral	Amount of ore min	Content of Li_2O	Reserves of ore
Spodumene	70%	5%	245 tons
Amblygonite	Not determined	9	Not determined
Lepidolite	50	2	129
Zinnwaldite	100	1.5	5.5
Rubellite	80	1.5	4

Twenty-five tons of lepidolite ore were exported to Japan from Wönsan. Thirty tons were retained at the mine.

c. Pagam-ni, Nam-myön, Ch'unch'ön-gun, Kangwön-do

Location: About 16 km from the Ch'öngp'yöng Station of the Kyöngsöng—Ch'unch'ön Line along the Pukhan-gang (river), through Ch'öngp'yöng Mine and along the Hongch'ön-gang (river), and also 15 km south along the Pukhan-gang from the Kap'yöng Station of the Kyöngsöng—Ch'unch'ön Line and 4 km along the Hongch'ön-gang from the junction of the two rivers.

Geology: Rocks in the vicinity consist of granite-gneiss and metamorphic rocks of the pre-Cambrian System.

Deposit: A pegmatite dike, 4 m wide, intrudes the metamorphic rocks and is exposed for a distance of 20 m. The lepidolite crystals are large, 1–2 cm in diameter, and arranged like petals on a flower.

d. Ch'öngp'yöng Mine, Homyöng-ni, Nam-myön, K'ap'yöng-gun, Kyonggido

Position: Pegmatites are situated across the Pukhan River and at a spot 4 km from the Ch'öngp'yöng Station of the Kyöngsöng—Ch'unch'ön Line. It extends 800 m north-south.

Geology and deposit: Pegmatite veins rich in tourmaline intrude gneiss of the Rensen System. There are ten veins on the north side of the river, and two on the

south. They go approximately north and have individual strikes and dips, but may combine below the surface. A vein along a metamorphosed limestone is the largest.

Eight veins on the north side were prospected. No. 2 and No. 5 veins cutting the limestone contain a large amount of lepidolite.

Ore: There are small scales and large crystals of lepidolite. The large crystals are as much as 3 cm in diameter, and accumulate partially in the center of the pegmatite veins. The small ones are found in masses with albite, associated with rubellite.

Reserves: The mine was being prospected. Lepidolite is found in the No. 2, No. 5 and No. 6 veins. The No. 2 vein is the largest, 30 m in length and 2 m in width, and has the highest Li_2O content. The width of the richest part is about 30 cm, and the content of lithium minerals in the ore is 50 percent. The reserves were found to be 67 tons.

e. Tanyang Mine, Tanyang-gun, Ch'ungch'öng-pukto (TATEIWA, 1944; HARADA, 1944)

Location: 4 km southeast of the town of Tanyang, Tanyang-gun, west of Kumi-ri along the Han-gang (River) on the north side of Mt. Sa-bong, 350 m up.

History: This mine was the most exploited, having been discovered in 1934, and became the property of the Japan Rare Metals Company in 1942. The ore was exported to Imajuku, Fukuoka Prefecture, Japan.

Geology: A pegmatite dike intrudes limestone of the Chōsen System; width 2–5 m, length 140 m. The lower half of the vein, which dips 40° – 45° , is aplitic and the upper half pegmatitic. The central zone consists of quartz. In the upper selvage of the central quartz, lepidolite is found and on the lower edge, zinnwaldite. In the lower aplitic part, small crystals of zinnwaldite are found. A small amount of columbite and beryl are also present.

Reserves: Principal ore minerals are zinnwaldite and lepidolite. The amount of lepidolite is less than one-fourth that of the zinnwaldite. The lithia mica content is about 2 percent. As the width of the vein is 3 m, the length 100 m and the depth 30 m, the amount of mica present may be 450 tons.

f. Ulchin Mine, Ulchin-gun, Kangwōn-do

Location: To Samgul-li, Ulchin-gun, it is 110 km by rail from the Yōngju Station of the Kyōngsōng—Kyōngju Line. The mine is 6 km from Samgul-li and the route passes the copper-pyrite deposit at Wangbi-ri.

Blocks containing large crystals of cassiterite are found at the southwest portion of the property.

Geology and deposit: A lens-like stock of granite intrudes crystalline schists and phyllite of the pre-Cambrian system, which strikes approximately east. Pegmatite veins, No. 3 and No. 4, intrude parallel to the rock—granite contact plane. Pegmatite No. 1 and No. 2 intrude into the strike plane of dolomitic limestone

some distance away. Partial accumulations of zinnwaldite, lithia phengite, lepidolite and amblygonite, altered spodumene and blue tourmaline occur in these veins. No. 1 and No. 2 have a similar character and contain small scales of lepidolite and silver-white lithia phengite, and may be connected underground. Much amblygonite is found in the rock waste. The width of No. 1 vein is 2 m and its length 400 m. In No. 3 and No. 4 veins, large crystals of lithia mica are found in the quartz mass.

Ore: The amount of amblygonite present is larger than that from the Munch'on Mine. It resembles feldspar, but the cleavage is rather indistinct. Spodumene crystals are almost entirely altered, and fresh crystals cannot be found. Three tons per day of ore containing more than 3 percent Li_2O , selected by hand, were sent to Yŏngju. When the flotation plant is completed, 10,000 tons of ore a month from No. 3 and No. 4 veins can be expected. If amblygonite were added to the ore, the amount would be greater.

g. Puksang-ni Mine, Tanyang-gun, Ch'ungch'ŏng-pukto

Location: This mine is located about 4 km southeast of Puksang-ni. A train connects Kyŏngsŏng to Ch'ungju, from where a bus can be taken to the town of Tanyang. The deposit is situated on a hillside of a pass leading to Kasal-li, which is an hour and a half distance by foot.

Geology and deposit: A pegmatite vein, which may belong to the Bukkokuji Series, intrudes limestone of the Chōsen System in the form of a sill or dike. Outcrops are found at three places.

Ore: Protolithionite (dark bluish-green), lepidolite (colorless to deep pink) and zinnwaldite (reddish-brown) are found. They accumulate in coarse graphic parts. The mica content is 2–4 percent. In the finely aplitic parts, the mica content is 0.1–1.0 percent.

Reserves: At the No. 1 deposit, the vein is 1.8 m wide, but decreases to 0.3 m in the gneisses and schists at the summit of the hill. No. 2 and No. 3 veins are 1.0–0.7 m wide and contain about 1 percent mica. No. 1 vein is 14 m long; its depth is unknown.

h. Songgye-ri, Hansu-myŏn, Chech'ŏn-gun, Ch'ungch'ŏng-pukto (KINOSAKI, 1942)

Location: About 15 km southeast of Ch'ungju, 9 km south of Hwanggang-ni, Hansu-myŏn, and about 7.5 km northeast from Suanbo-onch'ŏn (hot spring).

Geology and deposit: Biotite-granite, which may belong to the Bukkokuji Series, intrudes pre-Cambrian limestone and slate. Pegmatite, porphyritic granite, spessartite, wolframite-quartz-and fluorite-veins are associated with the biotite-granite.

Pegmatite, containing lithia mica, strikes east through a limestone and dips 60° S. Its width is 30 cm, more or less. Outcrops occur at four places over a distance of 80 m. They consist of blocks of one dike cut by faults running $N 40^\circ W$.

Ore: Lithia micas and a small amount of rubellite are found. There are two varieties of lithia mica; one is pale violet and the other pale brownish-red. The lithia mica crystals are scales less than 1 cm across. The optical angle of the former is not constant, and there is a uniaxial variety.

Reserves: The content of lithia mica in pegmatite varies from 3 to 20 percent (averaging 6 percent). The horizontal extension of the pegmatite is thought to be 90 m (in one vein). It is 50 m wide and 25 m deep. The entire content of micas appears to be 100 tons.

i. Taesal-li, Taesan-myön, Sösan-gun, Ch'ungch'öng-namdo (HARADA & ISHIKAWA, 1944)

Location: The mine can be reached by train to Hongsöng, on the Kyöngnam Line, from Ch'önan Station of the Kyöngsöng—Pusan Line and by bus to Sösan, by truck 21 km from there and 3 km by foot.

Geology and deposit: The geology consists of metamorphic rocks of the Rensen (Yönch'ön) System and gneisses of the Shögen (Sangwön) System. The country rock consists of dolomite and at the contact with pegmatite contains diopside.

The pegmatite strikes approximately north in the dolomite, and dips east 45°–60°. Its extension to the south is 5 m, and its width is 5 m. It stretches out on the sand beach and is cut by a fault. Lepidolite, zinnwaldite and beryl are found.

Ore: The principal ore mineral is lepidolite, which is accumulated in the central part. Its size attains 10 cm in diameter and the mass is arranged like petals of a flower.

Reserves: It is divided into five zones (Table 6).

Table 6. Content of Lepidolite in the Pegmatite.

Zone	Width	Percent of lepidolite
A	70 cm	—
B	30	1
C	100	10
D	60	2
E	40	—

The maximum amount of lepidolite present is 10 percent; the average is about 4 percent. The entire amount cannot be known, because of its poor outcrops. It is not found in the selvages.

j. Tajihol Mine, Onjöng-ni, Chyögam-myön, P'yöngsan-gun, Hwang hae-do (TAKAHAMA, 1937)

Location: Onjöng-ni can be reached by bus for Haeju from either P'yöngsan or Kümju on the Kyöngsöng-Üiju Line. The mine is on a hill, 100 m high, 1 km southeast from Onjöng-ni.

Geology and deposit: The country rock consists of biotite-granite, in which xenoliths of dolomite are included and intruded by syenite-porphry, two veins of pegmatite and a gold-silver-bearing quartz-vein. One vein contact with the upper wall of the gold-vein is 1.5–2 m in width and 300 m long.

Ore: Lepidolite and zinnwaldite, commonly found in large crystals 6 cm in diameter. The content of lithia-micas in the whole deposit is estimated at 1 per cent.

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