研究報文

GOLD-BEARING AXINITE-QUARTZ VEINS IN THE
DIABASE ZONE ALONG THE WESTERN MARGIN OF
THE HIDAKA BELT, HOKKAIDO

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INTRODUCTION

It has been known that the placer gold was abundant in the Hidaka mountains of the southern-central Hokkaido. The source of the gold, however, has not been discovered for a long time. In 1961 Miyamoto who had engaged in exploring for the gold deposits in the western area of the Hidaka mountains had found the two quartz veins with numerous gold grains at the upstream of the Penkeabukasanbe-zawa branching from the Shunbetsu river, about 35 km north-north-east of Shizunai town. The present writers investigated these veins in the following year and also explored their neighbourhood to discover new veins in 1964 and 1965. During these surveys we found many axinite-quartz veins, though they have no gold.

All of the veins are emplaced within diabase bodies and the occurrence of the axinite is quite different from that in several other localities in Japan. Furthermore, the gold deposits do not have any other ore minerals except gold. Gold-bearing axinite quartz veins of this kind are, therefore, very characteristic in its occurrence as well as its genesis.

The present paper will give the description of the properties and genetical discussion of the veins briefly, particularly of the gold bearing veins.

GEOLOGICAL SETTING

Along the axial zone of Hokkaido, there are two metamorphic belts with N-S trend parallel each other. These belts are associated with the Mesozoic complex which is composed of the Triassic to Jurassic formations of considerably disturbed sediments and effusives. The metamorphic belt and its

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surroundings on the eastern side are called the Hidaka belt, which is characterized by the occurrence of various plutonic and metamorphic rocks, while the western side is the Kamuikotan belt composed of the ophiolites and its metamorphic deviates. Both of the belts are comprised to the Alpine period. Both belts are separated from each other by an insertion of a narrow belt of Cretaceous synclinorium. The detail works on the geology of the metamorphic belts have been carried out (cf. Hunahashi, 1957, Minato, *et al.*, 1965 and others).

Diabasic rocks along the western margin of the Hidaka belt crop up continuously on the western side of the Hidaka mountains and form a very narrow belt of 120 km long and 4~0.2 km wide. The rocks consist of fine-grained diabase, medium-grained diabase and diabasic tuffs which had been produced by the initial igneous activity at the geosynclinal stage. Both sides of the diabase zone are bordered by sheared zone or fault of large scale. The formation of the eastern outside consists of sheared slate, chert, and tuffs. Occasionally small sheets or dikes of serpentinite and trondhjemite are seen in the formation. In the area in question, the whole of the diabasic rocks is always composed of a fine-grained variety of which the pillow structure is hardly found owing to intense deformation, otherwise it remains partially. It, however, is assumed that the diabase have formed primarily pillow structure. Noticeable pillows showing the ellipsoidal form of 1.0~0.3 mm in diameter have chilled margins of several mm thick with dark green colour. The marginal part shows variolitic texture, while the inner is subophilitic (Fig. 5a). Axinite quartz veins with or without gold are restricted to the area of the eastern side of the zone.

MODE OF OCCURRENCE

Many axinite quartz veins, 1~40 m long and 2~30 cm wide, are found in the present area as shown in Fig. 3. Two different trends are roughly observed in the arrangement of the veins; N60°E and N60°~85°W. Their dips are generally steep though their directions are variable to the north or south. No remarkable alterations caused by the emplacement of the veins have been observed in the country rocks, except the mylonitized parts at a distance of several mm from the contact. The mylonitic parts are associated with some minerals such as chlorite, albite, and sometimes calcite or prehnite, including the large amount of fragments of the country rocks as relict. The appearance of the veins differs slightly in proportion to the quantity of axinite and felsic minerals such as quartz, albite and calcite but the principal characteristics hardly vary with the ratio of the amount of each mineral.

The gold-bearing veins are only two of A and B in Fig. 2, as stated before. The veins do not differ from the others in appearance, except that the gold-bearing ones contain quartz predominantly. The vein-A runs in the direction

Fig. 1. Geological map of the north-eastern area of Shizunai Town and the location.

1. Kawabata formation (Neogene Tertiary), 2. Yezo group (Cretaceous), 3. Diabase tufts (Upper Jurassic), 4. Fine-grained diabase (Upper Jurassic), 5. Kamui group (Jurassic), 6. Serpentinite, 7. Trondhjemite, 8. Hidaka metamorphic belt, 9. Fault, 10. Gold deposits, and exploring area, 11. Antimony deposits.

Fig. 2. Distribution of axinite quartz veins in Fig. 1.
A, B: Gold bearing veins.

of N75°E to E-W with dip of 60°SE and has 16–18 cm thick and 40 m long. The vein-B has the trend of N75°E and the dip of 50°SE measuring 20 m long and 10–33 cm wide (Fig. 3). It is noticed that the offset veinlets branching from the main vein consist of almost pure quartz without gold or axinite.

NATURE OF VEIN

The veins consist of three parts which are different in colour; purplish, yellow-greenish, and whitish. These three parts are nearly parallel each other (Fig. 4).

The purplish part consists of the aggregate of axinite crystals. This part is remained in irregular vein-like or lenticular shapes within the other parts because it is considerably replaced by the following parts. It is evident that the axinite is crystallized at the earliest stage.

The yellow-greenish part is resulted from the replacement of the country

Fig. 3. Cross section of vein-B.

1. Diabase, 2. Axinite rich part, 3. Gold-bearing stripe.

Fig. 4. Inner structure of vein-A.

1. Diabase, 2. Purplish part, 3. Yellowish-green part, 4. Whitish part, 5. Gold grain.

rocks owing to the formation of secondary minerals. The numerous rock fragments, however, are included in it as relict which are remarkably brecciated and sometimes indicate the original texture of subophitic or variolitic. A sequence of the deposition of the altering minerals is as follows; very fine-

grained minerals up to 0.05 mm of epidote, actinolitic amphibole, and albite are formed at first stage, in the following stage albite becomes larger in grain size of 0.5~2.1 mm, and prehnite crystallizes at the last stage of this part. Albite of the part is of high sodic variety different from that of the country rocks, *ie.*, An₄.

The whitish part, occupying the greater part of the veins, is mainly composed of quartz with a small amount of chlorite and calcite. Quartz forms the mosaic aggregate, of which each grain is elongated owing to a significant deformation in the direction parallel to the vein. The calcite replaces extremely axinite and other minerals crystallized previously. The chlorite develops with slender form between aggregate of quartz and albite and is sometimes observed in quartz crystals as fine inclusions with worm-like segments. Thus, it can be explained to have been crystallized at a stage slightly prior to the emplacement of quartz. Calcite is a mineral of the last stage, because it penetrates all other minerals as slender veinlets.

Gold is generally found along the stripes of the yellow-greenish part remained in the quartz vein, and rarely in druse. The deposition of this element is, therefore, to be slightly later than that of quartz and perhaps earlier than calcite. As the gold forms fairly larger grains of 0.01~1.0 mm and not rarely 3 mm, it can be seen by naked eye. Au content is very high, 104~312 gr per ton in the vein-A, but 1.0~20.5 gr per ton lower than that of the vein A in the vein-B.

PROPERTIES OF AXINITE

The axinite forms an aggregate of subhedral or euhedral crystals, however, those suitable for angle measurement do not occur. The subhedral grains are generally 0.8 to 2.0 mm long and not rarely to 5 mm, while the euhedral ones

Fig. 5. Microscopic photograph

Fig. 5a. (left). Fine-grained diabase showing subophitic texture.

Fig. 5b. (right). Thin section of axinites.

Table 1. X-ray data of axinite

ASTM 6-0448 6-0449		Penkeabukasanbe-zawa		ASTM 6-0448 6-0449		Penkeabukasanbe-zawa	
d(A)	I	d(A)	I	d(A)	I	d(A)	I
3.68	60	3.69	37	2.179	20	2.176	33
3.46	80	3.46	50	2.163	70	2.16	39
3.42	5	3.41	30	2.134	30B	2.13	31
3.28	60	3.28	37	2.060	50	2.058	33
3.23	5	3.23	33	2.040	50	2.04	33
3.19	5	3.19	3.8	2.014	30B	2.014	35
3.16	90	3.15	100	1.998	30B	2.006	40
3.08	40B	3.08	35	1.989	50	1.997	46
3.02	50	3.02	35	1.973	5	1.97	30
2.998	60	2.998	40	1.955	40	1.957	32
2.968	50	2.968	35	1.926	50	1.92	31
2.931	30	2.92	37	1.895	10B	1.895	30
2.874	30	2.88	40	1.808	20	1.81	30
2.839	40	2.84	38	1.788	40	1.765	31
2.812	100	2.80	62	1.744	10	1.746	31
2.792	40	2.788	35	1.732	30	1.73	34
2.760	40	2.746	33	1.721	30	1.72	36
2.667	40	2.66	36	1.704	20	1.698	29
2.643	40B	2.644	33	1.691	10	1.686	31
2.575	50	2.578	33	1.680	10	1.68	31
2.564	60	2.56	37	1.668	40	1.667	40
2.526	30	2.522	30	1.652	40	1.66	38
2.489	20	2.48	32	1.636	50	1.647	38
2.474	20	2.468	31	1.623	30	1.63	33
2.444	50	2.442	34	1.608	20	1.605	29
2.424	50	2.417	33	1.597	30	1.595	30
2.396	10	2.392	30	1.580	40	1.578	37
2.363	50	2.37	32	1.570	20	1.57	31
2.318	5	2.33	31	1.538	30	1.53	34
2.292	10	2.298	29	1.516	20B	1.514	30
2.71	30	2.276	30	1.495	30	1.492	31
2.250	30	2.265	32	1.478	20	1.477	33
2.226	10	2.24	30	1.460	40B	1.46	32
2.206	30	2.21	33	1.442	10	1.44	32
2.190	60	2.19	35	1.435	10	1.43	30
				1.426	30	1.426	30

CuK α (Ni-filter), 25KV, 15mA, Scanning Speed 2°/min, Div. Slit 1°, Rec.
Slit 0.2mm, Count Full Scale 400.c/s, Time Constant 2sec.

are not larger than 0.5 mm. They are grayish-red purple in colour and have no pleochroism. The mineral is always fresh except that it is replaced by calcite veinlets. Its optical properties are as follows;

$$\begin{array}{ll} 2V(-) = 69^{\circ} - 70^{\circ} & D = 3.26 \\ N_1 = 1.678 & N_2 = 1.687 \\ N_2 - N_1 = 0.009 & N_F - N_C = 0.014 \end{array}$$

The data by X-ray powder defraction are given in Table 1, compared with the data of ASTM.

The chemical composition is shown in Table 2. Chemically, the axinite of this area is very similar with that from Jokionen, Finland (Simonen and Wiik, 1952). It should be noticed that the axinite in question is characterized by high.

The chemical formula calculated on the basis of (O, OH)=32.00 is as follows :

This is in close agreement with the ideal formula of axinite (Ca, Mn, Fe⁺², Mg)₃ Al₂ BO₃ [Si₄ O₁₂]OH.

Table 2. Chemical composition of axinite

	(1)	(2)	(3)	(1 - a)	
SiO ₂	42.50	41.76	42.95	B	1.998
TiO ₂	tr.	0.27	0.14	Si	8.092
Al ₂ O ₃	17.49	16.92	17.69	Al	3.872
Fe ₂ O ₃	1.54	1.52	0.24	Fe ⁺³	0.218
FeO	8.26	8.48	9.36	Mg	0.605
MnO	0.59	2.99	0.69	Fe ⁺²	1.297
MgO	2.16	1.66	1.59	Mn	0.094
CaO	19.56	19.71	19.69	Na	0.022
Na ₂ O	0.06	0.13	0.33	Ca	3.935
K ₂ O	0.02	0.00	0.06	K	0.005
H ₂ O+	1.52	1.91	0.64	OH	1.906
H ₂ O-	0.09	0.32	0.00		
B ₂ O ₃	6.16	4.95	6.54		
Total	99.95	100.62	99.97		

- (1) Axinite from Penkeabukasanbe-zawa: K. Aoki (This Paper).
 (2) Axinte from Kannon-yama: Analyst; K. Yagi (Watanabe *et al.*, 1953).
 (3) Axinte from Jokionen: Analyst; H. E. Wiik (Simonen and Wiik, 1952).
 (1-a) Atomic ratios on the basis of (O, OH)=32.00.

DISCUSSION

Hitherto the occurrence of axinite has been reported from several localities in Japan in which Kannon-yama, Tohoku (Watanabe *et al.*, 1953), or Obira and Yamaura mines, Kyushu (Wada, 1915, Ito and Takeuchi, 1952) are well known. These authors explained the formation of axinite as the result of skarnization of the stage related to the intrusion of acid plutonic rocks such as granite and granodiorite. However, no igneous bodies or skarns have been found in the vicinity of the present area. As mentioned above, the axinite is obviously found in the veins which cut through the diabase. Farther, quartz, albite and calcite are always noticed as invariable associations of it.

Recently the similar veins have been found in the diabase at Shimokawa and Shizunai mines of Hokkaido. The latter locates on the eastern side of the same diabase zone, about 12 km south-south-east of this area. Therefore, it may be valuable to investigate the ore deposits of Shizunai mine for the genetical consideration of the axinite. The mine was sporadically worked from 1948 to 1964, and yielded stibnite of about 320 tons. There are several veins running in the direction of $N40^{\circ}W$ to $N80^{\circ}W$ with the dip of 70° to $90^{\circ}SW$. Sawa (1958) has described that main minerals associated with the stibnite are quartz, chlorite, sericite and calcite accompanied with a small amount of minute grains of native gold and other metals. A vein with the large amount of axinite, furthermore, are found besides these minerals. This vein represents apparently the similar features to the veins in question because of the geological situation at the eastern side of the belt, the identical trend of the veins and the similar mineral assemblages. Thus, the writers suppose that both deposits have been formed under the same geological condition. It is clear that the gold-bearing axinite quartz veins are produced by hydrothermal solutions. The axinite from the present area is interpreted to have been formed at a stage nearly simultaneous with or slightly prior to the deposition of the solutions, which could have risen along echelon fractures in the eastern side of the diabase zone. It is also evident that the formation is not related with the igneous activities of the diabase itself at the geosynclinal stage but with the later event during the orogenic movement.

It is generally assumed that the boron in axinite is derived from acid magmas. For instance, Yagi *et al.* (1968) has mentioned that a boron mineral, datolite, in a skarn associated with the intrusion of trondhjemite has been formed under the close relation with the boron element derived from its magmas. Such trondhjemite intrusives are found on the eastern outside of the diabase zone where the Shizunai mine locates. If the rocks were related to the formation of the deposits, they may be laid in the depth under the surface of the area. Provided the assumption is correct, it is then probable

that the age of the deposition should be the Cretaceous, because the intrusion of trondhjemite was evidently in the Cretaceous. It, however, is still obscure whether the acid intrusives are related with their formation or not in the case under consideration, for they are nowhere found within the diabase zone so far. The problem is still open for the future subject.

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要 約

日高西縁輝緑岩帯の含金・斧石-石英脈

鈴木 守・藤原 哲夫

日高山脈の各河川流域では、古くから砂金の採取が行なわれてきたが、その源は長い間明らかでなかった。たまたま、日高帯西縁の輝緑岩中に、肉眼金を多量に含む石英脈が発見され、しかもこの脈に、多量の斧石が伴なわれていることが明らかになった。この地域には、多数の斧石-石英脈が発達しているが、現在のところ、金を含むものは2本しかみつかっていない。

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