"BOSA" QUARTZ VEINS, ESPECIALLY THE FINE-GRAINED QUARTZ AGGREGATES, OF THE KONOMAI MINE IN HOKKAIDO, JAPAN

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1. Introduction

Generally, quartz is the most common gangue of ore bodies, especially of gold-silver quartz veins, though it shows various properties in various places on account of the differences in the state of aggregation and nature of the quartz grains as well as the kinds of the associated minerals. These properties may be resultant from the varying circumstances controlling the course of development of the ore deposition. Accordingly, detailed observations on each of the aggregative facies of quartz and their mutual relations in the veins are often very useful in considering the genesis of the ore deposits.

The ore deposits of the Konomai Mine are mostly comprised in gold-silver quartz veins, in which the special loose aggregates of granular quartz are contained. The term "bosa" or "boso" quartz veins is used locally in this mine for the ones constituted of the aggregates including all the types of quartz which occur such as sandy, saccharoidal, lamellar, tabular etc. It seems that the often found in some other mines, where they sometimes considered as a crushed or oxidized part, otherwise as an enriched part of calcite or adularia.

This paper presents a study of the "bosa" quartz veins of the Konomai Mine; it is a discussion of the genesis of the ore depsoits and the distribution of the assay values based upon the results of that study.

In northeastern Hokkaido, there is a metallogenetic province which is characterized by the existence of various hydrothermal ore deposits especially of gold-silver, copper-lead-zinc, and quicksilver, which are genetically related to the volcanics in Neogene Tertiary. The term "Kitami Mining District" is quite suitable for this province. In the central part of the district lies the Konomai Mine which is now the largest gold-silver mine in Japan; it yielded about 3,000 kg gold and 35,000 kg silver during 1955. The productive capacity is about 1,400 tons of ore per day. (Fig. 1)

The sedimentary rocks in the vicinity of the Konomai Mine are grouped into two large divisions—pre-Cretaceous Complex and Neogene Tertiary Series. The latter is subdivided into the Konomai Groups consisting of shale and tuff and the Syanahuti Groups. Hydrothermal

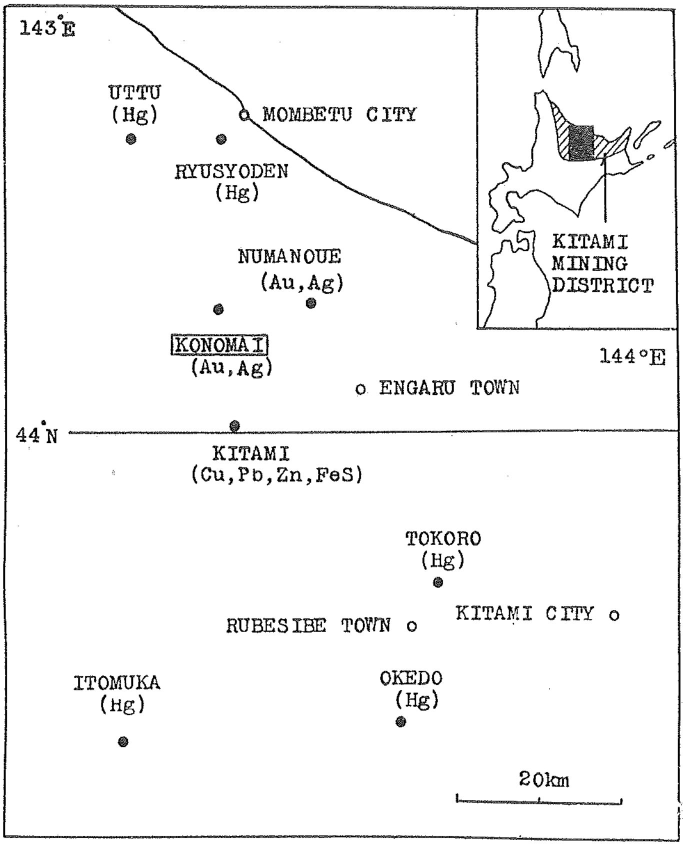

Fig. 1. Index map showing location of the Konomai Mine, Hokkaido.

mineralization may have been associated with rhyolite and andesite of the intra- or post-Konomai Epoch. Most of the andesitic rock is distributed in the northern part and rhyolite is developed in the southern part of the mine area. The syanahuti Groups and associated basalt are younger than the mineralization.

In this area, a well mineralized zone of about 2 km width extends with N–S trend for a distance of more 20 km. In this zone there are many swarms of veins, mostly gold-silver bearing adularia-calcite-quartz veins, with E–W and N45°E strike, which are grouped into the Sanno, Kuttyannai, Sumiyosi, Motoyama and Yakeyama Ore Deposits respectively (Fig. 2).

The amount of calcite in the northern veins is greater than that in the southern ones. "Bosa" quartz veins develop in the central three ore deposits.

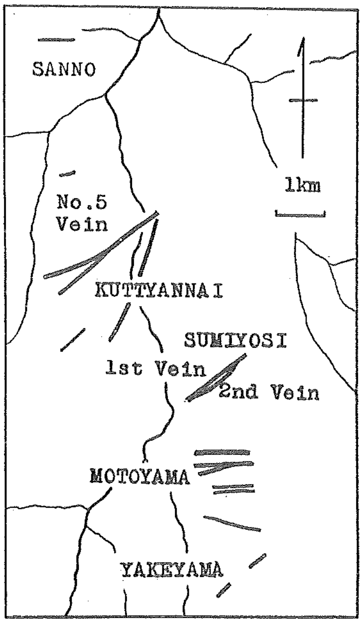

Fig. 2. Distribution of the Sanno, Kuttyannai, Sumiyoshi, Motoyama and Yakeyama Ore Deposits of the Konomai Mine.

2. Occurrence

"Bosa" quartz veins of the No. 5 Vein.—The No. 5 Vein which belongs to the Kuttyannai Ore Deposits is one of the representative veins in the Konomai Mine. Its dimensions are as follows: strike-side length is 2,000 m; dip-side length is 500 m; average width is 10 m. In the west part of the vein it bifurcates into the "Hanging Branch-Vein" and the "Foot Branch-Vein".

The No. 5 Vein is divided into four facies from the standpoint of the vein structure—coarse-banded part, fine-banded part containing high grade ore, clayey part, and veinlets with drusy part (URASIMA 1953).

Most of "bosa" quartz veins are recognizable in the first and the fourth of those facies. They occur as members of the bands formed of various mineral assemblages, and often constitute veinlets at the later stage of the deposition. Sometimes they grade with each other into massive quartz veins. Accordingly, it is considered that "bosa" quartz veins were not always formed by crushing but by primary deposition.

"Bosa" quartz veins are mostly recognizable in the central part of the No. 5 Vein, and calcite is usually not found in that part. Calcite is concentrated in the "Foot Branch-Vein" and the eastern part of the main vein, but is scarcely found in the central part of the "Hanging Branch-Vein", in which a great deal of kaolinite and montmorillonite, and also some marcasite are contained (SUDO 1953, URASIMA 1952). These mineral assemblages are seen in the altered wall-rock abutting on each part of vein.

As "bosa" quartz veins of the No. 5 Vein occur with intimate relation to kaolinite, montmorillonite and marcasite, it is assumed that they have originated under a particular condition which was effected by weak acidic solution. The condition does not show any supergene oxidation because the most part of "bosa" quartz veins contain nothing of iron-hydroxide and other secondary minerals.

"Bosa" quartz veins of the Sumiyosi 1st and 2nd Veins.—The Sumiyosi Ore Deposits were found in 1951 (URASIMA 1951) ; the dimensions of the Sumiyosi 1st Vein are as follows: strike-side length is 1,000 m; dip-side length is 130 m; average width is 5 m. The Sumiyosi 2nd Vein is a hanging branch of the 1st Vein.

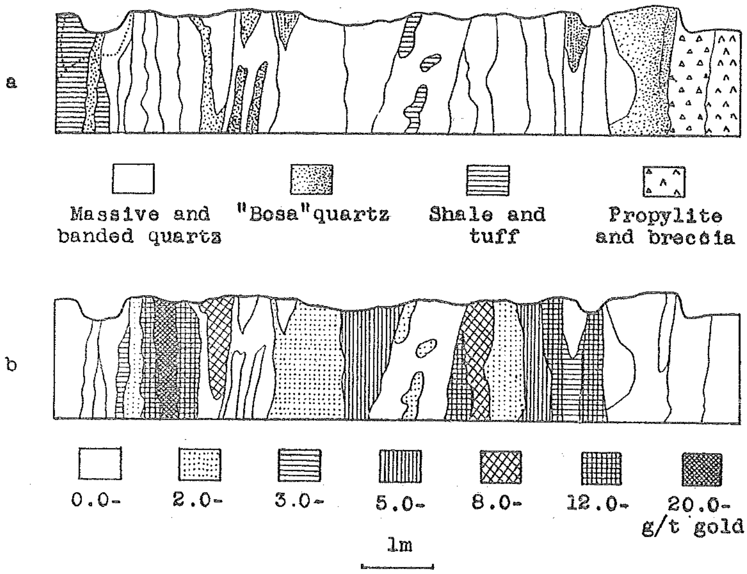

Fig. 3. A profile of the Sumiyoshi 1st Vein.
a: Sketch map of the western wall at the No. 3 Adit.
b: Assay map of the above.

"Bosa" quartz is contained in both veins, and is especially concentrated in the western part of the 2nd Vein. Figure 3 presents a profile of the 1st Vein, and shows that "bosa" quartz veins are members of the bands constituting the vein. The most part was formed at the later stage of the ore deposition. It has been found that gold and silver are usually poor in these veins. These facts are also supported by the papers of TAKASHIMA (1954) and MATSUDA (1955). TAKASHIMA says that the temperature required for the formation of "bosa" quartz as measured by the decrepitation method is 132°C; it is lower than that of the gold-bearing gray quartz in the same vein.

Quartz and adularia are the principal vein minerals of the Sumiyosi Ore Deposits; a small amount of marcasite can be found there but no calcite.

There are abundant brown "bosa" quartz veins stained by iron-hydroxide, but as they are, in origin, white "bosa" quartz ones found under the boundary of the oxidized zone, the formation of "bosa" quartz is seen not to require supergene oxidation.

3. Properties

The constituents of "bosa" quartz veins are subdivided into four groups from their aggregate shapes—angular, lamellar, saccharoidal and platy "bosa" quartz.

Anglar-shaped "bosa" quartz.—Each piece of angular-shaped "bosa" quartz is a quartz aggregate surrounded by platy openings. The simple one sometimes measures over 5 cm in diameter. It resembles adularia or calcite crystal in shape. But it is not a single or pseudomorphous crystal, for there is often a druse in it and it has not regular plane angle (Plate 1, Fig. 4). Thin sections cut parallel to the surface of each piece of angular "bosa" quartz show that it is formed of an aggregation of minute granular quartz crystals. A section cut perpendicular to the surface shows the quartz crystals growing from the surface plane with sometimes a druse. The grain size of quartz crystals is mostly under 1 mm in diameter.

Lamellar "bosa" quartz.—This is lamellar quartz aggregate with platy cavities of 1 mm or less in thickness. The walls of the cavities are flat and the end sides are irregular (Plate 1, Fig. 5). Under the microscope it is seen that one laminae is formed of minute granular quartz.

Saccharoidal "bosa" quartz.—Saccharoidal "bosa" quartz is the most common type of this material. Sometimes the entire veinlets are constituted of this type. It often accompanies other "bosa" forms and milky massive quartz is included in it. The size of each piece of it is not uniform, but it has been reported that 35% of those from the Sumiyosi Ore Deposits measure 0.063–0.01 mm in diameter (KATAYAMA et al. 1952). Microscopically, the constituents of saccharoidal "bosa" quartz are mostly angular aggregates of minutes granular quartz and are partly idiomorphic crystals of quartz. The shape of the former resembles that of angular "bosa" quartz or lamellar quartz in thin section (Plate 7, Fig. 7).

Platy "bosa" quartz.—This is an aggregate of plates covered or not covered by comb quartz, and drusy platy or thin dog-tooth-like quartz aggregates belong to this type (Plate 6, Fig. 6), though they are not always loose. Microscopically, one plate of it is a plate-shaped aggregate of minute granular quartz. When there is comb quartz over the plate the structures are not continuous with each other. Some platy aggregates of quartz are enclosed within the other massive quartz (Plate 7, Fig. 8). They may be pseudomorph after any platy minerals.

As is mentioned above, there are four types of "bosa" quartz. Except some platy "bosa" quartz, they come into touch or partly mix and grade continuously into each other in the occurrence, shape and aggregate state of quartz crystals. Each piece of "bosa" quartz is principally formed of minute granular quartz crystals and its surfaces are surrounded by smooth planes. It is, therefore, considered that they were formed under continuous action during the ore deposition. This view will be supported by the next section.

The following shows the chemical composition of "bosa" quartz and ore.

	1	2	3
SiO_2	97.49$^{wt.\%}$	97.76$^{wt.\%}$	80.79$^{wt.\%}$
TiO_2		0.01	—
Al_2O_3	0.70	0.79	10.99
Fe_2O_3		0.37	4.43
MgO	tr.	none	0.65
CaO		1.17	0.64
Ig. loss	1.67	0.48	4.84
Total	99.86	100.58	102.58

1. Angular "bosa" quartz of the No. 5 Vein analyzed by the writer.
2. Saccharoidal "bosa" quartz of the Sumiyosi 2nd Vein analyzed by Minato (Katayama et al. 1952). CaO includes FeO.
3. High grade ore of the No. 5 Vein analyzed by the Konomai Mine.

Figure 3b which is a gold assay map of the Sumiyosi 1st Vein at the No. 3 Adit shows that "bosa" reserves of the No. 5 Vein, the Sumiyosi 1st and 2nd Veins and the Motoyama Ore Deposits is roughly calculated at 1,000,000 tons (KATAYAMA et al. 1952).

4. Consideration

After observations on the occurrences and natures of "bosa" quartz veins one may say that there is no doubt but that the peculiar states of the quartz aggregates were formed during the primary ore deposition. It is inferred that the cavity-rich texture, the chief character of such loose quartz aggregate, was formed by the dissolution of some platy mineral and by the consequent druse-formation. This dissoluted mineral seems to have been calcite, because now "bosa" quartz veins never contain calcite. The following experiment suggests its dissolution in the veins.

Figures 9 and 10 are the microscopic photographs of the aggregate states of calcite quartz from the eastern No. 5 Vein. In these figures, calcite is platy, developed paralelled to c (0001), and the intervals between the calcite plates are filled with minute granular quartz.

If a specimen of the above described calcite-quartz aggregate is placed in dilute hydrochloric acid, calcite crystals are dissolved easily. The remaining quartz aggregates have appearance and microscopic texture similar to those of pieces of "bosa" quartz.

Therefore, it is considered that the formation of "bosa" quartz veins of the No. 5 and the Sumiyosi 1st and 2nd Veins occurred according to the following sequence.

It seems that some of the calcite in the original aggregates of "bosa" quartz crystallized earlier than others in these veins. If the condition of the hydrothermal solution changed during or after the crystallization, the calcite might be dissolved or partly replaced by quartz. The writer calls this action the first dissolution. The condition of the action seems to have been effected by weak acidic solution, for calcite was dissolved and marcasite and kaolinite were formed near "bosa" quartz veins. The shape of "bosa" quartz was controlled by the texture and amount of calcite. So-called white "bosa" quartz veins are the products of such a first dissolution.

If white "bosa" quartz veins were stained by iron hydroxide during supergene oxidation (secondary dissolution), so-called red "bosa" quartz would be formed. If the country rock veined by quartz-nets is weathered away, lamellar "bosa"-like quartz mass is often formed. But, the mass is an aggregate of the simple comb quartz. On the one hand the dissolution might be rapid along the fault zone, on the other hand "bosa" quartz veins might be easily crushed by the faulting. The resultant quartz aggregates are both called crushed "bosa" quartz, though crushing is not always a necessary condition.

It is considered that the primary dissolution acted upon the wall-rock alteration, for iron sulphides in the wall-rock near the part with "bosa" quartz veins are in the form not only of pyrite, but also of marcacite.

The natures and genesis of such quartz aggregates have been described and discussed in the following studies.

According to MORGAN (1925), JULIUS VON HAAST observed pseudomorphous after calcite in New Zealand in 1866 or earlier, and the first record of pseudomorphous lamellar quartz in a mining district was made by COX (1882). MCKAY (1892) described platy quartz.

It is well-known that LINDGREN (1905a and b) noted lamellar pseudomorphous quartz and the thin plate of quartz in the lodes of the De Lamar district, and that he noted quartz replacing a thin tabular mineral, probably calcite. He also described the lamellar quartz of the Waihi Mine as an intimate intergrowth of quartz and calcite and the pseudomorphous quartz after platy calcite of the Hauraki Mine and the Annie Laurie Mine. Afterwards he (1913) stated that lamellar quartz formation had nothing to do with surface waters. The lamellar quartz in Sumatra was illustrated by CARON (1915).

A little later EMMONS (1917) applied the term negative pseudomorphs to cavities formed by the dissolution of calcite from a quartz-calcite vein-stone, and stated about the genesis that "the thin blades of silica remain as pseudomorphs of the calcite cleavge." But ADAMS (1920) said, "the arrangement of laminae in most lamellar quartz of De Lamar, Jarbidge, Gold Road, and Bodie does not recall cleavage directions."

LACROIX (1922) and SCHRADER (1923) later described pseudomorphous quartz after calcite. RANSOME (1923) inferred that the lamellar structure of lamellar quartz was controlled by lamellar aggregates of platy calcite, their interstitial granular quartz and fine grained adularia in the Tom Reed vein.

Summarily MORGAN (1924 and 1925) introduced many descriptions of so-called pseudomorphous quartz in the literatures. He stated, "their ability to form the remarkable intergrowths revealed by the removal of the calcite in solution can be readily understood", and that "sugary" quartz of the Waihi Mine was not formed by crushing but that calcite had been removed in solution in the zones of oxidation. Various sorts of quartz of the mines in Western Australia was described by DUNN (1929). He stated that saccharoidal, cellular, skeleton, and fibrous quartz were mostly formed by the removal of some mineral.

WATANABE (1930 and 1939) studied the lamellar quartz of the Takadama and Mizusawa Mines, and concluded that the lamellar structure was controlled by the original platy structure.

The "bosa" quartz veins of the Konomai Mine now under consideration studied bv KATAYAMA et al. and by the writer (1953). KATAYAMA et al. maintained that the quartz aggregates were formed by stirring during the crystallization. TAKASHIMA (1954) and MATSUDA (1955) described the occurrence of "bosa" quartz veins, though they did not fully discuss the sequence of the formation.

In conclusion, according to the present writer's study, "bosa" quartz veins of the Konomai Mine are essentially not formed by crushing, secondary replacement, or oxidation, but they are mostly constituted of negative pseudomorphous and interstitial quartz aggregates containing many cavities formed by the dissolution of calcite crystals during the primary deposition. The structure of "bosa" quartz veins resembles still that of the quartz-calcite veins. "Bosa" quartz veins may not rarely be found in the quartz-calcite-adularia veins which usually develop in the gold field with andestic volcanism. The writer has found "bosa"-like quartz veins of some gold-silver mines in the Kitami District and in southern Kyusyu.

In the Konomai Mine it is an important problem to determine how "bosa" quartz veins relate to the ore prospecting. As the outcrops of the veins with "bosa" quartz do not always make their appearance, sometimes such veins have been regarded as blind veins. Gold and silver are poor in "bosa" quartz veins because "bosa" quartz originated form calcite-quartz aggregates. "Bosa" quartz veins do not always show the existence of oxidation of fault zone, because they are essentially fresh and one of the primary veins. Accordingly "bosa" quartz veins are not directly related to secondary enrichment by oxidation.

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Explanation of
Plate 6

Plate 6

Fig. 4. Angular-shaped "bosa" quartz.

Fig. 5. Lamellar "bosa" quartz.

Fig. 6. Platy "bosa" quartz.

Fig. 4.

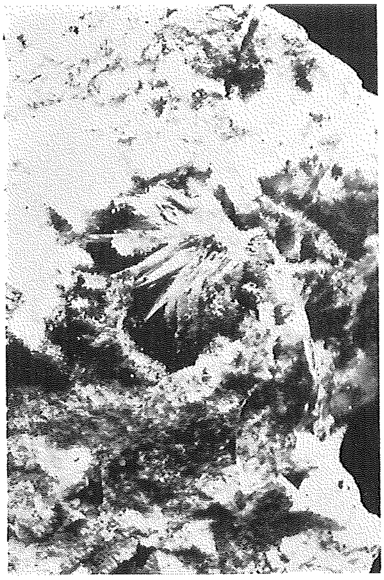

Fig. 6.

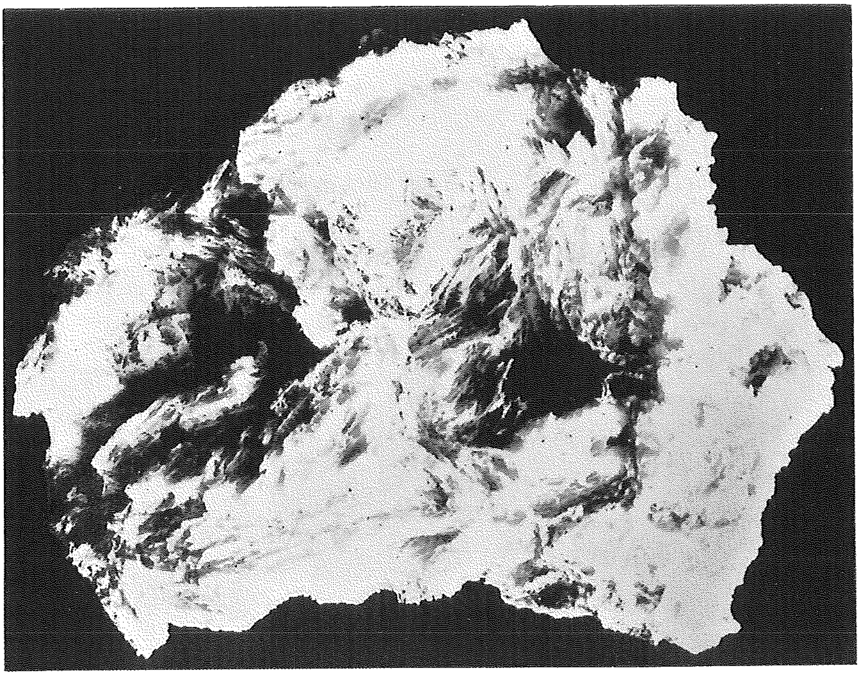

Fig. 5.

Explanation of

Plate 7

Plate 7

Fig. 7. Saccharoidal "bosa" quartz in thin section. ×90.

Fig. 8. Platy quartz aggregate surrounded by minute granular quartz crystals in thin section. ×90.

Fig. 9. Calcite-quartz aggregate regarded as the original one of saccharoidal "bosa" quartz in thin section. Gray, platy calcite; white, granular quartz and adularia. ×90.

Fig. 10. Calcite-quartz aggregate regarded as the original one of lamellar "bosa" quartz in thin section. Gray, platy calcite; white, granular quartz and adularia. ×90.


Fig. 7.


Fig. 8.


Fig. 9.


Fig. 10.