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Short Articles

Preliminary study on the characteristics of Tsagaan tsakhir uul gold deposit, Bayankhongor, southern Mongolia

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Abstract: The Tsagaan tsakhir uul gold deposit is located at the southeastern part of the Bayankhongor metallogenic zone, Mongolia, and is highly prospective for gold mineralization. The mineralized area is composed of Proterozoic migmatized limestone and marble-bearing schists, Early Cambrian biotite or two-mica granodiorites, and small dioritic stocks of Late Carboniferous age. Small number of NE-striking dykes of diorites, aplites, pegmatites, and quartz porphyries are also distributed in the area cutting Cambrian granodiorites. Gold mineralization is represented by several localities of quartz vein sets and veinlet zones, occurring both in Cambrian granodiorites and Proterozoic migmatized schists. Wall rock alteration is developed weakly as silicification, sericitization, albitization, chloritization and pyritization. In the area three types of quartz veins are observed: (1) metamorphic quartz veins; (2) mesothermal quartz veins; (3) epithermal quartz veins. Mesothermal quartz veins are richest in gold content. Within mesothermal veins gold is often associated with pyrite, chalcopyrite, galena and is also found as free grains in quartz. Gold content in quartz veins show a wide range between 0.1 and 749.6 g/t. Gold grains are bright to golden yellow in color and has grain size of 0.1 mm to 3.0 mm. The fineness of gold (1000 Au/Au+Ag+impurities) varies from 830 to 940 giving an average value of 900. Most of the fluid inclusions observed in quartz are two phase L>V and range between 0.3 μm and 10 μm in size. The homogenization temperature of mesothermal veins ranges from 160℃ to 356℃. Not many facts are known for the epithermal veins in this district but our study has indicated that the homogenization temperatures of the quartz vein range from 107℃ to 120℃. The apparent salinity of fluid inclusions in mesothermal quartz ranges between 1.74 and 6.74 wt.% NaCl equiv, with an average 4.18 wt.% NaCl equiv. Based on this preliminary study, we have concluded that at Tsagaan tsahir uul the mineralizing fluid for mesothermal system was CO_2-bearing and of low salinity, and that effective deposition of gold within the system happened at temperatures from 160℃ to 260℃, although the obtained temperatures show wider range.

1. Introduction

The Tsagaan tsakhir uul gold deposit is located at a southeastern part of Bayankhongor metallogenic zone of Mongolia, whicn is well known for the gold mineralization since last century. Antholopological ruins indicate that small-scale ancient mining was common in this area. Modern geological study was carried out at scale 1:25,000 in the area between 1968 and 1970 by German geologists and they estimated gold reserves as 14.0 t. This note presents geological and fluid inclusion data regarding to auriferous mesothermal quartz veins of the Tsagaan tsakhir uul gold deposit to base future geochemical discussion for gold exploration.

2. Geologic setting of Bayankhongor area

Basically the Bayankhongor metallogenic area exhibits NW-trending geologic structure, and consists of several zones. They are, from southwest to northeast, Baidrag salient, Bürd insialic basin, Bayankhongor ophyolite zone, Zag series and Khangai basin (Fig. 1). The Baidrag salient occupies southwestern portion of the area, and has NW-trending linear structure. It consists of Archean to Proterozoic tonalite gneisses,

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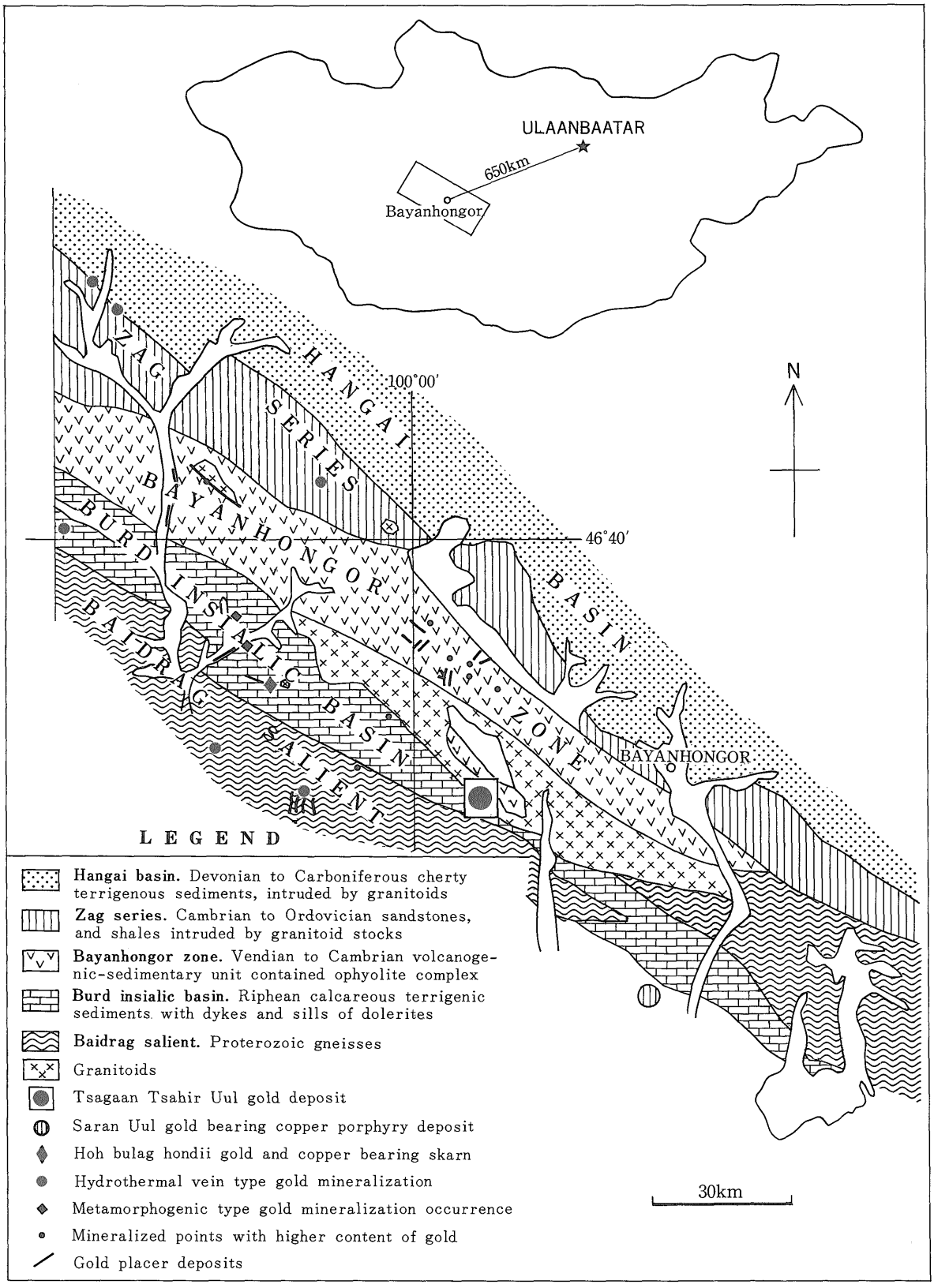


Fig. 1 Sketch map of Bayankhongor gold bearing area
(Bayankhongor is written as Bayanhongor and Khangai as Hangai in this figure).

migmatites, crystalline schists, marbles, and amphibolites. The Bürd insialic basin is situated next to the Baidrag salient. It also shows NW-trending structure such as folding. The basin consists of Riphean calcareous terrigenous sediments in which black shales, limestones and siltstone alternate. They are often intruded by dykes and sills of dolerites. Bayankhongor zone borders on the Bürd insialic basin in southwest with the Bayankhongor deep fault, and on the Khangai basin in northeast with the Bayankhongor fault. It consists of Vendian to Cambrian layered complex of metamorphosed hyperbasites, gabbros and pyroxenites, parallel dyke swarms, pillow lavas and volcanogenic and calcareous sediments. The Zag series is distributed in southern and southeastern part of the Khangai basin, consisting of Middle Cambrian to Lower Ordovician polimictic sandstones, siltstones, shales, rare conglomerates. They are intruded by small stocks of Ordovician granites and granodiorites. The Khangai basin is situated at the north-eastern part of the area. It consists of Devonian to Carboniferous terrigenous cherty sandstones, volcanogenic-sedimentary rocks, and is intruded by Permian and Permian to Triassic granodiorites and granitoids.

3. Geology of Tsagaan tsakhir uul gold deposit

The Tsagaan tsakhir uul area (Fig. 2) is composed of Proterozoic migmatized limestone and marble-bearing schists and Early Cambrian biotite and two-mica granodiorites, which are intruded by small stocks of Late Carboniferous diorites, and mostly longitudinal, rarely NE striked dykes of diorites, aplites, pegmatites and quartz porphyries (Andreas, 1976). The gold deposit is represented by several localities of quartz veins and veinlet zones, occurring both in granodiorites and in migmatized schists. Most of the mineralized veins run N-S direction, extending from a few tens to 1000 m along strike and dipping 50-70 degree westward. Thickness of the veins range from 0.1 m to 0.5 m. Veins include white, light gray and gray crystalline quartz and nests and veinlets of calcite and flakes of sericite. Wall rock alteration is developed weakly as silicification, sericitization, albitization, chloritization and pyritization.

Based on the shape, distribution and mineralization characteristics, three types of quartz veins are recognized in the mineralized area: a) metamorphic quartz veins, distributed in Proterozoic schists at the western part of the Guchin gol Valley. Quartz veins are coarse grained, have banded structure, and almost barren in gold; b) so called "mesothermal" quartz veins, distributed at the southern and south western contact between granodiorite and schists. The fractures strike N 10° W-N30° W and N10° E-N10° W, and are filled with fine to coarse grained quartz and gold. Quartz exhibit white, whitish gray, and gray in color. Thickness of veins varies from 0.1 m to 0.45 m and extension along the strike, from 170m to 2800m. Wall rock alteration is weak and recognized as silicification, sericitization, and pyritization. Mesothermal quartz veins are found at two main localities in the area: southern part of the mountain "Tsagaan tsakhir uul" and northern and eastern part of Mt. Ulaantolgoi. Gold content in the mesothermal quartz veins show a wide range. For example, at the veins No. 1, 2, 3, and 6, which are distributed in southern part of Tsagaan tsakhir uul, it ranges from 0.8 g/t to 273.2 g/t. The No. 10 vein in northern part of Ulaantolgoi has a range from 0.5 g/t to 749.6 g/t. In the alteration zone adjacent to quartz veins, gold is detected up to 17 g/t, but mode of occurrence has not been clarified yet; c) so called "epithermal" quartz-calcite veins. This is developed along NE-trending Tsagaan tsakhir uul fault with varying thickness, 5 to 200 m, and extension of about 4km. In the quartz vein several cross cutting relation are observed but the tectonic history has not clarified yet. Alteration envelope of this vein is up to 300 m in width and is composed of chlorite and sericite. Spatial relation between mesothermal and epithermal system has not been observed. An AAS analysis revealed that the gold content is 0.38 g/t (Jargalan and Gantsetseg, 1996)

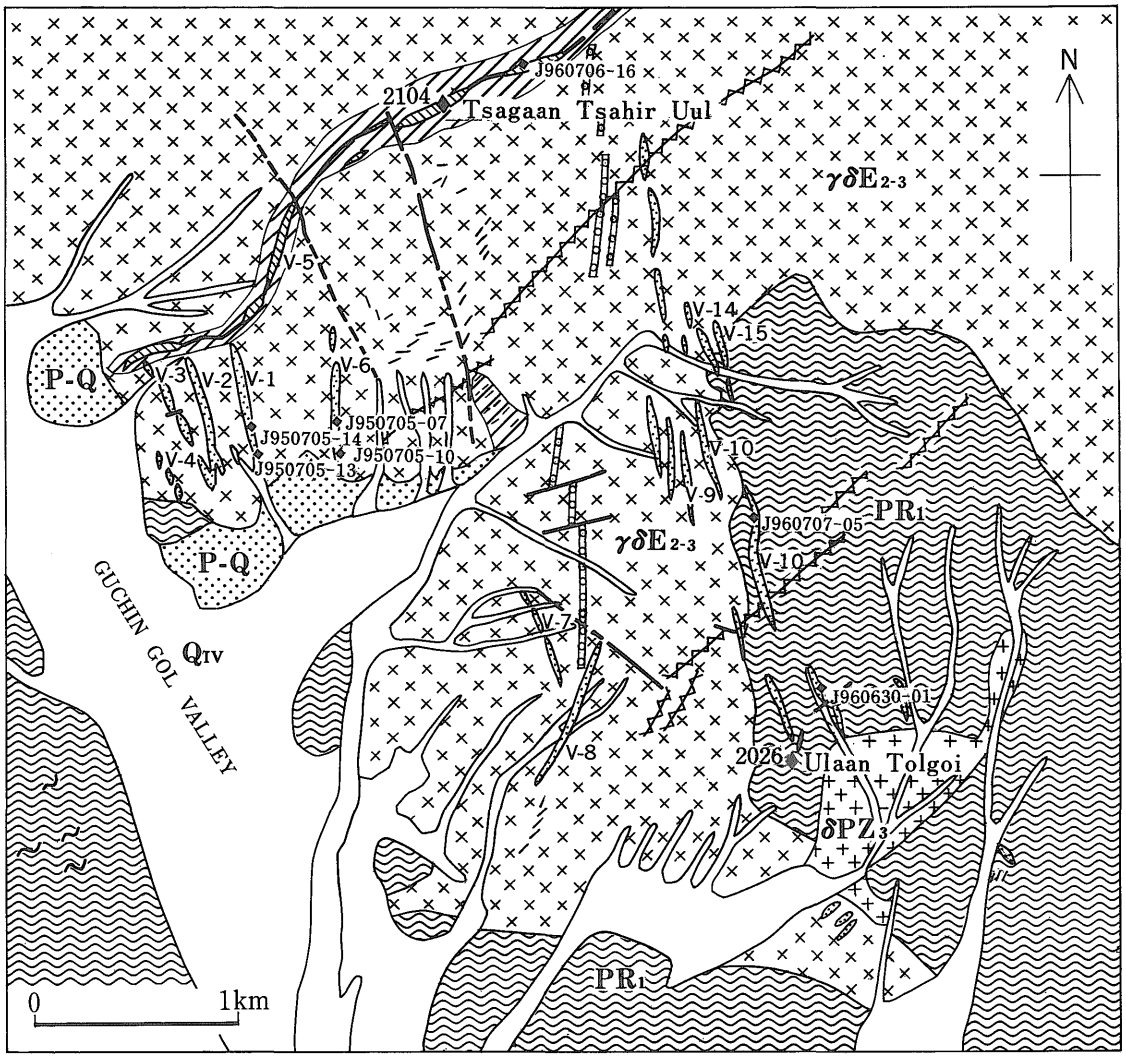
4. Ore mineralogy

Based on the structure and texture, mesothermal veins can be divided into three stages. Major gold mineralization occurs in the stages 1 and 2 (Fig. 3). The mineral assemblage is variable depending on the stages. The characteristic features of ore minerals in each stage are briefly described as follows.

Stage 1: The main mineral is quartz, which is coarse to medium grained and white to whitish gray in color. Pyrite, gold and minor arsenopyrite occur as ore mineral. Gold is associated with pyrite, with grain size ranging from 0.1 to 0.3 mm. Pyrite has been heterogeneously oxidized and altered to goethite or lepidocrocite.

Stage 2: This stage carries middle to fine grained whitish gray to gray quartz. In this stage ore minerals are seen as pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, gold and tellurobithmuthite. Gold is associated with pyrite, chalcopyrite, galena or occurrs as free gold in quartz. Gold grains are bright or golden yellow in color and has grain size of 0.1 mm to 0.3 mm (Fig. 4). The fineness of gold (1000× Au/Au+Ag+impurities) varies from 830 to 940 giving an average value of 900.

Stage 3: This stage contains whitish gray to gray colored fine-grained barren quartz containing small nests and stringers of calcite, and flakes of sericite. Some veinlets exhibit zonality.



LEGEND

- **Recent.** Sands and loams with gravels, debrices
- **Tertiary to Quarternary.** Red clays with pebbles and gravels
- **Lower Proterozoic.** Migmatized schists with layers of marbles, quartzites and amphiboles
- **Late Paleozoic.** Middle grained diorite
- **Middle to Late Cambrian.** Two mica and biotititic granodiorite
- Basic dykes
- Dyke of quartz porphyry
- Mesothermal quartz veins (not to scale)
- Quartz veinlet zones
- Epithermal quartz vein
- Metamorphic quartz vein
- Host rock alteration. Chloritization and sericitization
- Faults
- J960701 Sample points and numbers

Fig. 2 Geologic map of Tsagaan tsakhir uul gold deposit area

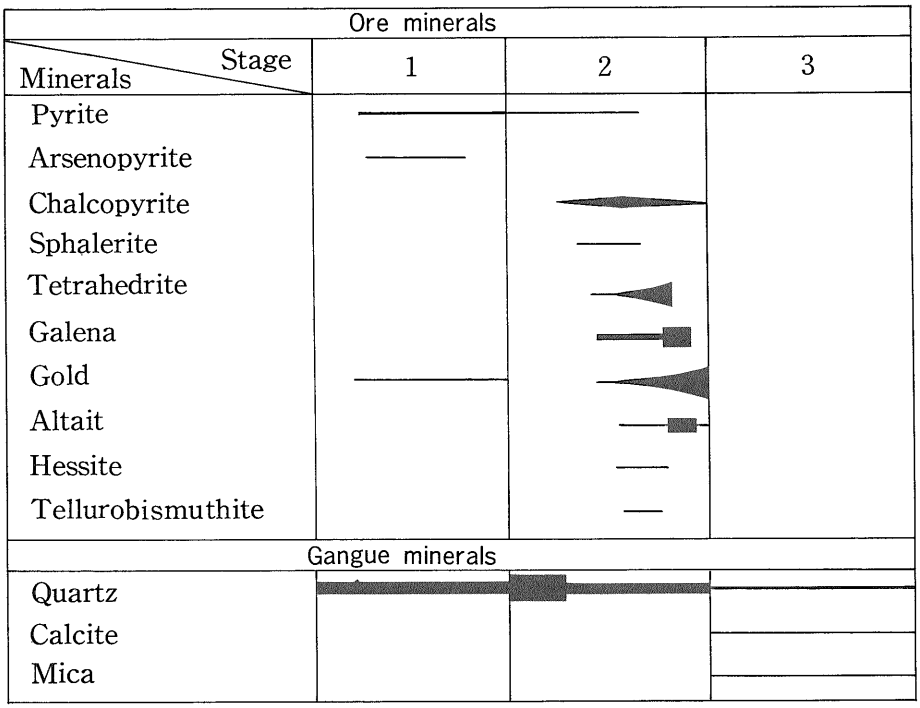


Fig. 3 Mineralization stages and paragenetic sequence of ore and gangue minerals in Tsagaan tsakhir uul gold deposit

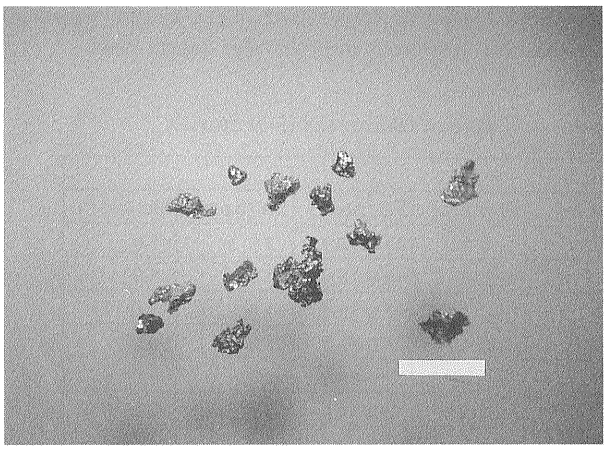


Fig. 4 Gold grains from quartz vein, No. 1, sample No. J 950706-01. Bar indicates 2 mm.

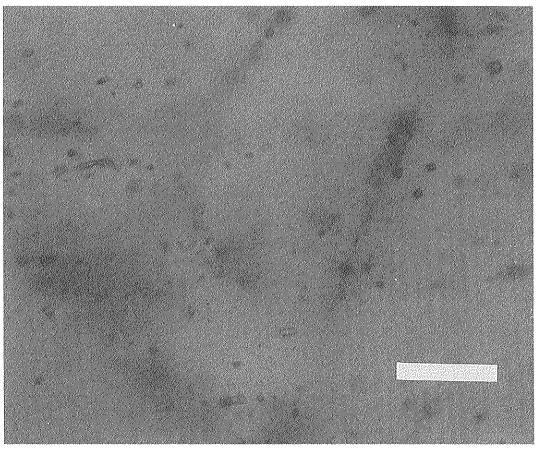


Fig. 5 Inclusions in auriferous quartz vein, No. 10, sample No. J 950708-13. This portion has Au=2.8 g/t. Bar indicates 20 μm.

5. Fluid inclusion data

We have measured homogenization and ice melting temperatures of fluid inclisions in quartz in order to understand thermal history of hydrothermal fluids in the mesothermal auriferous quartz veins, and epithermal quartz veins along the Tsagaan tsakhir uul fault. Eleven samples were prepared and 53 inclusions were studied using U.S.G.S type gas-flow heating/freezing system. Most of the inclusions in quartz are between 3 μm and 10 μm in size (Fig. 5). Measurements were carried out for primary inclusions larger than 4 mm in size. The homogenization temperatures of mesothermal veins range from 160 to 260℃ (Fig. 6 and Table 2). Most inclusions are 2 phase L>V. Homogenization temperature of epithermal quartz veins was between 107° and 123℃. The apparent salinity of fluid inclusions for mesothermal quartz veins, estimated based on ice melting temperature ranges between 1.74 and 6.74 wt.% NaCl equiv, with an average value of 4.18 wt.% NaCl equiv. During the freezing of inclusion for mesothermal quartz vein

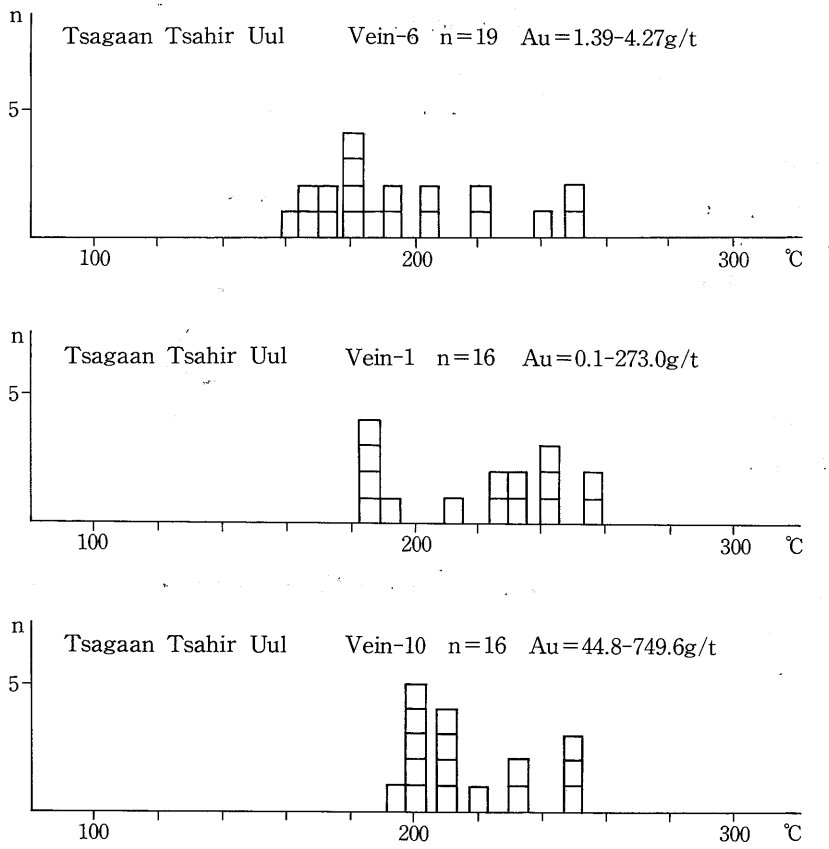


Fig. 6 Histogram showing homogenization temperatures measured for auriferous mesothermal quartz veins

Table 1 Chemical composition of auriferous quartz veins of Tsagaan tsakhir uul gold deposit

N	Vein	Element content								
		Au (ppm)	Ag (ppm)	As (ppm)	Sb (ppm)	Hg (ppm)	Bi (ppm)	Te (ppm)	Se (ppm)	Mo (ppm)
1	Vein-1	<0.1-273.2	0.2-45.5	2.0-25.0	2.0-94.0	<1.0-17.0	<1.0-5.0	<5.0-12.0	<5.0	<5.0
2	Vein-2	<0.1-741.0	<0.1-43.8	1.0-28.0	<1.0-77.0	<1.0	<1.0-47.0	<5.0-18.0	<5.0	<5.0
3	Vein-3	<0.1-168.2	<0.1-42.5	1.0-19.0	<1.0-16.0	<1.0-3.0	<1.0-26.0	<5.0-39.0	<5.0	<5.0-11.0
4	Vein-4	<0.1-73.7	<0.1-0.7	1.0-2.0	1.0-2.0	<1.0-41.0	<1.0	<5.0-19.0	<5.0	<5.0
5	Vein-6	<0.1-12.1	<0.1-4.1	3.0-18.0	1.0-3.0	<1.0	<1.0	<5.0-16.0	<5.0	<5.0
6	Vein-7	<0.1-40.1	<0.1-10.4	1.0-20.0	<1.0-125.0	<1.0	<1.0-57.0	<5.0-58.0	<5.0	<5.0-24.0
7	Vein-8	<0.1-2.7	<0.1-14.7	1.0-21.0	<1.0	<1.0	<1.0-29.0	<5.0	<5.0	<5.0-11.0
8	Vein-9	<0.1-11.6	<0.1-7.2	<1.0-94.0	<1.0-47.0	<1.0-2.0	<1.0-89.0	<5.0-19.0	<5.0	<5.0-44.0
9	Vein-10	<0.1-749.6	<0.1-83.3	<1.0-86.0	<1.0-400.0	<1.0-4.0	<1.0-29.0	<5.0-42.0	<5.0	<5.0
10	Vein-14	<0.1-0.8	<0.1-2.7	<1.0-4.0	<1.0	<1.0	<1.0	<5.0-13.0	<5.0	<5.0
11	Vein-15	<0.1-19.9	<0.1-5.7	<1.0-14.0	<1.0	<1.0	<1.0	<5.0-7.0	<5.0	<5.0
12	Vein-5	<0.1-0.38	<0.1-2.0							

Gold and silver content is determined by AAS method at the Central Geological Laboratory, Mongolia

we noticed that some inclusions contain CO_2.

6. Concluding remarks

Our fluid inclusion analysis demonstrated that so called "mesothermal" quartz veins, exposed at the Tsagaan tsakhir uul gold mineralization area, are typically of mesothermal: gold mineralization of this area was formed from low salinity solution at temperature approximately 130°-260℃. But it seems that higher grade portion of vein has a narrower range in homogenization temperature (Fig. 6). This

Table 2 Homogenization temperatures of inclusions in auriferous quartz veins from Tsagaan tsakhir uul gold deposit

Vein type	Sample number		Number of measured inclusion	Homogenization temperature ℃	Mineral assemblage	Content g/t	
						Au	Ag
Meso-thermal	J950705-13	Vein-1	8	210.0-258.0	Qtz-py-gld	1.39	<2.0
	J950705-14	Vein-1	8	180.0-260.0	Qtz-py-gld	54.46	4.45
	J950705-07	Vein-6	12	165.0-258.0	Qtz-gld	3.36	<2.0
	J950705-10	Vein-6	7	165.0-210.0	Qtz-py-gld	4.27	4.45
	J950630-01	Vein-10	12	193.7-230.0	Qtz-gld-py-chp	729.6	<2.0
	J950707-05	Vein-10	4	193.0-255.7	Qtz-py-chp-mal-azu	<0.1	19.77
Epitherm	J950706-16	Vein-5	2	123, 107	Qtz-car	0.38	<2.0

Qtz: quartz
gld: gold
py: pyrite
chp: chalcopyrite
mal: malachite
azu: azurite
car: carbonate

fact could be important to perform exploitation and geochemical discussion in this area. Homogenization temperature of the vein along the Tsagaan tsakhir uul fault showed typical epithermal range although limited in number of analysis.

As clarified with this reconnaissance study the Tsagaan tsakhir uul area has a high potential for gold exploration due to the overprinting of two types of hydrothermal mineralization. It could be an important topic to elucidate the relationship between the mesothermal and epithermal deposits to establish a better guideline for the gold exploration in the area.

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モンゴル国ツァガンツァヒルウール金鉱化帯の予察的研究

S. Jargalan・村尾　智

要　旨

ツァガーンツァヒルウール金鉱化帯はモンゴル国のバヤンホンゴル帯東南部に位置する．一帯には原生界の石灰岩，結晶片岩，カンブリア紀黒雲母花崗閃緑岩，両雲母花崗閃緑岩，石炭紀の花崗閃緑岩，小規模なペグマタイト，アプライト，石英斑岩が露出する．金鉱化作用は結晶片岩とカンブリア紀の花崗閃緑岩に胚胎する石英脈中にみられ，エピサーマル型とメソサーマル型がある．前者は局所的で品位もやや低い．後者は場所によっては749.6 g/tの品位を示し，最大直径3 mm，平均純度900の金粒子を産する．流体包有物は気液2相（L＞V）でエピサーマル系では107-123℃，メソサーマル系では160-256℃の均質化温度を示した．また一部の包有物には二酸化炭素が含まれている．メソサーマル系では金品位と流体包有物の均質化温度に関係があるらしく，品位のより高い場所で均質化温度の範囲が狭い．