CHAPTER 3 AREA A

3–1 Location

As shown in Fig. 1, the Area A is about 15km west-northwest of Omkoi, encompassing an area of 7.5km² centered approximately on 17° 52'N latitude and 98° 14'E longitude.

Two major streams in the area, the Huai Sa Ngin in the east and Huai U Tum at the western edge flow to the north with many tributaries trending E-W to NW-SE. Topography of the surveyed area is steep mountainous terrain ranging 1,100∿1,500m in height, with relative relief of 400m. The mountain system trends mainly N-S.

An unpaved road connecting Omkoi to Mae Khong to the southwest passes through Area A from NE to SW. Distance from Omkoi to the area is about 25km, and can be negotiated in about 1½ hours by 4 wheel drive vehicle in the dry season. However, the road is almost completely impassable in the rainy season.

Results of geochemical prospecting (stream sediments) during the 1st phase indicate overlapping zones of chemical anomaly for niobium, tantalum, tin and tungsten. Niobium and tantalum in particular exhibit a zone of high anomaly (Huai Sa Ngin ∿ Huai U Tum geochemical anomalous zone) and it is considered highly possible that the zone contains ore deposits.

3–2 Geology and Ore Deposits

3–2–1 Geology

The area corresponds to the center of the Triassic granite batholith (northeast granite mass) widely distributed in the northeastern Yang Kiang area. The entire Area A is covered by granitic rock, except for minor alluvium along streams (Fig. 25).

Granite is composed of K-feldspar bearing porphyritic biotite granite, fine to medium grained two mica granite, pegmatite and aplite. Biotite granite is thought to be the result of activity occurring during the Triassic, and two mica granite and dike rocks during the Cretaceous.

1. Medium to Coarse Grained K-Feldspar Porphyrite Bearing Biotite Granite

This rock is distributed widely in the south and northeast, and characteristically contains megaphenocryst of K-feldspar 1-5cm in size. Weathering is generally significant, and soilization at the surface has progressed.

Localized distribution of gneissose facies with oriented biotite is observed along the Huai Sa Ngin, which flows northward in the east of the area. Massive facies prevail in most of the remaining area. An isotopic age of 73 ± 1.5Ma was determined by the K/Ar method for this rock

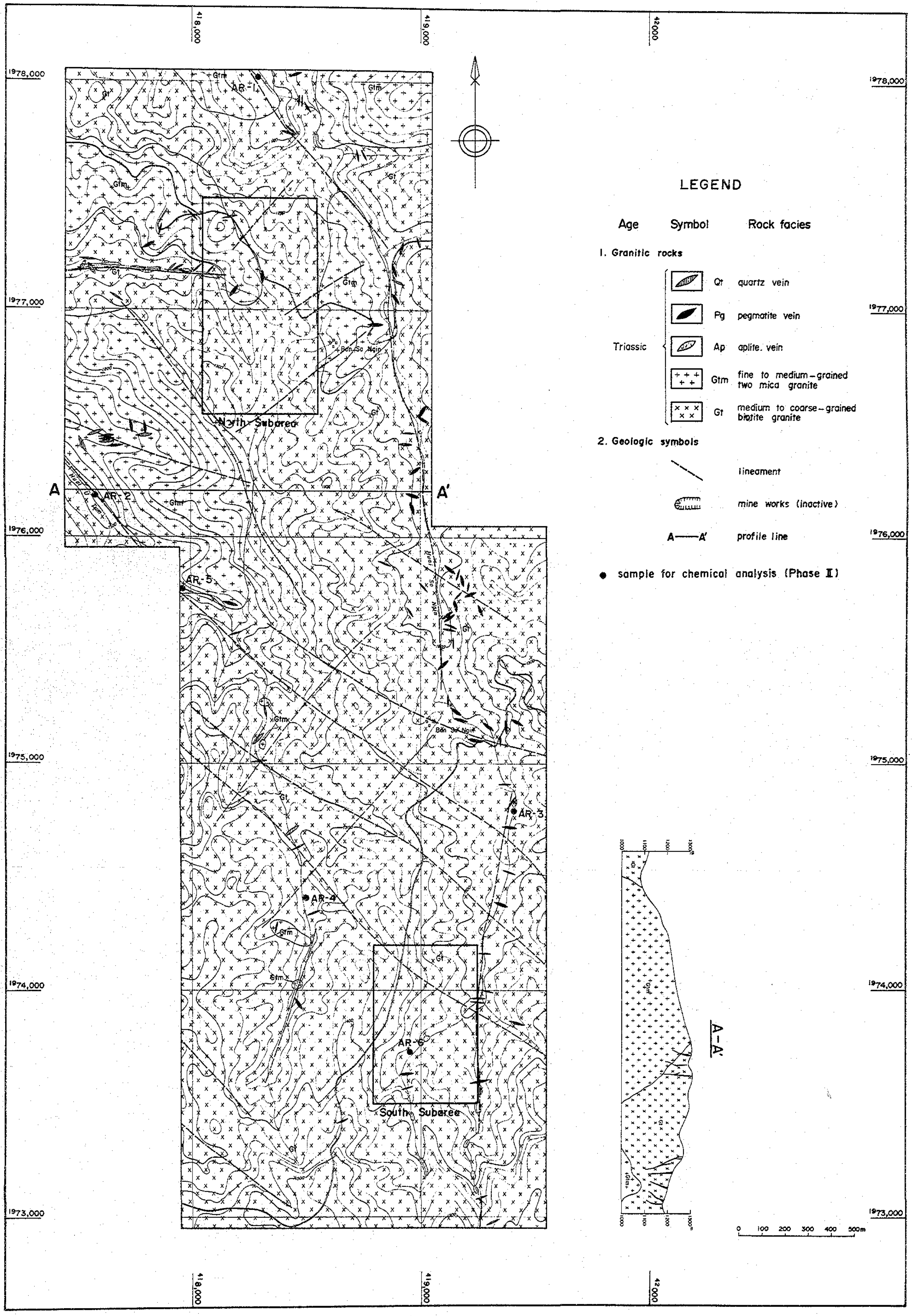


Fig.25 Geologic map and profile (Area A)

under the phase I geologic survey.

Primary rock forming minerals are quartz, K-feldspar, plagioclase and biotite. Zircon, apatite and opaque minerals occur as accessories. Ilmenite is the opaque mineral, and amounts are minor. Fine muscovite replacing plagioclase, chlorite along the outer rim and cleavage of biotite, and leucoxene replacing muscovite and ilmenite are the secondary minerals observed.

2. Fine to Medium Grained Two Mica Granite

This rock is distributed in the north and northwest of the area, and occurs as small masses in the biotite granite. The porphyritic texture of K-feldspar commonly observed in the biotite granite is not strongly evident.

Primary rock forming minerals are quartz, K-feldspar, plagioclase, muscovite and biotite. There are cases where the primary muscovite occurs in quantities equal to or exceeding that of the biotite. Secondary minerals are the same as for biotite granite, being minor amounts of muscovite and biotite replacing plagioclase and leucoxene replacing ilmenite.

3. Pegmatite and Aplite

These rocks occur sporadically as dikes several centimeters to several meters wide. The size and density of distribution tend to increase in and around the biotite granite area rather than the area of two mica granite.

The prevailing trend of the dike swarm is E-W in the southern part of the area, and three trends, N-S, NW-SE and NE-SW prevail in the northern part of the area.

The main rock forming minerals are K-feldspar, quartz, plagioclase and muscovite. Tourmaline, garnet, zircon, monazite, rutile and beryl are the accompanying main accessory minerals, and a small amount of cassiterite and columbite-tantalite series minerals are found in some samples.

Rocks are poorly exposed in the area, and observed outcrops of pegmatite are limited to the area along streams. Nevertheless, the presence of pegmatite boulders at various locations suggest that hidden pegmatite veins exist in the area.

3–2–2 Geologic Structure

Phase I geologic survey identified major trends of geologic structure in the region of NW-SE, NE-SW and N-S.

Specifically, the structural trend of sedimentary rock and prevailing fracture system trend are NW-SE. The NE-SW and N-S trend directions are considered to be secondary.

The geologic structure in the area closely reflects the above discussed regional trends. The distribution of two mica granite, the orientation of dike swarm intrusion and the direction of lineaments indicated by drainage system anomaly and alignment of saddles on ridges indicate NW-SE, NE-SW and N-S trends for geologic structure.

The NW-SE structural system includes the direction of the longer axis of two granite distribution, the direction of the straight valley of the Huai U Tum to the north outside the area, and the orientation of straight valley ∿ mountain system saddles.

The NE-SW structural system is expressed by the direction of extension of mountain system saddles.

The N-S structural system is represented by the straight valley of the Huai Sa Ngin and the direction of extension of the mountain system.

Furthermore, dikes and quartz veins, considered to be clear indicators of fracture systems, trend NW-SE ∿ E-W, NE-SW and N-S. These systems correspond well to the development of lineaments in the surrounding area.

3–2–3 Alternation

With the exception of weathering, the common alterations observed are plagioclase in the medium to coarse grained K-feldspar bearing porphyritic biotite granite being altered to muscovite, and chloritization and muscovitization of biotite. Muscovitization is marked in the periphery of pegmatites and aplites, suggesting that pneumatolytic and/or hydrothermal activity genetically related to these dikes may have caused the formation of muscovite. At the northeastern end of the area, biotite granite is partially recrystalized suggesting the possibility of thermal metamorphism.

Plagioclase in the fine to medium grained two mica granite has also been subjected to alteration, although weak in comparison to that occurring in the biotite granite.

3–2–4 Ore Deposits and Mineralization

In the area, there are three known ore deposits: 2 locations (A-1, A-2) along the Huai Sa Ngin and 1 deposit (A-3) along the Huai U Tum. These are all small scale, secondary deposits in tin bearing sand and gravel bed, and have been worked.

A-1 and A-3 deposits were worked for about one year circa 1980, by 10∿20 workers producing 2t/mo of shipping grade ore. The A-2 deposit has been reportedly worked by the local people, but without success. Primary tin deposits have not been found as yet in the area.

Supplemental geologic survey was performed by panning of heavy minerals along major streams and in stream sediments and pegmatite veins to study mineral composition and content (Table 9). As a result, cassiterite and scheelite were found in most to the area. In particular, a concentration of mineral indication (A-4 and A-5) was seen at the middle reaches of the Huai Sa Ngin and tributaries of the Huai U Tum (Fig. 26).

Details of existing ore deposits and mineral indications are given below.

1. A-1 (ore deposit)

This ore deposit is located at the lower catchment of the Huai Sa Ngin in the northeast of the area. Old workings of 30 X 20m or less are scattered in a 500 X 100m area centered on soil sampling point X3, Y0.5.

Ore deposits are contained in tin bearing sand and gravel bed, 1 to 2m thick, along the Huai Sa Ngin. Cassiterite is the main ore mineral accompanied by and minor amounts of scheelite and columbite-tantalite. Vein ore is composed mainly of garnet and zircon. Results of analysis of panning samples (O-1, O-2), as shown in Table 9, indicate the following grades of crude ore: SnO_2 : 27∿30g/m^3 ; WO_3 : 0∿1g/m^3 ; Nb_2O_5 : 1g/m^3 ; and Ta_2O_5 : 2g/m^3 .

A number of pegmatite veins, less than 3m in width, intrude into the biotite granite in the vicinity of the above ore deposits, or upstream thereof. Trend of intrusion is NW-SE∿E-W and N-S. Although no tin, tungsten, etc. was discerned by naked eye observation, small to extremely small amounts of cassiterite were found in the heavy mineral concentrate by panning. These pegmatite veins are considered to be the source of the mineral deposits.

2. A-2 (ore deposit)

This ore deposit is located at the upper reaches of the Huai Sa Ngin at the southeast of the area. Small scale, old workings of 10 X 30m or less are scattered around soil sampling points X44∿49, Y17.5 and X42∿48, Y15 along the Huai Sa Ngin and its tributaries.

Ore deposits are contained in tin bearing sand and gravel bed, 1 to 2m thick, along the stream. Deposits stretch 2∿4m laterally across the river. Cassiterite is the main ore mineral accompanied by a minor amount of scheelite. Vein ore is composed mainly of garnet and zircon. Distribution of observable pegmatite veins around the ore deposits is small, suggesting that ore minerals were either transported from upstream or originated from as yet undiscovered pegmatite veins nearby.

3. A-3 (ore deposit)

This ore deposit is located at the upper reaches of the Huai U Tum in the northwest of the area. Small scale, old workings of 10 X 50m or less are scattered in an area about 500m along a tributary of the Huai U Tum, centered approximately on soil sampling point X8, Y4.

Ore deposits are contained in tin bearing sand and gravel bed, 1 to 2m thick, along the stream. Deposits stretch 1∿10m laterally across the river.

Cassiterite is the main ore material in the heavy mineral concentrate of stream sediment, accompanied by an extremely small amount of scheelite and columbite-tantalite. Vein ore is

Table 9 Assay of Ore Samples in Area A

No.	Sample No.	Locality	Description	Sn(%)	W(%)	Nb(%)	Ta(%)	Raw material (ℓ)	Heavy mineral (g)	SnO_2 (g/m³)	WO_3 (g/m³)	Nb_2O_5 (g/m³)	Ta_2O_3 (g/m³)
1	AO–13	Huai Sa Ngin (X11, Y14)	weathered pagmatite	9.03	0.40	0.43	0.99	100	5	5.7	0.3	0.3	0.6
2	AO–20	Huai Sa Ngin (X25, Y16)	weathered pegmatite	1.87	0.41	0.43	0.91	50	2	1.0	0.2	0.3	0.4
3	AO–31	Huai Sa Ngin (X31, Y19)	stream sediment	55.8	0.54	0.74	2.93	100	22	155.9	1.5	2.3	7.9
4	AO–43	Branch of Huai U Tum (X6, Y5)	weathered pegmatite	14.4	0.25	2.38	2.77	30	10	60.9	1.1	11.3	11.3
5	AO–57	Branch of Huai U Tum (X8, Y1.5)	stream sediment	46.9	0.89	1.08	2.52	40	32	476.3	9.0	12.3	24.6
6	AO–70	Branch of Huai U Tum (X47, Y9.5)	stream sediment	66.5	3.10	0.79	4.78	70	4	48.1	2.2	0.6	3.3
7	O–1*	Huai Sa Ngin (X1, Y8.5)	stream sediment	6.49	0.08	0.28	0.36	30	10	27.4	0.3	1.3	1.5
8	O–2*	Huai Sa Ngin (X2, Y8.5)	stream sediment	11.3	0.32	0.35	0.57	30	8	38.3	1.1	1.3	1.9
9	O–3*	Branch of Huai U Tum (X8, Y3.5)	stream sediment	17.2	0.35	0.33	0.56	25	15	131.0	2.6	2.8	4.1
10	O–4*	Branch of Huai U Tum (X8, Y3)	stream sediment	1.92	0.27	0.22	0.35	60	10	4.1	0.6	0.5	0.7

* from the phase I survey

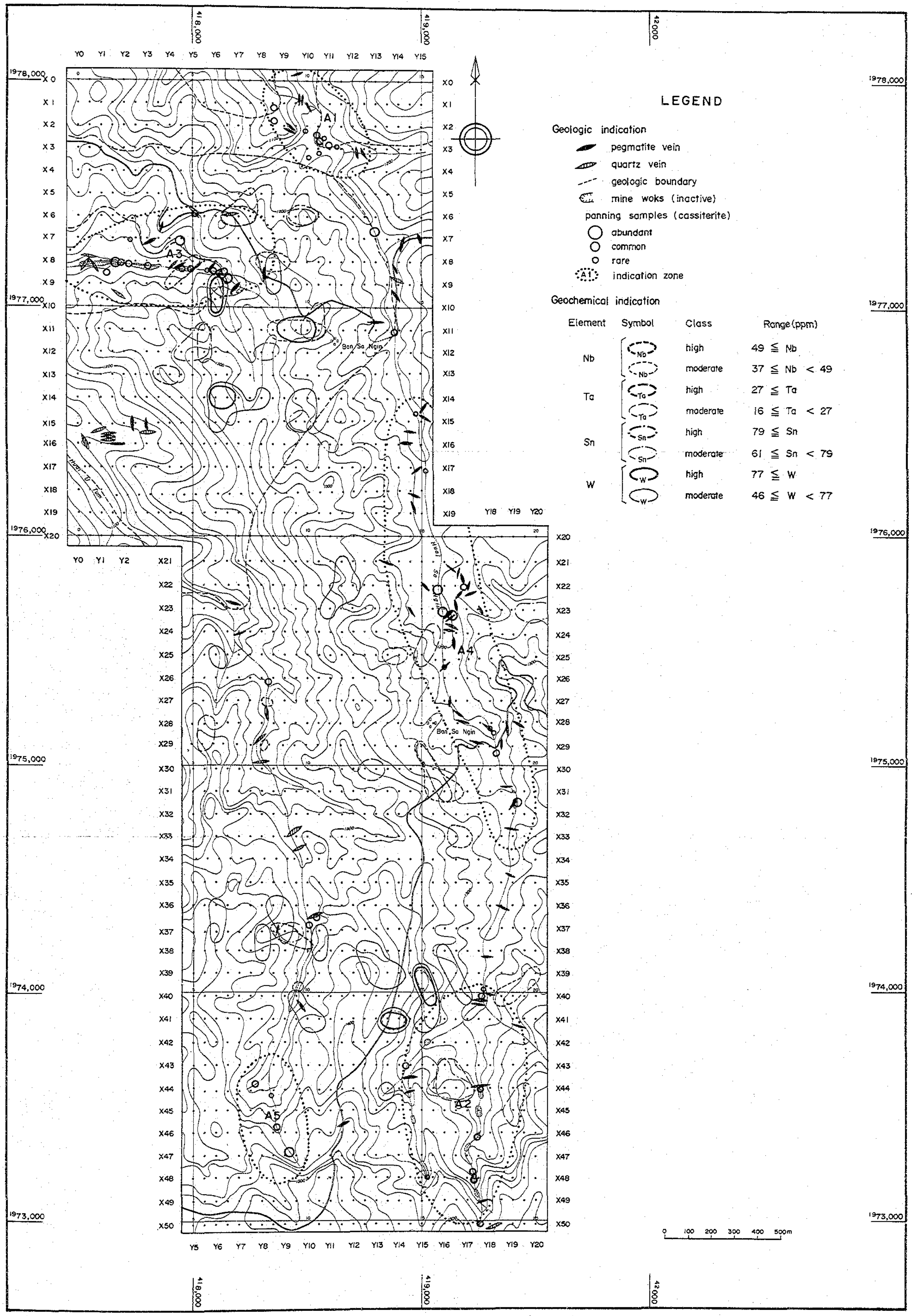


Fig.26 Mineral indication map (Area A)

composed mainly of garnet. As shown in Table 9, results of anlysis of panning samples (AO-57, O-3, O-4) indicate the following grades of crude ore: SnO_2: 4∿476g/m^3; WO_3: 1∿9g/m^3; Nb_2O_5: 1∿12g/m^3; and Ta_2O_5: 1∿25g/m^3. In comparison with other ore deposits and mineral indications, ore content is high, with Ta_2O_5 being of particularly high grade.

A number of pegmatite and quartz veins, less than 1m in width, intrude into the biotite in the vicinity of the above ore deposits, or upstream thereof. Trend of intrusion is NW-SE, and NE-SW. Some of these veins contain 1cm long crystals of beryl. The heavy mineral (AO-43) from the veins shows relatively high content of cassiterite and columbite-tantalite. As shown in Table 9, results of analysis indicate the following grades of crude ore: SnO_2: 61g/m^3; WO_3: 1g/m^3; Nb_2O_5: 11g/m^3; and Ta_2O_5: 11g/m^3.

Although tourmaline is present in quartz veins, ore minerals are not identified on the basis of naked eye observation.

4. A-4 (mineral indication)

This zone is located at the middle reaches of the Huai Sa Ngin and encompasses soil sampling points X14, Y14 and X38, Y19. A2 ore deposits are located 2 km upstream, and A1 deposits 2km downstream.

Numerous pegmatite veins, less than 2m in width, intrude the biotite granite. Trend of intrusion is N-S, and NW-SE. Cassiterite is the main heavy mineral ore, accompanied by an extremely small amount of scheelite. Vein ore is composed mainly of garnet. As shown in Table 9, results of analysis of panning samples (AO-31) indicate the following grades of crude ore: SnO_2: 156g/m^3; WO_3: 2g/m^3; Nb_2O_5: 2g/m^3; and Ta_2O_5: 8g/m^3.

Heavy minerals in the pegmatite are garnet, cassiterite, zircon, and beryl, in some cases accompanied by minor amounts of columbite-tantalite, monazite, xenotime, rutite, and anatase. As shown in Table 9, results of analysis of panning samples (AO-13, 20) indicate low values for tin, tungsten, niobium, and tantalum.

Consequently, ore minerals in the stream sediment are considered to be derived from pegmatite veins in the vicinity or from upstream.

5. A-5 (mineral indication)

This zone is located at the upper reaches of a tributary of the Huai U Tum, and covers the area encompassing soil sampling points X43, Y8∿X47, Y10.

Ore minerals among the heavy minerals in stream sediment are mainly cassiterite accompanied by lesser amounts of scheelite. Vein minerals are composed of garnet accompanied in some cases by monazite and zircon. As shown in Table 9, results of analysis of panning samples (AO-70) indicate the following grades of crude ore: SnO_2: 48g/m^3; WO_3: 2g/m^3; Nb_2O_5: 1g/m^3; and

Ta_2O_5 : 3g/m^3.

In and around the zone, the number of obvious pegmatite veins are limited, and the ore minerals in stream sediment are thought to have derived from adjacent areas or as of yet undiscovered pegmatite veins.

3–3 Geochemical Prospecting by Soil

3–3–1 Survey Method

1. Sampling and Preparation

Soil samples from the B-horizon were collected by the rectangular grid system. Sampling lines were spaced at 100m intervals, and sampling points were set at 50m intervals on the lines.

The prospecting area was set along the Huai U Tum and Huai Sa Ngin in order to cover the anomalous zones for niobium, tantalum, tin, and tungsten, identified in the phase I survey as lying in the direction NNW-SSE from Huai Chi Non (Area B) to Huai U Tum ∿ Huai Sa Ngin (Area A). E-W was selected as the direction of sampling in order to identify ore belts with the above described orientation.

Sampling lines and points were set in accordance with the sampling plan by a simple process using a pocket compass and measuring tape. Although A-horizon varies in thickness 0∿60cm, soil samples from B-horizon were generally obtainable at 20∿40cm from the surface.

Collected soil samples were air dried, sieved, and the -80 mesh fraction was subjected to chemical analysis.

Number of samples was 1,591.

2. Pathfinder Elements and Chemical Analysis

Since the objective of prospecting is the identification of mineral deposits of niobium, tantalum, tin and tungsten, it would be conceivable to consider lithium, beryllium, fluorine and boron also as somewhat effective geochemical pathfinder elements. However, in view of the design precision of this stage of the survey, pathfinder elements were restricted to only those directly indicative of mineralized zones, namely the 4 target minerals themselves: niobium, tantalum, tin and tungsten.

The quantities of these 4 pathfinder elements were chemically analyzed by means of inductively coupled, plasma emission spectrography. Critical detection level is 1ppm.

3–3–2 Analysis of Geochemical Data

1. Classification of Anomalous Values

Mean values and standard deviations were used to decide the threshold values and the subdivisions of the background and anomaly zone.

And the frequency distribution and cumulative frequency distribution histogram were also used to confirm these subdivisions.

Anomaly classifications are shown in Table 10.

Table 10. Division into anomaly value levels in Area A

Division / Element	Background Values		Anomaly Values		
	Low	High	Low	Middle	High
Nb	∿21	22∿28	29∿36	37∿48	49∿
Ta	∿4	5∿8	9∿15	16∿26	27∿
Sn	∿34	35∿45	46∿60	61∿78	79∿
W	∿16	17∿27	28∿45	46 47	77

Unit: ppm

2. Distribution of Zones of Geochemical Anomaly

Analytical values were divided into 5 levels on the basis of classifications for geochemical anomaly as discussed in the previous section. These were plotted on a topographical map, and zones of anomaly were identified (Fig. 26). Distribution of zones of anomaly is discussed below.

Although there are no distinct large scale anomalous zones for any of the pathfinder elements, each element exhibits a number of small scale zones occurring in clusters.

Anomalous zones for all elements appear to overlap in the vicinity of tributary catchment of the Huai U Tum in the north. Niobium and tantalum show relative overlap in the center to south.

(1) Niobium

Three anomalous zones for niobium are seen in the area.

One zone ranges from line X6 to line X12 at the upper reaches of Huai Sa Ngin. The zone consists of 5 large to small patches of medium anomaly, with irregular contour and maximum anomalous value of 72ppm.

Another zone is distributed at the middle reaches of the Huai Sa Ngin, eastward from line X24 and point Y5 on line X36. It consists of scattered patches of anomaly with maximum value of 52ppm.

A third zone is found at the upper reaches of the Huai Sa Ngin, extending southward from line X39, consisting of small scattered patches of medium to high anomaly.

(ii) Tantalum

The area contains 3 zones of anomaly for tantalum, closely overlapping the anomalous zones for niobium. The zones are of medium to high anomaly.

One zone is centered around a tributary of the Huai U Tum, from line X2 to X16, and is of moderate anomaly. Maximum anomalous value is 35ppm.

Another zone is found in the middle of the area, and consists of several patches of medium to high anomaly from line X27 to X35. These anomalies show NW-SE trending.

The third zone is seen at the upper reaches of the Huai Sa Ngin in the southeast. In particular, a 100 X 150m patch of medium anomaly extends from line X43 to line X44 with maximum value of 31ppm. In addition, small scale anomalies are distributed along the Huai Sa Ngin.

(iii) Tin

Relatively distinct concentrations of anomaly are seen around a tributary of the Huai U Tum in the north and at the middle and upper reaches of the Huai Sa Ngin in the east. In addition, low to medium anomalies are scattered along the Huai U Tum.

At the Huai U Tum tributary, a zone of low anomaly stretches from line X6 to line X16. Within the zone, there are scattered patches of medium anomaly. Maximum anomalous value is 84ppm.

A zone of low anomaly extends south from line X39 at the middle to upper reaches of the Huai Sa Ngin. Patches of medium to high anomaly, with maximum value to 83ppm, are seen within the zone.

(iv) Tungsten

Two relatively distinct, medium to highly anomalous zones are seen.

One is around a tributary of the Huai U Tum and the upper catchment thereof in the north. It consists of 5 small to large patches of medium to high anomaly, with maximum value of 180ppm.

The second is highly anomalous zone in the south, particular in the vicinity of ridges, with maximum value of 260ppm.

3. Discussion

The geochemical exploration revealed that the locations of geochemical anomalies of niobium, tantalum, tin, and tungsten roughly coincide, and are distributed at the topographical upper slope of the known ore deposits and mineral occurrences.

Especially, around the placer deposit in the tributary of Huai U Tum as well as in the middle stream of Huai Sa Ngin, highly anomalous areas of these elements are overlapping in the same area suggesting the possibility of finding promising tin, tungsten, niobium, and tantalum bearing pegmatite in the area.

3–4 Trench Survey

Trench survey was performed to identify distribution of mineral indications in zones of geochemical anomaly found during the 2nd phase survey, clarify mineralization in the survey area and evaluate the ores present.

For each element (niobium, tantalum, tin, tungsten), numerous small zones of geochemical anomaly are widely scattered throughout the area. However, the zones of high anomaly tend to be found in the north and south. An area of high anomaly was selected for each element, and trenches at 2 to 5 locations were excavated in each area. As shown in Fig. 27, 28, trenches are located at 10 sites in the north (T-1∿T-10) and at 10 sites in the south (T-11∿T-20).

Trench dimensions are 1m width, 2m depth and 25m length. Trench axes are N-S. Total trench length is 500m.

3–4–1 Geology

Through this trench survey, many dikes were observed in trenches. Pegmatites are observed in every trenches except T-6. Aplites were only in three trenches, and quartz veins are in five trenches.

The results of trench observations in each anomalous zone are as follows:

(a) Anomalous zones of niobium and tantalum (T–1 to T–3)

Pegmatite veins are composed mainly of feldspar, quartz and muscovite. A number of pegmatites, 10 to 120cm in width, and a small number of quartz veins, 1 to 2cm in width, were seen.

(b) Anomalous zones of niobium and tungsten (T–4, T–5)

Pegmatites, less than 20cm in width, are composed mainly of quartz and feldspar.

(c) Anomalous zones of niobium, tantalum and tungsten (T–6 to T–8)

Pegmatites, 10 to 80cm in width, are composed of mainly feldspar, quartz and muscovite and small amount of tourmaline.

(d) Anomalous zones of tungsten (T–9, T–10)

A few of pegmatites, 10 to 40cm in width, composed mainly of feldspar, and aplite veins, 40 to 200cm in width, were seen.

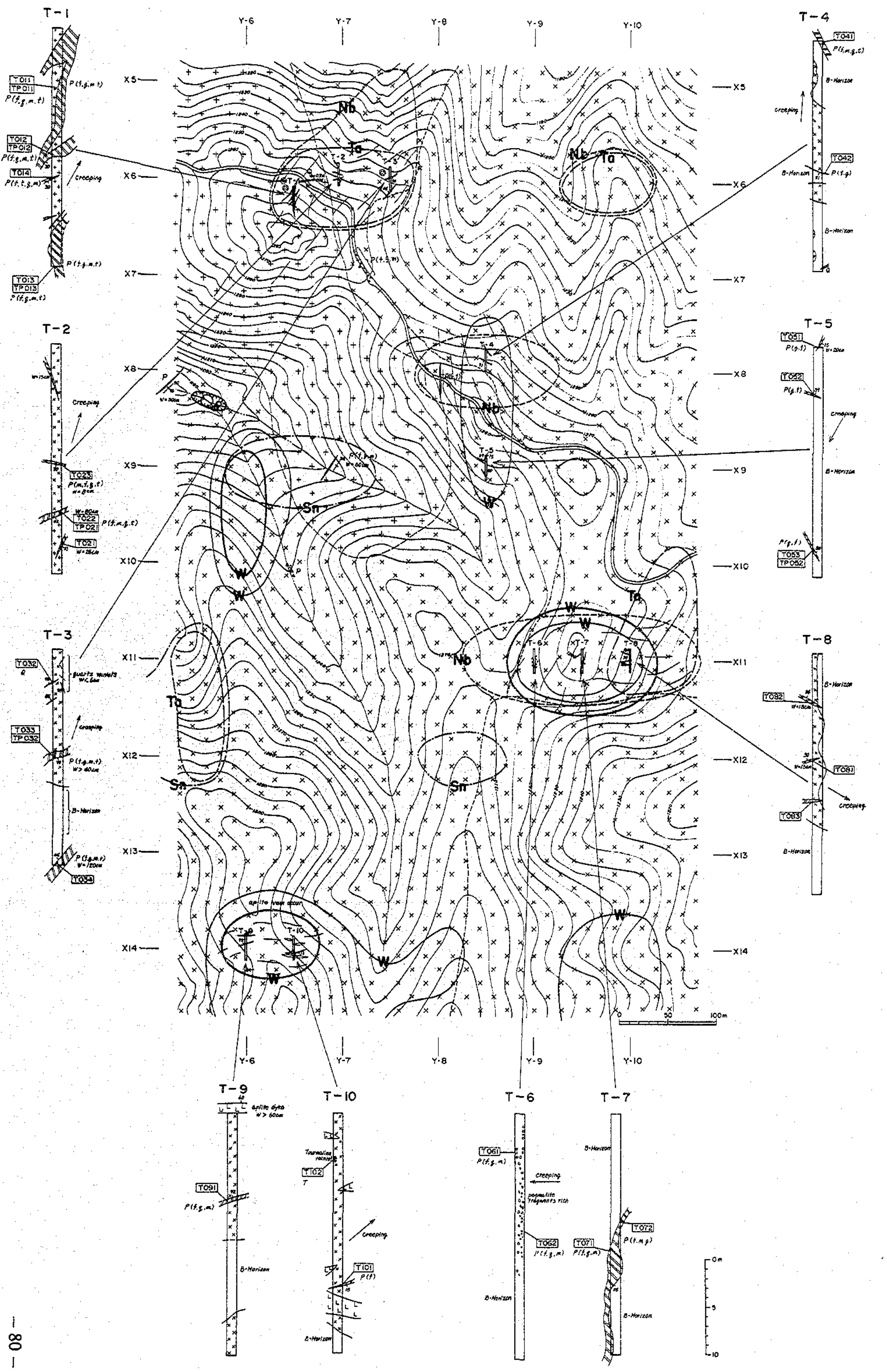
(e) Anomalous zones of tin, tungsten and niobium (T–11, T–12, T–15)

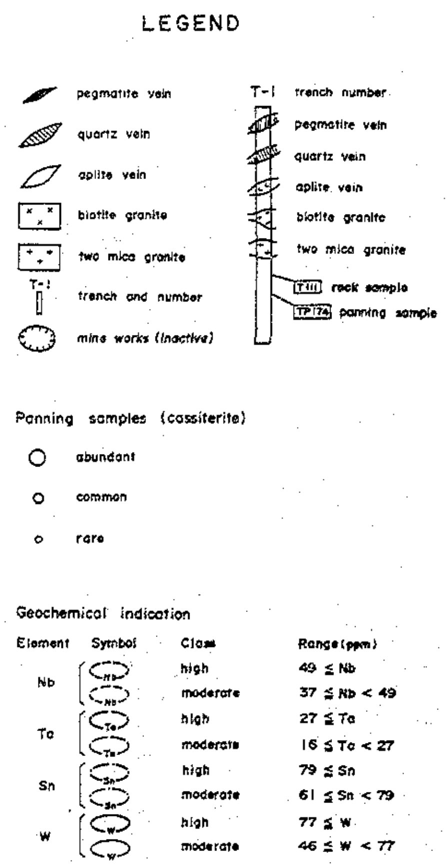
Few pegmatites are seen. Quartz veins and tourmaline veins, 0.5 to 3cm in width, were observed.

(f) Anomalous zones of tin and tungsten (T–13, T–14)

Pegmatites were not seen. Quartz vein, 5 to 20cm in width, were observed.

(g) Anomalous zones of tin and tantalum (T–16 to T–20)



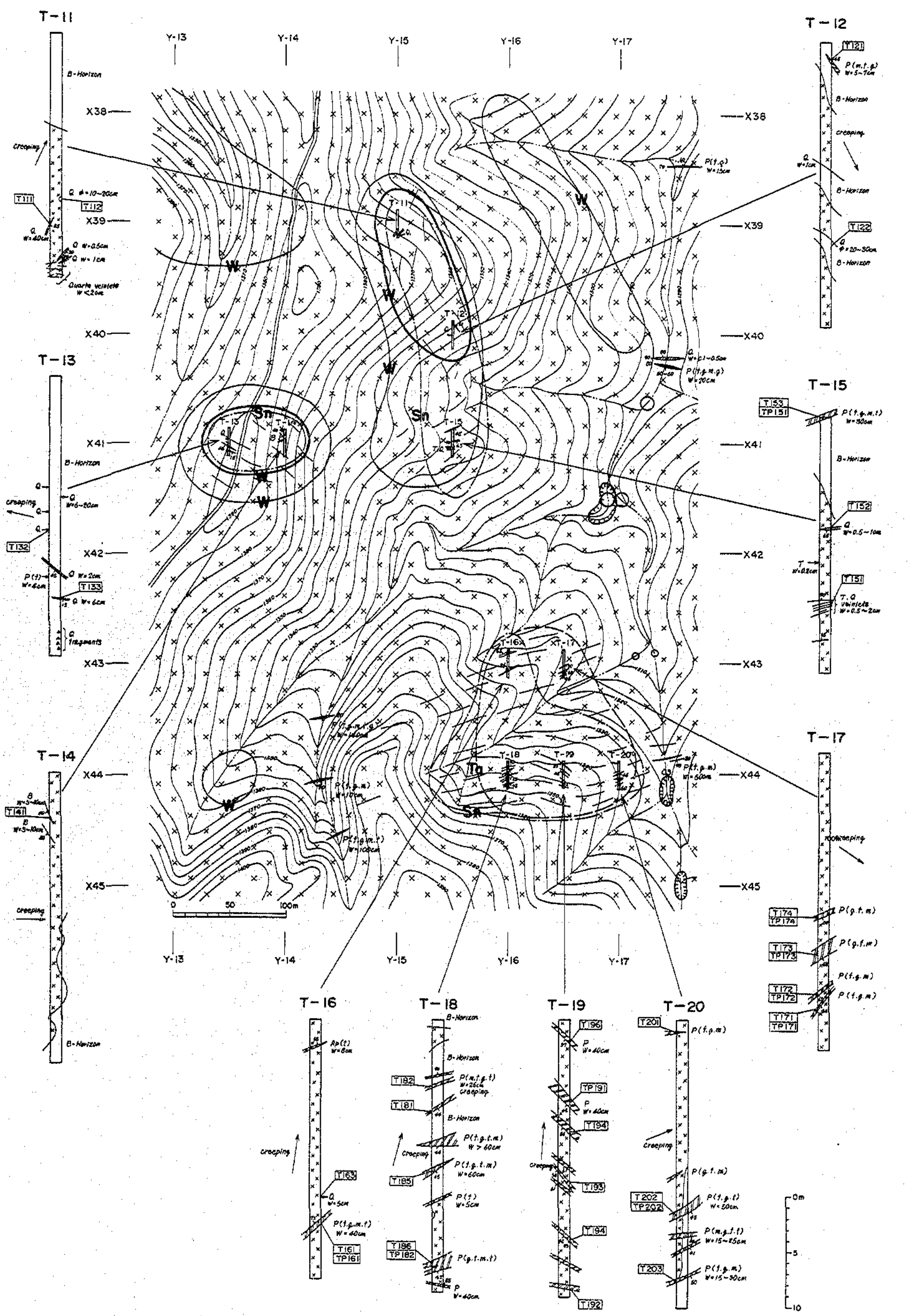


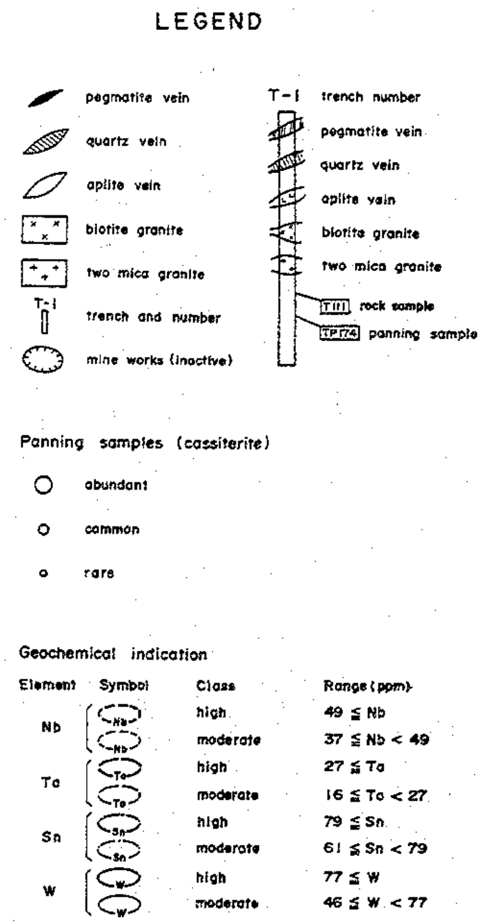
Assay

Sample No.	Sn(%)	W (%)	Nb(ppm)	Ta(ppm)	remarks
T 011	0.004	0.001	40	18	P(f,q,m,t)
T 012	0.005	0.000	35	27	P(f,q,m,t)
T 013	0.004	0.001	32	15	P(f,q,m,t)
T 014	0.005	0.000	15	<10	P(f,t,q,m)
T 021	0.004	0.001	16	<10	P(m,f,q,t)
T 022	0.003	0.001	82	48	P(f,m,q,t)
T 023	0.008	0.001	24	42	P(m,t,q,f)
T 032	0.001	0.001	5	<10	Q
T 033	0.011	0.001	80	41	P(f,q,m,t)
T 034	0.007	0.001	74	57	P(f,q,m,t)
T 041	0.004	0.002	98	31	P(f,m,q,t)
T 042	0.001	0.000	11	<10	P(q,f)
T 043	0.001	0.001	15	<10	P(q,f)
T 051	0.002	0.002	42	25	P(q,f)
T 053	0.003	0.002	15	<10	P(q,f)
T 061	0.003	0.002	21	<10	P(f,q,m)
T 062	0.003	0.002	37	20	P(f,q,m)
T 071	0.002	0.001	74	39	P(f,q,m)
T 072	0.002	0.001	21	11	P(f,m,q)
T 081	0.012	0.002	88	34	P(f,q,m)
T 082	0.002	0.001	12	<10	P(f,q,m)
T 083	0.004	0.001	30	18	P(f,q,m)
T 091	0.005	0.030	23	<10	P(f,q,m)
T 101	0.003	0.006	16	<10	P(f)
T 102	0.003	0.002	21	<10	T

P ; pegmatite vein, Q ; quartz vein or quartz block
T ; tourmaline vein
f ; feldspar, q ; quartz, m ; muscovite, t ; tourmaline

Fig.27 Synthetic map of Trench Survey (north subarea in Area A)





Assay

Sample No.	Sn(%)	W (%)	Nb(ppm)	Ta(ppm)	remarks
T 111	0.001	0.001	4	< 10	Q
T 112	0.003	0.004	6	< 10	Q
T 121	0.013	0.009	170	160	P(m.f.q)
T 122	0.001	0.001	6	<10	Q
T 132	0.001	0.005	3	<10	Q
T 133	0.002	0.011	7	<10	Q(q.t)
T 141	0.007	0.016	21	<10	granite
T 151	0.008	0.016	8	<10	Q(q.t)
T 152	0.004	0.009	12	<10	Q
T 153	0.011	0.009	45	110	P(f.q.m.t)
T 161	0.009	0.004	58	96	P(f.q.m.t)
T 163	0.000	0.000	<1	<10	Q
T 172	0.010	0.007	170	300	P(f.q.m.t)
T 173	0.011	0.004	69	130	P(q.f.m)
T 174	0.009	0.004	76	110	P(q.f.m)
T 182	0.004	0.004	49	37	P(m.f.q.t)
T 185	0.018	0.008	82	200	P(q.f.m)
T 186	0.01	0.005	130	73	P(f.q.t.m)
T 192	0.008	0.002	68	140	P(m.f.q.t)
T 193	0.004	0.004	72	89	P(m.f.q.t.b)
T 194	0.005	0.002	45	25	P(m.f.q.t)
T 196	0.005	0.004	59	20	P(m.f.q.t)
T 201	0.012	0.002	31	32	P(f.q.m)
T 202	0.009	0.005	72	64	P(q.f.m)
T 203	0.008	0.006	70	47	P(f.q.m.t)

P ; pegmatite vein, Q ; quartz vein or quartz block
T ; tourmaline vein
f ; feldspar, q ; quartz, m ; muscovite, t ; tourmaline

Fig.28 Synthetic map of Trench Survey (south subarea in Area C)

A large amount of pegmatites, 20 to 70cm in width, composed mainly of muscovite, quartz, and feldspar, partially accompanied with tourmaline, were seen.

The general features of these dike rocks are as follows:

A large amount of pegmatites are distributed in this area. These pegmatites vary markedly in width from 5 to 140cm, and branch and wind irregularly. Most of them are composed mainly of quartz, feldspar, muscovite and tourmaline, although some have other accessory minerals. Garnet and zircon were detected by panning from pegmatites in the trench. A very small amount of cassiterite, tantalite-columbite, rutile, scheelite, and wolframite were identified by microscopic observation and EPMA qualitative analyses.

A small number of quartz veins, 1 to 10cm in width, and quartz blocks were seen in five trenches. Some of these quartz veins contain tourmaline.

Several aplite veins were observed in T–9 and T–10.

In terms of direction the above dikes were extremely irregular. However, they showed a tendency to strike N60°E to E-W and dip to the south.

3–4–2 Chemical Analyses

Nb, Ta, Sn and W contents of these dikes observed in the trenches were analyzed for studying mineralization (Fig. 27 to 28).

The analytical values of pegmatites is Nb: 11 to 170ppm, Ta: <10 to 300ppm, Sn: 10 to 180ppm, W: 0 to 300ppm.

The analytical values of quartz veins is Nb: <1 to 12ppm, Ta: <10ppm to Sn: 0 to 80ppm, W: 0 to 160ppm.

It is generally recognized that the niobium, tantalum and tin contents of pegmatites are higher than those of quartz veins. On the other hand the tungsten content of quartz vein is higher than that of pegmatites. There are some exceptions.

3–5 Discussion

Based on the geological and geochemical data obtained so far, the geology, geological structure and ore deposits will be discussed hereunder.

Biotite granite and two mica granite both belonging to the Triassic igneous activity cover most of the area, and pegmatite, aplite and quartz vein intrude these granites.

In general, the two mica granite in southeast Asia including Thailand is considered to be the product of biotite granite subjected to pneumatolytic to hydrothermal activity and forming muscovite after biotite (Hutchson 1983).

In this area, muscovitization of biotite is observed along the pegmatite vein intruding the biotite granite. But most of the muscovite in the two mica granite is primary muscovite. Judging from the fact that the porphyritic texture of K-feldspar common in the biotite granite is not recognized in the two mica granite, and the chemical composition of those two granites is not the same, the biotite granite and the two mica granite in this area are considered to be two independent rock masses.

The direct relation between the two granites was not discerned in the field. The occurrence and distribution of the two types of granite suggest that after the formation of biotite granite batholith, the two mica granite intruded as stock, and subsequently pegmatite, aplite and quartz vein intruded into both granites.

The fracture system observed in the Yang Kiang Area is composed of the prominent NW-SE system and subordinate systems of NE-SW and N-S. The trend of lineaments, elongated distribution of two mica granite as well as the intrusive trend of dikes are harmoneous with the regional geological structure suggesting that the geological structure in this area is fully controlled by the regional structure.

In this area the placer deposits and mineral indications of tin and tungsten are found along the main streams. These mineral occurrences are tin and tungsten bearing sand and gravel bed, and belong to the placer deposit type. In this area alluvium is poorly developed so that the ore deposits and mineral occurrences are rather small in scale.

On the other hand, in the upstream of these ore deposits and mineral occurrences, a considerable number of pegmatites are observed in the granitic rocks. The weathered pegmatite was examined by panning and yielded tin, tungsten, niobium and tantalum minerals, suggesting that these ore minerals in the placer deposits in the area have originated from the pegmatites. Noteworthy high grade contents of columbite-tantalite series minerals were found in the ›eryl bearing pegmatite in the tributary of Huai U Tum.

This kind of beryl bearing pegmatite is also observed along the stream of Huai Sa Ngin, suggesting that more undiscovered beryl bearing pegmatite covered by soil may exist in the area.

In general, the pegmatite carrying minerals of berylium, lithium, secium, tantalum, tin and so on, are considered to be formed around the top of the granitic intrusive body at the depth of 3.5 to 4 km in shallow cases and 6 to 7 km in deep cases. When the pegmatite was formed in the intruded country rock it would be within 2 km from the intruding granite body. Following this general principle, the igneous rock genetically related to the ore deposits in this area can be inferred to be the two mica granite now cropping out its top portion of intrusive body.

The geochemical exploration revealed that the locations of geochemical anomalies of niobium, tantalum, tin, and tungsten roughly coincide, and are distributed at the topographical upper slope of the known ore deposits and mineral occurrences.

Especially, around the placer deposit in the tributary of Huai U Tum as well as in the middle stream of Huai Sa Ngin, highly anomalous areas of these elements are overlapping in the same area suggesting the possibility of finding promising tin, tungsten, niobium, and tantalum bearing pegmatite in the area.

Dikes composed mainly of pegmatite were found in most of trenches. Analyses show that niobium, tantalum, tin and tungsten contents of these dike rocks are nearly coincide with geochemical anomalous values except tungsten in the above mentioned anomalous zone (b) and (c), and tin in (f). This fact indicated that geochemical anomalies originate from pegmatites.

In the trench T–16 to T–20, many pegmatites were observed. These pegmatites contain twice to five times as much tin, niobium and tantalum as those in other trenches. The maximum value of tungsten content of pegmatite in trench T–9 is 300ppm. However, these are not enough to be exploited as a primary ore deposit.

Around trenches T–16 to T–20, 2 to 12 g/m^3 of panning concentrates of stream sediment, containing cassiterite, tantalite-columbite, rutile, monazite, ilmenite etc., were collected. Old workings of placer deposits exploited by local people are scattered along the streams. These facts suggest that source of these placer deposits are supplied from pegmatites, and most promising areas of placer deposits have already been mined or prospected. Therefore, it is difficult to discover new placer deposits.

CHAPTER 4 AREA C

4–1 Location

As indicated in Fig. 1, the area is 8.0km^2 about 20km west of Omkoi, and centered on 17°48′ north latitude and 98°16′ east longitude.

The main stream in the area is the Nam Mae Hong, flowing from the southwest corner to the northeast corner. The river channel of the Nam Mae Nong follows a straight course from the south to the center of the area in a northwest direction. However, from the center towards the north, the river abruptly changes its course to due north, exhibiting an anomalous drainage system. Tributaries of the river junction at mainly right angles, and flow in a NE-SW direction. With the exception of the flatland along the Nam Mae Hong, terrain is mountainous ranging 1,000∿1,500m in elevation, with relative relief of 500m. The mountain system mainly trends NNW-SSE.

An unpaved road connecting Omkoi to Mae Khong at the southeast passes through Area C from north to south. The distance between Omkoi and Area C is about 55km, and can be negotiated by four wheel drive vehicle in 3½ hours in the dry season. Access by motor vehicle in the rainy season is not possible.

Results of geochemical prospecting during phase 1 indicated zones of high geochemical anomaly for tin, tungsten, niobium and tantalum oberlapping in the area. The tin and tungsten anomalies are particularly classified as high, and assumed to have high possibility of ore deposit.

4–2 Geology and Ore Deposits

4–2–1 Geology

Geology of Area C is composed of Cambro-Ordovician sedimentary sequence, Ordovician limestone formation, and Devono-Carboniferous sedimentary sequence, all intruded by granitic rock and overlain in unconformable manner with Quaternary river sediments (Fig. 29).

1. Cambro-Ordovician Sedimentary Sequence

This sequence is distributed intermittently in a narrow belt NNW-SSE in the vicinity of mountain crest to the east of the Nam Mae Hong. It is composed of sandstone and shale. However, original rock texture is largely indistinct due to skarnization from granite intrusion and severe oxidation occurring at the ground surface.

Judging from the regional structural setting, the sequence could conceivably be roof pendant within the two mica granite mass. The distribution appears to be controlled by NW-SE

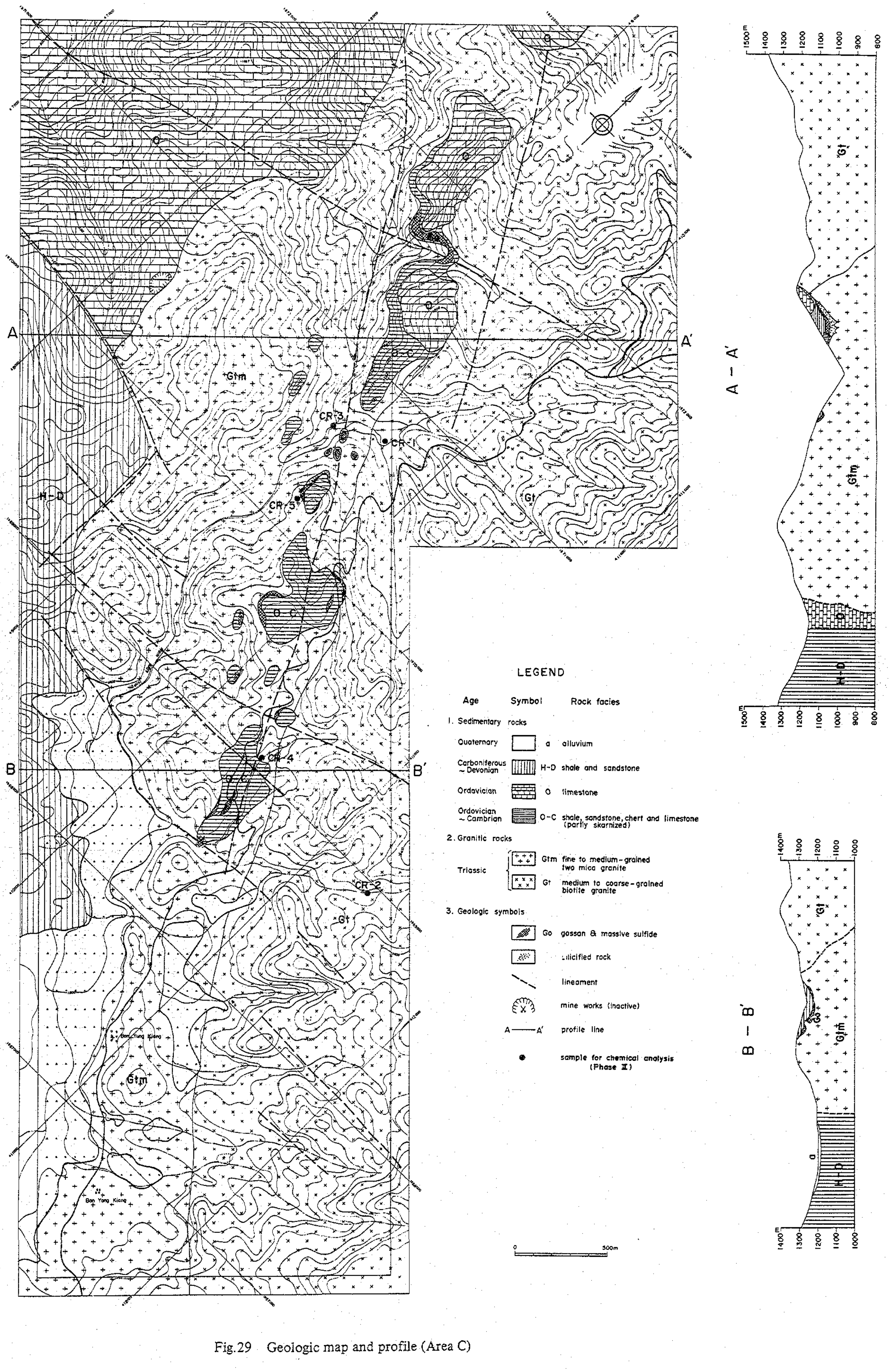


Fig.29 Geologic map and profile (Area C)

trending geological structure.

2. Ordovician Limestone Formation

This formation is distributed in the northwest corner and extends over a broad area to the north of the area.

Limestone is gray and stratified. At the contact with two mica granite, the limestone is partly recrystallized and pale green skarn minerals are observed.

Limestone structure strikes NW-SE and dips to the east. It is in NE-SW trending fault contact with the younger Devono-Carboniferous sedimentary sequence.

3. Devono-Carboniferous Sedimentary Sequence

This sequence is distributed on the western bank of the Nam Mae Hong. Lithofacies are predominantly black shale and red shale. Phylitic∿schistose texture is partially present in the vicinity of contact with granite. However,skarnization is generally weak.

The sequence is covered by Quaternary stream sediment in the south. The extent of distribution in the north is estimated on the basis of floats due to the absence of outcrops.

4. Quaternary Sediment

Quaternary sediment widely covers area along the main Nam Mae Hong, and is composed of loose sand and gravel 1∿3 m thick.

5. Granitic Rocks

Granitic rocks are composed of medium to coarse grained, K-feldspar bearing porphyritic biotite granite, fine to medium grained two mica granite and aplite.

Biotite granite is considered the result of igneous activity during the Triassic, and two mica granite during the Cretaceous.

(i) Medium to Coarse Grained, K-Feldspar Bearing Porphyritic Biotite Granite

This type of rock is distributed over a wide part of the east, forming a batholith mass characteristically including megaphenocryst of K-feldspar varying in size from 1 to 5cm. Massive facies are dominant; no gneissose texture was observed.

Primary rock forming minerals are quartz, K-feldspar, plagioclase and biotite. Accessory minerals are zircon, apatite and opaque minerals. Opaque minerals consist of only a very small amount of ilmenite. Secondary minerals are fine muscovite replacing plagioclase, chlorite replacing biotite and leucoxene replacing ilmenite.

(ii) Fine to Medium Two Mica Granite

This rock is distributed in the center of the area as stocks extending 1.5km X 5km. Periphery of the belt is fine grained, a relation with surrounding rock is estimated to be intrusive.

Primary rock forming minerals are quartz, K-feldspar, plagioclase, muscovite and biotite.

The granite is characterized by the large amount of primary muscovite in relation to biotite. Accessory minerals are zircon, apatite, and ilmenite. Observed secondary minerals are muscovite replacing plagioclase, chlorite and muscovite replacing biotite, and leucoxene replacing ilmenite.

At the western boundary of the two mica granite where Ordovician limestone formation and Devono-Carboniferous sedimentary sequence are in contact, granite has undergone white argillization (kaolinization). Chloritization is prevalent at the eastern boundary where contact is with biotite granite. At the boundary with roof-pendant Cambro-Ordivician sedimentary sequence, severe silicification of fine grained granite is observed.

(iii) Aplite

This rock is observed mainly as scattered floats of 5 to 60cm. Observed outcrops are limited. Main rock forming minerals are quartz, K-feldspar and muscovite.

4–2–2 Geological Structure

Phase I geological survey identified major structural trends in and around the area of NW-SE, NE-SW and N-S. General trend of sedimentary rock and prevailing facture systems is NW-SE. NE-SW and N-S trending directions are secondary.

The regional geological structure is well reflected in the geological structure of the area. The major structural trends of NW-SE, NE-SW and N-S are clearly expressed by the orientation of rock units as well as lineaments indicated by drainage system anomaly and alignment of saddles of the mountain system.

The NW-SE structural system is expressed by the trend of intrusion of two mica granite, the straight portion of the Nam Mae Hong valley and the alignment of the mountain system.

The NE-SW structural system is indicated by the direction of the fault boundary of the Ordovician limestone formation and the Devono-Carboniferous sedimentary sequence. This is also the orientation of the straight valleys of the tributaries of the Nam Mae Hong as well as the lineaments expressed by alignment of saddles of the mountain system.

The N-S structural system is expressed by the abrupt change of the course of the Nam Mae Hong at the northern part of the area, and by the alignment of the straight tributaries of the Nam Mae Hong.

4–2–3 Alteration

Except for surface weathering, observed alteration of the area are skarnization, silicification, kaolinization and muscoviti-chloritization.

Hedenbergite-epidote skarn is marked in the Cambro-Ordovician sedimentary sequence scattered as roof pendant in the two mica granite. The skarn zone is accompanied by dissemination of chalcopyrite, sphalerite, pyrrhotite, pyrite and scheelite. Skarn has been subjected to strong oxidation at the ground surface, forming gossan mainly composed of goethite.

Silicification is prominent in the lower part of the skarn zone. Silicification is also seen in the two mica granite surrounding the skarn zone. Magnetite and chalcopyrite occur in the silicified zone in disseminated or small veined form.

Kaolinization is widely seen in the two mica granite, being particularly marked in and around the area of contact with sedimentary rock where it forms a 50 to 400m wide and 2∿3km long kaolin zone extending NW-SE. In the southeast, the kaolin zone widens and alteration is more intense. The zone is mainly composed of kaolinite, muscovite, quartz and tourmaline, with relic minerals of K-feldspar and quartz also being present.

Muscoviti-chloritization is marked in the skarn zone, and also widely occurs in the granitic rocks. In the granite, plagioclase has been replaced by muscovite and biotite has been replaced by chlorite and muscovite.

The majority of this alteration is considered to be genetically related to intrusion of two mica granite, and to subsequent pneumatolytic∿hydrothermal activity.

4–2–4 Ore Deposits and Mineralization

No ore deposits have been heretofore recorded in the area; however, a number of scattered small scale gossans manifest the occurrence of ore minerals. These small gossans are distributed in a zone 200m wide and about 3km long, stretching NNW-SSE. The zone continues to the north out of the area for about 1.5km (Fig. 30).

These gossans are mainly composed of goethite, with relic minerals of magnetite and hematite.

Old workings are found in the gossan, including shafts at 2 locations (C1 ore deposits and C2 ore deposits, respectively).

1. C1 Ore Deposits

C1 ore deposits are located near the stream in the vicinity of soil sampling points C17∿28. The ore deposit was formed in the skarnized Cambro-Ordovician sedimentary sequence, as well as in the underlying silicified two mica granite.

Skarn zone outcrop occurs for about 5 meters. Main component minerals are fine grained garnet, hedenbergite, quartz and calcite, with minor dissemination of sphalerite, chalcopyrite and scheelite. In the weakly skarnized zone, original texture of sandstone and shale remains, suggesting that the original rock may have been Cambro-Ordovician sedimentary sequence. Goethite

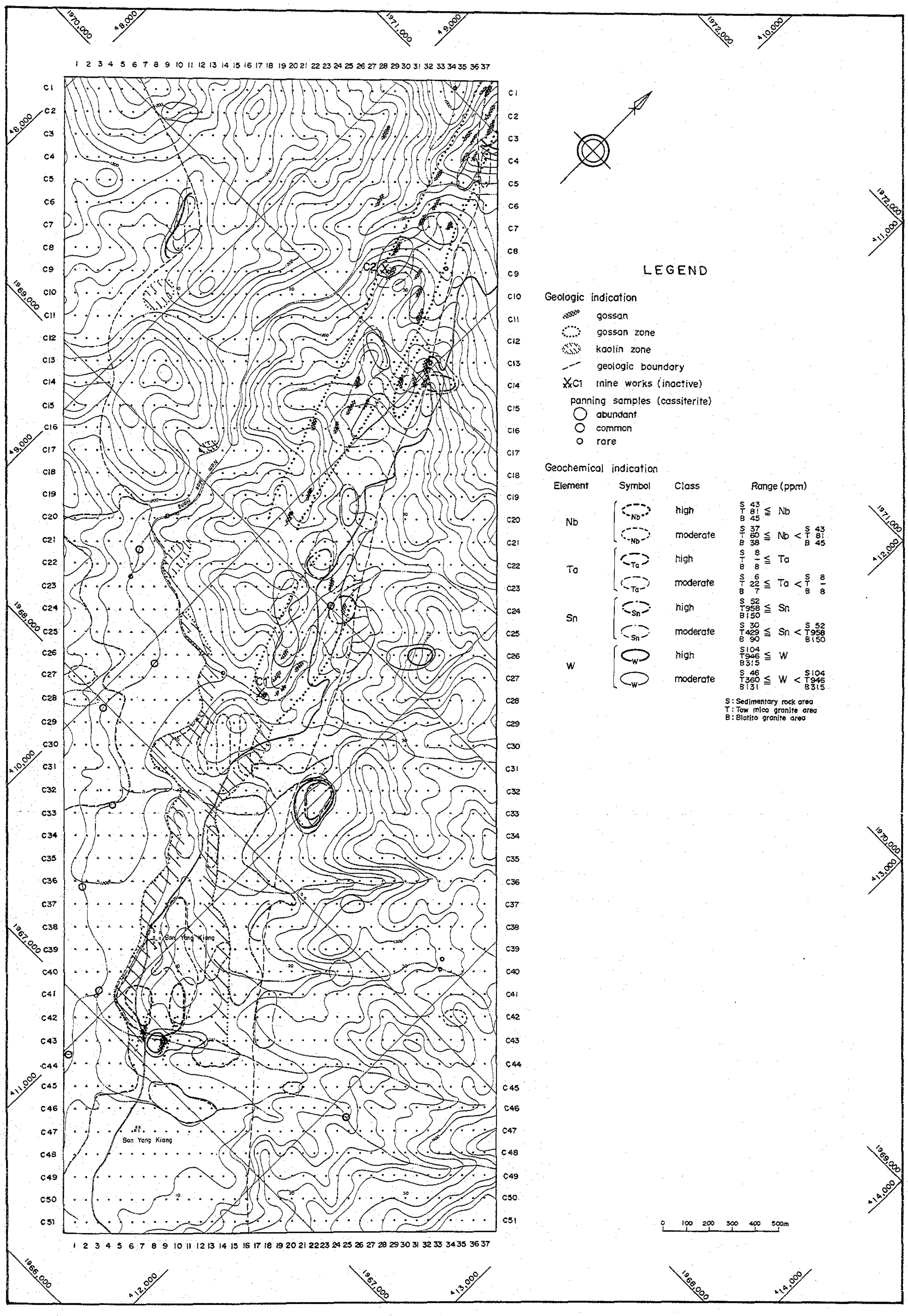


Fig.30 Mineral indication map (Area C)

boulders, 2 to 3m in diameter, are scattered at the apparent upper horizon of the skarn zone.

A silicified zone is distributed at the apparent lower horizon of the skarn zone forming a small water fall 3m high in the stream bed. A small gallery along the ore vein is seen in the silicified zone. The gallery is aligned in the N30°E direction, and extends for 2m at which point the remainder of the gallery is blocked by ground collapse. Ore deposit occurs as both network and dissemination in the two mica granite. However, extent of mineralization is unclear due to poor outcropping of rock. Ore minerals in thin veins are mainly magnetite, with a small amount of chalcopyrite. In disseminated portions, the main ore mineral is pyrrhotite, accompanied by chalcopyrite and pyrite. Two mica granite, the host rock of the ore deposit, has undergone hydrothermal alteration, forming quartz, muscovite and chlorite.

Results of analysis of ore samples taken from the disseminated ore in the silicified zone and from the skarn zone are shown in Table 11. The former contains 1,900ppm of tungsten and 6,600ppm of copper, and the latter contains 4,800ppm of zinc.

2. C2 Ore Deposit

C2 ore deposit is located near soil sampling points C9∿29 in the north of the area. As with the C1 deposit, the ore body has formed in skarn zone and silicified zone. The confirmed mineralized area is about 80m X 40m∿50m, and is the largest mineral mainfestation in the area (Fig.31).

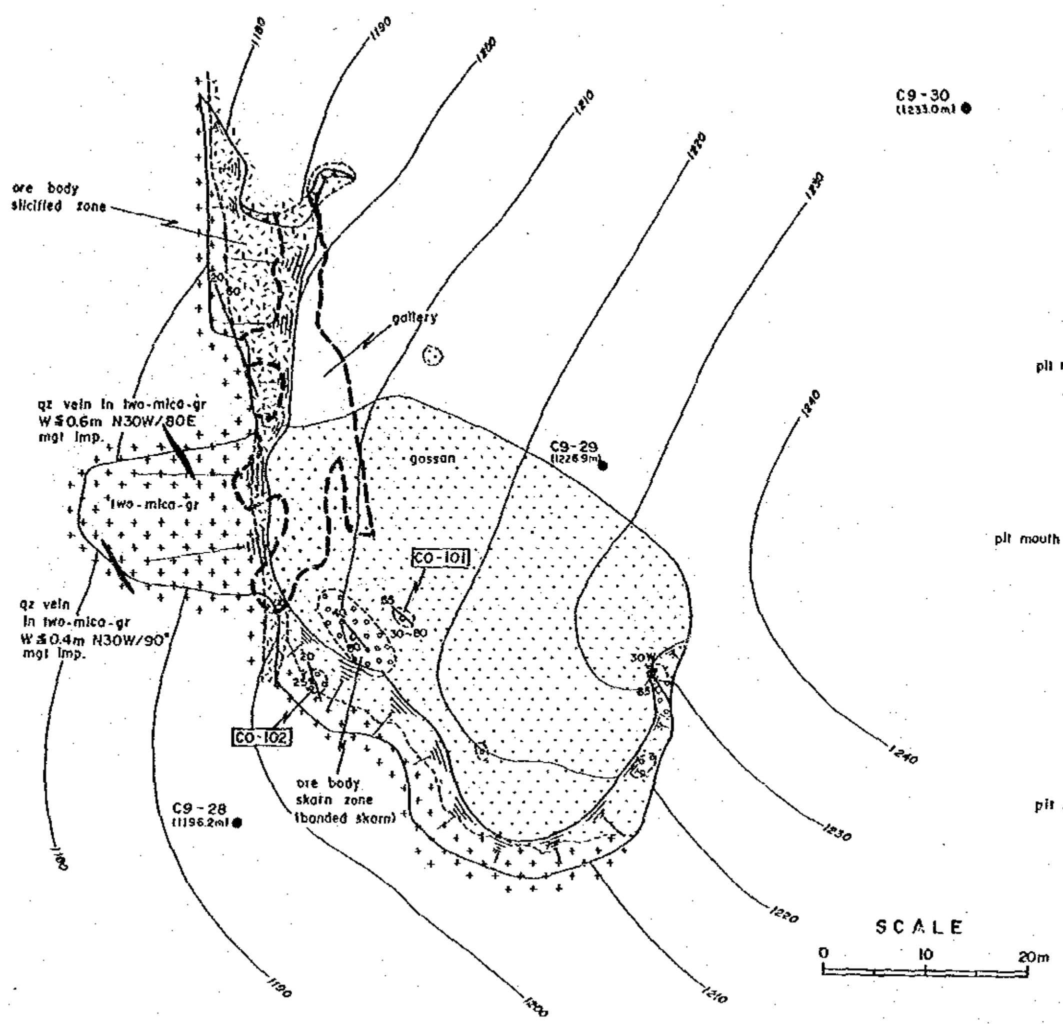
The ore deposit is divided into four zones. In descending order they are: surface oxidized zone (gossan), skarn zone, silicified zone and two mica granite zone.

The gossan forms crust covering the surface and the thickness is estimated at 5 to 60cm. It is composed mainly of goethite, gradually changing to skarn underneath.

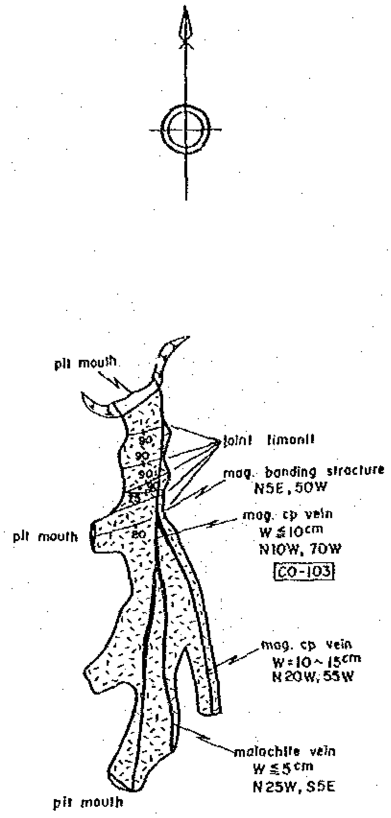
The exposure of the skarn zone is limited, occurring as a small fenster of less than 10m in the above described surface oxidation zone. Principal component minerals are epidote, K-feldspar, quartz and muscovite. Banded skarn, with 1 to several millimetres wide bands of goethite in the above composition, is dominant.

The orientation of banding is NW-SE. Principal ore minerals are goethite and pyrrhotite, with small amounts of pyrite and chalcopyrite

Silicified zone is believed to distributed in vein form at the apparent lower portion of the skarn zone. The principal component mineral is quartz, with magnetite and chalcopyrite in disseminated to banded form. Remains of old workings are seen in this silicified zone. Size of workings is 50m in the N-S direction and an average 5∿7m (maximum of 10m) in the E-W direction. At the east side, workings are excavated to a maximum of 10m. Boundary with two mica granite at the side is relatively distinct. Strike and dip of formation is N20°E and 60°N, which closely corresponds to the direction to which the old workings extend.



Surface geologic sketch



Gallery geologic sketch

LEGEND

- gossan zone
- skarn zone
- silicified zone
- two mica granite
- quartz vein
- gallery
- CO-101 ore sample
- ● C9-28 geochemical soil sample

Ore chemical analyses (ppm)

Sample No.	Description	Sn	W	Nb	Ta	Cu	Pb	Zn	Ag
CO-101	Green skarn (Banded)	2,000	310	15	8	20,500	48	720	92
CO-102	Green skarn	2,300	140	8	3	3,400	<5	160	12
CO-103	Magnetite chalcopyrite disseminated silicified ore	3	5	<2	2	580	<5	90	1

Soil chemical analyses (ppm)

Sample No.	Description	Sn	W	Nb	Ta
C9-28	Brown silt	690	600	18	5
C9-29	Reddish brown silt	1,700	390	16	5
C9-30	Light brown silt	690	320	22	3

Fig.31 Geologic sketch of the C2 orebody

Two mica granite in the vicinity of the silicified zone has undergone thermal alteration, forming muscovite and quartz. Quartz veins accompanied by magnetite with width of 40∿60cm, are seen in the rock. Strike of the veins is NNW-SSE, and dip is to the E.

As shown in Table 11, results of ore analysis from each zone indicate tin at 2,000∿2,300ppm, tungsten at 140∿310ppm and copper at 3,400∿20,500ppm in the skarn zone and only small values for the same in the silicified zone.

3. Other Mineral Indications

Heavy mineral samples were taken from stream sediment to supplement surface survey. Samples were studied for mineral composition and results are indicated in Table 12. Sphalerite, xenothime, ilmenite, scheelite, wolframite and columbite-tantalite are seen in a wide area along the main Nam Mae Hong and its tributaries. Grades of ores as determined from geochemical analysis of heavy minerals from stream sediment are shown in Table 12. Samples CO-19 and CO-29, recovered from the vicinity of the gossan, bear relatively high grades of niobium, tantalum, tin and tungsten.

Also, a skarnized zone formed by strong alteration of two mica granite extends in the southeast of the area.

4–3 Geochemical Prospecting by Soil

4–3–1 Survey Method

1. Sampling and Preparation

B-horizon soil samples were collected by the same 100m x 50m rectangular grid system as for Area A.

As a result of geochemical prospecting of stream sediment in the phase I survey, anomalies of niobium, tantalum, tin and tungsten were detected along the Nam Mae Hong with orientation of NW-SE. The main direction of faults and geological structure also show NW-SE. It appeared from the above that the mineralization in this area was related to the NW-SE fracture system.

Because of this, Area C was aligned in the same direction, and sampling lines were arranged in the direction of NE-SW to effectively detect mineral indication.

The collected soil samples were air-dried and screened. The -80 mesh fraction were subjected to chemical analyses.

The samples totaled 1,658.

2. Pathfinder Elements and Chemical Analysis

Since the objective of prospecting is the identification of mineral deposits of niobium,

Table 11 Assay of Ore Samples in Area C

No.	Sample No.	Locality	Discription	Sn(ppm)	W(ppm)	Nb(ppm)	Ta(ppm)	Cu(ppm)	Pb(ppm)	Zn(ppm)	Ag(ppm)
1	CO–101	C2 ore body (C9–29)	Green skarn (banded)	2,000	310	15	8	20,500	48	720	92
2	CO–102	C2 ore body (C9–29)	Green skarn	2,300	140	8	3	3,400	<5	160	12
3	CO–103	C2 ore body (C9–29)	Silicified ore	3	5	<2	2	580	<5	90	1
4	CO–107	C1 ore body (C28–17)	Sulfide ore	56	1,900	13	3	6,660	17	310	9
5	CO–108	C1 ore body (C28–17)	Green skarn	230	79	27	12	240	230	4,800	8
6	CO–109	Near C2 ore body (C11–31)	Oxidized ore (Gossan)	73	390	5	4	2,780	68	4,900	2

Table 12 Assay of Panning Samples in Area C

No.	Sample No.	Locality	Discription	Sn(%)	W(%)	Nb(%)	Ta(%)	Raw Material (ℓ)	Heavy mineral (g)	SnO_2 (g/m^3)	WO_3 (g/m^3)	Nb_2O_5 (g/m^3)	Ta_2O_5 (g/m^3)
1	CO–11	Nam Mae Hong (C41–3)	Stream sediment	18.5	1.17	0.23	0.13	100	12	28.2	1.8	0.4	0.2
2	CO–19	Branch of Nam Mae Hong (C24–24)	Stream sediment	3.85	0.43	0.26	0.09	70	250	174.6	19.3	13.2	3.9
3	CO–24	Branch of Nam Mae Hong (C30–28)	Stream sediment	1.08	0.13	0.14	0.04	30	6	2.7	0.3	7.1	0.1
4	CO–27	Branch of Nam Mae Hong (C43–9)	Stream sediment	6.41	3.78	0.04	0.03	20	225	915.8	536.6	6.8	4.5
5	CO–29	Branch of Nam Mae Hong (C46–25)	Stream sediment	5.07	1.29	0.23	0.09	10	6	38.6	9.8	2.0	0.7

tantalum, tin and tungsten, and in view of the design precision of this stage of the survey, pathfinder elements were restricted to only those directly indicative of mineralized zones, namely the 4 *target minerals themselves: niobium, tantalum, tin and tungsten.*

The quantities of these 4 pathfinder elements were chemically analyzed by means of inductively coupled, plasma emission spectrography. Critical detection level is 1ppm.

4–3–2 Analysis of Geochemical Data

1. Classification of Anomalous Values

Mean values and standard deviation were used to decide the threshold values and the subdivisions of the background and anomaly zone. And the frequency distribution and cumulative frequency distribution histogram were also used to confirm these subdivisions.

Anomaly classifications are shown in Table 13.

Table 13. Division into anomaly value levels in Area C

Area	Division / Element	Background area		Anomaly area		
		Low	High	Low	Middle	High
Sedimentary rock	Nb	~26	27 ~ 31	32 ~ 36	37 ~ 42	43 ~
	Ta	~ 2	3	4 ~ 5	6 ~ 7	8 ~
	Sn	~10	11 ~ 17	18 ~ 29	30 ~ 51	52 ~
	W	~ 8	9 ~ 19	20 ~ 45	46 ~ 103	104 ~
Two mica granite	Nb	~32	33 ~ 43	44 ~ 59	60 ~ 80	81 ~
	Ta	~ 8	9 ~ 13	14 ~ 21	22 ~	
	Sn	~86	87 ~ 192	193 ~ 428	429 ~ 957	958 ~
	W	~52	53 ~ 137	138 ~ 359	360 ~ 945	946 ~
Biotite granite	Nb	~25	26 ~ 31	32 ~ 37	38 ~ 44	45 ~
	Ta	~ 4	5	6	7	8 ~
	Sn	~32	33 ~ 53	54 ~ 89	90 ~ 149	150 ~
	W	~22	23 ~ 54	55 ~ 130	131 ~ 314	315 ~

Unit : ppm

2. Distribution of Zones of Geochemical Anomaly

Analytical values were divided into 5 levels on the basis of classifications for geochemical anomaly as discussed in the previous section. These were plotted on a topographical map, and zones of anomaly were identified (Fig. 30). Distribution of zones of anomaly is discussed below.

The zones of anomaly for each element in Area C are distinct. Particularly notable anomalies for all elements were detected in the two mica granite area.

A different distribution of anomalies was seen for niobium - tantalum and tin-tungsten. The main anomalous zone for tin and tungsten is situated in the middle to northwest of Area C. The main anomalous zone of niobium and tantalum is found near Yang Kiang village in the south.

(i) Niobium

In the area of sedimentary rock, a zone of low anomaly is distributed from line C26 to line C30, with a maximum anomalous value of 54ppm.

In the two mica granite area, medium to high anomalies are broadly distributed from line C29 to line C42. Especially high anomaly, with a maximum value of 110ppm is found in an area 100m X 250m from line C41 to line C42. In addition, some low anomalies with an orientation of NNW-SSE are distributed from line C17 to line C25.

In the biotite granite area, zones of low anomaly lie sporadically in the south. However, no notable anomalous area is present.

(ii) Tantalum

In the area of sedimentary rock, a zone of low anomaly overlapping with that of niobium is distributed from line C26 to line C30.

In the two mica granite area, a low to medium anomaly extends from line C28 to line C42. This anomaly is moderate with a maximum anomalous value of 29ppm, and extends over an area 350 X 500m from line C37 to line C42. In addition, low to medium anomalies with an orientation of NNW-SSE are seen.

In the area of biotite granite, small-scale, low to moderate anomalies are scattered on the south side of line C30.

(iii) Tin

In the area of sedimentary rock, zones of moderate to high anomaly are distributed at the boundary with two mica granite from line C5 to line C8.

In the two mica granite area, zones of moderate to high anomaly, 100 to 500m wide, are distributed intermittently in the direction of NNW-SSE near the boundary with biotite granite from line C1 to line C27. Anomalous values exceeding 500ppm are recognized in places. The maximum anomalous value is 2,500ppm.

In the biotite granite area there are three medium to high anomalies near this area's border with two mica granite. Among them a high anomaly with the maximum anomalous value of 2,200ppm lying from line C1 to line C5 and a zone of moderate anomaly with a maximum anomalous value of 1,100ppm lying from line C13 to line C14 both extend from the zones of anomaly in the two mica granite. A zone of moderate to high anomaly lies from line C31 to line C32 with an area of 100m X 150m, and a maximum anomalous value of 1,500ppm.

(iv) Tungsten

At the boundary between sedimentary rock and two mica granite, lying from line C1 to line C3 and from line C6 to line C8, there are zones of moderate to high anomaly with maximum anomalous values of 770ppm and 1,200ppm, respectively.

Zones of moderate to high anomaly, ranging from 300 to 500m in width, are distributed intermittently in the direction of NNW-SSE over the two mica granite and biotite granite areas. Although this distribution overlaps that for tin anomaly, there is a zone of moderate to high anomaly near line C42 that does not overlap with tin anomaly.

Samples with concentration of more than 1,000ppm were collected from a number of places. Maximum anomalous value is 4,000ppm.

In the area of biotite granite, there is a zone of low to moderate anomaly distributed in the direction of NNW-SSE from line C35 to line C40.

3. Discussion

Geochemical exploration revealed the distribution of tin and tungsten anomalies trending NW-SE and those anomalies coincide with the distribution of the gossan zone.

As a whole, the anomalous area of tin and tungsten and the anomalous area of niobium and tantalum are continuously developed. This clear zonal distribution trending NW-SE suggests the existence of mineralization and alteration controlled by the structure of the same trend. In the anomalous area, many highly anomalous values exceeding 1,000ppm of tin and tungsten are included. This suggests the existence of undiscovered, promising mineralized zones in the area.

4–4 Drilling Survey

Drilling survey was conducted in the geochemical anomalous zone rich in tin and tungsten, indicated by geochemical prospecting (Fig. 32).

(1) Geology

The sedimentary rocks are composed mainly of mudstone and shale, and minor amount of limestone and quartzite. These rocks are strongly weathered, resulting in original rock texture being illegible. The roof pendants of these sedimentary rocks are 500x500m and 300x600m on a large scale, and 50x50m to 150x200m in width on a small scale. Thickness of them is generally 30 to 50m, partially more than 50m.

Skarnization was found along the boundary between granite and sedimentary rocks, and in those sedimentary rocks in drill cores. Skarn minerals consist mainly of epidote, hedenbergite, amphibole, garnet, quartz and minor amount of vesuvianite and wollastonite.

Sericitization, silicification, tourmalinization and skarnization are visible alterations in granites. It could be seen under microscope that biotite has been chloritized, and feldspar sericitized and kaolinized. Kaolinization is predominant in the alteration with subordinate amount of sericitization, tourmalinization and silicification. Silicification is usually found along the boundary between granite and sedimentary rocks several meters in thickness.

Weathering has led to decomposition and disintegration of the original rock mass to depths of scores of meters all over the area. Sedimentary rocks have been altered into clayey rock and massive sulfide composed mainly of pyrrhotite has been strongly oxidized to be gossan consisted mainly of goethite. Granitic rocks have been greatly weathered to decomposed soil to depths of 10 to 20m.

(2) Ore deposits

Mineralizations were observed in almost sedimentary rocks of roof pendants, and are scattered in sedimentary rocks. Contact metasomatic ore deposit has been formed here, replacing limestone or calcareous rocks.

Mineralizations are observed in almost sedimentary rocks of roof pendants, and are scattered in more than 3km long, and 200 to 300m in width strip extending towards the north-northwest from the center of this area to north limestone area.

The drilling survey has shown the presence of a considerable skarn zone and massive sulfide beneath the limestone at 1km north of Area C. This suggests that mineralization is higher a grade in a NNW direction.

There are two kinds of orebodies in skarn; one is the dissemination of sphalerite and chalcopyrite, another a massive sulfide composed of abundant pyrrhotite with minor amount of chalcopyrite.

It has clarified in this drilling survey that individual orebody is lenticular and untraceable, 20 x 20m to 70 x 100m wide and 3 to 27m thick. Three orebodies can be traced in drill holes MJTY-14,20, MJTY-36, 37, MJTY-26, 53 which are neighboring each other.

Ore minerals consist mainly of sphalerite, chalcopyrite, pyrrhotite, magnetite and minor amount of galena, covelline, arsenopyrite, bismuth minerals. Although tin, together with tungsten, indicated geochemical high anomalous values, and analytical values of drill core also show same amount of values, tin minerals could not have been detected by microscopic observation and EPMA qualitative analyses.

In the niobium and tantalum geochemical anomalous zone, strong kaolinization more than 30m thick is detected, but niobium and tantalum contents of drill core are as much as geochemical anomalous values.

In this survey, ore assay has been performed for 209 ore samples collected from drill cores. Assayed components are Cu, Pb, Zn, Sn, W, Nb, Ta, Au, Ag. Cd was also assayed for 65 samples which contain more than 0.5% of Zn. The results of the analysis are shown in Appendix 7.

Cu : The highest assay value of Cu is 5.34% in green skarn. Generally, Cu content of mineralized rocks is 0.2 to 0.8%.

Pb : The highest assay value of Pb is 11.6% in green skarn. Only a few samples contain more than 1%. Generally, Pb content of mineralized rocks is lower than 0.1%.

Zn : The highest assay value of Zn is 13.3% in green skarn. Generally, Zn content of mineralized rocks is 1 to 4%.

Cd : The assay values are 0.01 to 0.2%.

Sn : The highest assay value of Sn is 0.45% in green skarn. Generally, Sn content of mineralized rocks is lower than 0.1%.

W : The highest assay value of W is 0.44% in green skarn. Generally, W content of mineralized rocks is lower than 0.1%.

Nb, Ta : The assay values of Nb and Ta are 31 to 91ppm and 14 to 28ppm respectively in the south part of Area C where granites are kaolinizated. Other assay values of Nb and Ta are Nb: 3 to 20ppm and Ta: $<$10ppm in the central part and the north part of Area C.

Au : The assay values of Au are 0.1 to 0.5g/t except 30.8g/t in the extent from 29.20 to 30.00m depth in the drill hole MJTY-29.

Ag : The highest assay value of Ag is 373g/t. Generally the assay values of Ag are higher than 100g/t in the core containing relatively high Pb and Zn.

Copper and zinc are relatively concentrated in this area. Ore reserve was approximately calculated with cut-off grades of 1.0% Zn and 0.5% Cu on the basis of geological interpretation and the geological sections which have been obtained from the results of the drilling survey. This calculation was made on 12 orebodies (Fig. 32).

The equation to be used in the calculation is;

Ore reserve = Area of orebody x half of the maximum orebody thickness in core log x specific gravity (3.3) x safety ratio (0.7).

The result of the calculation is shown in Table 14. Each ore reserve ranges from 4,000 to 379,000 tons. Only 2 orebodies are more than 100,000 tons, and most of the orebodies are 10,000 to 100,000 tons. Copper orebodies vary in grade from 0.53 to 2.00% Cu, and 2 of them are more than 1% Cu. Zinc orebodies contain grades of 1.11 to 3.99 Zn. The total ore reserve is estimated to be 899,000 tons with average grade of 0.49% Cu, 0.08% Pb, 1.17% Zn, 27g/t Ag.

The massive sulfide composed mainly of pyrrhotite is roughly estimated to be 1,000,000 tons with 0.2 to 0.4% Cu in addition to ore reserve.

4–5 Discussion

Based on the result of geological survey, geochemical data and drilling survey obtained so far, the geology, geological structure and ore deposits will be discussed hereunder.

The area is composed of three groups, namely sedimentary rocks ranging in age from Cambrian to Carboniferous, granitic rocks intruded into the former sedimentary rocks and alluvium.

The sedimentary rocks are classified into three formations, that is Ordovician system and Devono-Carboniferous system covering a narrow zone in the southwestern side of the area, Cambro-Ordovician system distributed as scattered small scale roof pendant.

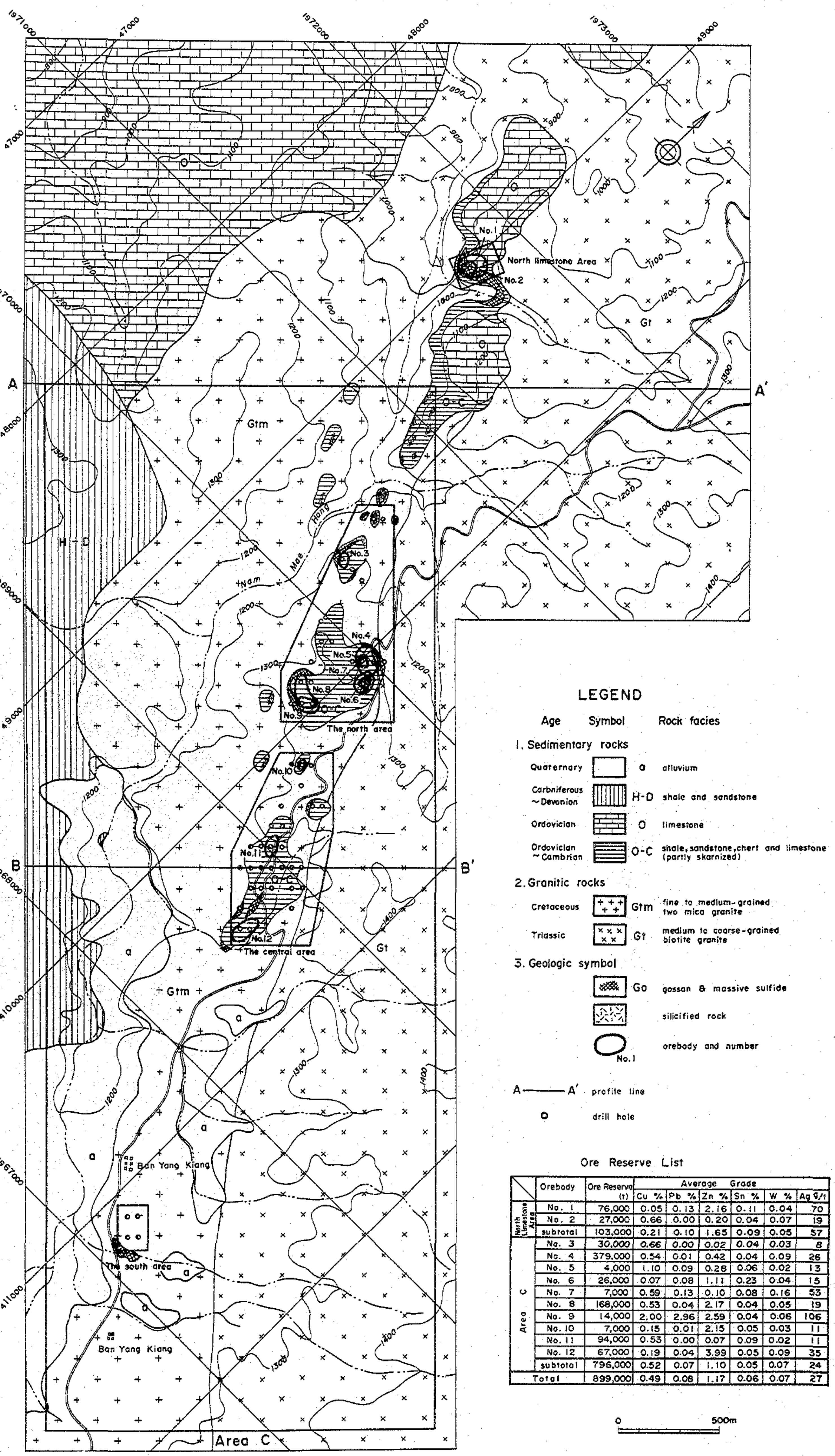
The granitic rocks composed of biotite granite and two mica granite cover a major portion of the area. The relation of the two granite is not clear, but in the regional sense the two mica granite occurs in a rectangular area of 1.5km x 5.0km, elongated to NW-SE to NNW-SSE. The straight boundary with biotite granite suggests that the two mica granite intrudes the other.

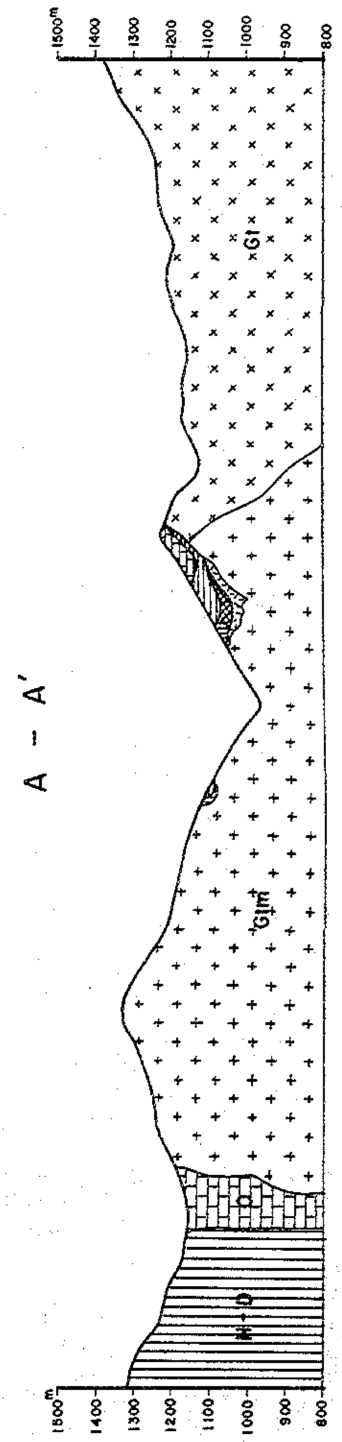
The lithology and texture of those two types of granite, biotite granite and two mica granite, are different suggesting that these two granites are independent rock masses.

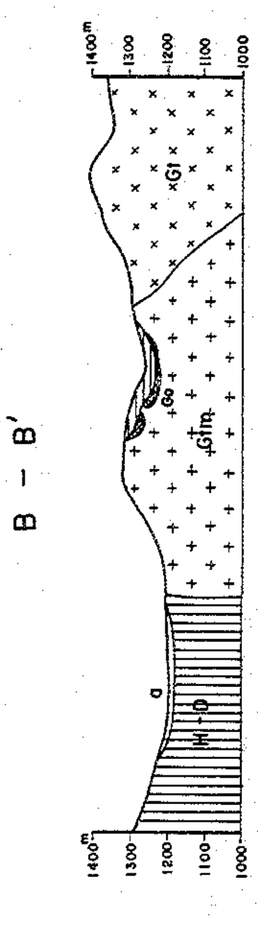
The main structural trend of the area is NW-SE to NNW-SSE and faults of the same trend cutting the sedimentary rocks are developed in the northwest of the area. These facts suggest that after the igneous activity formed the biotite granite batholith, intrusion of two mica granite took place along the NW-SE to NNW-SSE trending structural line.

Many scattered gossans were found in the area of two mica granite. These gossans are distributed in a narrow gossan zone 200m wide and about 3km long, elongated NNW-SSE.

The gossan zone occurs with a skarn zone suggesting that the gossan is weathered product of







Ore Reserve List

	Orebody	Ore Reserve (t)	Average Grade Cu %	Pb %	Zn %	Sn %	W %	Ag g/t
North Limestone Area	No. 1	76,000	0.05	0.13	2.16	0.11	0.04	70
	No. 2	27,000	0.66	0.00	0.20	0.04	0.07	19
	subtotal	103,000	0.21	0.10	1.65	0.09	0.05	57
Area C	No. 3	30,000	0.66	0.00	0.02	0.04	0.03	8
	No. 4	379,000	0.54	0.01	0.42	0.04	0.09	26
	No. 5	4,000	1.10	0.09	0.28	0.06	0.02	13
	No. 6	26,000	0.07	0.08	1.11	0.23	0.04	15
	No. 7	7,000	0.59	0.13	0.10	0.08	0.16	53
	No. 8	168,000	0.53	0.04	2.17	0.04	0.05	19
	No. 9	14,000	2.00	2.96	2.59	0.04	0.06	106
	No. 10	7,000	0.15	0.01	2.15	0.05	0.03	11
	No. 11	94,000	0.53	0.00	0.07	0.09	0.02	11
	No. 12	67,000	0.19	0.04	3.99	0.05	0.09	35
	subtotal	796,000	0.52	0.07	1.10	0.05	0.07	24
Total		899,000	0.49	0.08	1.17	0.06	0.07	27

Fig.32 Synthetic map of Drilling Survey (Area C)

skarn by oxidation on the ground surface.

The skarn zone is mainly composed of epidote and quartz and sporadically is occurring garnet and hedenbergite. In this skarn zone, mineralization of copper, zinc, tin, tungsten, and rare occurrence of lead and silver have been observed. A part of the skarn zone keeps a relic of original texture of sandstone and shale. Judging from the relic texture as well as the surrounding geological setting, the original rock might be the Cambro-Ordovician sedimentary sequence. The sedimentary rocks forming roof pendant are considered to be controlled structurally by the NNW-SSE trending structural system.

The silicified zone altered from two mica granite carrying mineralization of iron and copper is underlying the skarn zone. Conclusively, the skarn zone and the silicified zone are the product of pneumatolytic to hydrothermal activity subsequent to the intrusion of the two mica granite. The skarn zone was formed in the sedimentary sequence and the silicified zone was formed in the granite. The difference of alteration product with each lithology may be caused by that of chemical composition of the mother rock.

In and around the contact boundary between the two mica granite and Ordovician-Carboniferous sedimentary sequence, distinct kaolinization is observed and forms a narrow kaolin zone continuing from the central part of the area to the south with increasing intensity of alteration. Component minerals are kaolinite, quartz, muscovite, and tourmaline suggesting pneumatolytic and/or hydrothermal alteration took place in and around the boundary.

Drilling survey was conducted in the geochemical anomalous zone rich in tin and tungsten indicated by geochemical prospecting.

As the result of drilling survey, 12 orebodies were discovered. They are distributed over a zone 200 to 300m wide and more than 3km long. Each orebody is lens-shaped ranging small from 20x20m to 70x100m wide and from 5 to 10m thick, and not widely traceable. These orebodies are low grade, and each ore orebody are relatively small and scattered. Therefore it seems to be diffucult to warrant exploitation in the area.

Therefore it seems to be difficult to warrant exploitation in the area.

However, ore promising area exists between the limestone area and Area C, where the distribution of roof pendant limestone and a scattering of gossans suggest the presence there of ore deposits. Further study of the area extending NNW of Area C would be expected.

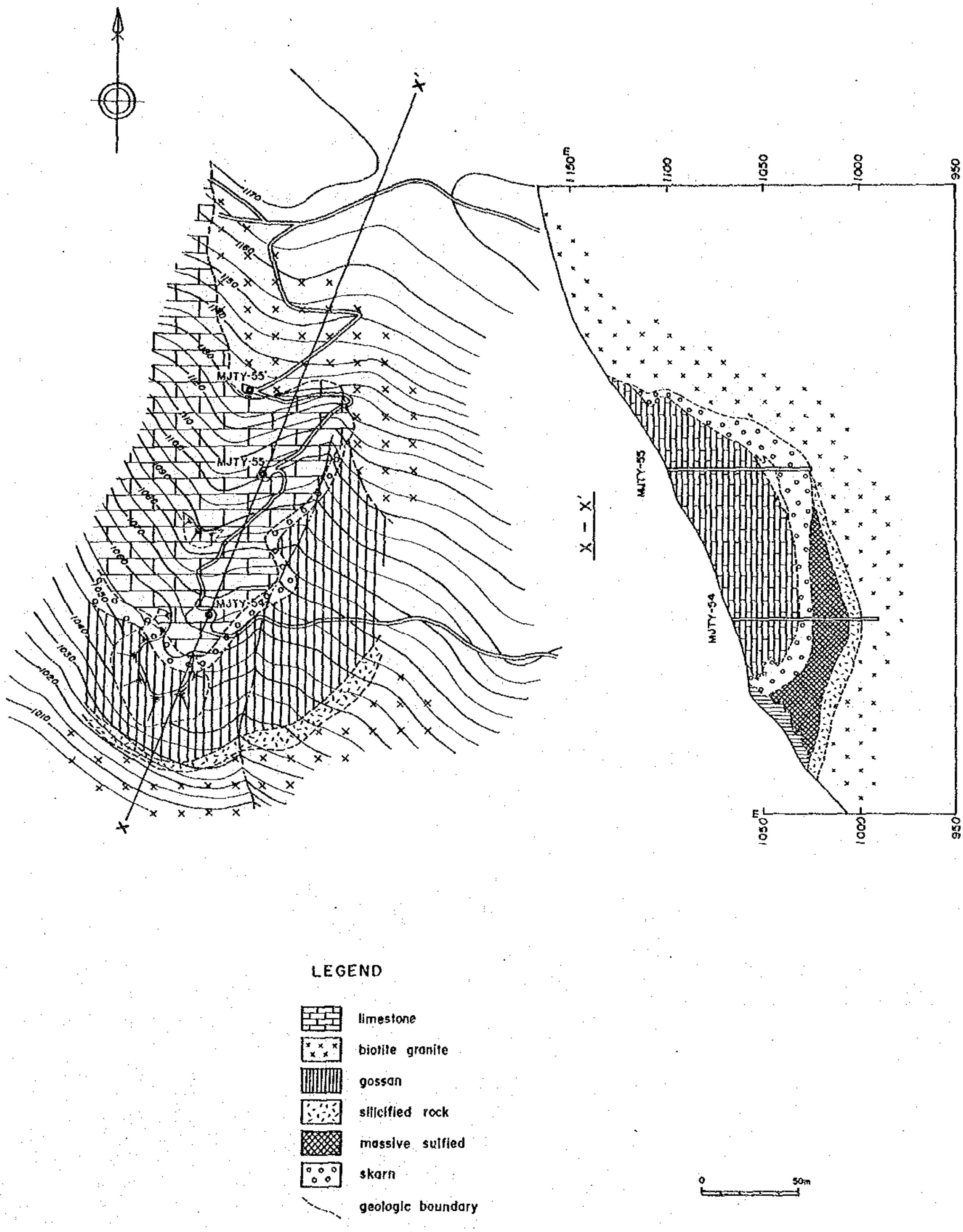


Fig.33 Geologic map of north limestone area

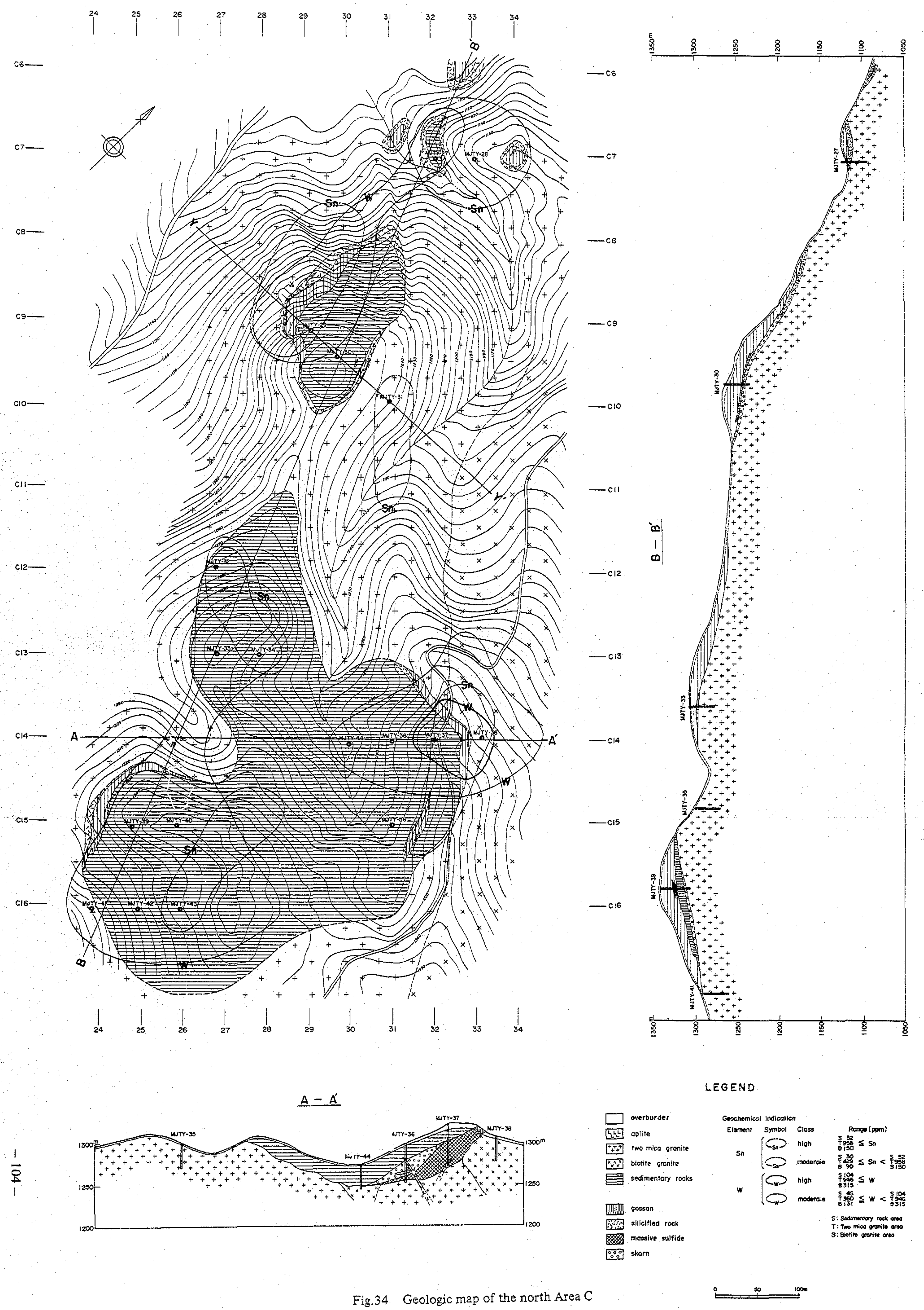


Fig.34 Geologic map of the north Area C

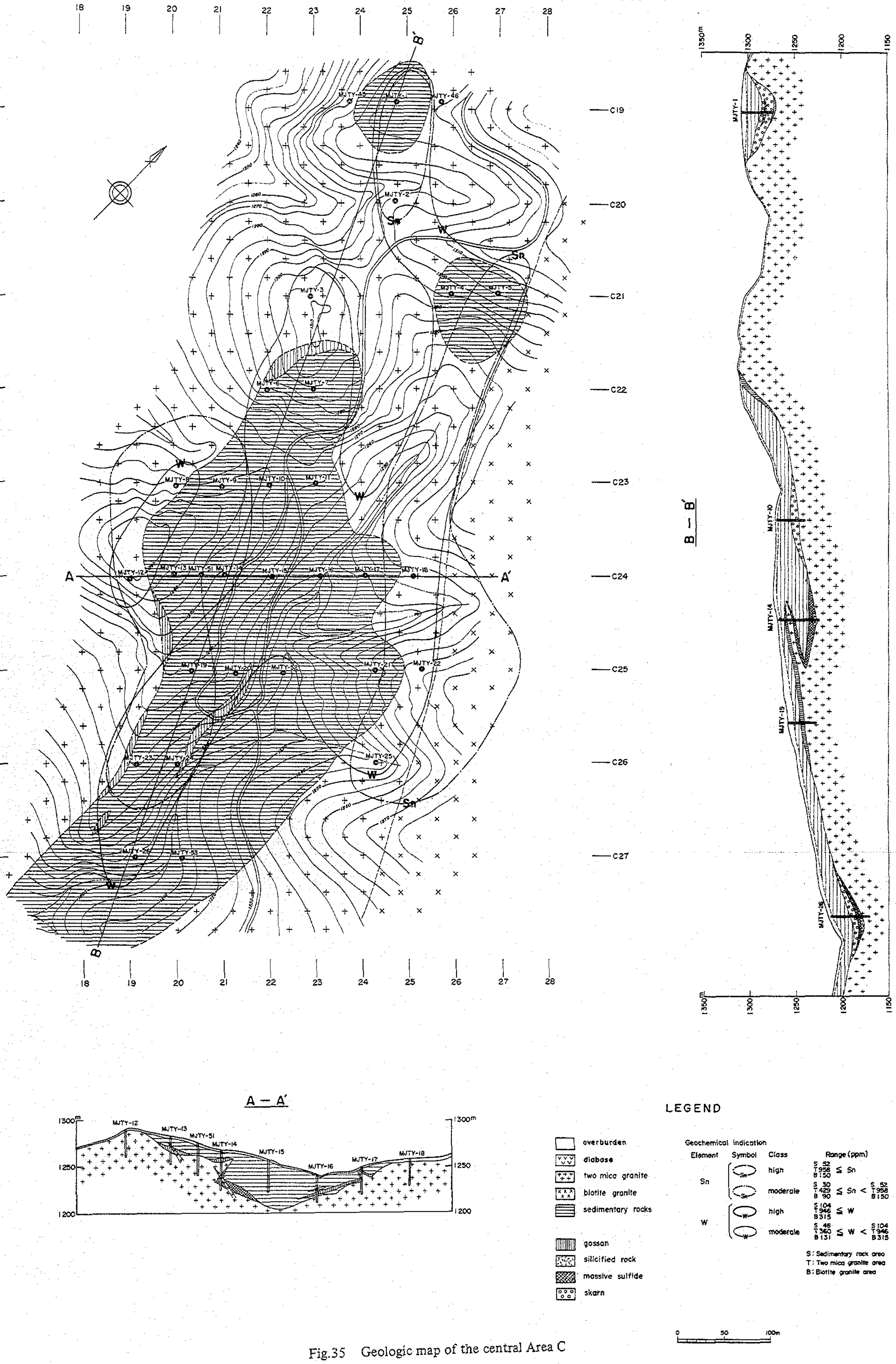


Fig.35 Geologic map of the central Area C

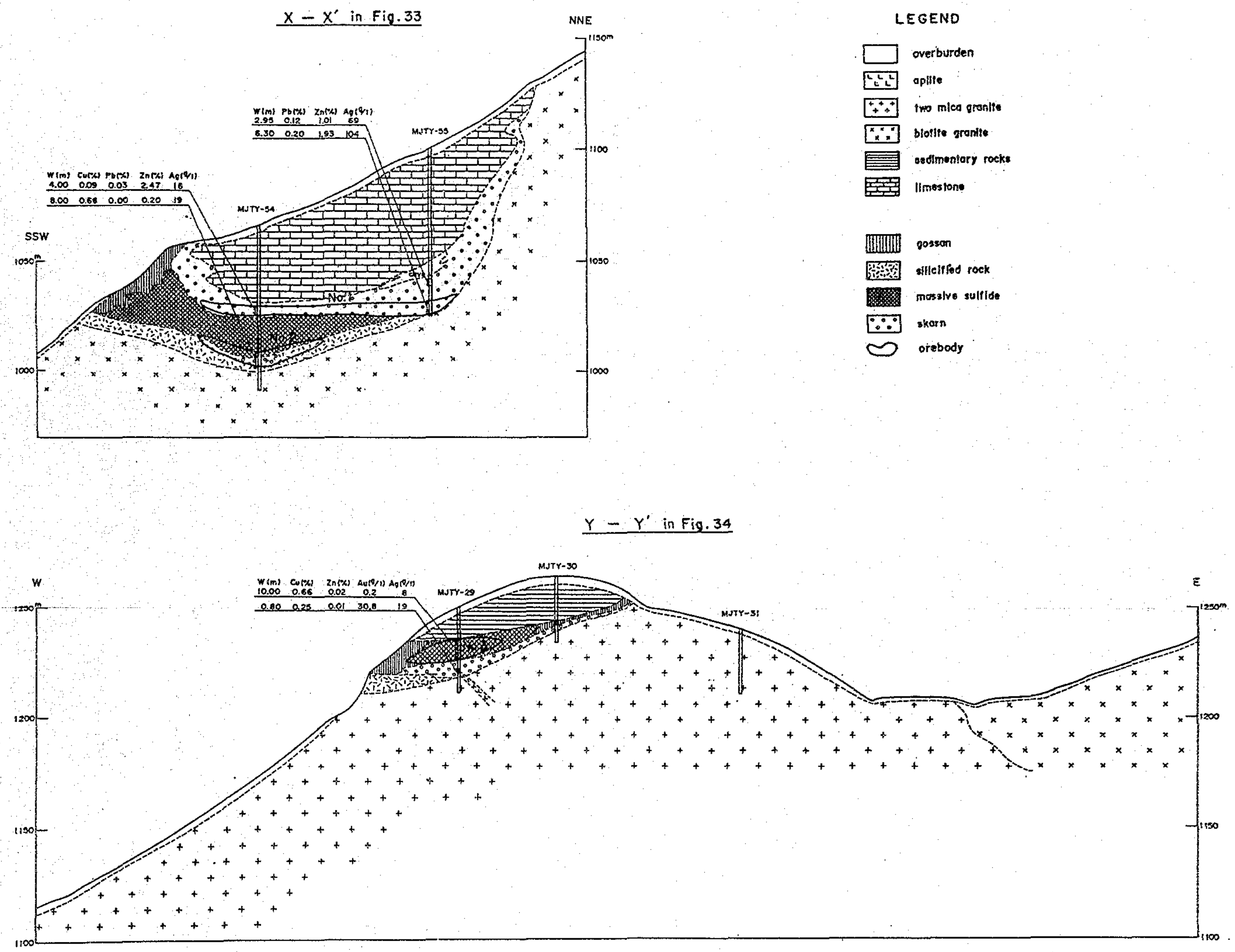


Fig.36 Geologic profile of drilling 1

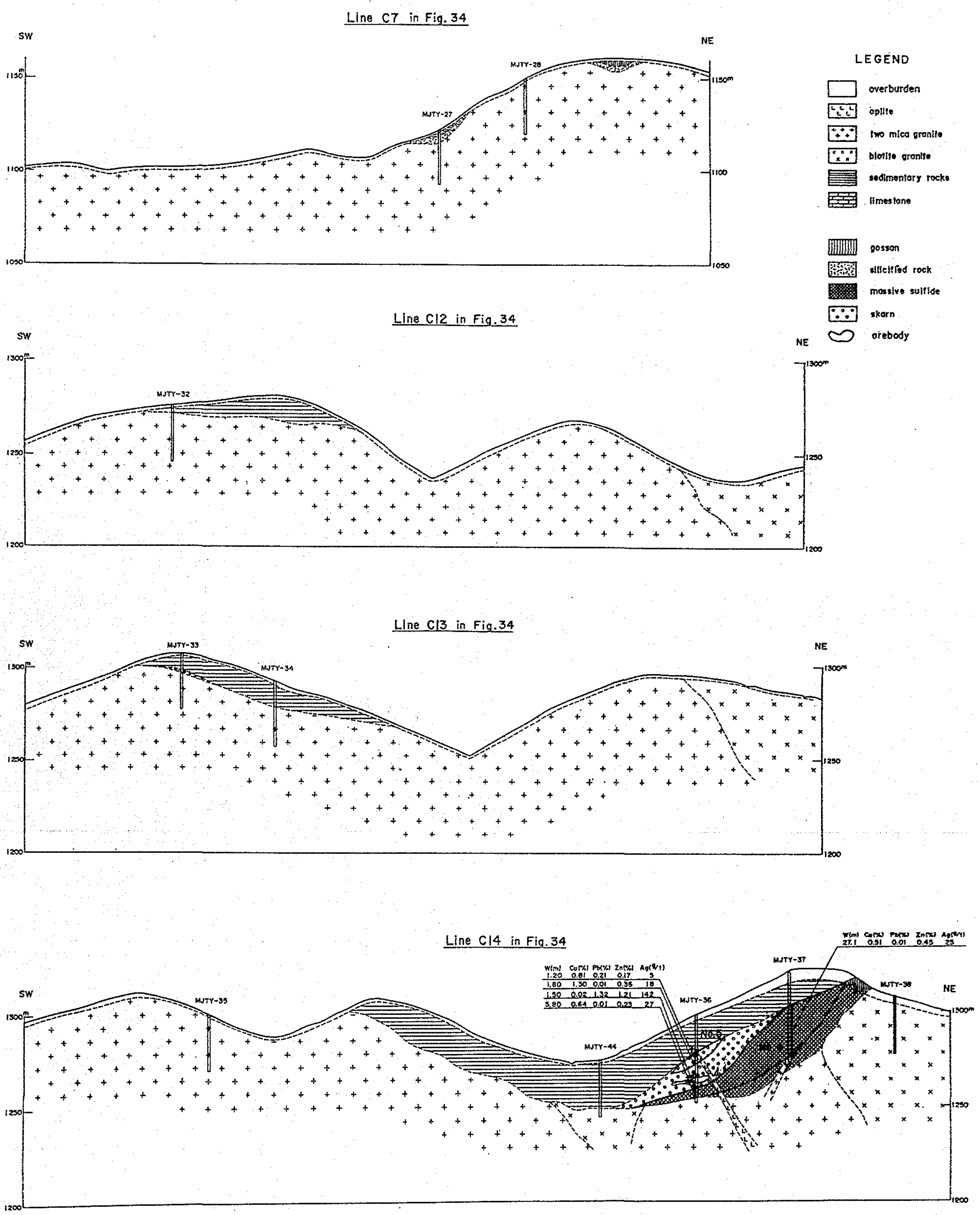


Fig.37 Geologic profile of drilling 2

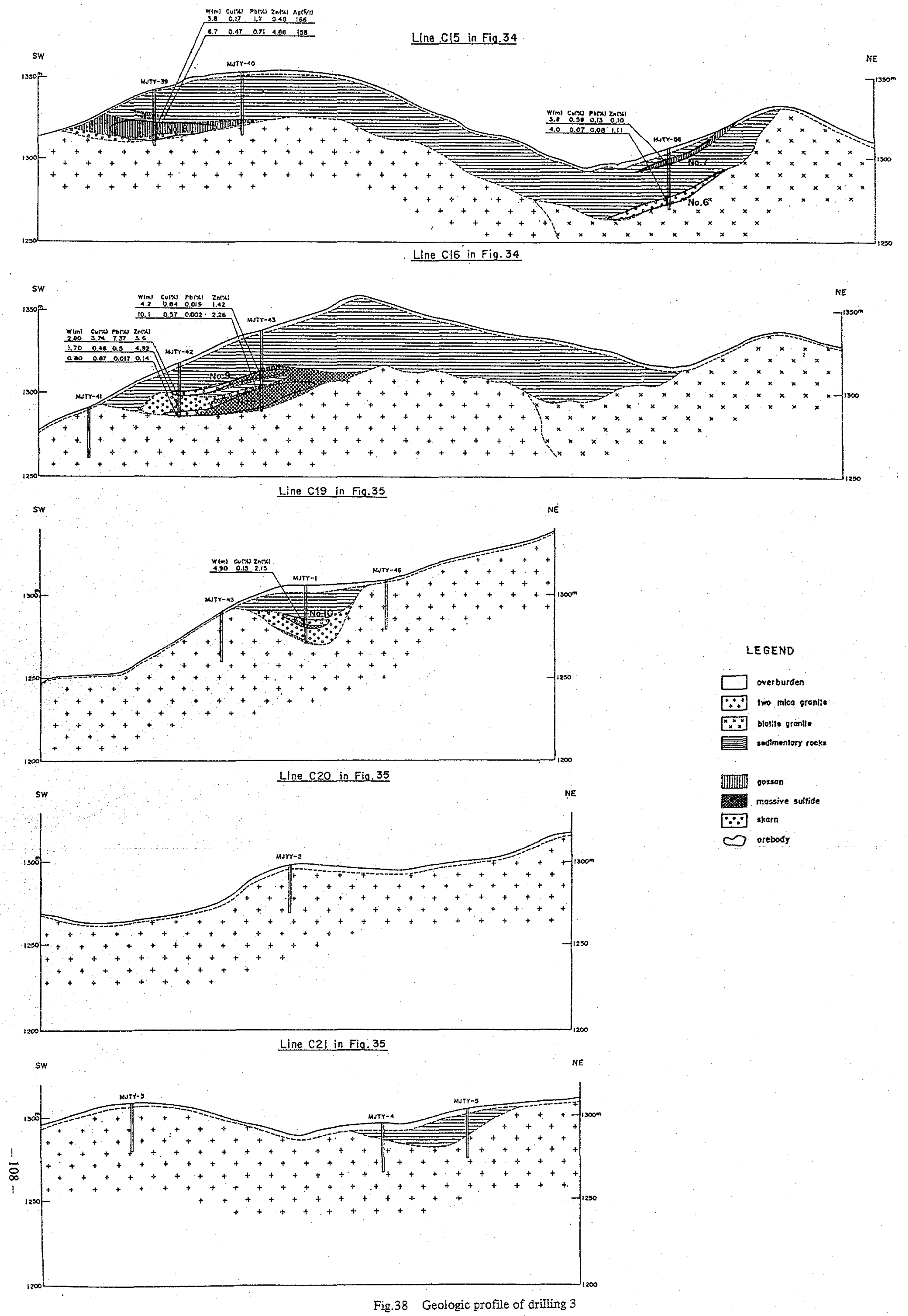


Fig.38 Geologic profile of drilling 3

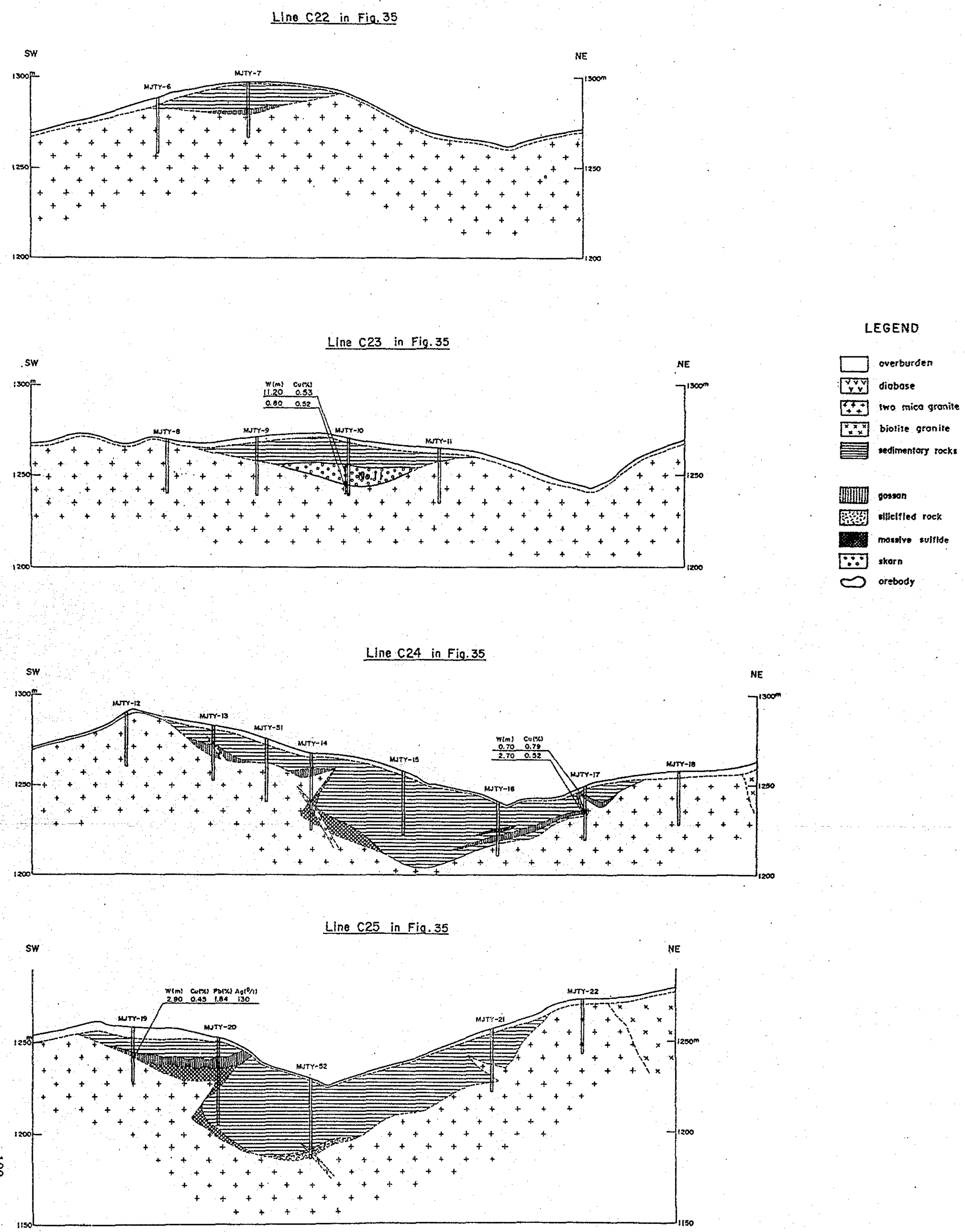


Fig.39 Geologic profile of drilling 4

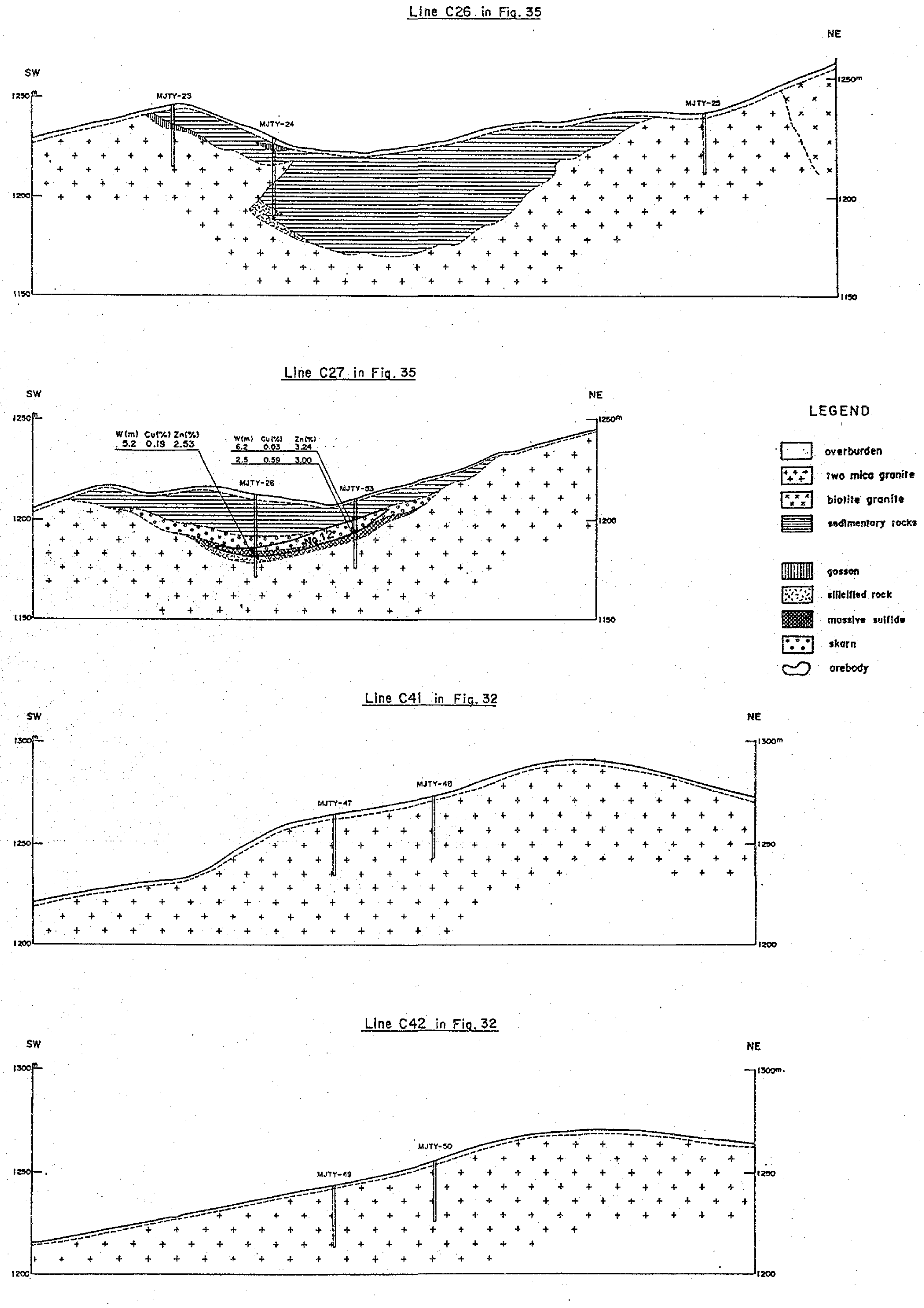


Fig.40 Geologic profile of drilling 5

Table 14 Ore Reserve List

Area	Orebody	Area (m^2)	Maximam Thickness (m)	Possible Ore Reserve (t)	Average Grade						Ore Type
					Cu%	Pb%	Zn%	Sn%	W%	Ag g/t	
North Limestone Area	No. 1	10,440	6.3	76,000	0.05	0.13	2.16	0.11	0.04	70	green skarn
	No. 2	2,960	8.0	27,000	0.66	0.00	0.20	0.04	0.07	19	massive sulfide
	sub total	–	–	103,000	0.21	0.10	1.65	0.09	0.05	57	–
Area C	No. 3	2,560	10.0	30,000	0.66	0.00	0.02	0.04	0.03	8	massive sulfide
	No. 4	12,120	27.1	379,000	0.54	0.01	0.42	0.04	0.09	26	massive sulfide
	No. 5	1,080	3.0	4,000	1.10	0.09	0.28	0.06	0.02	13	green skarn
	No. 6	5,600	4.0	26,000	0.07	0.08	1.11	0.23	0.04	15	green skarn
	No. 7	1,520	3.8	7,000	0.59	0.13	0.10	0.08	0.16	53	gossan
	No. 8	13,200	11.0	168,000	0.53	0.04	2.17	0.04	0.05	19	massive sulfide ~ gossan
	No. 9	2,880	4.2	14,000	2.00	2.96	2.59	0.04	0.06	106	massive sulfide
	No.10	1,200	4.9	7,000	0.15	0.01	2.15	0.05	0.03	11	green skarn
	No. 11	7,280	11.2	94,000	0.53	0.00	0.07	0.01	0.02	11	green skarn
	No. 12	8,000	7.2	67,000	0.19	0.04	3.99	0.05	0.09	35	green skarn ~ massive sulfide
	sub total	–	–	796,000	0.52	0.07	1.10	0.05	0.07	24	–
	Total	–	–	899,000	0.49	0.08	1.17	0.06	0.07	27	–

* Ore Reserve = Area x Thickness x 0.5 x 3.3 (s.g.) x 0.7 (safety ratio)

PART III CONCLUSION AND RECOMMENDATION

PART III CONCLUSION AND RECOMMENDATION

CHAPTER 1 CONCLUSION

As the results of reconnaissance geological and geochemical survey in the first phase, detailed geological and geochemical survey in second phase, and trench and drilling survey in the third phase, the following conclusions are obtained.

(1) Stratigraphy in the area was established by the classification of rock facies comparing with geochronologic data.

Granitic rocks were divided into five masses, and geochemical characteristics indicated that all of them belong to S-type granite and tin bearing granite.

(2) Tin and tungsten vein-type deposits and their placer deposits occur in the granite stock of southwest end of the area. Both of them have already been developed.

Old workings of placer deposits of tin and tungsten are scattered along the streams in the east granite mass distribution.

(3) From the first phase and the second phase survey, Area A (Huai Sa Ngin to Huai U Tum) and Area C (around Yang Kiang village) were extracted as the areas with high possibility of mineral deposit of niobium, tantalum, tin and tungsten.

Trench survey in Area A and drilling survey in Area C led to the following conclusions.

Area A

(i) Dike rocks composed mainly of pegmatite were seen in most of the trenches and analytical values of the niobium, tantalum, tin and tungsten of dike rocks nearly coincide with geochemical anomalies values. This indicates that geochemical anomalies originate from pegmatite.

(ii) Although pegmatites in trench T-16 to 20 showed relatively high values of tin, niobium and tantalum, these minerals are not present in ore grade sufficient to warrant the exploitation for primary ore deposits.

(iii) Tin and tungsten minerals were found in panning samples collected in the streams around geochemical anomalous zones where the above mentioned trenches are located, and old workings of placer deposits are scattered along the streams. These suggest that pegmatites are the source of placer deposits.

(iv) Most promising areas of placer deposits have already been mined by local inhabitants, and the probability of discovering new placer deposits would seem to be low.

Area C

(i) Sedimentary rocks as roof pendant are scattered on a small scale in the distribution of granites.

(ii) Contact metasomatic ore deposits were found along the boundary between granites and sedimentary rocks, replacing limestone or calcareous rock. Mineralizations were also confirmed in the limestone area 1km NNW of Area C.

This suggests that mineralization is predominant in this direction.

(iii) Ore minerals are composed of sphalerite, chalcopyrite, pyrrhotite, scheelite, magnetite, pyrite and galena, and a small amount of bismuth, silver and tin minerals. The major ore minerals are sphalerite and chalcopyrite.

(iv) Ore reserve is estimated at 899,000 tons, Cu:0.49%, Pb:0.08%, Zn:1.17%, Ag:27g/t. This is too low a grade to warrant exploitation.

CHAPTER 2 RECOMMENDATION FOR THE FUTURE

Extension of mineralization is expected from Area C toward the northwest where limestone is widely distributed.

We recommend that geophysical survey such method as IP would be carried out in order to detect distribution and depth of mineralization. This could be followed by drilling in order to ascertain the presence of orebodies.

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