CHAPTER 6 SURVEY OF AREA B

CHAPTER 6 SURVEY OF AREA B

6–1 Location

This area is located about 14 km north of Omkoi, and there is Yong Ku Mine at the south end of it. Its area is 3.25 km^2. It presents a relatively gentle landform with an altitude between 1,000 m and 1,100 m.

From Yong Ku Mine an auto road extends for exclusive use by the mine, which connects with National Highway 1,099.

As the result of the geochemical survey by stream sediment, the anomalies of niobium, tantalum, tin and tungsten were found to overlap with each other in this area. When one see these more minutely, however, one finds there is an extensive high tungsten anomaly area around the mine; the niobium and tantalum anomaly lies a little away to the northeast side of the mine; and the tin anomaly overlaps with the tungsten anomaly but is limited to the neighborhood of the mine.

The drilling and trenching were conducted to select the most promising area in these anomaly areas.

6–2 Geologic Mapping

(1) Geology

This area is in a zone at the north extremity of the Omkoi area where the Precambrian metamorphic rocks and limestone are distributed. Almost all this area is occupied by metamorphic rocks which intercalate limestone, but the Cretaceous(?) aplite, pegmatite and quartz veins appear locally, and the Quaternary alluvium is distributed along major streams (Fig. 19).

The Precambiran metamorphic rocks are roughly classified, from their lithofacies, into migmatitic biotite paragneiss, biotite paragneiss, quartz schist, quartzite, pelitic schist, and calc-silicate rocks.

The metamorphic rocks and limestone have a general strike of NW and dip to the northeast.

(i) Migmatitic biotite paragneiss (Gm)

This rock, distirbuted in the southwest end of the area, apparently corresponds to the lowest part of the metamorphic rocks. Generally it is massive and fine- to medium-grained. At some places it lacks distinct gneissic structure, and is very similar to the Cretaceous granite distributed to the west of this area. However, the facts that in most cases it presents fine gneissic structure due to biotite and that it is at some places interlaid with lenticular biotite paragneiss which is explained later, made the writer classify it as migmatitic paragneiss. According to microscopic observation of representative samples, its main components are quartz, perthitic orthoclase, plagioclass and biotite. The part of the feldspar has been sericitized from inside, and part of the biotite has been sericitized or chloritized.

(ii) Biotite paragneiss (Gp)

Two relatively thick strata of this rock are distributed in the middle of the area, and additionally it is found in the form of thin layers in the northeast of the area. Ordinarily gneissic structure due to biotite is distinct, and the fine-grained part and the medium- to coarse grained part often lie one upon another in an alternate layer form at intervals of 0.5 to 5 m. In the medium- to coarse grained part the porphyroblasts of potash feldspar, 0.5 to 2 cm in size, are observed showing angen gneiss structure. According to microscopic observation of samples of the medium-grained part, the main minerals are quartz, potash feldspar, plagioclass, and biotite; potash feldspar is found in a small quantity except for the porphyroblasts. The biotite is often yellowish green, and as a whole considerable chloritization is found. Feldspar that has been replaced by sericite from its peripheries is comparatively fresh.

In the areas with distribution of this rock, boulders and small outcrops of the calc-silicate rocks are occasionally found. The biotite parageiss intercalates thin lenses of calcareous rocks.

(iii) Quartz schist, quartzite, and pelitic schist (Qs)

These rocks are distributed in three horizons from the middle to the northeast of the area. Among the three horizons, the quartz schist is predominant in the lower horizon and the upper horizon; it is light pink to light gray, and has distinct schistose structure, about 1 to 2 mm in size. The component minerals of quartz schist are almost all fine-grained quartz, but a small amount of muscovite is recognized in some parts.

The quartzite is gray and fine-grained and lacks distinct schistose structure; in most cases it is found as thin layers in pelitic schist.

The pelitic schist is relatively predominant in the area along the southeastern tributary of the Tung Ting Creek; besides this area it is intercalated in quartz schist as thin layers. This rock is dark gray to dark brown, being dark green at times; it has distinct schistose structure, 1 to 5 mm in size. The dark gray to dark brown schist has the main component minerals of quartz, feldspar, biotite, muscovite, and graphite.

The dark green schist, which is found very rarely, is mainly formed of chlorite.

(iv) Limestone (Ls) and calc-silicate rock (Cs)

These rocks often occur in the form of small lenses or thin layers, 10 m or less in width, in biotite paragneiss, quartz schist, and pelitic schist.

However, in the northeast of the area, the calc-silicate rock layer with an apparent maximum width of about 70 m is distributed.

The limestone is found in the Tung Ting Creek and its tributary on its southeast. It is light gray to gray and fine-grained; narrow banding, 1 to 2 mm, are clearly seen. It contains grayish white flint nodules, 1 to 10 cm in size. Its main component is fine-grained calcite; it also contains small quantity of quartz and feldspar.

The calc-silicate rock is distributed at various parts of the area. It is light green to dark green; almost all of it has schistose structure, but it is massive in part. In some parts of this rock the lenticular quartz veins are recognized. Particularly, at the calc-silicate layer of the maximum width of about 70 m found in the northeast of the area, white quartz veins, less than 1.5 m in thickness, is found in a gently inclining sheet form (N45°W/35°E) or in parallel with the schistose structure (N45°W/60° to 80°E).

This calc-silicate layer gradually change, toward the northwest, into light gray, fine-banded limestone. Its main component minerals are diopside, chlorite, quartz, orthoclase, and plagioclase. At some parts it is disseminated with very small quantit y of pyrite and scheelite.

(v) Aplite (Ap) and pegmatite (Pg)

The Cretaceous(?) aplite and pegmatite are found in the forms of small dikes and sheets cutting across the metamorphic rocks.

The aplite appears with comparatively high frequency in the vicinities of Yong Ku Mine, but in the other parts it is distributed only sporadically.

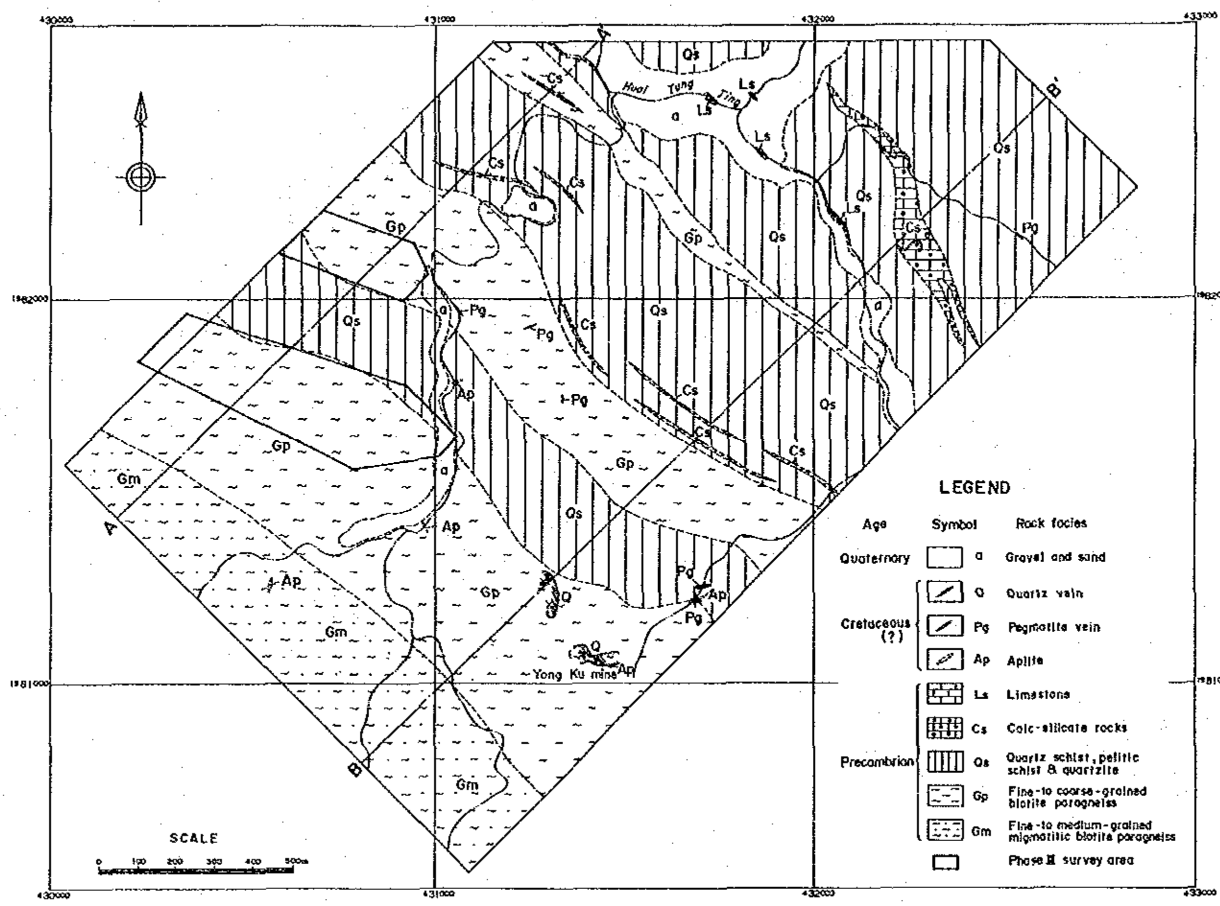
It is light yellowish white and fine grained. It is found as dikes and sheets 3 m or less in width.

The main direction of the intrusion of the dikes is N70° to 80°E/90°. In the case of sheets, their direction is N35° to 45°W/35° to 50°E, which is nearly parallel with the schistose structure of the metamorphic rocks.

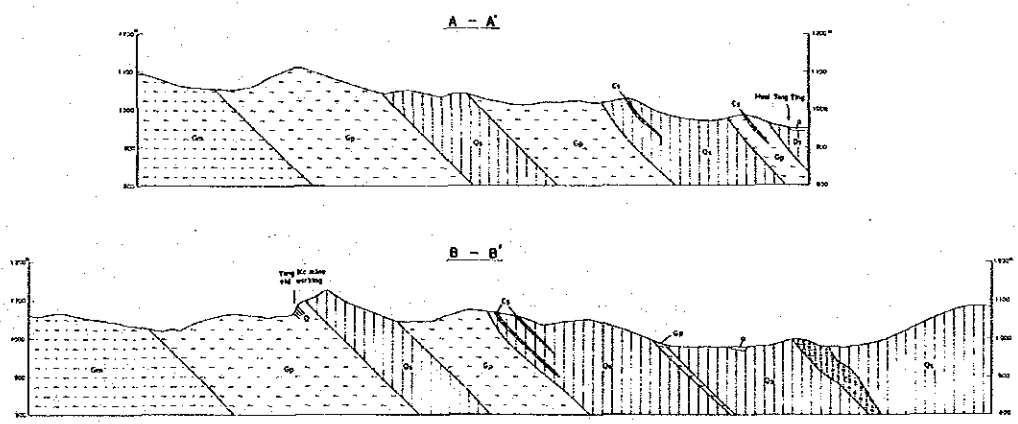
According to microscopic observation, the main component minerals are quartz, plagioclase, and orthoclase; in addition it contains very small quantity of muscovite and opaqu mineral, which has turned into leucoxene.

e The pegmatite appears with high frequency in the neighborhood of Yong Ku Mine like the aplite, and is also found in the middle and northeast of the area. It takes the two forms of dikes less than 5 m and ordinarily 0.3 to 2 m in width.

The direction of the intrusion of the pegmatite in a dike form is N70° to 80°E/80°S to 90° in the surroundings of Yong Ku Mine, and N45°W/90° in the northeast of the area. The pegmatite in a sheet form lies in the direction of N40° to 50°W/30° to 60°E, which is parallel with the schistose structure of the metamorphic rocks. Its component minerals are quartz,



Geologic map



Geologic profile

Fig. 19 Geologic Map of the Area B

orthoclase, plagioclase, muscovite, biotite, and tourmaline; at some places biotite and tourmaline do not exist.

(vi) Alluvium (a)

The Quaternary alluvium is distributed along the Tung Ting Creek and its tributaries; it is formed of unsolidified gravels, sand and clay.

(2) Geological Structure

At some parts of the outcrops of the metamorphic rocks and limestone distributed in this area, there is development of drag folds in the extent of 3 to 8 m. In addition, one finds small-scale faults and fracture systems indicated by the directions of the intrusion of dikes of aplite and pegmatite and quartz veins and lineaments found from aerial photographs.

The drag folds show in almost all cases the form that as against the northeast-dipping fold axis the northeast wing inclines gently toward northeast and the southwest wing inclines sharply toward northeast. And it is indicated that a main anticline axis exists to the southwest of the area and that this area is located on the northeast wing of the anticline. This leads one to the presumption that the metamorphic rocks and limestone in this area, as a whole, have a strike of northwest and lie one upon another with a dip of about 45° toward northeast, though there are some repetitions due to small-scale foldings.

As for the fracture systems, three ones in the directions of NW, NS, and NNE to NE are recognized. Of these the NW system is predominant in the area and is parallel with the fold structure and the schistose structure of the Precambrian, indicating the main structure direction around the area. The NS and NNE to NE systems are considered to be fracture directions secondary to that in the NW direction.

(3) Alteration

In the area, in addition to regional metamorphism in the Precambrian and subsequent periods, skarnization and kaolinization due to hydrothermal process are found.

The skarnization extended to limestone and calcareous rock of Precambrian age, and caused the formation of diopside-epidote skarn (calc-silicate rock). The greater part of the calc-silicate rock in the area is considered to have been formed by the regional metamorphism affecting limestone and calcareous mudstone, but some of it is penetrated by scheelite-containing quartz veins, and is disseminated with a very small quantity of scheelite. Particularly, in the northeast of the area there is a case that, though a part cut through by large quantity of quartz veins has been skarnized, some place in the part's northeast extension remains as light gray banded limestone because the quantity of quartz veins is small. Also in its vicinity there is tourmaline pegmatite, 4 m wide, that indicates igneous activity. These facts make one presume that, in some part of the calc-silicate rocks distributed in this area, there are places of skarnization owing to hydrothermal process.

The kaolinization is recognized along the creek in the northeast of the area, where there is massive white rock which seems to originate from pelitic schist. Also, at some part, pelitic schist has been turned into white kaolin along thin pegmatite veins, indicating the fact of kaolinization owing to pneumatolysis or hydrothermal process.

(4) Mineral Deposit and Mineralization

In this area as a known mineral deposit, there is Yong Ku Mine. Besides this there are unexplored mineral indication zones supported by pegmatite veins, quartz veins and skarn zones. Details of Yong Ku Mine are seen in Chapter 3, 3–5, (1).

(i) Yong Ku Mine (in working, see in Fig. 4)

The mineralized veins are pegmatite veins and quartz veins accompanied by cassiterite, wolframite, and scheelite; they occur in parallel with the gneissic structure of biotite paragneiss (N25° to 50°W/36° to 70°E), which is the country rock. The scale of each of these veins is generally 2 to 60 cm in width and 10 to 30 m in strike extension, but a case in which a vein could be traced more than 80 m with discontinuities is reported (Vichit and Khuenkong, 1983). Some parts of the pegmatite veins and quartz veins contain tourmaline. Epidote is occasionally observed along quartz veins.

The cassiterite occurs only locally, but it is said that it was found in relatively large quantity at the remains of mining sites on the northeast side of the ridge.

The wolframite and scheelite are found in almost equal quantities. These minerals are observed in small amounts in the pegmatite veins and quartz veins, but rather are concentrated in 1 to 10 cm wide, hydrothermally biotitized zones developed at the boundaries of these veins.

The fluorescence of the scheelite under ultraviolet rays is mostly blue, but some grains are light white to light yellow, which suggests the existence of powellitic scheelite in a small quantity.

According to the result of analysis of the ore samples, the content of WO_3 in crude ore from the biotitized zone at the quartz vein boundary is 0.27%, while concentrate of scheelite and wolframite has 71.3% of WO_3. The contents of niobium, tantalum, and tin are extremely low in both the two samples.

(ii) Unexplored mineral indication zones

In Area B, mineral indications due to pegmatite veins, quartz veins, and skarnized zones are distributed at various parts, but the mineralized part that can be confirmed by the naked eye and under microscope is only the skarn disseminated very slightly with scheelite at a point about 0.9 km northwest of Yong Ku Mine. This skarn is cut through by a thin quartz vein containing scheelite 5 mm in size, and in the skarn itself scheelite grains 1 mm in size are seen sporadically. However, the ore grade as a whole is extremely low, and the WO_3 content is presumed to be 0.00n % by the naked eye. Among the pegmatite veins the one of the biggest scale is a tourmaline-two-mica pegmatite vein found in the northeast of the area, 4 m in width, with a strike and dip of N45°W/90° (?). Near this vein a few pegmatite veins, about 5 cm in width, running in parallel are found. Among the quartz veins, at a point along a mountain ridge 0.9 km northwest of Yong Ku Mine, big floats of quartz from high-temperature coarse-grained quartz veins are found in a large quantity, though the size of the outcrops and the vein direction are not known certainly. Some of the floats contain tourmaline, and some others have thin bands of biotite.

Since, in this area, judging from the scale and frequency of appearance of pegmatite veins and quartz veins, the scale of skarnized zones, and the result of analysis of geochemical prospecting samples, occurrence of mineralized parts was expected in the northeast of the area and in the vicinity of the ridge 0.9 km northwest of Yong Ku Mine, the heavy minerals in stream sediment in these areas were collected and studied about the mineral species and their contents as the complementary work to the geological mapping. As the result, a large quantity of cassiterite (3.1 kg/m^3) was found in a small creek 0.9 km northwest of the mine, and also at various other places cassiterite, wolframite, scheelite, and very small quantity of columbite-tantalite, struverite-ilmenorutile, monazite, xenotime, zircon, ilmenite, magnetite, and limonite were found.

The large quantity of cassiterite found in the small creek 0.9 km northwest of Yong Ku Mine is 1 cm in maximum grain size, ordinarily 3 to 8 mm, and its roundness is very low, which suggests that the source is very near. The cassiterite is light yellow or light purple to light brown, and originate from quartz veins. The contents of nibium and tantalum in this cassiterite are extremely low.

In another small creek north of this creek small quantities of light brown to light yellow cassiterite, wolframite and scheelite were found. Stream sediment in a creek 1.5 km north-northwest of Yong Ku Mine contains more niobium-tantalum minerals than tin and tungsten minerals, but all of these are in extremely small quantity On the other hand in the northeast of the area there are very small quantity of niobium-tantalum minerals and cassiterite. The cassiteriate is dark brown and pleochroic to some extent, so that it is presumed that it originates from those tourmaline pegmatite whose outcrops have been confirmed, together with the niobium-tantalum minerals. However, the contents of the niobium, tantalum, tin and tungsten minerals in the stream sediment are low.

6–3 Geochemical Prospecting

(1) Sampling

Six hundreds and seventy-four samples were collected and offered to chemical analysis in proportion to the Area A. However, the spacing between sampling lines was 100 m and the interval between sampling points was 50 m. The direction of sampling lines was decided to be laid out in NE-SW direction to pick out effectively mineralized zone and fracture systems in general trend of NW-SE, ENE-WSW and NE-SW.

(2) Chemical Analysis

(i) Pathfinder Element

Since it was at the stage of semi-detailed survey, four elements of niobium, tantalum, tin and tungsten were chosen for pathfinder element in proportion to the Area A.

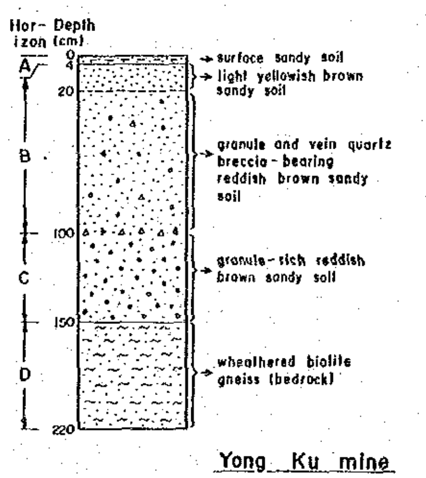
(ii) Method of Analysis

The analytical method was same to Area A.

(3) Soil profile and Content of pathfinder elements by the difference of depth and grain size of soils

In this area there is predominately reddish brown clayey soil. The depth of geochemical sampling was in equal to Area A. Also, same as Area A, the variation of content of four elements are studied by the difference of depth and grain size of soil in the whole soil profiles from the pit walls of open-cut mining in Yong Ku mine (Fig. 20).

As the result of this study, contents of four elements in –30 to +80 mesh fraction were obviously higher than ones of –80 mesh fraction much the same of Area A.



Sample No.	Nb	Ta	Sn	W (ppm)
YKS-1	22	4	61	94
	4	1	17	89
YKS-2	22	5	65	92
	5	2	20	31
YKS-3	23	5	69	97
	4	1	24	46
YKS-4	21	4	63	82
	8	2	37	21
YKS-5	24	4	63	83
	5	1	19	32

Geochemical values are as below :
upper row ; of –30 and +80 mesh fraction
lower row ; of –80 mesh fraction

Fig. 20 Representative Soil Profile and Geochemical Data

(4) Classification of Geochemical Anomaly Values

The classifications of geochemical anomaly values of each pathfinder element were divided according to the standard of Area A. This result is set forth in Table 9.

Table 9 Classifications of geochemical background and anomaly zones

ppm

Element	Background		Anomaly		
	Low	High	Low	Moderate	High
Nb	– 23	24 – 29	30 – 41	42 – 54	55 –
Ta	– 2	3 – 4	5 – 8	9 – 13	14 –
Sn	– 18	19 – 21	28 – 39	40 – 55	56 –
W	– 6	7 – 15	16 – 39	40 –104	105 –

(5) Distribution of Geochemical Anomaly Area

On the basis of the classification of geochemical anomaly in the preceding section, anomaly areas of each element were picked out, as shown in Fig. 21.

Niobium and tantalum anomaly areas are distributed in the northeast and northwest overlapping each other.

Tantalum anomaly is higher than niobium one.

Tin anomaly areas are arranged in the NW-SE direction in the northwest.

Tungsten anomaly areas are also distributed overlapping tin anomaly ones with higher anomaly values than those of tin.

Besides these, tin anomaly areas overlapping niobium and tantalum ones are distributed in the northeast.

The distribution of anomaly area for each element is as follows:

(i) Niobium:

Low anomaly areas in the northeast, low and moderate ones in the northwest and low but extensively wide one are distributed. Among these anomaly areas, moderate anomaly area in the northwest extends in a scale of 150 m by 300 m with high anomaly value of 72 ppm. Another two have two or three sampling points with moderate anomaly values. These appear to extend in the WNW-ESE direction.

(ii) Tantalum:

Low anomaly areas with moderate one in the northeast and moderate anomaly area with

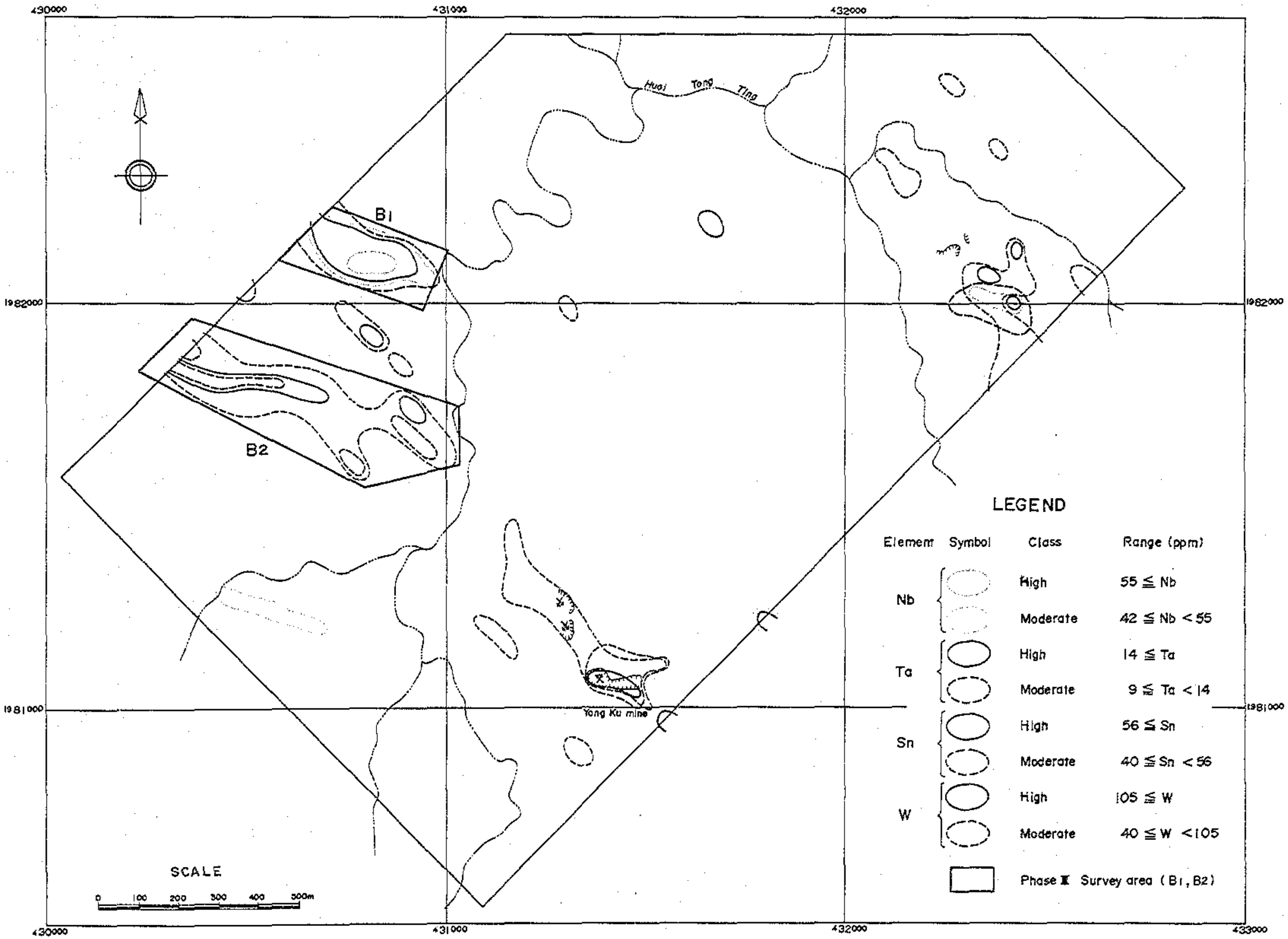


Fig. 21 Geochemical Anomaly Map of the Area B

a scale of 200 m by 150 m in the northwest are distributed. The latter includes high anomaly area with maximum anomaly value of 29 ppm. This one overlaps niobium anomaly area and is wider than niobium one.

(iii) Tin:

Low anomaly area including moderate one around the Yong Ku mine extends in a narrow belt in the northeast direction and continues up to the ridge in the northwest edge. In the northeast, low anomaly area with moderate anomaly area are distributed along the ridge in the northwest direction.

(iv) Tungsten:

Anomaly areas are distributed overlapping tin anomaly area and are wider and higher than tin ones. Moderate anomaly area extends in narrow belt along the ridge and continues to the ridge in the northwest edge. The latter is wider and higher than the former.

(6) Evaluation of Geochemical Anomaly Area

Above-mentioned geochemical anomaly areas were assessed in the use of the relationship among geological structure, alteration and location of mineralized zones. This result is as follows. However, the anomaly area, where directly related to the Yong Ku mine, was excepted.

(i) Tin and tungsten anormaly area in the northwest part

This area is the most concentrated tin and tungsten anomaly area in Area B and is situated on the elongation of mineralized vein in NW-SE direction of Yong Ku mine. A large quantity of cassiterite was found from stream sediment. There is a possibility that a promising mineralized zone occurs as an extension of the mineralized veins of Yong Ku mine.

(ii) Niobium and tantalum anomaly area in the northwest part

This area is the most concentrated anomaly area with high anomaly. In metamorphic rocks, gneissose structure in the direction of NW-SE is well developing. Niobium and tantalum-bearing pegmatite veins are inferred.

(iii) Tin, niobium and Tantalum anomaly area in the northeast part

This is a moderate to high anomaly area, which distributes in the direction of NW-SE. It is parallel with the strike of country rock. Therefore it is conceivable that it reflects the existence of mineralized vein in this direction. But niobium, tantalum and tin contents are low. It is a low possibility of finding the promising mineralized zone.

6–4 Drilling Survey and Trenching Survey

The present surveys are a following-up survey through drilling and trenching in Phase III in Areas B_1 and B_2 which were selected from the geochemical anomaly area to the northwest of the Yong Ku mine, picked out as the result of the Phase II survey.

In both these areas, to find mineralized veins with efficiency, survey sites were arranged by combining drilling and trenching so that they cross the directions of presumable mineralized veins at right angles (Fig. 22).

Area B_1, which is situated about 1 km northwest of the Yong Ku mine, is a niobium and tantalum geochemical high anomaly area, and the occurrence of niobium and tantalum-containing pegmatite veins was expected.

In this area five holes (30 m each; 150 m in total) were drilled and 10 trenches with a total length of 270 m were excavated.

Area B_2, which is situated about 0.9 km northwest of the Yong Ku mine and contiguous to Area B_1 on its southwest, is a tin and tungsten geochemical anomaly area, and the occurrence of mineralized veins similar to those of the Yong Ku mine was expected.

In this area 26 holes (30 m each x 22 holes, 40 m x 1 hole, and 50 m x 3 holes; 850 m in total) were drilled and 28 trenches with a total length of 610 m were excavated.

The results of the surveys in these two areas are as follows:

(1) Area B_1

The rock revealed by the drilling and trenching is pegmatite for the most part, with schistose and gneissic rocks seen locally. The pegmatite has turned into white clay or light-greenish yellow clay through kaolinization and montmorillonitization.

Such argillization is presumed to be widely extended both horizontally and vertically. Accorcing to the results of analysis, most of the niobium content are not more than the geochemical threshold value, and the greater part of tantalum content come under the level of medium to high anomaly values. There are no high niobium or tantalum content that could be called mineral indication.

Since the schistose rocks hardly contain niobium or tantalum, the geochemical anomaly area picked out in this area is considered to derive from pegmatite.

(2) Area B_2

In addition to quartz veins and pegmatite veins intruded in biotite paragneiss, pelitic schist and quartz schist, there is calc-silicate rock interlaid in the above-mentioned rock.

As the result of the surveys, tungsten mineral indications were confirmed in Drill Holes

MJT–29, 38, and 43 and Trench B_2–10 from examination under ultraviolet rays and the result of chemical analysis (Fig. 23).

In Drill Hole MJT–29, scheelite is densely concentrated on the foot wall side of a 20 cm–wide quartz vein existing about a 10.60 m depth, and the high content of 6.06% of WO_3 was found in the extent of 10.70 to 10.80 m depth; in addition, the quartz vein indicated 130 ppm of W and its hanging wall side 230 ppm of W. In the extent of 10.00 to 10.80 m depth which includes this quartz vein, about 0.78% of WO_3 content is estimated.

The hanging wall side of calc-silicate rock lying in the extent of 12.60 to 13.60 m depth indicated 0.18% of WO_3, and its foot wall side 0.19% of WO_3; so that about 0.14% of WO_3 is estimated from the extent of 12.00 to 14.00 m depth which includes the calc-silicate rock. On its hanging wall side tin content is high as indicated by the instance of 240 ppm of Sn.

In Drill Hole MJT–38, scheelite grains, a few millimeters in diameter, are scattered in the upper half of calc-silicate rock existing in the extent of 11.30 to 12.50 m depth, and about 1.06% of WO_3 is estimated from the extent of 11.50 to 12.00 m depth (Fig. 24).

In Drill Hole MJT–43 comparatively high values of tin and tungsten content were found as follows: the skarn zone in the extent of 11.85 to 12.30 m depth contains a mm–sized scheelite grains and shows 0.19% of WO_3 and 650 ppm of Sn; the calc-silicate rock zone in the extent of 8.30 to 8.50 m depth shows 0.20% of WO_3 and 590 ppm of Sn.

In Trench B_2–10, fine grains of scheelite are disseminated in 20 cm–wide quartz rich calc-silicate rock lying along the gneissic structure of the country rock and in its hanging and foot walls; WO_3 content was found to be 0.48 to 1.56% and Sn content to be 110 to 210 ppm; these are relatively high values. In the extents of 3.0 m on the hanging wall side and 0.5 m on the foot wall side of this mineralized vein, there are small-scale parallel veins, the former indicating 1.38% of WO_3 in a 5 cm width and the latter 0.49% of WO_3 in a 10 cm width. Scheelite is particularly concentrated in skarnized calc-silicate rock in quartz veins.

As Drill Holes MJT–45, 46 and 47, which aimed at the extensions of these mineralized veins didn't intersect mineral indications: the scales of the individual mineralized veins are considered small and their continuity deficient. However, in Drill Holes MJT–29 and 43 made on the northwest-side strike extension of the mineralized veins in the Trench B_2–10, there is calc-silicate rock with mineralization at the depth of about 12 m of both the holes; these sections are considered to be on the same horizon. In Trench B_2–5 cut to the northwest of Drill Hole MJT–43 there is calc-silicate rock, which indicated 100 ppm of W. Pebbles of quartz vein and calc-silicate rock are scattered from the surroundings of the two-drill holes to Trench B_2–5. So that, in this neighborhood including the mineralized vein found in Trench B_2–10, calc-silicate rock with mineralization lies intermittently or in an echelon form along the gneissic structure of the country rock.

In Drill Hole MJT–38 calc-silicate rock is interlaid in the extent from 11.30 to 12.50 m depth, and scheelite grains, a few millimeters in diameter, are scattered in the upper half of the extent, the value of 1.06% of WO_3 being indicated in the extent from 11.50 to 12.00 m depth. Aiming at the extension of this mineral indication, Drill Holes MJT–49, 50 and 51 were bored. In Drill Hole MJT–50 calc-silicate rock was confirmed though no mineralization was recognized.

On the south side of Drill Hole MJT–38, several boulders of calc-silicate rock containing scheelite were found. With these as the center, in the NW–SE direction, pebbles of quartz vein and calc-silicate rock are scattered. These facts indicate that the calc-silicate rock in Drill Hole MJT–38 extends in the NW–SE direction. And it is presumed that along the line connecting this hole and Drill Hole MJT–29 lying to the northwest of it, the mineralized veins of this area occur either intermittently or in an echelon form.

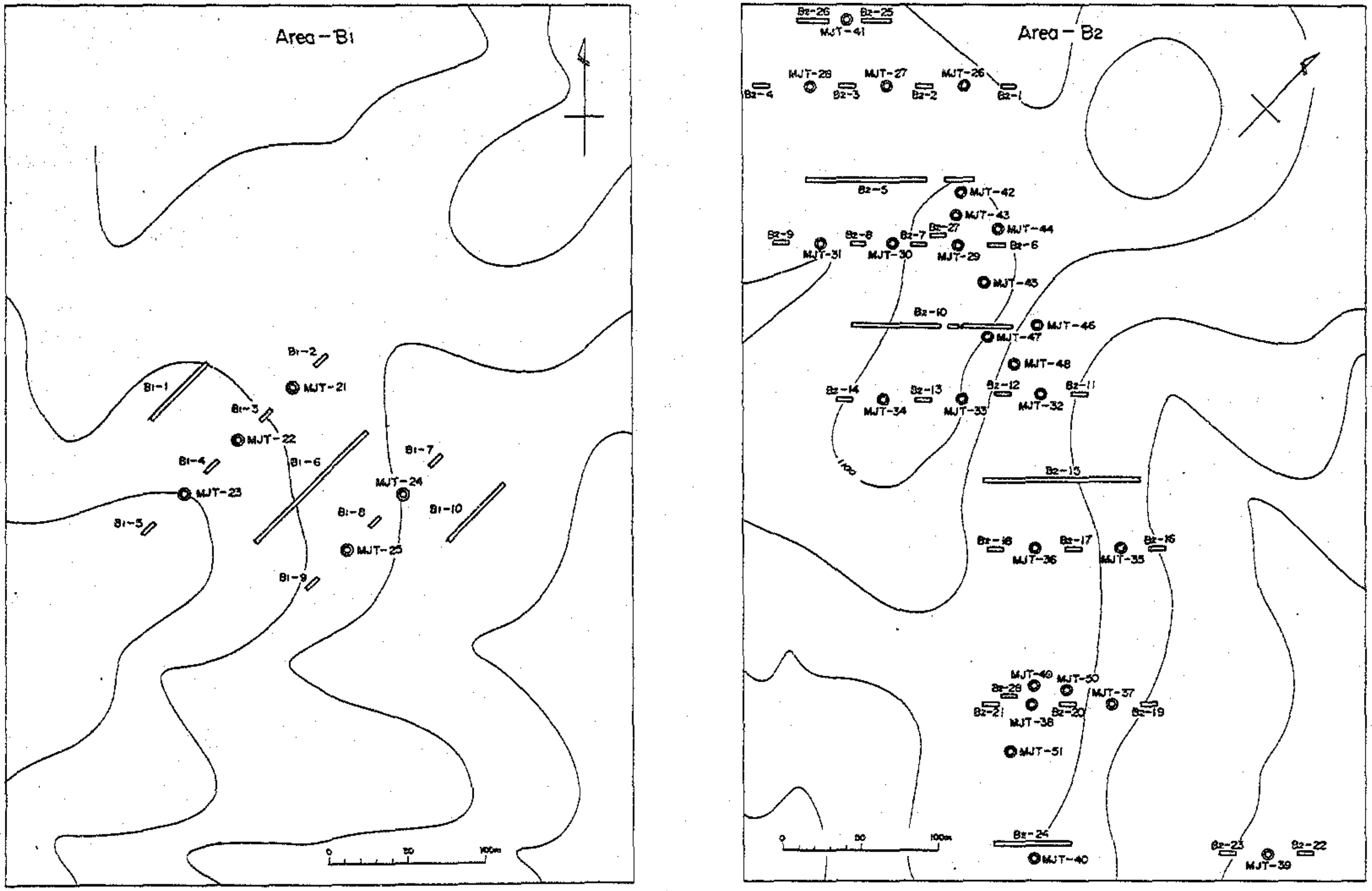


Fig. 22 Location Map of Drilling and Trenching Points of the Area B

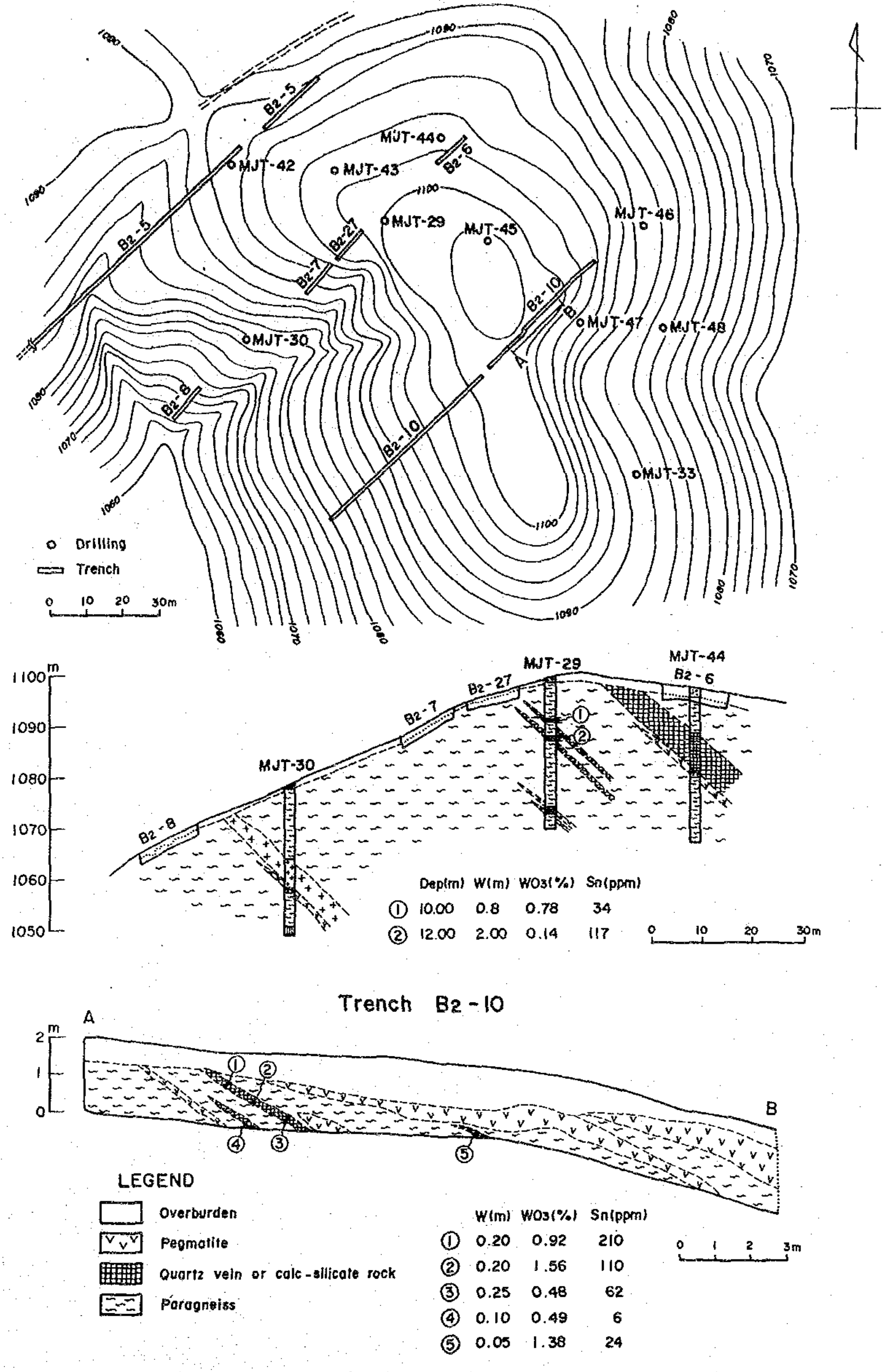


Fig. 23 Geological Profile of Drilling (MJT–29, 30, 44) and Geological Sketch of Trench B_2 –10

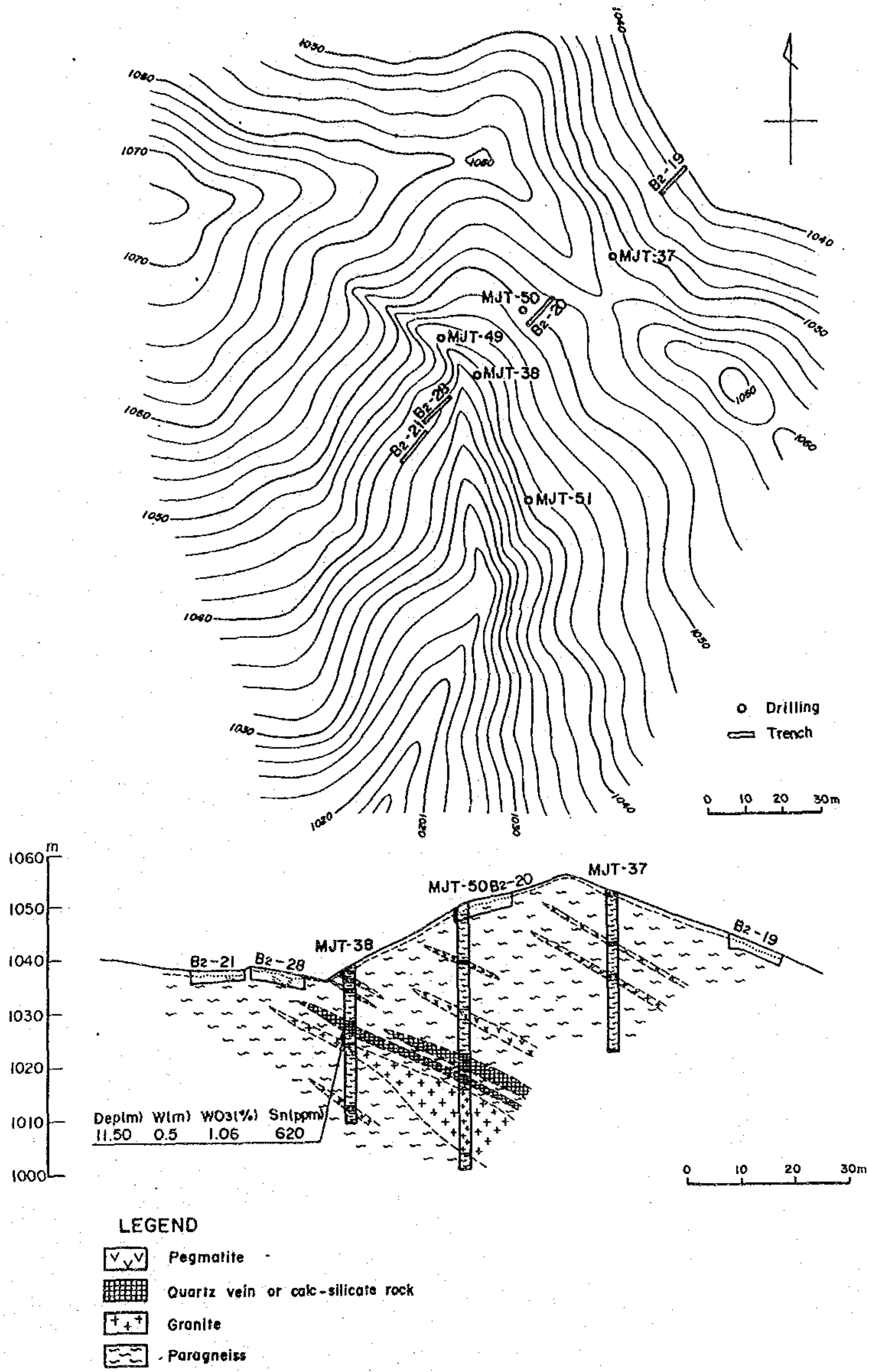


Fig. 24 Geological Profile of Drilling (MJT–37, 38, 50)

CHAPTER 7 SURVEY OF AREA C

CHAPTER 7 SURVEY OF AREA C

7–1 Location

Area C is situated about 20 km southwest of Omkoi. Its area is 2 km^2. This is a rugged mountainous area with altitudes between 1,100 m and 1,300 m.

There is an auto road from Omkoi to Ban Mae Lan which is 14 km away from Omkoi. From this to the selected survey area the distance is about 13 km along the Hat River.

7–2 Geologic Mapping

(1) Geology

This area is located in the middle of the Triassic foliated granite mass which occupies the western half of the survey area. Almost all of the area is covered with granitic rocks, but small basalt dike has been intruded into the granite; also the Quaternary alluvial sediment is distributed along the Hat River and its tributaries (Fig. 25).

The Triassic granitic rocks are classified, by the lithofacies, into medium- to coarse-grained biotite granite, fine-grained biotite granite, aplite and pegmatite.

(i) Medium- to coarse-grained biotite granite (Gt1b)

This rock is distributed over the whole of the area and has the features of porphyritic texture due to potash feldspar phenocrysts, 1 to 4 cm in size generally, and foliation due to biotite. According to microscope observation of samples of coarse-grained parts, the main component minerals are quartz, perthitic orthoclase, plagioclase, and brown biotite; the minor component minerals are opaque minerals. The potash feldspar phenocrysts are perthitic orthoclase, which poikilitically contain small grains of quartz, orthoclase, and plagioclase. The biotite has been partly chloritized; a part of the feldspar has been sericitized from inside; a part of the opaque minerals is pyrite.

(ii) Fine-grained biotite granite (Gt3)

This rock appears as NS-oriented dikes, less than 25 m in width, in the southwest and the northeast corner of the area. The middle of a dike is gray and formed of porphyritic, fine-grained biotite granite containing potash feldspar phenocrysts, less than 1 cm in size, but the closer to the peripheries, the more dimunitive become the phenocrysts, and at the boundaries they show light gray, aphanitic chilled margin. In the chilled margin silicification and pyritization are observed.

(iii) Aplite (Ap) and pegmatite (Pg)

The aplite appears as NS-oriented dikes, less than 5 m in width, at the southeast corner and the southeast extremity of the area. All of the aplite is light gray to light pink and fine-grained. The main component minerals are quartz, plagioclase, potash feldspar, and muscovite. The aplite found at the southeast corner is accompanied by pegmatite.

The pegmatite, in addition to appearing as dikes with the maximum width of 5 m in the southwest of the area, occurs as large boulders at various parts of the area. Most of it is tourmaline-muscovite pegmatite, but at times the pegmatite contains beryl, and locally lacks tourmaline.

The pegmatite of the biggest scale in the area is NS-oriented tourmaline-muscovite pegmatite, 5 m in width, which accompanies aplite at the southeast corner. The other pegmatite dikes have a width of 0.2 to 0.5 m; they lie in either of the two directions: NNE or ENE.

(iv) Basalt (Ba)

This rock is found in the form of a small dike in the NNE direction with 1~2 m in width, intruded into the medium- to coarse-grained biotite granite in the lowest reaches of a tributary of the Hat River on its north. It is dark gray, and fine-grained; its main components are pyroxene, plagioclase, and opaque minerals. Although the time of its formation is not definitely known, it is presumed to be of Triassic age.

(v) Alluvium (a)

The Quaternary alluvium, distributed in lowlands along the Hat River and its tributaries, mainly composed of gravels and sand of granitic rocks and quartz veins.

(2) Geological Structure

The medium- to coarse-grained biotite granite distributed in this area has the feature of foliation due to biotite. Here also seen is the development of fracture systems indicated by dikes, pegmatite veins, quartz veins, and lineaments known from aerial photographs.

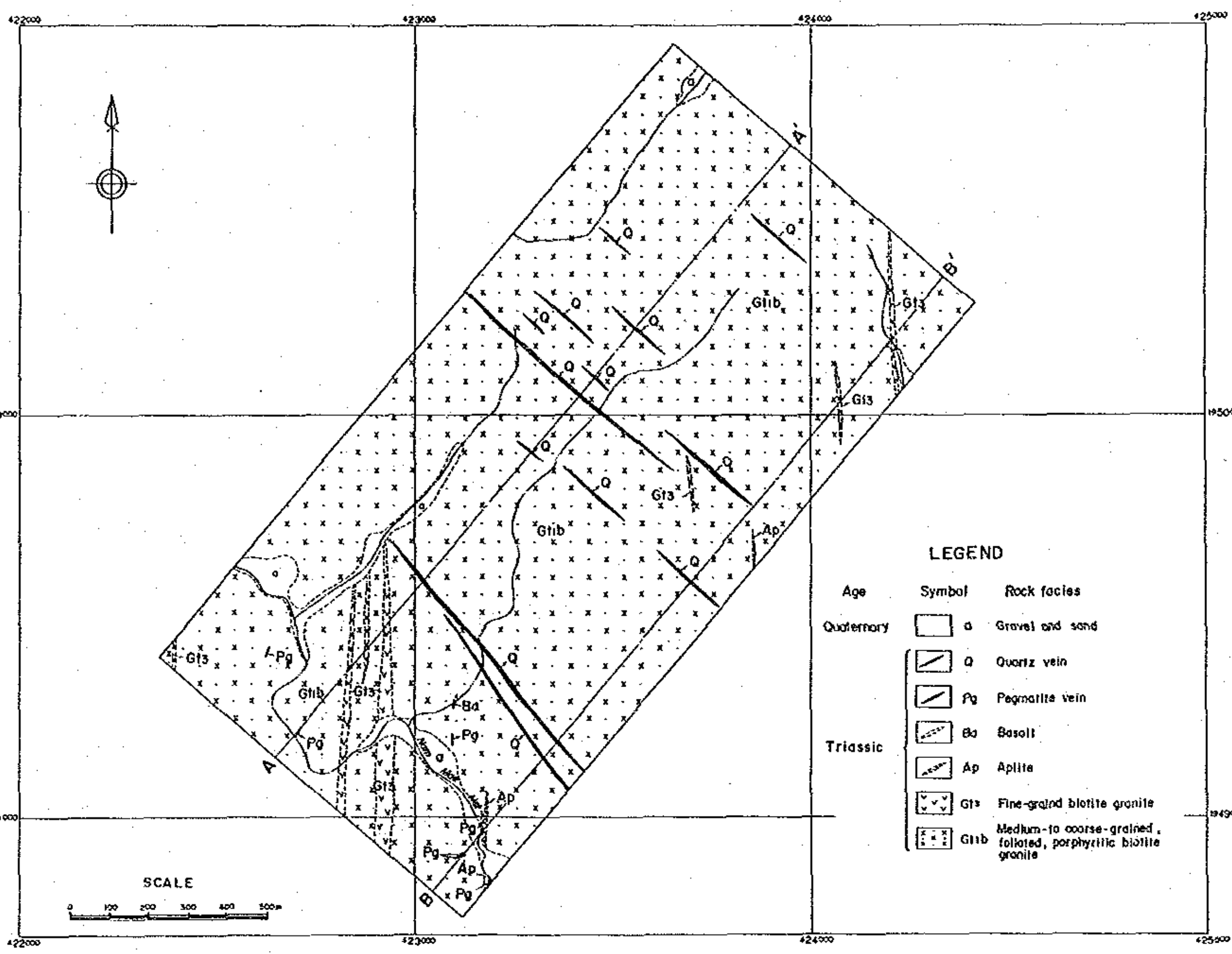
Most of the foliation has the orientation of NS to NNW and a medium to steep dip toward the northeast. This nearly concurs with the direction of the intrusion of the medium- to coarse-grained biotite granite bodies.

The fracture systems are roughly divided into the directions of NS to NNE, NW, ENE and NE. The NS to NNE direction is the direction of the intrusion of dikes of fine-grained biotite granite, aplite dikes, and some of the pegmatite dikes, and corresponds with the direction of the regional intrusion of the medium- to coarse-grained biotite granite bodies.

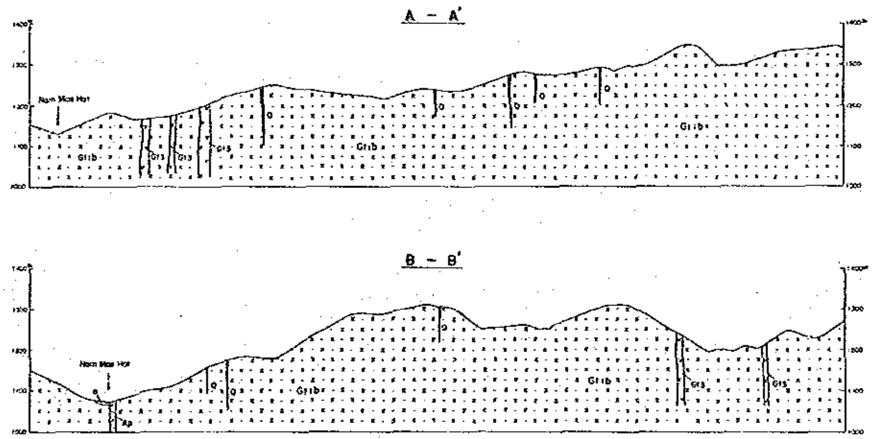
The fractures in the NW direction, which is the direction of the intrusion of quartz veins, are developed at various parts of the area, and form a major fracture system in the area.

The fractures in the NNE direction, which is the direction of the intrusion of pegmatite veins, appear less frequently.

The fractures in the NE direction, which is the direction of the intrusion of 1- to 3 cm-wide



Geologic map



Geologic profile

Fig. 25 Geologic Map of the Area C

quartz veins, appear only locally as outcrops, but the lineaments known by the aerial photographs are developed in this direction as well.

(3) Alteration

In this area, except for weathering, sericitization, chloritization and silicification owing to hydrothermal process are found. The sericitization and chloritization is recognized in medium- to coarse-grained biotite granite in the surroundings of NW-oriented quartz veins developed in the area. The biotite in the medium- to coarse-grained biotite granite along quartz veins has been entirely replaced by sericite or chlorite; and notable schistose structure parallel with the veins is found.

At parts where sericitization is most intense, the medium- to coarse-grained biotite granite presents an appearance which might be called gray sericite schist over a width of about five meters from the quartz vein.

The silicification is recognized at some parts of the surroundings of NW-oriented quartz veins and at the circumferences of the fine-grained biotite granite dikes.

At the silicified parts of the medium- to coarse-grained biotite granite, the original rock, occasionally remains in the breccia form. The circumferences of fine-grained biotite granite dikes present the original chilled margin, but they have been intensely turned grayish white and aphanitic. The silicification is accompanied by trace amount of pyrite and chalcopyrite.

(4) Mineralization

Pegmatite veins and quartz veins are found in the area. Most of the pegmatite veins are tourmaline-muscovite pegmatite, and some of them at the southeast corner of the area have a width of about 5 m. Large boulders containing beryl, about 2 cm in diameter, are found in the southeast of the area.

The quartz veins are mainly formed of fine-grained quartz; and tourmaline, muscovite, and biotite are found very rarely. Almost all the quartz veins in this area are NW-oriented; the biggest ones have a 10 m width and strike extension of more than 700 m; they have caused sericitization, chloritization and silicification to the country rock.

The silicified parts of the medium- to coarse-grained biotite granite and fine-grained biotite granite are disseminated with very small quantities of pyrite and chalcopyrite.

In the area niobium-tantalum minerals, cassiterite, wolframite and scheelite were not found megascopically in any of the outcrops of pegmatite veins or quartz veins or their boulders. So that, to complement the geological mapping, heavy minerals in stream sediment of a tributary of the Hat River on its north were collected, and a study was made of the kinds of the minerals and the contents of niobium; tantalum, tin, and tungsten in the stream sidement.

As the result, as heavy minerals, besides orange-colored garnet and tourmaline, extremely small quantities of columbite-tantalite, struverite-ilmenorutile, cassiterite, wolframite, scheelite, monazite, xenotime, zircon, rutile, ilmenite, and magnetite were confirmed. However, the contents of niobium, tantalum, tin, and tungsten in the stream sediment obtained from chemical analysis values of the bulk heavy minerals were found extremely low.

7–3 Geochemical Prospecting

(1) Sampling

Four hundreds and thirty-nine samples were collected in Area C and analized for the same elements as in the cases of Areas A and B.

The spacing between sampling lines was 100 m and the interval between sampling points was 50 m as same as Area B. The direction of sampling lines was decided to be laid in NE–SW direction to effectively pick out the major fracture system in the NW–SE direction.

(2) Chemical Analysis

(i) Pathfinder Elements

Since it was at the stage of semi-detailed survey, four elements of niobium, tantalum, tin and tungsten were selected for pathfinder element as same as Area A and Area B.

(ii) Method of Analysis

The analytical method was same to Area A and Area B.

(3) Nature of Soil

Light brown sandy soil predominates in this area reflecting the bedrock.

(4) Classification of Geochemical Anomaly Values.

The classification of geochemical anomaly values of each pathfinder element were made according to the standard of Area A and Area B.

However, for the anomaly zones for niobium and tin, since the standard deviation of these two pathfinder elements is smaller than that in the other two areas, the anomaly zones were only divided by the approximate value of the values of $M + 3\sigma$ into the low anomaly zones and the moderate anomaly zones. The detail of the above-mentioned is set forth in Table 10.

Table 10 Classification of Geochemical Background and Anomaly Zones (Area C)

ppm

Area	Element	Background		Anomaly		
		Low	High	Low	Moderate	High
	Nb	– 24	25 – 29	30 – 41	42 –	
	Ta	– 3	4 – 5	6 – 9	10 – 15	16 –
	Sn	– 25	26 – 29	30 – 38	39 –	
C	W	– 7	8 – 14	15 – 25	26 – 46	47 –

(5) Distribution of Geochemical Anomaly Area

On the basis of the classification of geochemical anomaly in the preceding section, anomaly areas of each element were picked out, as shown in Fig. 26.

Small-scale low anomaly areas for all the elements are scattered and sporadic moderate to high anomaly values are found at places but are not concentrated. Distribution of anomaly area shows no correspondence with geology and geological structure.

(i) Niobium:

Small-scale low anomaly areas are scattered. Moderate anomaly areas are situated in the western end and the southern end.

(ii) Tantalum:

Small-scale low anomaly areas are scattered. Only a high anomaly area is located in the western end.

(iii) Tin:

Small-scale low anomaly areas are scattered. So much higher anomaly area is in half of this area. Most of moderate anomaly value are distributed in spot.

(iv) Tungsten:

Low and moderate anomaly areas are scattered in the northeastern part. High anomaly value is observed in only 3 points.

(6) Evaluation of Geochemical Anomaly Area.

Of all these elements small-scale anomaly areas are only scattered without any concentration. Quartz veins and pegmatite veins are found. However, they show no mineral indication and the contents of the elements in stream sediment are low. Therefore there is little posibility of occurrence of mineralized zone.

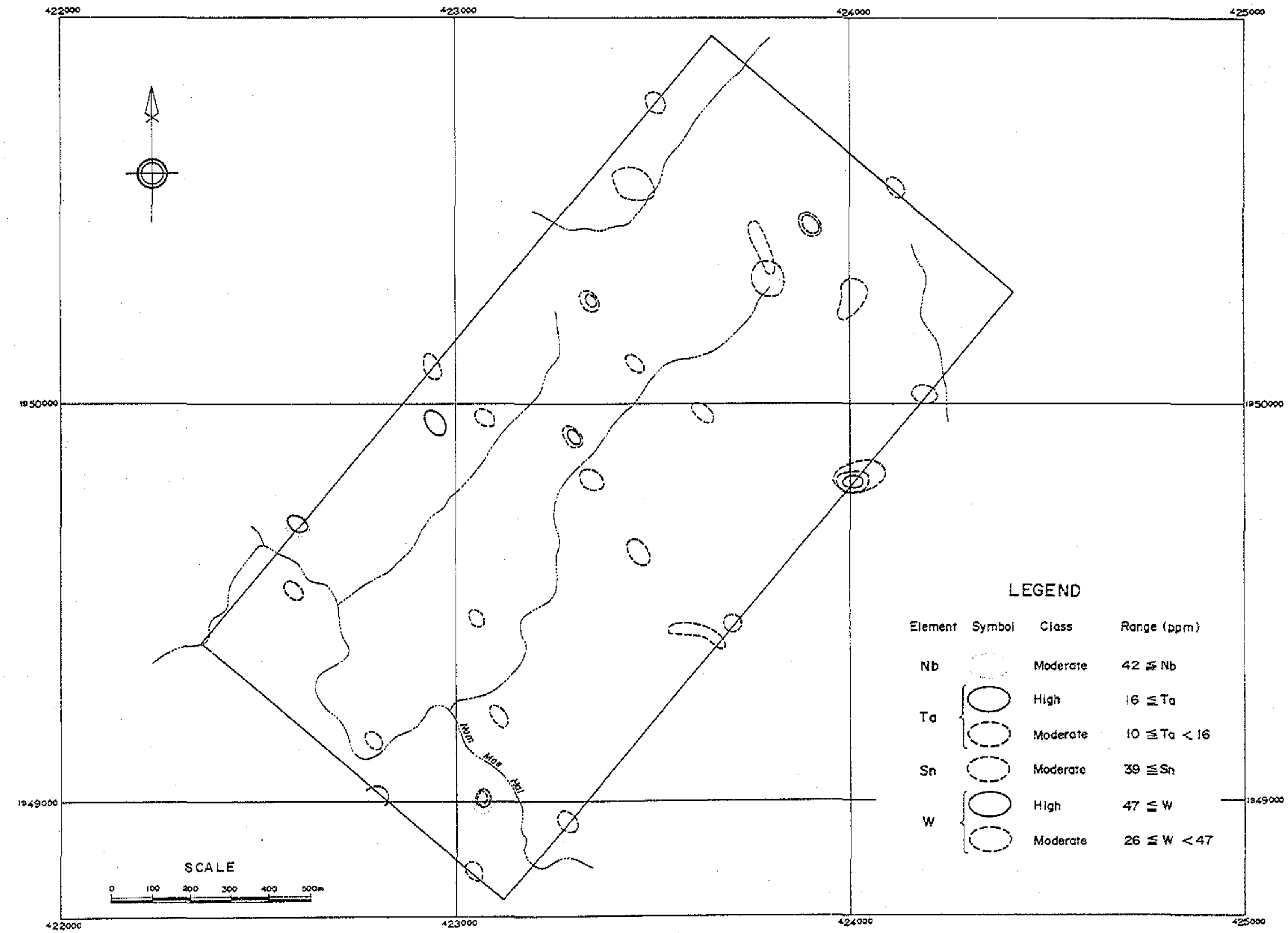


Fig. 26 Geochemical Anomaly Map of the Area C

CHAPTER 8 CONCLUSION AND RECOMMENDATION

CHAPTER 8 CONCLUSION AND RECOMMENDATION

8–1 Conclusion

In this Survey, regional geological survey and geochemical prospecting by stream sediment were made in the first phase, detailed geological survey and geochemical prospecting by soil in the second phase, and geological survey by trenching and drilling survey in the third phase. In this course, the scopes of the surveys were narrowed down to more promising areas, and the following conclusion was formed.

1) Through the lithostratigraphic classification of various rocks in the whole Survey Area and the age determination of granitic rocks, the stratigraphy has been established. In particular, the areas where Triassic and later granitic rocks are distributed were delineated, and it was revealed that those are of tin granite.

2) There are primary and secondary ore deposits of tin and tungsten in the Survey Area; it has been found that the principal mineralized veins lie in the NW–SE direction, which is in harmony with the main geological structure of the Survey Area.

3) As the results of the surveys of Phase I and Phase II, the four areas of A_1, A_2, B_1 and B_2 were picked out, and drilling survey and trenching survey were carried out in these areas. These survey have lead to the following conclusion.

(i) Area A_1

Mineral indications are found in tungsten-containing quartz veins and pegmatite veins intruded in biotite granite.

Those indications are scattered in this area with limited continuity.

(ii) Area A_2

Muscovite-biotite granite, the country rock, has high tin contents of 30 to 80 ppm. Thus they may be metallogenetically specialized tin granite, but no mineralized vein are found.

(iii) Area B_1

A large number of pegmatite veins are found, and it is brought to light that the niobium and tantalum geochemical anomalies derive from them, but none of them indicates so much high content as to be called mineral indication. The pegmatite has been altered into white clay.

(iv) Area B_2

Tungsten-containing quartz veins and clac-silicate rock which are intruded or interlaid along the gneissic structure of biotite paragneiss are found at several places. Those mineral indications show WO_3 contents in the extent of 0.48~1.56%.

8–2 Recommendation

In Area B_2, the confirmed tungsten-mineralized veins and those floats of calc-silicate rock, quartz vein and skarn are arranged in the NW–SE direction which is the trend of the main mineralized veins. This evidence suggests that there still are possibilities of emplacement of undiscovered mineralized veins in the area.

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