Chapter 2 Mineralization

2-1. Outline

The following types of mineralizations are known in the survey area from previous surveys.

① Mineralization of skarn deposits

② Mineralization of copper-molybdenum dissemination

③ Mineralization of pyrite dissemination

④ Mineralization of gold

A promising skarn ore deposit occurs in the detailed survey area, and it is described in the next chapter. Another skarn type mineral indications were found at the marginal zones of granitic rocks of Bt. Raja and near Pulaukidak. They are skarns accompanied by mangetite-specularite (hematite), magnetite-copper minerals and goethite. These mineral indications remain unravelled in detail.

The copper-molybdenum dissemination is, in view of its location, probably caused by the skarn mineralization, though the details also remain unravelled. The mineral indication has been known from only one location, and its extension seems to be small.

Mineral indications of pyrite dissemination occur at the margin of Bt.Raja, at the south side of the S. Senawar quartz diorite body, and at the sites of andesite intrusives. Thay are associated with silicification and/or argillization, but they are not accompanied by any mineralization of copper, zinc and lead.

The above-mentioned ① to ③ types of mineral indications are known from 46 localities in total, and they are divided as following types (excluding the detailed survey area).

① Skarn type · · · · · · · · · · · · · · · · · · 6 localities

② Copper-molybdenum dissemination type · · · · 1 localities

③ Pyrite dissemination type · · · · · · · · · · 39 localities

Most of these mineral indications can also be grouped as follows from the viewpoint of their distribution.

Mineral Indications of Zone I · · · · · · 15 localities

Mineral Indications of Zone II · · · · · 16 localities

The mineral indications of Zone I are distributed in the area around Bt.Raja and Pulaukidak, and possibly related to the skarn type mineralization. The mineral indications of Zone II are probably related to the intrusion of quartz diorite in the lower stream of S. Senawar, and corespond to silicification zone accompanied by pyrite dissemination. Gold placer grains are contained more or less in stream sediments of the survey area, and it is conceived that the gold mineralization may be widespreaded over the survey area and its outside. Since gold placer grains are collected from the streams in the area underlain by the Hulusimpang Formation, the gold mineralization might have taken place during and/or after Tertiary age, and thus they might have derived from another series of mineralization differed from those of the types ① and ② .

Gold placer grains are known to occur exclusively from stream sediments in the S. Rawas

Formation, but no significant mineralizations are recognized. In such area, remarkable quartz segregation veins are embedded in surrounding slates. It may be inferred that the quartz segregation veins are source of those gold placer grains. This case will be touched again in the next chapter.

2-2 Mineralizations and Principal Mineral Indications

The mineralizations mentioned in the preceding section and some main mineral indications are described here.

(1) Skarn Mineralization

Mineral indications accompanied skarn minerals and embedded in situ in the formation were found at four localities. Hematite boulders and pyrite boulders accompanied skarn minerals were also found at two localities.

a) Mineral Indication of S. Betung

Two mineralizations are present at the S. Betung, a southwest branch of S. Menalu and at the junction point of these two streams(Table 9 , Fig, 12). These locations are also situated at the northeastern boundary of the granite body constituted the Bt.Raja. There are two mineral indications. One [1] is situated at the upper stream and is characterized by dissemination of specularite (hematite) in skarns, and another [2] is specularite-limonite beared in weathered rocks. The mineral indication [2] is not clear to contain skarn minerals. Magnetite boulders and oxidized-copper-stained magnetite boulders were found in near the river beds. The mineral indications of [1] and [2] are situated at the places respectively of 70 m and 350 m apart from the granite boundary.

X-ray diffractive analsis detected the presence of abundant magnetite, a small amounts of goethite and andradite and a trace amounts of hematite, and quartz from magnetite bouldr (BR-103) collected from the point near the mineral indication [1]. The sample(BR-100) collected at mineral indication [1] is mostly of andradite. The chemical analysis indicates that above two samples contain no significant values of nonferrous metals.

b) Mineral Indication of S. Suban

The Mineral indication was found at the junction of S. Rawas and the S. Suban, 1 km dawn stream from Pulaukidak. A magnetite-garnet mineralization zone was found over 7m in extention on the left bank of S. Suban at the place 40 m upper from the junctionn. Magnetite and garnet occur in 3 cm to 5 cm wide bands with strike N 30° W. Similar type boulders are scattered on the right bank of S.Suban. It is suggested that the mineralization zone has an

Table 9 List of Mineral Indications (1)

Reconnaissance survey area

Mineralized zone	Point of zone	Location	Formation	Host rocks	Mode of Mineralization Alteration	Mineral assemblage	Remarks
[I]	1	S. Meliki	S. Rawas	slate sandstone	silicification	Py	quartz veinlet (N60°W, 70°SW)
	2	S. Kutur	S. Rawas	slate	silicification	Py	dissemination of pyrite
	3	S. Betung	S. Rawas	limestone?	skarnization	Skarn Mg, Spe	garnet skarn, width 8m, weathered outcrop
	4	S. Menalu	S. Rawas	slate limestone	silicification	Po,Py	quartz veinlet with green skarn (N70°W, 55°NE) width 2∿5 mm
	5	S. Pedang	(Float)	limestone?	skarnization?	Hm	N30°W tunnel has been situated at a brook where floats were discovered
	6	S.Sungsang	S. Rawas	slate limestone	pyritization	Py	dissemination of pyrite
	7	S. Menalu	−	granite	silicification	Py,Cp,Ga, Sp,Mo	joint filling pyrite vein width 1 ∿ 2 mm
	8	S. Suban	−	limestone?	skarnization	Skarn Mg	garnet skarn width 7 m
	9	S. Pangi	S. Rawas	limestone slate	skarnization	Skarn Py	width 0.15 m garnet with green mineral
	10	S. Seri	−	limestone	skarnization	Skarn Py	green skarnized limy float
	11	S. Seri	S. Rawas	slate	silicification	Py	dissemination of pyrite
	12	S. Suban	S. Rawas	andesite	pyritization	Py	dissemination of pyrite
	13	S. Suban	S. Rawas	sandstone	silicification	−	silicification only
	14	S. Simpang	S. Rawas	sandstone tuff	silicification	Py	dissemination of pyrite
	15	S. Puar	S. Rawas	slate andesite	silicification	Py	dissemination of pyrite
[II]	16	S. Senawar Seni	S. Kuwis	tuff	silicification	Py	dissemination of pyrite
	17	S. Senawar Seni	S. Kuwis	tuff	silicification	−	silicification only
	18	S. Senawar	S. Kuwis	sand stone	silicification	Py	dissemination of pyrite
	19	S. Senawar	S. Kuwis	tuff andesite	silicification	Py	dissemination of pyrite
	20	S. Keruh	S. Kuwis	slate tuff	argillization silicification pyritization	Py	pyrite dissemination in shear zone (width 0.6 m, N55°W, 65°SW)
	21	S.Mengkulan	S. Kuwis	diorite slate basalt	pyritization silicification	Py	dissemination of pyrite
	22	S. Kuwis	−	diorite	silicification	Py	dissemination of pyrite
	23	S. Labi	S. Kuwis	tuff	silicification	−	silicification only
	24	S. Kerali	−	basalt	silicification	Py	dissemination of pyrite width 100 m
	25	S. Kutur	S. Rawas	slate	argillization	−	argillization only
	26	S. Meliki	S. Rawas	andesite	silicification	Py	dissemination of pyrite

Abbreviation
Py : Pyrite   Po : Pyrrhotite   Spe : Specularite
Cp : Chalcopyrite   Mo : Molybdenite   Hm : Hematite
Ga : Galena   Mg : Magnetite
Sp : Sphalerite   Mal : Malachite

Table 9 List of Mineral Indications (2)

Reconnaissance survey area

Mineralized zone	Point of zone	Location	Formation	Host rocks	Mode of Mineralization Alteration	Mineral assemblage	Remarks
	27	S. Maloko	S. Rawas	slate	argillization silicification	Py	quartz vein with pyrite
	28	S. Buluh	S. Rawas	slate	silicification	Py	dissemination of pyrite
	29	S. Limun	S. Rawas	diorite sandstone	pyritization	Py	dissemination of pyrite
(II)	30	S. Labi	-	diorite	pyritization	Py	dissemination of pyrite
	31	S. Kuwis	(S.Kuwis)	diorite tuff	pyritization	Py	dissemination of pyrite
	32	S. Kulus	Napallicin	tuff	silicification	Py	dissemination of pyrite
	33	S. Kuwis	S. Kuwis	tuff	pyritization	Py	dissemination of pyrite
	34	S. Kasai	-	quartz diorite	argillization	Py	dissemination of pyrite
	35	S. Kuwis Besar	Hulusimpang	tuff	argillization	-	argillization only
	36	S. Minak Terang	Hulusimpang	tuff	argillization	Py	pyrite along joint
	37	S. Minak Serut	Hulusimpang	tuff	silicification	-	silicification only
	38	S. Tiku	Hulusimpang	tuff	pyritization	Py	dissemination of pyrite
	39	S. Pelantingan	S. Minak	shale	pyritization	Py	dissemination of pyrite
	40	S. Graga	S. Minak	siltstone	pyritization	Py	dissemination of pyrite
	41	S. Minak	S. Minak	andesite	silicification	-	silicification only
	42	S. Glagahhilir	S. Minak	tuff	argillization	Py	dissemination of pyrite
	43	S. Semamba	S. Minak	tuff	silicification	Py	dissemination of pyrite
	44	S. Maling	S. Minak	tuff	pyritization (silicification)	Py	dissemination of pyrite
	45	S. Tarum	S. Minak	shale	silicification	Py	pyrite along joint
	46	S. Tiku	S. Minak	tuff	silicification	Py	dissemination of pyrite

Abbreviation
Py : Pyrite
Cp : Chalcopyrite
Ga : Galena
Sp : Sphalerite
Po : Pyrrhotite
Mo : Molybdenite
Mg : Magnetite
Mal : Malachite
Spe : Specularite
Hm : Hematite

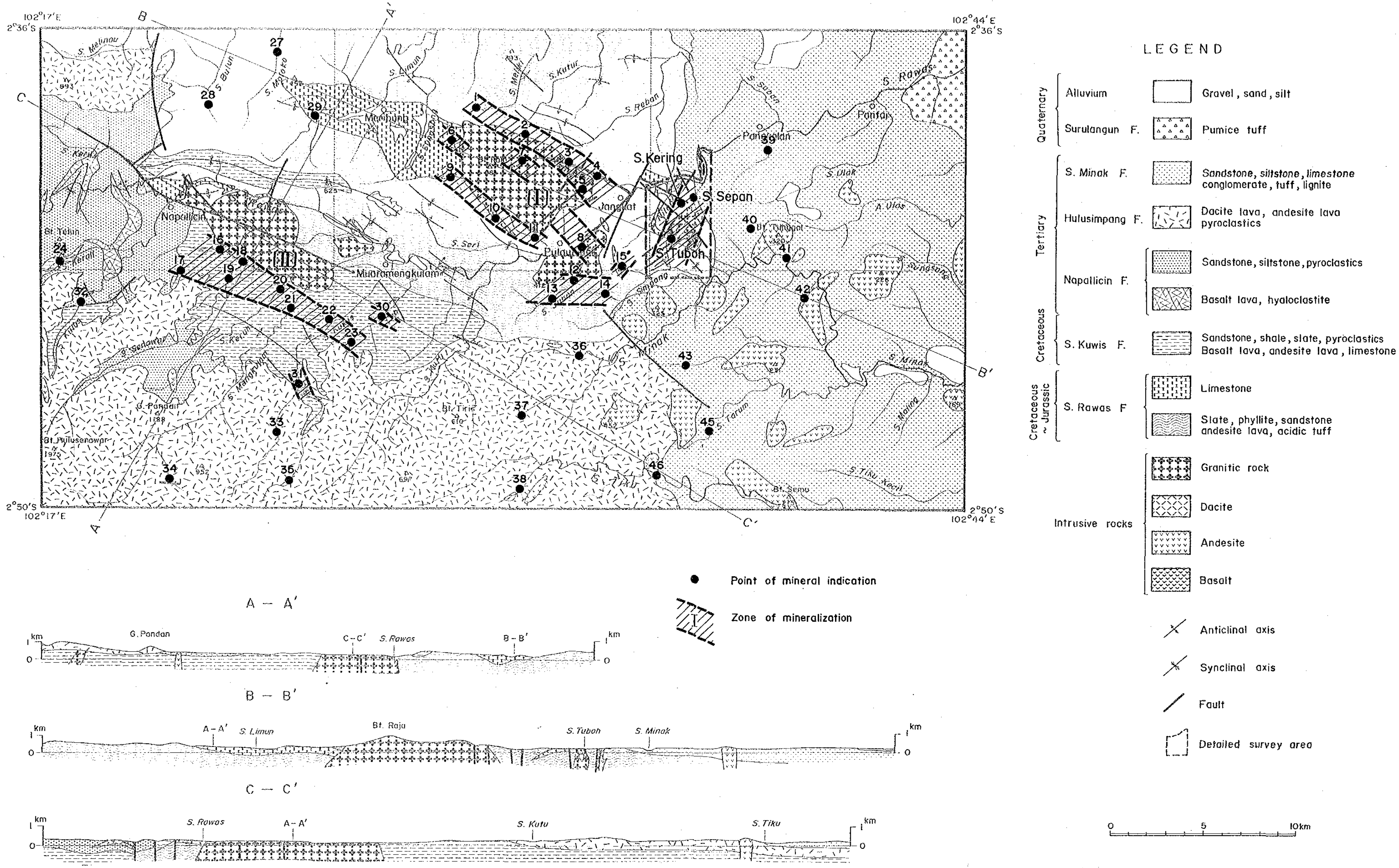


Fig. 11 Distribution Map of the Mineral Indication

extension greater than the width of S. Suban, 20 m. A holocrystalline greenish black coloured rock (dioritic ?) occurs in the downstream near the mineralization zone, and a granite porphyry with pink-coloured potassic feldspar crops out at further down the stream. X-ray diffractive analysis detected the presence of magnetite, andradite, cuprite, hematite and quartz in the sample (AR-137).

A intercalated hornfels of 2 m width within granite is existed at the 300 m upper stream from the mineral indication, but it has undergone no skarnization.

c) Mineral Indication of S. Pangi

A skarnization zone was found at the upper stream of S. Pangi, a branch of S. Sungsong to the southsest of Meribung. It is situated at the contact zone between a southeastern extension of the Mersip Limestone Member and the granite porphyry of Bt.Raja. Skarns associated with secondary iron minerals are embedded along a small fissure with 15 cm in width in limestone exposure (6 m wide and 4 m high) at the place. The limestone is dark grey in colour and not recrystallized. The small skarnized fissurs strike N40° E and dip 15°. Skarn minerals occur in the apparent hanging-wall side, and iron minerals are concentrated as a band of 1cm～2cm in thickness in the apparent foot-wall side. X ray diffract analysis detected abundant grossular and a small amounts of calcite, chlorite, epidote and plagioclase in the sample (CR-44) collected from this site..

(2) Mineralization of Copper-Molybdenum Dissemination

The mineral indication was found from the upperstream of S.Menalu. It is shown in Point of Zone 7 in Table 9. It occurs in the granite porphyry of the Bt.Raja, and consists of thin filmy veinlets of chalcopyrite-pyrite-galena-sphalerite and spotted molybdenite. Chemical analysis data detected no significant result to suggest the presence of the above minerals. This seems to be due to uneven distribution of the minerals in the sample assayed.

(3) Pyrite Dissemination

Pyrite disseminations are densely distributed in the Zone II, while they are also found in places in the Zone I. However, no other ore minerals are contained except pyrite in the dissemination. This is also proved by chemical analysis data. X-ray diffractive analysis data reveal that these silicitication zones consist of quartz, calcite, chlorite and sericite.

(4) Gold Mineralization

The places where local inhabitants are collecting gold from stream sediments by panning are extensively distributed all over the survey area. However, it is still quetionable whether the area is a "gold-producing belt" with high gold potentiality or not. It is really that there is enough gold to collect 0.5~1 g of gold grains a day by panning. It is heard that a little-finer-sized nugget is sometimes collected.

In the survey area, gold is recognized from stream sediments in the area underlain exclusively by the Tertiary system as well. Therefore, the gold mineralization is assumed to have taken place during and/or after Tertiary in age. At those times, in the survey area, activities of basalt, andesite, dacite and quartz diorite porphyry are considered to have occurred. It is unknown that these activities are responsible for the gold mineralization. However, in the tuffs of the Hulusimpang Formation, irregular aggregates of drusy quartz sometimes occur. The fact seems to be consistent with the available information that the gold deposits in the Sumatra Island (e.g., those in the vicinity of Bengkulu) are mostly derived from quartz veins which are emplaced within the Hulusimpang Formation. However, it is generally accepted that the gold mineralization in the Sumatra Island is related to Quaternary volcanic activities. In the survey area, however, there is no evidence of Quaternary volcanisms. But, another story may be given, if the gold mineralization can take place at an area several tens of kilometers apart from the related volcanic center. Namely it is expected from the topographical viewpoint that an extension of one of the branches of the main volcanic chain in the Sumatra Island runs through the northwestern part of the survey area. In any case, the geochemical survey data indicate that the geochemical anomaly of gold used to be found in the area underlain by the Hulusimpang Formation (Part 4, Chapter 2); and the gold mineralization has taken place probably during and/ or after the Hulusimpang stage.

On the other hand, placer golds are also collected from some streams in an area exclusively underlain by the S. Rawas Formation as well. However, in spite of the fact that neither quartz veins as associated with gold nor any other types of mineralizations are recognized in the area, thin-finger-sized nugget is sometimes collected from the area according to local inhabitant. In connection with this, one possibility that such a gold are possibly originated from pelitic rocks. Many segregated quartz veins are frequently observed in the peritic rock of the S.Rawas Formation. If gold contained in the pelitic rock were extracted during metamorphysm under the some physico-chemical condition and segregated with quartz vein, the possibility is pointed out that a part of gold occurring in the area underlain by the S. Rawas Formation may be derived from the pelitic rocks by such metamorphic differentiation.

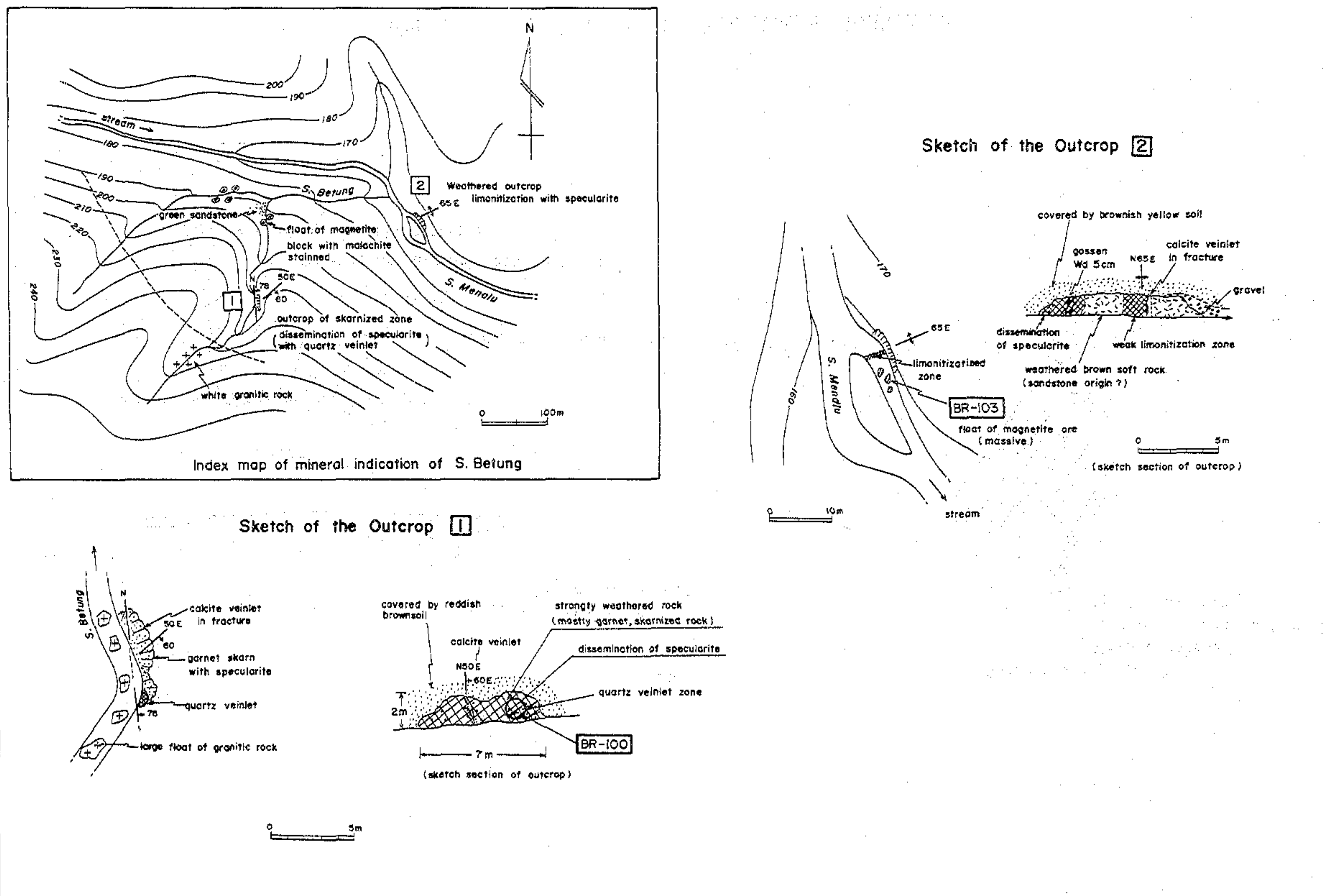


Fig. 12 Sketch of the S.Betung Mineral Indication

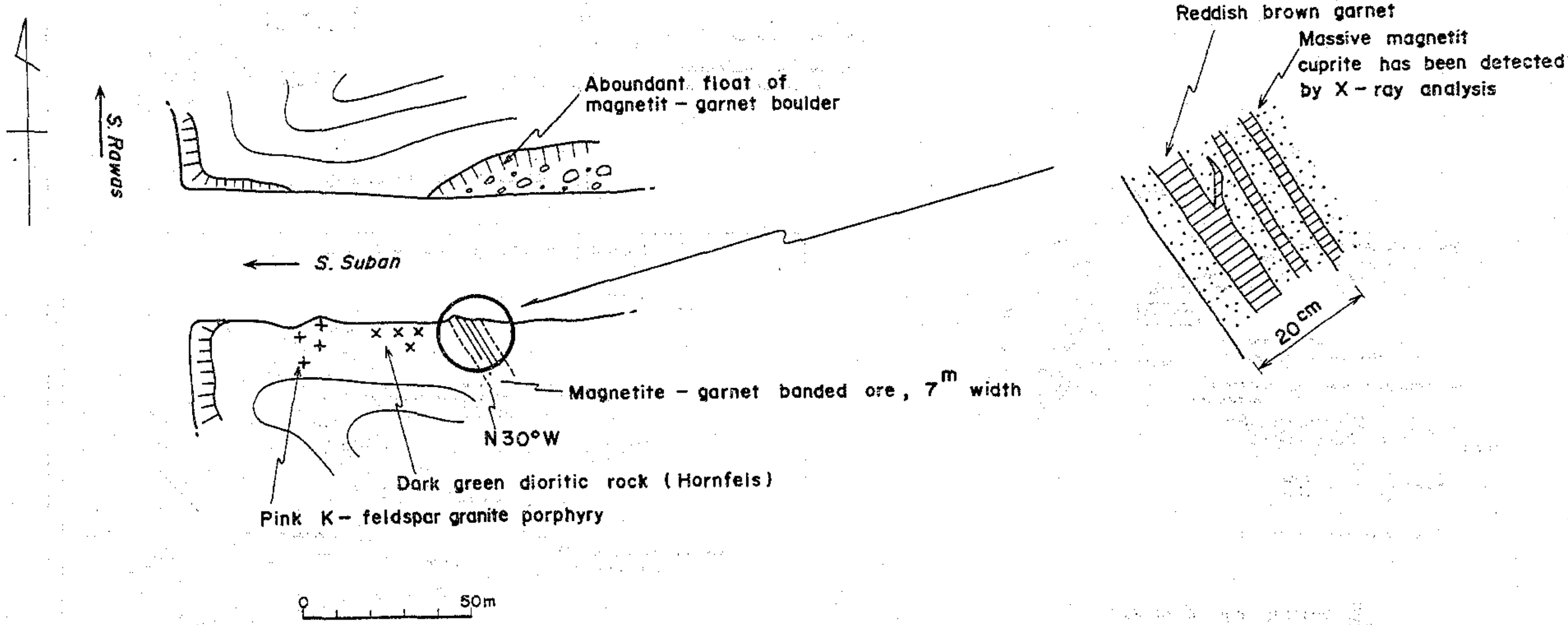


Fig. 13 Sketch of the S.Suban Mineral Indication

Table 10　Results of X-ray Diffractive Analysis

凡　例

mal	: malachite	ca	: calcite	◎	: abundant
bro	: brochantite	sid	: siderite	○	: common
cup	: cuprite	am	: amphibole	∘	: a few
at	: atacamite	px	: pyroxene	•	: rare
ga	: galena	ep	: epidote		
ce	: cerussite	ch	: chlorite		
sp	: sphalerite	se	: sericite		
smi	: smithsonite	k	: kaolin mineral		
hem	: hemimorphite	q	: quartz		
hyd	: hydrozincite	pl	: plagioclase		
py	: pyrite	kf	: potash feldspar		
mt	: magnetite				
il	: ilmenite				
he	: hematite				
go	: gothite				
lep	: lepidocrosite				
an	: andradite				
gr	: grossularite				

Table 10 Results of X-ray Diffractive Analysis

試料No.	mal	bro	cup	at	ga	ce	sp	smi	hem	hyd	py	mt	he	go	lep	an	gr	ca	sid	am	px	ep	ch	se	k	q	pl	kf	Remarks
AR 57	∘					◎								∘		•?							•?			∘			
AR 74	•	∘					∘	○	∘	∘				∘	∘	∘		∘?		•			•?			○			
AR 75											•							•				•	∘	•		○	○	∘	
AR 108					•?						∘		•?										∘	•	?	◎			
AR 109						○							∘	∘		∘										○			
AR 110						○														•		∘	○	∘		○			
AR 112					•	○								∘	∘	•		•?								○			
AR 113		•		•		○								∘	∘							○	∘	∘		○			
AR 114					∘	○							∘	∘		∘							∘			○			
AR 122							∘												○	•?	◎[1]		∘			○			[1]hedenbergite
AR 123		•?			•?	∘			∘	∘			∘	∘	∘	∘		∘					•?			○			
AR 125								○														○	○	∘		∘			
AR 126	∘					∘			∘	∘			∘?	∘	∘	○							∘			○			
AR 127	•								∘	○			∘	∘						•						○			
AR 128							○		∘														•?			○			? ∘
AR 130						◎								∘	∘														
AR 131						◎																							
AR132-2																◎										∘			
AR 133					∘?						○												•?			◎			
AR 135					∘?						○															○			
AR 137			∘									○	∘			○										∘			
BR 77																		○					○	∘		◎	○		
BR 95																		◎			∘					•			
BR 100														∘		◎										∘			
BR 103												◎	•	∘		∘										•			
BR 105													◎	•												•			
CR 18											∘							○					∘	∘		○			
CR 44																	◎	∘				∘	∘			•?	∘	?	
CR 51											∘													∘		◎	∘		
CR 62														∘					○						○	○			

Table 11 Results of Assaying

Sample No.	Cu %	Mo %	Pb %	Zn %	Hg %	Ag g/t	Au g/t
AR-57	10.40	<0.001	31.90	0.59	<0.001	390.0	0.07
AR-74	8.20	0.001	1.42	8.86	<0.001	230.0	0.27
AR-80	0.26	<0.001	0.21	0.30	<0.001	11.0	<0.07
AR-99	1.33	<0.001	39.10	0.27	<0.001	976.8	0.21
AR-109	0.40	<0.001	17.70	0.40	<0.001	320.0	0.27
AR-110	0.34	<0.001	10.60	0.23	<0.001	66.0	<0.07
AR-111	0.14	<0.001	55.10	0.05	<0.001	1826.8	0.41
AR-112	0.72	<0.001	13.10	0.72	<0.001	122.0	0.21
AR-113	0.38	<0.001	5.82	0.17	<0.001	21.0	<0.07
AR-114	0.63	0.001	17.50	0.30	<0.001	150.0	0.27
AR-115	0.43	<0.001	1.17	0.43	<0.001	31.5	0.14
AR-116	1.12	<0.001	4.20	9.20	<0.001	182.0	0.14
AR-117	0.84	<0.001	40.80	0.59	<0.001	2725.1	0.31
AR-118	4.29	<0.001	19.30	0.77	<0.001	1885.0	0.34
AR-119	1.18	<0.001	4.62	1.64	<0.001	280.0	0.21
AR-120	1.02	<0.001	49.60	0.18	<0.001	1080.4	0.31
AR-121	0.90	<0.001	9.67	1.11	<0.001	235.0	0.07
AR-122a	2.97	0.001	4.34	13.10	<0.001	188.0	<0.07
AR-123	5.18	0.001	8.56	9.58	<0.001	469.2	0.89
AR-124	2.36	<0.001	15.00	1.64	<0.001	766.9	0.21
AR-136	0.29	<0.001	0.69	3.47	<0.001	240.0	0.07
BR-77	0.07	<0.001	0.11	0.10	<0.001	5.0	0.34
BR-95	0.03	<0.001	0.06	0.03	<0.001	5.5	0.07
BR-97	0.02	<0.001	0.04	0.03	<0.001	1.7	<0.07
BR-100	0.01	<0.001	0.03	0.01	<0.001	4.4	0.89
BR-103	0.08	<0.001	0.01	0.02	<0.001	2.8	<0.07
BR-105	0.03	<0.001	0.02	0.03	<0.001	2.8	0.14
CR-18	0.01	0.002	<0.01	0.01	<0.001	1.0	<0.07
CR-44	<0.01	0.004	0.01	0.03	<0.001	1.0	<0.07
CR-51	<0.01	<0.001	0.01	0.02	<0.001	0.5	<0.07

Table 12 Results of Microscopic Observation of Polished Specimens

No.	Sample No.	Ore Mineral												
		Cp	Cc	Cv	Ma	Ga	Sp	Py	Po	Mar	Mt	He	Li	Gn
1	AR57				△								△	△
2	AR74	◎		△			△	○						
3	AR80							○			◎	△		
4	AR107							○						○
5	AR108							○						◎
6	AR122	△				△	○	△						◎
7	AR126			△		◎							△	△
8	AR127	◎		△		△	○	○					○	△
9	AR128	•					◎	•		△				○
10	AR130		△	△		△		△					△	△
11	AR132-1	○				△	◎	△				△		△
12	AR132-2	•				△	○					△		○
13	AR132-3	△				△	◎							○
14	AR132-4	○				○	○	○				?	?	△
15	AR132-5	△				△	◎							○
16	AR132-6	△				△	◎							○
17	AR132-7	△				△	◎					△?		○
18	AR132-8	△				△	◎					△?		○
19	AR132-9	△				△	○					△?		○
20	AR132-10	△				△	◎					△?		○
21	AR132-11	○				○	◎	△		△			△?	△
22	AR132-12	○				○	◎	○		△		△?		△
23	AR133			△		△	○							◎
24	AR134	△		•		△	△	○						◎
25	AR135							○				○	△	◎
26	AR137										◎	△?	△	◎
27	BR95								△					◎
28	BR100										◎	•	△	
29	BR103										◎	△	△	△
30	BR105										△?	◎	△?	•

Cp : Chalcopyrite
Cc : Chalcocite
Cv : Covelline
Ma : Malachite
Ga : Galena
Sp : Spharelite
Py : Pyrite

Po : Pyrrhotite
Mar : Marcasite
Mt : Magnetite
He : Hematite
Li : Limonite
Gn : Gangue

◎ : abundant
○ : common
△ : rare
• : trace

Chapter 3 Geology and Ore Deposits in the Detailed Survey Area

3-1 Outline

The detailed survey area ($18\ km^2$) were carried out in the old mining claim which had ever been staked off in the dutch colonial time. The detailed survey area covers in the area ranging from the south bank of S. Rawas to the S. Minak, and is situated at 21 km up from Surulangun along S. Rawas.

The detailed survey area is generally low in elevation, and even the highest peak reaches only 187 m above sea level. This is quite different in topographic condition, comparing with other known skarn-type mineralization areas located in high mountain lands. The area consists of low mounds or hills surrounded by swamp.

Three mineral indications located at S. Tuboh, S. Kering and S. Sepan had ever been prospected during the Dutch colonial time in the area. The prospecting data are available from a report by DICKMAN (1917). However, since some data, especially attached maps, are missing, and the locations of the old trenchs, pits, shafts and drilling sites are uncertain. The description by BEMMELEN (1970) on the three indications mentioned above are essentially quoted from the DICKMAN's data.

Among the three indications, the S. Tuboh mineral indication is evidently of a skarn type deposit contained mainly a high-grade lead ore associated with zinc, copper and silver. The ore deposit is extrardinarily high in ore grade and large in scale among all mineral indications found in the whole survey area including the reconnaissance sruvey area.

This deposit seems to have a close genetic relation to a quartz monzonite, and has been formed at the boundary or junction between the quartz monzonite and limestones

3-2 Geology and Geologic Structure

The detailed survey area consists mainly of the S. Rawas Formation and quartz monzonite inturded into it, and the Kuwis Formation are exposed in the northern part, overlying the S. Minak Formation, and quartz diorite porphyry has intruded into the Formation.

The S. Rawas Formation can be lithologically divided into three stratigraphic units, namely upper unit, middle unit and lower unit. They are the An-Phyl rock facies characterized by sericitic phyllites, andesitic pyroclastics and andesite lavas (lower unit), the Ls-Tf rock facies characterized by limestones accompanied by some acidic tuffs, sandy tuffs, fine tuffs and sericitic phyllites (middle unit), and the Ss-Sl rock facies consisting mostly of sandstones and slates (upper unit).

The S. Kuwis Formation is limitedly exposed along the S. Nilau, northwest of the area, and is estimated at 300 m～ 500 m in thickness. The Formation consists exclusively of dark brown to brownish black shales which are calcareous in some place. Slaty cleavages tend to become remarkably towards the upper stream. The structure of S. Kuwis Formation is not consistent in that of the S. Rawas Formation, and it is suggested that both Formations are in relation of unconformity as same as the structure in the reconnaissance survey area. In the detailed survey area, however, they are bounded by a fault.

The S.Minaku Formation overlies directly the S. Rawas Formation and the S. Kuwas Formation, lacking the Napallicin Formation and the Hulusimpang Formation.

A conglomerate at the basal part consists of sub-angular boulders or pebbles of quartz derived probablly from segregation veins in the S. Rawas Formation.

This Formation is composed of siltstones, sandstones, tuffaceous sandstones, sandy conglomerates and lignite beds, and dips gently southwest or northeast.

Foldings and faultings trended NE-SW direction are predominantly present in the detailed survey area. Other faults with N-S direction are also present. The foldings developed at the north side of the quartz monzonite body in the central part area is probablly of box-folding owing to a up-lifting block movement around there.

The anticlinal structure extending from the mid-stream of S.Nilau to S.Kering is disturbed by faults of NW-SE system, but it is clearly bent from NW-SE to NE-SW direction. The fact may suggest that the area has ever undergone not only the compressional stress toward NW caused by the block uplifting in the central part, but also the effect of another stress in N-S direction. The synclinal structure may also have been formed the similar tectonic movement in the southeastrn part of the area.

The fault system of NE-SW direction is important, since it may have a direct relation to intrusion of quartz monzonite. This fault has played an important role on the forming and distribution of the ore deposits, especially of unit ore bodies, because the faults displace the limestones in the area. The unravelling of properties of this fault should be taken into considerations for the future prospecting on the mineral indication of S. Tuboh.

3-3 Igneous Activity

There are a large quartz monzonite body with elongation in NE-SW direction and a small body of porphyritic quartz monzonite intruded the formerin the center part of the detailed survey area. These intrusive rock bodies have been undergone dissemination of a small amount of pyrrhotite. Especially, the quartz monzonite at the S. Tuboh mineral indication constitutes a part of the host rocks of the ore deposit. As already mentioned, the porphyritic quartz monzonite has been dated as 40.1 ± 2.0 Ma in radiometric absolute age. The quartz monzonite contains a considerable amounts of mafic minerals (around 30 %), corresponding in colour index to monzonite, but nepheline apears through norm calculation, suggesting it alkaline granite.

The quartz diorite porphyry elongated to N-S direction crops out penetrating the S. Minak Formation in the northeastern part of the detailed survey area. No thermal effect owing to the intrusion is observed in the the S. Minak Formation. This may be due to tuffaceous rock of the S. Minak Formation surrounding the intrusion, and also due probsbly to intrusion at low temperatures.

An andesite, which may be called "andesite porphyry", has intruded in the southern part of the

Fig. 14 Generalized Geologic Map of the Detailed Survey Area

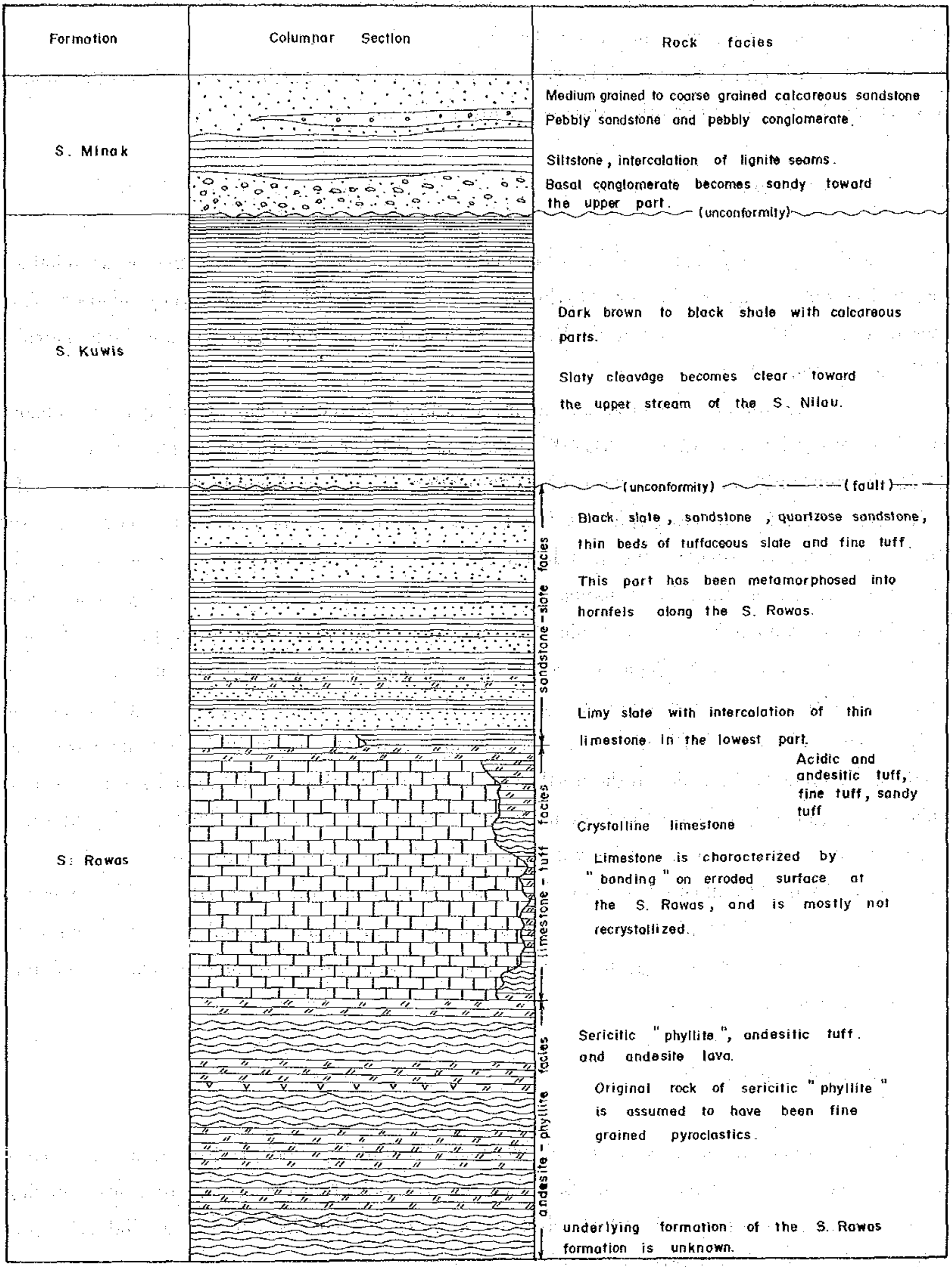


Fig. 15 Schematic Geologic Column of the Detailed Survey Area

area. This rock could be a shallow facies of the quartz monzonite mentioned before.

A very small intrusive rock of andesite penetrating the S. Minak Formation is exposed in the north side of S.Sepan mineral indication. Andesites of similar rock facies are also known from S. Nilau, but they are very small in size less than 1 m in width.

On the banks and bottom of S. Rawas, a basalt (dorelite) stock has intruded into the boundary between the S. Rawas Formation and the S. Minak Formation.

3-4 Metamorphism and Alteration

Sericitic phyllites found in the lower to middle units of the S. Rawas Formation are distinct in schistosity and cleavage and show silky luster. The associated tuffaceous rocks also are similar rock facies. These indicate that the S. Rawas Formation has undergone a regional metamorphism of the green schist facies.

On the other hand, a silicification zone is exposed at the margin of the quartz monzonite, especially along its elongation to NE-SW direction, and the regional metamorphic facies of the S. Rawas Formation disappears owing to the silicification. The regional metamorphic facies of the S. Rawas Formation appears again at 1.5 km south and far of the S. Tuboh mineral indication. However, in the S. Kering mineral indication area, there is no silicification zone at only 75 m northwest apart from the mineral indication, while the strata has undergone An-Phyl rock facies of a regional metamorphism. The silicification zone tends to become widespreaded from the uppermost stream of the S. Sepan to the south, in the east side of the quartz monzonite body, and also the silicification zone is also extensively distributed to the northeast of the quartz monzonite body. Namely, the silicification zone surrounding the quartz monzonite body is narrower in the northwestern side while wider in the northeastern side and southwestern side and southeastern side. This facts suggest that the depth of emplacement of the quartz diorite is shallow in the northern part to the northwestern part and relatively deep in the southern part to the southeastern part, or in other words that the quartz diorite has probably intruded from south towards north. However, in the middle stream of S. Nilau, limestone is recrystallized to marble, and a small scale silicification zone is also existed in the places, suggesting that another quartz monzonite or other similar intrusive rock lies concealed in this vicinity.

3-5 Mineralization

In the detailed survey area, three mineral indications of S. Tuboh, S. Kering and S. Sepan had been prospected in the past. The S. Tuboh mineral indication consists of four ore showings . About these, as already mentioned, the description by BEMMELEN(1970) is available. In the following, it is briefly reviewed as a reference.

(1) The S. Tuboh Indication

The mineral indication is situated at 3.5 km south of S. Rawas, consisting of a ore outcrop near the upperstream of S. Tuboh, a branch stream of S. Simpang (a branch stream of S. Minak), and ore deposits at the old prospecting sites. As "Tuboh" means poison in local language, these mineral indications might have been known from quite a long time ago.

The mineral indications are observed at the two old procpecting sites (each of which has a shaft) and from two outcrops of ores. One of the ore outcrops located at the uppermost stream may be of a float. These four mineral indications arrange along the quautz monzonite intrusion. Figures 16, 17, 18 and 19 show sketches of trenches and pits located at most southwestern mineral indication and prospected more in detail among these mineral indications, judging from the amount of ores piled at the mine site.

This mineral indication was found within a skarnized and decolored part of quartz monzonite and in a portion bounded by two or more quartz monzonite masses, and consists of sandy or earthy limonite-quartz ores mixed up galena, sphalerite, chalcopyrite, pyrite and oxidized copper miaerals. Accordingly ores, especially high grade ores, are embedded as form sandwitched by masses of quartz monzonite The decoloured and weakly-skarnized quartz monzonite also contains high grades of Pb and Zn, as a part of of the ore zone. Skarns are composed mainly of hedenbergite and subordinate amount of garnet, accompanied by gangue minerals of siderite, chlorite, epidote, calcite and quartz. Quartzs occured are so-called rock crystal, reaching 20 cm in maximum size.

Minerals contained in the S. Tuboh mineral indication were identified through microscopic observation and X-ray diffractive analysis as follows ;

(Primary Ore Minerals)

galena (PbS)	(common)
sphalerite (ZnS)	(common)
chalcopyrite ($CuFeS_2$)	(common)
pyrite (FeS_2)	(common)
marcasite (FeS_2)	(rare)
hematite (Fe_2O_3)	(rare)

(Secondary Ore Minerals)

- cerussite ($PbCO_3$)
- smythsonite ($ZnCO_3$)
- goethite (α-$FeOOH$)
- lepidochrocite (γ-$FeOOH$)
- malachite ($Cu_2(OH)_2CO_3$)
- brochantite ($Cu_4(SO_4)(OH)_6$)
- hydrozincite ($Zn_5(OH)_6(CO_3)_2$)
- hemimorphite ($Zn_4(OH)_2Si_2O_7 \cdot H_2O$)

(Gangue Minerals)

hedenbergite	(abundant)
andradite	(abundunt)
siderite	(abundant by case)
epidote	(common)
chlorite	(always occur,but small amount)
sericite	(rathercommon,butsmallamount)
amphibole	(sometimes occur)
quartz	(common, abundant)

From the result, the primary mineral association of the S. Tuboh mineral indication is summarized as galena-sphalerite-chalcopyrite-pyrite-(marcasite-hematite) of ore minerals and quartz-hedenbergite-andradite of main gangue minerals.

In addition, some samples collected from the ore piles at the mine site has magnetic susceptibility, suggesting presence of magnetic mineral in the ores.

Based on chemical analysis data on samples collected by line-sampling from the pits and trenches, the average ore grade of the S. Tuboh mineral indication is estimated by weighing the sampling interval as follows.

Location	No.of samples	width m	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Old pit	1	1.50	0.21	976.8	1.33	39.10	0.27
OTC-1	7	6.60	0.20	214.8	0.50	13.71	0.36
TA-2	6	4.70	0.21	941.6	1.46	19.01	2.06

Although the ore grades vary widely, general speaking, the contents of silver as well as lead are significantly high. It may thus define the ore deposit silver-lead bearing skarn type. The reason of Pb>Zn in their content will be unravelled after accumulating data of deeper portion by future prospecting.

They mineral indication seems to correspond to the site of shaft A by BEMMELEN(1970). Another outcrop with similar mineral composition was found on the left bank of the S.Tuboh, 75 m east of the above-mentioned mineral indication. At the outcrop, the ore with 60 cm ~80 cm in width occurs in the boundary between quartz monzonite at hanging wall and marble at foot wall. The average grade of the ore is as follows:

Location	No.of samples	width m	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Outcrop	3	3.0	0.43	542.8	3.50	10.53	6.81

At the 160 m north of the outcrop mentioned above, another old shaft is situated. This place seems to be further below the foot-wall- quartz monzonite of the above-mentioned outcrop. Its vicinity is underlain by a slightly-thick limestone bed, but only a small amounts of hedenbergite are scattered around the shaft.

The mineral indication at the northeastern-most is possibly a derived silicified boulder, which is about 1m x 0.8m x 0.3m in size, and stained with cerussite, chalcopyrite, limonite and malachite. Quartz, andradite and chlorite are the major gangue minerals The ore grade is as follows.

Location	No.of samples	width m	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Outcrop	1	-	0.57	390.0	10.40	31.90	0.59

As above-stated, the S. Tuboh mineral indication suggests the existence of a high grade ore deposit of silver-lead-(zinc-copper) type. The deposit is emplaced at the junction of limestone and quartz monzonite penetrating in the limestone. Therefore, it seems that the strike extention of the deposit (unit orebody) is determined by the extention of the junction. When the junction extension is long, in other words when the limestone is thick or the junction angle is gentle, the ore deposit could become large in scale. In the case of the S. Tuboh mineral indication, however, the junction angle is large (namely, the limestone and the quartz monzonite are almost perpendicular to each other) and the limestone itself is also not very large in scale. Accordingly, the extension of the unit orebody may not be long as large as several hundred meters. However, considerating the fact that general skarn type deposits used to be irregular in shape, it is still expectant that the unit ore body grows toward deeper part.

(2) The S. Kering mineral Indication

The mineral indication was found at 1.8 km north to northeast of the S. Tuboh and also 1.8 km south of the S. Rawas, and is situated on the left bank of the S. Kering (a branch of the S.Sepan) running to northeast. The mineral indication site is in a small hill which is 15 m high above the stream-bed and extends 120m in NE-SW and 75 m in NW-SE. An old shaft is found at the top of the hill. An collaped adit which appears to be connected with the shaft is also found at the slope 2 m high above the stream bed. Near the adit, a quartz block of 2m x 1.8m x 0.8m in size was found, and it is stained by oxidized copper minerals.

Investigation after cleaning two old trenches reveals that some cherty quartz blocks impregnated with a minor amount of galena are sporadically distributed in surface soils. The quartz blocks are about 5m x 3m in maximum size. Smaller blocks of silicified rock are similarly found in surface soils.

Thus, the S. Kering mineral indication is significantly different in mode of occurrence as well as in mineralogical or ore characteristics from the S. Tuboh mineral indication mentioned above. X-ray diffractive analysis data confirm only a possible presence of galena in addition to quartz and pyrite,as well as nacked eye observation.

(3) The S. Sepan Mineral Indication

This mineral indication is situated at 800m northeast of the S. Kering mineral indication. It forms a small hill, and eight quartz blocks with various sizes are scattered on the surface in a area of about 40m x 40m in the hill. Their condition and appearance are similar to those of the S. Kering mineral indication, but the quartz blocks are relatively large, exceeding 10m at maximum. Chemical analysis data on the biggest one by line-sampling show ore grade as follows ;.

Location	No. of samples	width m	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Float	1	10.0	0.07	240.0	0.29	0.69	3.47

(4) Other Mineral Indications

There are mineralized quartz blocks in a branch stream of the S. Kering near the S.Kerin mineral indication, in branch stream of the S. Spang from 1 km and 0.7 km southeast of the S. Kering mineral indication. They are chalcopyrite-disseminated quartz blocks of smaller than 0.6m x 0.4m x 1.0m in size, and resemble quartz blocks of S.Kering and S. Sepan mineral indications. The mineralized quartz blocks are distributed together with a number of blocks of quartz monzonite, and it may suggest that such a mineralized part is possibly embedded in the quartz monzonite.

3-6 Previous Description on Mineral Indications in the Detailed Survey Area

The previous description on the mineralizations in the detailed sarvey area by BEMMELEN (1970) is supposedly based on the paper by DICKMAN (1917). Since a part of the DICKMAN's report is missing, the BEMMELEN's description is briefly reviewed here.

a) Sungei * Tuboh (The S. Tuboh Indication) (* *Sic* same in the folowing)

The surface indication is elongated in NNE-SSW. Eleven pits and trenches, a shaft 34 m deep and eight drillings were carried out up to 1912. As a result, lead-zine ores were discovered and high silver contents were confirmed. The ores occured in the both sides of Hornblende-Porphyry. Of the drillings, only No.1 and No.3 drillings caught ores. The ores caught by the No.1 and No.3 drillings were of stringer type, 1.4 m and 0.5 m in vein width respectively andbetween two intrusive rock bodies.

At the contact between hornblende-porphyrite (Note: porphyry and porphyrite are both used in the text) and limestone and that between diorite and limstonewere recognized Lime-Silicate Rocks locally associated with sphalerite, galena and chalcopyrite. The ore deposit is irregular lense-like in shape, a few cm ~ 3.5 m in vein width and 30~35 m in strike extension. The mineral composition changes significantly to depth.

The ores consist of coarse-crystalline silica contact minerals (note: probably skarn minerals), sulfide minerals and calcite. The ores from the shaft are, in composition, 70 % gaugue minerals and 30 % sulfides (in volume ratio). Theoretically,estimated at 40 % sulfides in weight ratio, the composition giving ±40 % galena, ±40 % sphalerite, ±12 % chalcopyrite and ±5 % pyrite. Silver content is 400~600g/t in sulfide concentrates and roughly 200~300g/t in crude ores.

b) Sungei Kering (The S. Kering Indication)

The surface indication is 400 m in extension and found in the limestone zone on the left bank of S. Kering. This zone is bounded by schist at the western side and by Granodioritic rock at the eastern side.

This indication occurs in rather loose mass of quartz and limonite-mass within and/or on the clayey soil bed. By digging a 18.5m deep shaft and 4m wide adits (E, W, S, N), the existence of a contact-metasomatic type ore associated with remarkably weathered Hornblende-Porphyry was confirmed.

The ore is quite different from that of the S. Tuboh indication and consists of grey-coloured quartz masses (the color of which is due to fine-grained pyrite) and abundance of limonite. Galena, sphalerite and chalcopyrite in addition to pyrite are found in the quartz masses.

Here, ordinary contact minerals are lacking, and only crystalline limestone is occasionally found. The ore deposit strikes N 55° E, dips 90° and is 6～10 m in thickness.

The drilling No.1 penetrated an intrusive rock in limestone and confirmed the presence of a small amounts of garnet and sphalerite in the footwall side of the intrusive rock.

c) Sungei Sepan (S. Sepan Indication)

The outcrop is of broken piecies of rock blocks arranged in a chain over 60m in extension. Strikes NE-SW, dipping gently to the northeast. By using adits and drillings, the investigation was carried out down to 7 m and 16 m below the ground surface and ores were recognized at the both sides of an intrusive dike.

	Tunnel	Drilling
Foot wall ore	2.0 m	2.9 m
dike	1.0 m	2.5 m
hanging wall ore	4.0 m	1.5 m

The ores are similar to those of the S. Kering indication and consist of quartz and limonites with which a small amounts of galena, sphalerite, chalcopyrite and pyrite are associated as residual sulfides against weathering. Actinolite is commonly found, though it is more or less weathered. This suggests that the ores are possibly of contact metasomatic type in nature.

3-7 Consideration and Summary on the Mineralization of the Detailed Survey Area

(1) Consideration on Mineralization

Three major mineral indications in the detailed survey area can be classified, from the viewpoint of occurrence and mineral assemblage, into two groups of the S. Tuboh mineral indication and the S. Kering-S. Sepan mineral indication. It is unravelled that the S. Tuboh mineral indication is of a skarn type deposit accompanied by Pb, Zn, Cu, and Fe sulfide ores with high silver contents, setting aside the scale of the deposit.

The ore deposits are emplaced selectively at such places as small of quartz monzonite intrusives cut through limestone beds. Therefore, it seems that the scale of the deposits depends largely on the scale, distribution and structure of the limestones as well as the precence of the quartz monzonite intrusives. Silicification zones are distributed with the elongation generally treding NE-SW, along the quartz monzonite intrusive bodies. It thus appears that the post-quartz monzonite hydrothermal activity took place along the quartz monzonite intrusives, and a bonanza would been formed at the part of limestones replaced favourably by the activity. It is inferred that place where many narrow quartz monzonite intrusives have been intruded is most favorable condition for ore deposit emplacement, because these quartz monzonite intrusives are considered to provide effective paths of hydrothermal circulation, and also there are abundant limestone to be replaced easily. Such case would also cause consequently increasing extension of the junction boundary between the quartz monzonite and the limestone, and hence it would lead to enlarge the scale of the ore deposit produced. On the other hand, since the detail on the S. Kering -S. Sepan mineral indications are still unravelled, it is difficult to summerize the ore-formating process involved. According to the description of BEMMELEN (1970), the weathering reachs up to several tens of meters below the surface at these two mineral indications. However at outcrops of the mineral indications earthy limonites remain preserved under such a rainy climatic condition, in spite of earthy limestone has poor erosive resistibity against rainwater.

Certain peculiar condition would be requestd in order to preserve *in situ* the weathered products extending up to several tens of meters in depth. Such possible condition is of the combination of a pipe-like mineralized part with a number of fissures or cracks through which meteoric water easily descends to depth, and a hostrock with strong resistivity against weathering and erosions in the pipe-like mineralized part. Breccia-pipe type deposits are well known to be a type among skarn deposits (ATKINSON et al., 1982), but no such a breccia pipes conisted of quartz blocks alone is unknown in the general case. The quartz blocks in the S. Kering-S. Sepan mineral indications are aggregates of very fine-grained quartz accompanied by dissemination of very fine-grained pyrite, and it is apparent that they are just recrystallized from amorphous silica and amorphous iron sulfide, observing their rock fasies. It thus seems unlikely that they have been kept at high-temperature condition for a long time and have undergone completely metasomatism by silica. In other words, it is undesirably that they are the so-called breccia pipes.

As mentioned before, similar quartz boulders occur in some branch streams of the S. Sepan and the S. Kering, though they are not densely distributed in the two mineral indications mentioned above. They are possibly derived from certain mineralized parts (rather small in scale) of the pype formed in quartz monzonite intrusive rocks. If this is the right, the S. Kering and the S. Sepan mineral indications are also considered to be products of this sort of mineralization. It is suggested that the breccias are simply the products of silica-iron sulfide condensation rather than metasomatism, and also that the "limonites" observed are originally the porous or loose aggregates of very fine-grained pyrite. However, it is quite questionable that garnet and actinolite could accompany such a low-temperature mineralization as seen in the BEMMELEN's description.

d These two mineral indications constitute small hills or mounds with 10～15 m in relative elevation. It is very difficult to define that the hill or mounds represent the weathered pipes, namely those indications are of *in situ* formation, considering the properties of such a occurrence, shape, topographic location and so on. All the quartz blocks observed are "root-less rocks". The S.

Kering mineral indication and the S. Sepan mineral indication appear to just rest on the An-Phyl formation and the S. Minak Formation, respectively. Taking into consideration the shapes of the hills or mounds in addition to the observations mentioned above, it seems quite likely that those mineral indications has be transported by land-sliding.

If it can be unravelled that process of such a mineralization of the S.Tuboh mineral indication took place in the detailed survey area, in addition to the above-mentioned fundamental questions, it is very useful to select a promising target for future prospecting program. However, in order to solve the above problems, data for the far deep portions are indispensable as well as further detailed information on the geotectonic development and igneous activities in the whole survey area. It is not enough to discuss these problems at present, since to many assumptions have to be introduced. Therefore, in the following are only listed some matters which are considered to bear relation to the mineralization for future investigations.

① The two types of folding and faulting structures trending NW-SE and NE-SW are co-existing in the detailed survey area.

② The mineralization was caused by the hydrothermal activity which took place after the intrusion of quartz-monzonite (or monzonitic quartz-monzonite) and of porphyritic quartz-monzonite intruded successively. The the mineralizaion may dated to be slightly later than 40.1 ± 2.0 Ma. This is about 10 M.Y. younger than the age of the granitic rocks distributed around the Bgt,T.Raja and Pulaukidak.

③ The intrusive mode of the quartz monzonite appears to be strongly affected by faults trending NE-SW. These faults may be younger than faults of the NW-SE system. However, the similar fault system are also recognized in the area underlain by the Minak Formation. Therefore, NE-SW system faults may be not single stage faulting or some of the faults have been rejuvenated.

④ Granitic rocks are dominant in the area around Bt.Raja ～Pulaukidak, while rather alkaline rocks are predominated in the detailed survey area. It is required to unravel whether any significant correspondence or contrast exists between the above regional difference in petrochemical nature and the difference in deposit size and ore type.

⑤ It is also necessary to elucidate the physico-chemical conditions of formation of the S. Tuboh mineral indication.

(2) Summary on Mineralization

a) The mineral indications can be classified into two types. One of them is the skarn type deposit of which the S. Tuboh mineral indication is representative, consisting of galena-sphalerite-chalcopyrite-pyrite ores with significant amounts of silver and hedenbergite -garnet skarns. The other one is a pipe-like (?) deposit, of which the S. Kering-S. Sepan mineral indications are representative, characterized by blocks of fine-grained quartz disseminated with pyrite. b) The mineralization being responsible for the S. Tuboh mineral indication is due to the hydrothermal activity after the intrusion of quartz monzonite and porphyritic quartz monzonite penetrating it. The time of the activity is estimated at 40.1 ± 2 Ma, that is, slightly later than late Eocene ~ early Oligocene.

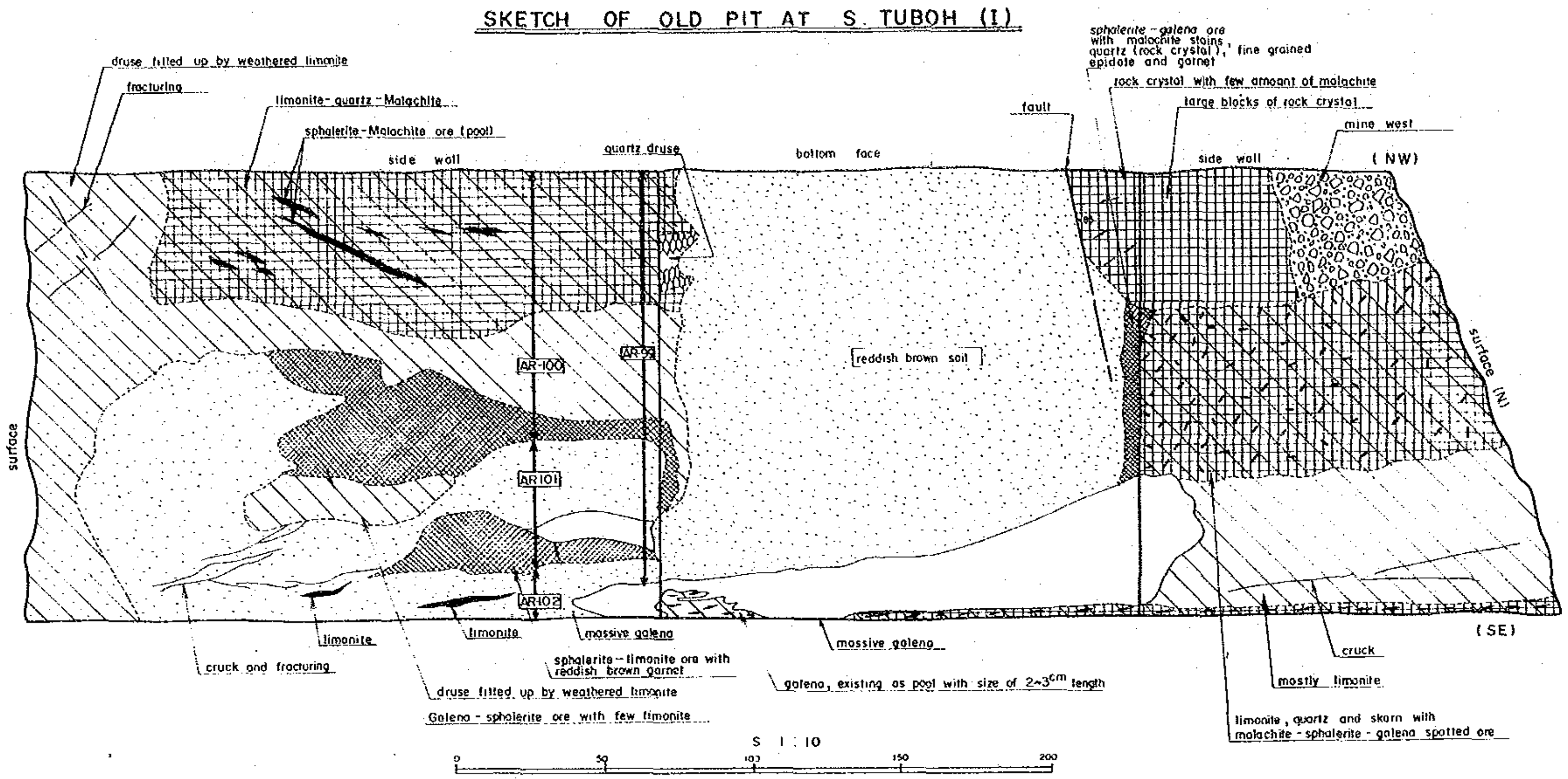
c) The S. Tuboh mineral indication is formed at the junction of limestones (and calcareous rocks) and quartz monzonite penetrating them. The scale of the junction extension, the number of branched bodies of quartz monzonite and the scale of limestones (and calcareous rocks) are considered to be major factors controlling the scale of deposit (unit orebody) especially its strike extension.

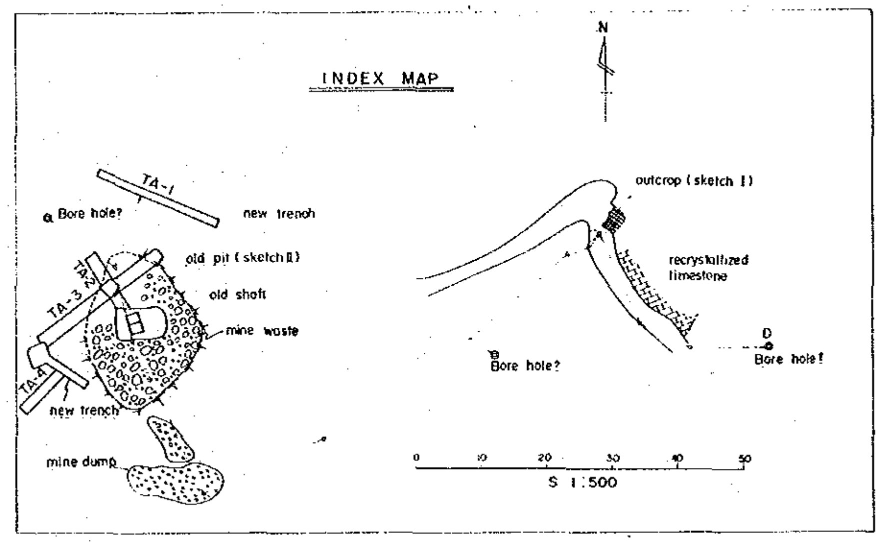
d) The S. Kering and the S. Sepan mineral indications are remarkably different in mode of occurrence and mineral assemblage from the S.Tuboh indication.

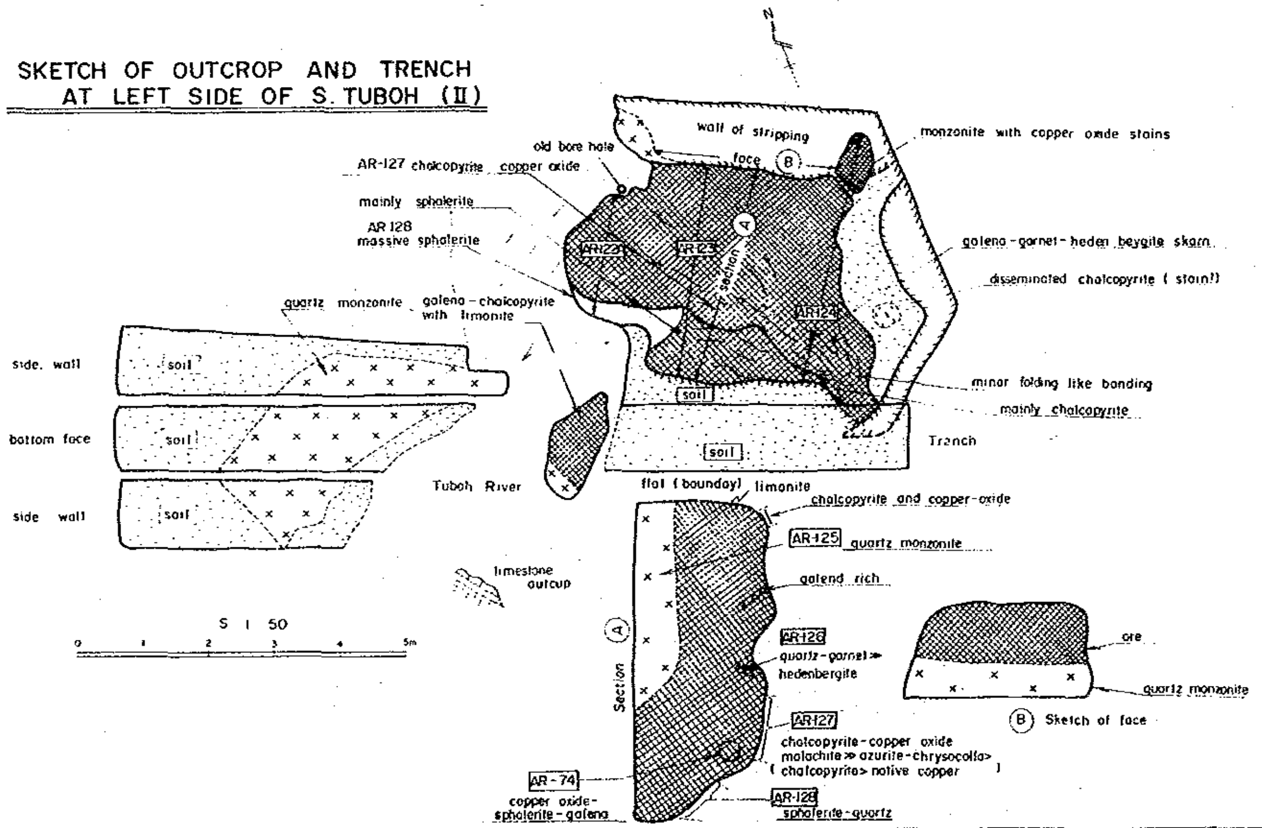
The former two mineral indications are similar in appearance to a sort of brecciapipe-type deposit. No reliable data have been obtained so far to support the idea that they are of skarn type.

e) The S. Kering and S. Sepan mineral indications are possibly allochthonous, transported by land-slide, according to the present situation of those mineral indication.

f) The S. Tuboh mineral indication is expected to be promising for high grade silver bearing ore deposit toward deep part, and is very interesting for future prospective target.







Chemical Assay Result of Ore Samples

	sample description	Au (/t)	Ag (/t)	Cu (%)	Pb (%)	Zn (%)	Mo %	Hg %	Remarks
old pit	AR- 99	0.21	976.8	1.33	39.10	0.27	<0.001	<0.001	wd 1.50m
out crop	AR-122A	0.07	188.0	2.97	4.34	13.10	0.001	<0.001	wd 1.8m
	AR-123	0.89	469.2	5.18	8.56	9.58	0.001	<0.001	wd 3.2m
	AR-124	0.21	766.9	2.36	15.00	1.64	<0.001	<0.001	wd 3.9m
	AR- 74	0.27	230.0	8.20	1.42	8.86	0.001	<0.001	spot sampling

LEGEND

↔ sampling line

AR-122 sample number

PL.

REPORT ON THE MINERAL EXPLORATION OF SOUTHERN SUMATERA AREA, THE REPUBLIC OF INDONESIA PHASE I

SKETCH OF PITS AND TRENCHES IN THE S. TUBOH MINERAL INDICATION

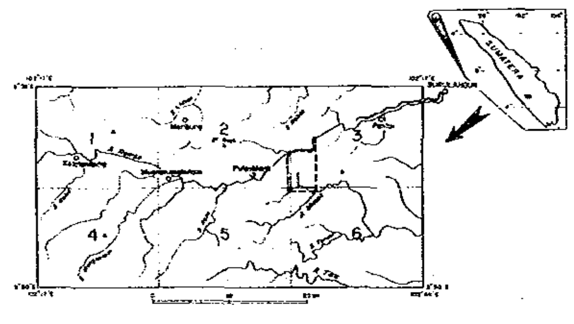


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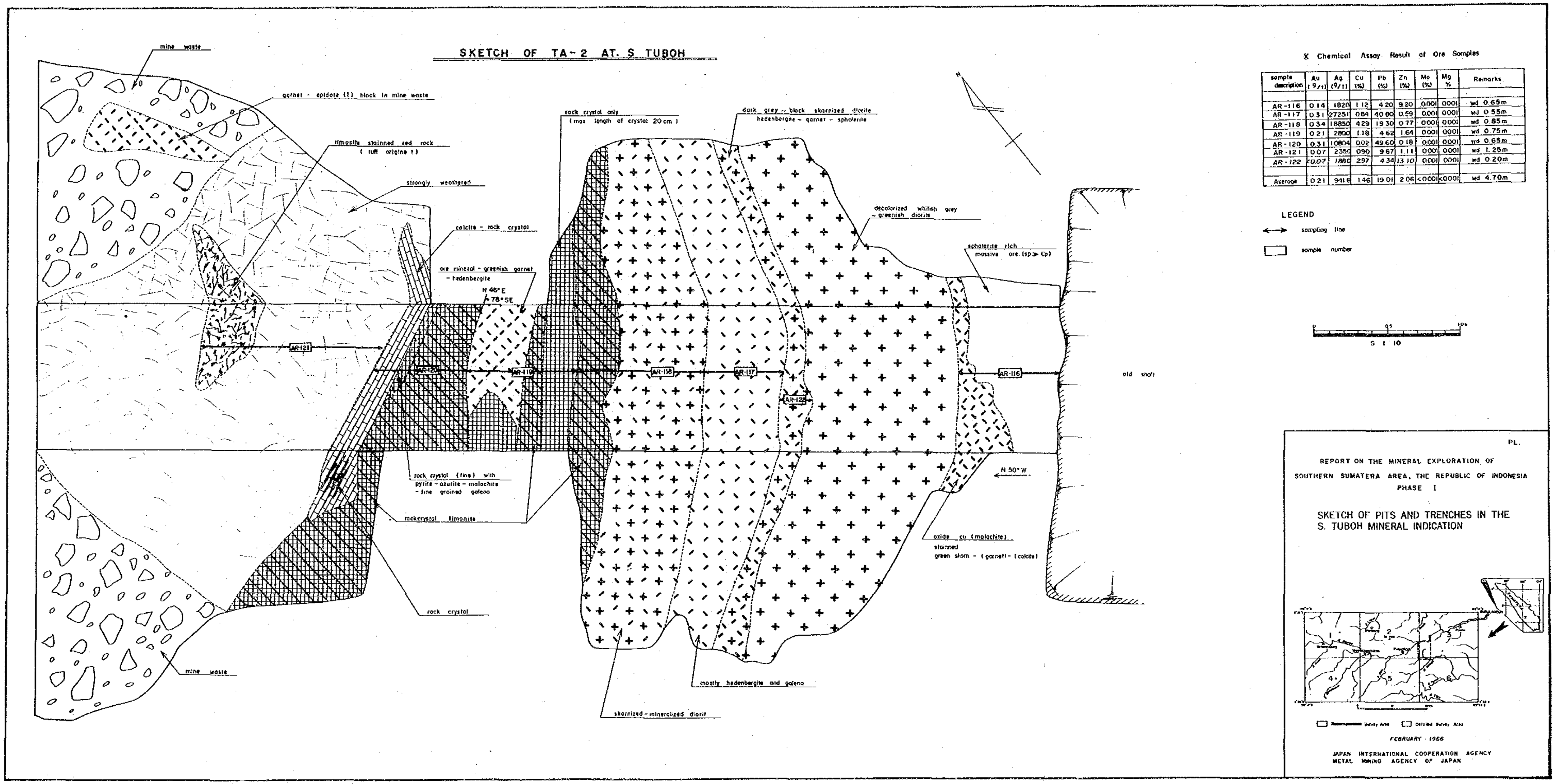
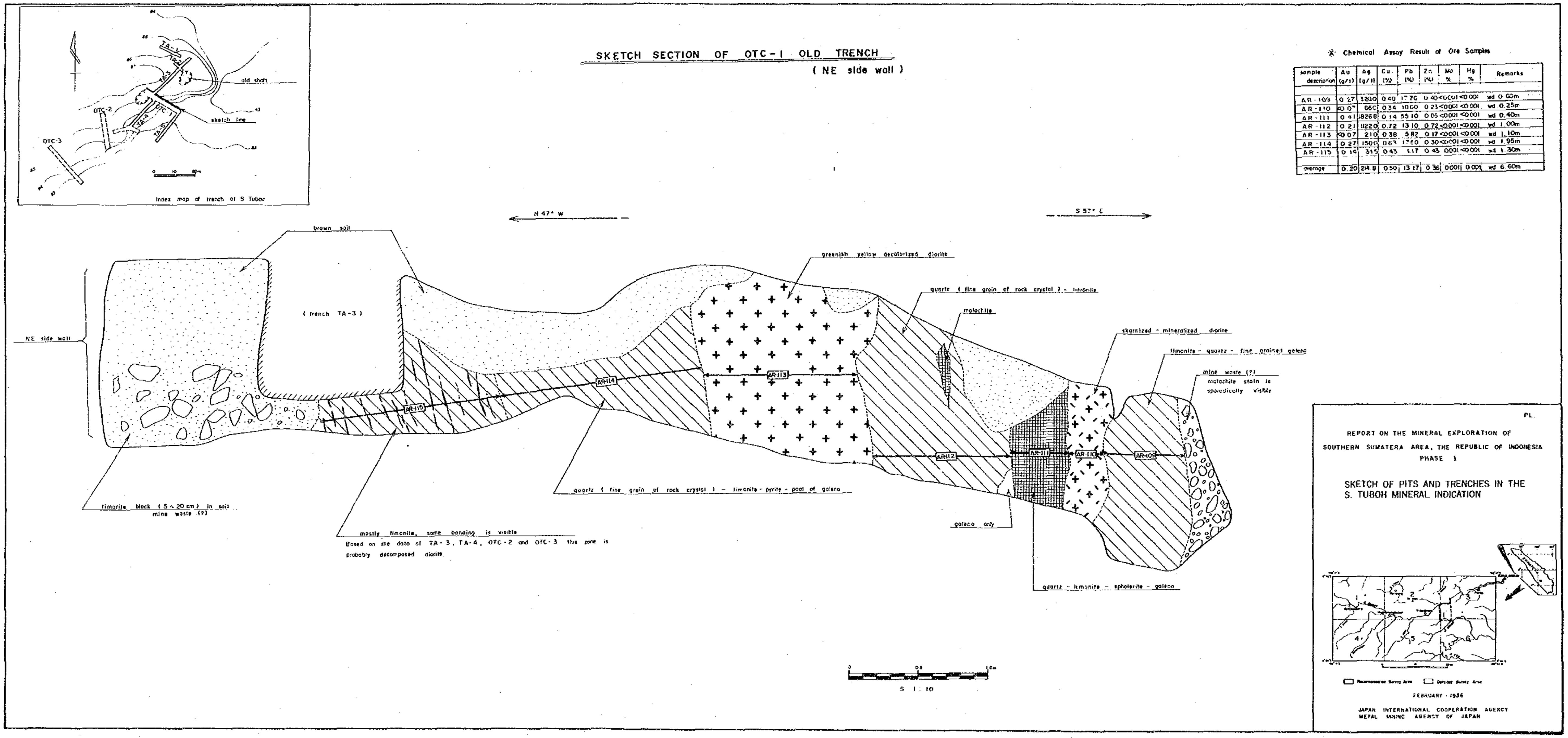
Fig. 16 Sketch of the Pits and Outcrop at the S.Tuboh Mineral Indication



※ Chemical Assay Result of Ore Samples

sample description	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	Mg %	Remarks
AR-116	0.14	1820	1.12	4.20	9.20	0.001	0.001	wd 0.65m
AR-117	0.31	27251	0.84	40.80	0.59	0.001	0.001	wd 0.55m
AR-118	0.34	18850	4.29	19.30	0.77	0.001	0.001	wd 0.85m
AR-119	0.21	2800	1.18	4.62	1.64	0.001	0.001	wd 0.75m
AR-120	0.31	10804	0.02	49.60	0.18	0.001	0.001	wd 0.65m
AR-121	0.07	2350	0.90	9.67	1.11	0.001	0.001	wd 1.25m
AR-122	<0.07	1880	2.97	4.34	13.10	0.001	0.001	wd 0.20m
Average	0.21	9418	1.46	19.01	2.06	<0.001	<0.001	wd 4.70m

Fig. 17 Sketch of the TA-2 Trench at the S.Tuboh Mineral Indication



※ Chemical Assay Result of Ore Samples

sample description	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo %	Hg %	Remarks
AR-109	0.27	3200	0.40	17.70	0.40	<0.001	<0.001	wd 0.60m
AR-110	<0.07	660	0.34	10.60	0.23	<0.001	<0.001	wd 0.25m
AR-111	0.41	18268	0.14	55.10	0.05	<0.001	<0.001	wd 0.40m
AR-112	0.21	1220	0.72	13.10	0.72	<0.001	<0.001	wd 1.00m
AR-113	<0.07	210	0.38	5.82	0.17	<0.001	<0.001	wd 1.10m
AR-114	0.27	1500	0.63	17.50	0.30	<0.001	<0.001	wd 1.95m
AR-115	0.14	315	0.43	1.17	0.43	0.001	<0.001	wd 1.30m
average	0.20	214.8	0.50	13.17	0.36	0.001	0.001	wd 6.60m

Fig. 18 Sketch of the OTC-2 Trench at the S.Tuboh Mineral Indication

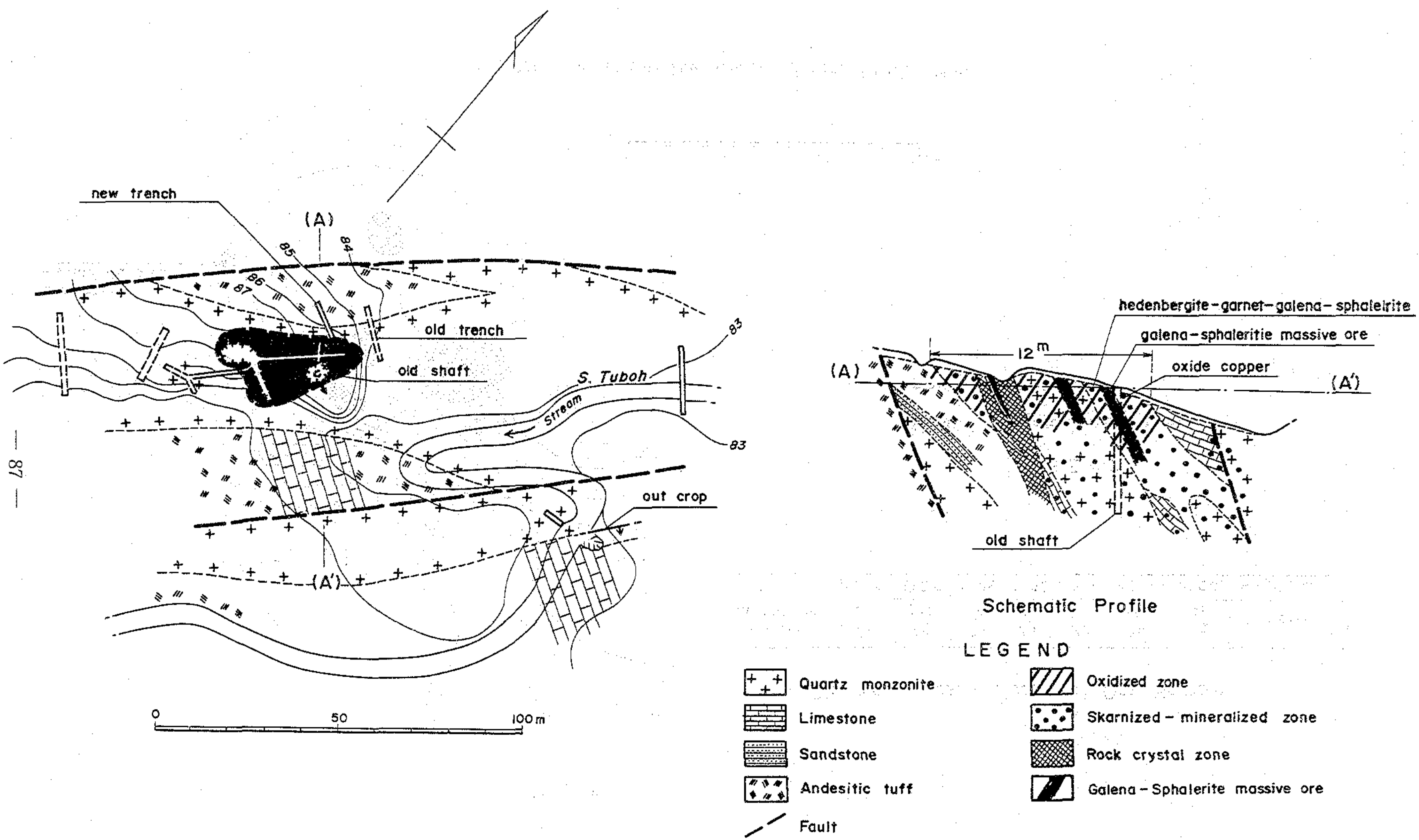
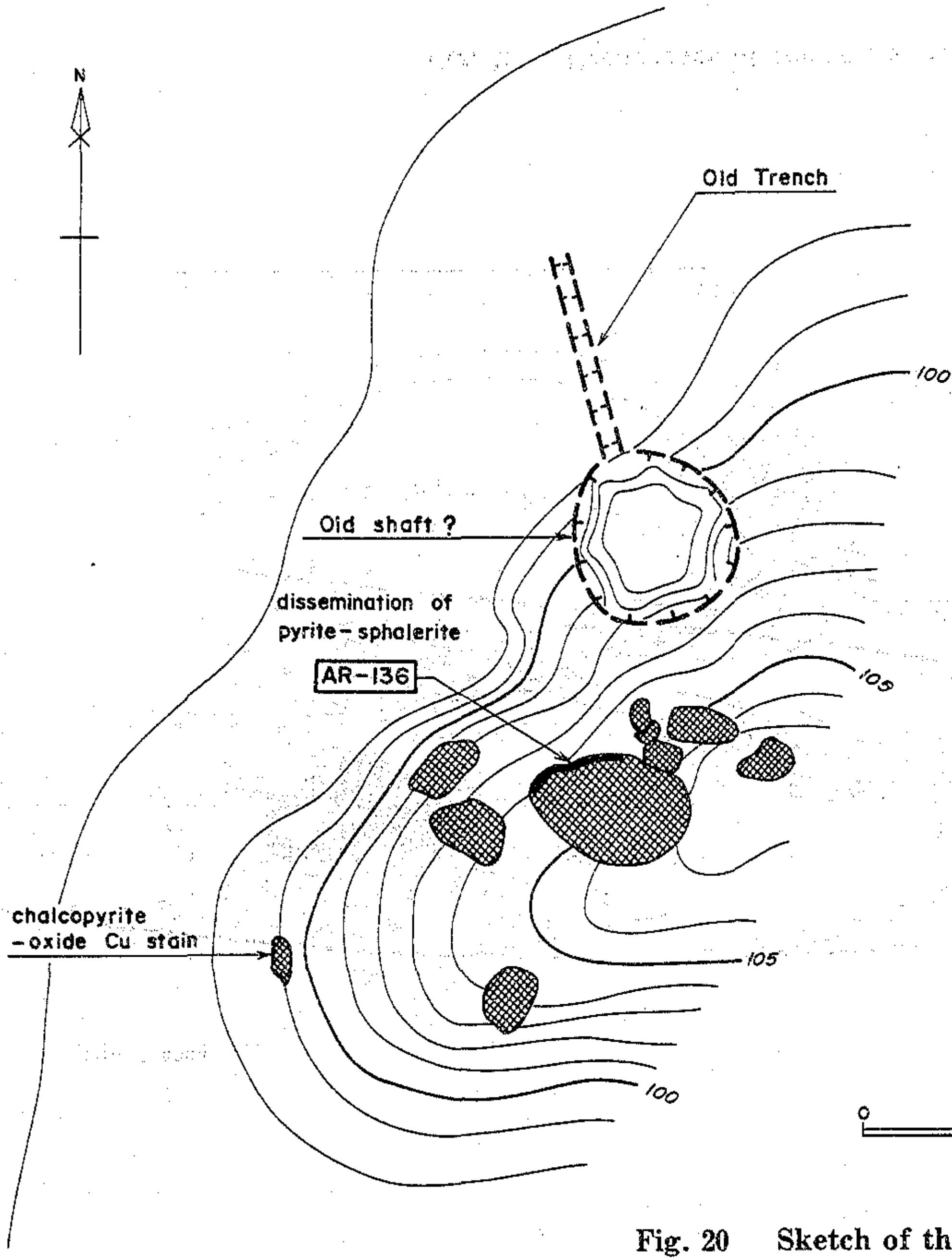


Fig. 19 Occurrence of the Ore at the S.Tuboh Mineral Indication



Chemical Assay Result of Ore Sample

Sample description	Au (g/t)	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	Hg (%)	Remarks
AR-136	0.07	240.0	0.29	0.69	3.47	<0.001	<0.001	wd 10.0 m

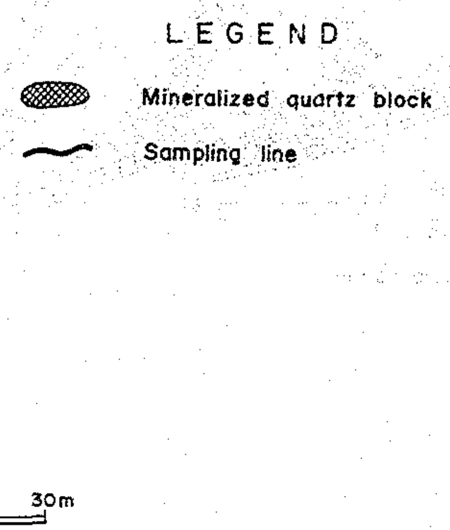


Fig. 20 Sketch of the S.Sepan Mineral Indication

Part 4 GEOCHEMICAL SURVEY

Part 4 GEOCHEMICAL SURVEY

Chapter 1 Sampling, Assay Method and Analytical Procedure

1-1 Sampling

Sampling for geochemical survey was carried out in parallel with the geological survey. Stream sediments of 20 to 100g in weight under 80 mesh in size were collected at each sampling point. Among the samples collected, 1,600 pieces from reconnaissance survey area and 150 pieces from the detailed survey area were provided for chemical analyses.

1-2 Assay Method

12 elements, namely Cu, Mo, Pb, Zn, Ag, Ni, Co, Cr, As, Hg, Li and Au, were assayed by means of atomic absorption or photometry, and their detection limits are as follows.

Cu・・・・・・2ppm	Mo・・・・・・1ppm	Pb・・・・・・1ppm
Zn・・・・・・1ppm	Ag・・・・・・0.1ppm	Ni・・・・・・1ppm
Co・・・・・・1ppm	Cr・・・・・・5ppm	As・・・・・・1ppm
Hg・・・・・・5ppb	Li・・・・・・1ppm	Ag・・・・・・1ppb

1-3 Analytical Procedure

The samples were collected in the rate of 1.3 pieces/km^2 in the the reconnaissance survey area and 8.3 pieses /km^2 in the detailed survey area. Therefor staistic data processing has been separately prosessed owing to different sampling density in these areas. The methods of disingration aralysis and principal component analysis have been applied with the aid of a computer, because of abundance of the data. Geochemical data processing, to which statistical methods are unapplicable, has been performed at the stage of extracting geochemical anomalies. The flow sheet of the data processing on geochemical survey is shown in Fig. 21.

Chapter 2 Geochemical Survey in the Reconnaissance Survey Area

2-1 Analytical Results

(1) Arrangement of assay results

All the assay data obtained are shown in Table 21. The assay values have first been converted into logarithms to figure out the maximum value, minimum value, mean value and standard deviation one ach element, and then frequency distribution diagrams and accumulated

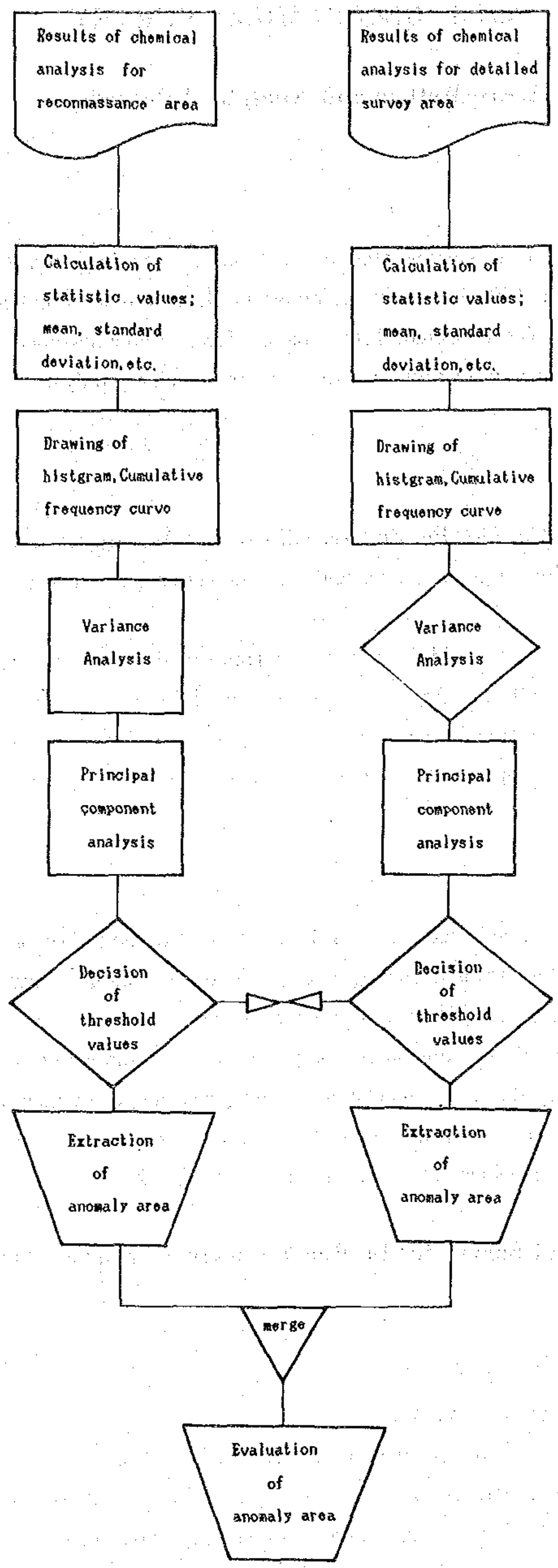


Fig. 21 Flow Chart of the Statistical Analyses for Geochemical Survey

Table 13 Statistic Values of Geochemical Analysis Correlated to the Geologic Units(1)

GEO CODE: 1

	N	MEAN	MEAN(LOG)	VARIANCE	ST.D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	259	5.481409	.738892	.078366	.279939	1.00	45.00	10.44	19.90
Mo	259	1.012346	.005329	.001908	.043675	1.00	3.00	1.12	1.24
Pb	259	6.186766	.791464	.101145	.318033	1.00	340.00	12.87	26.76
Zn	259	30.774030	1.488184	.103634	.321922	4.00	165.00	64.58	135.53
Ag	259	.112297	-.949632	.088516	.297517	.10	22.00	.22	.44
Ni	259	1.962786	.292873	.115775	.340257	1.00	38.00	4.30	9.41
Co	259	2.018288	.304983	.121514	.348588	1.00	20.00	4.50	10.05
Cr	259	19.659340	1.293790	.023761	.154146	8.00	70.00	28.05	40.00
As	259	2.530827	.403262	.053991	.232360	1.00	10.00	4.32	7.38
Hg	259	37.533590	1.574420	.013197	.114877	20.00	80.00	48.90	63.70
Li	259	13.022990	1.114711	.008601	.092741	6.00	28.00	16.12	19.96
Au	258	1.333662	.125046	.886759	.941679	.50	9730.00	11.66	101.95

GEO CODE: 2

	N	MEAN	MEAN(LOG)	VARIANCE	ST.D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	384	8.602487	.934624	.140925	.375400	2.00	119.00	20.42	48.46
Mo	384	1.022491	.009660	.003548	.059566	1.00	5.00	1.17	1.35
Pb	384	7.316436	.864300	.057923	.240672	1.00	40.00	12.73	22.16
Zn	384	64.923210	1.812400	.070727	.265946	11.00	345.00	119.77	220.95
Ag	384	.120212	-.920053	.088804	.298001	.10	12.30	.24	.47
Ni	384	3.268978	.514412	.211863	.460286	1.00	69.00	9.43	27.23
Co	384	4.281815	.631628	.208904	.457061	1.00	33.00	12.27	35.14
Cr	384	27.397630	1.437713	.098566	.313952	6.00	270.00	56.45	116.31
As	384	3.691734	.567230	.103299	.321402	1.00	53.00	7.74	16.22
Hg	384	38.537180	1.585880	.017158	.130989	10.00	240.00	52.10	70.45
Li	384	17.604820	1.245632	.025492	.159661	2.00	50.00	25.43	36.72
Au	384	2.226768	.347675	.987520	.993740	.50	9999.00	21.95	216.35

Table 13 Statistic Values of Geochemical Analysis Correlated to the Geologic Units (2)

GEO CODE: 3

	N	MEAN	MEAN (LOG)	VARIANCE	ST. D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	130	12.914710	1.111085	.037779	.194368	3.00	35.00	20.20	31.61
Mo	130	1.000000	.000000	.000000	.000000	1.00	1.00	1.00	1.00
Pb	130	8.172878	.912375	.057694	.240197	1.00	25.00	14.21	24.70
Zn	130	73.484000	1.866193	.032647	.180684	14.00	775.00	111.40	168.87
Ag	130	.113137	-.946395	.046872	.216500	.10	1.90	.19	.31
Ni	130	12.179680	1.085636	.087766	.296254	2.00	52.00	24.09	47.66
Co	130	9.796721	.991081	.026270	.162081	2.00	24.00	14.23	20.67
Cr	130	54.800200	1.738782	.037830	.194500	20.00	230.00	85.76	134.21
As	130	3.561406	.551621	.074578	.273090	1.00	24.00	6.68	12.53
Hg	130	43.225820	1.635743	.052397	.228904	20.00	260.00	73.22	124.04
Li	130	18.620830	1.269999	.027145	.164758	8.00	54.00	27.21	39.77
Au	130	1.295835	.112550	.533459	.730383	.50	200.00	6.97	37.44

GEO CODE: 4

	N	MEAN	MEAN (LOG)	VARIANCE	ST. D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	152	31.416640	1.497160	.036992	.192334	9.00	81.00	48.92	76.18
Mo	152	1.009162	.003961	.001184	.034416	1.00	2.00	1.09	1.18
Pb	152	4.140123	.617013	.114566	.338476	1.00	21.00	9.03	19.68
Zn	152	78.610230	1.895479	.012439	.111532	36.00	199.00	101.63	131.38
Ag	152	.108951	-.962769	.017218	.131218	.10	1.10	.15	.20
Ni	152	12.569200	1.099308	.078144	.279543	2.00	160.00	23.92	45.54
Co	152	14.653250	1.165934	.035535	.188508	3.00	51.00	22.62	34.91
Cr	152	62.024490	1.792563	.060671	.246316	23.00	520.00	109.37	192.84
As	152	3.916893	.592942	.037988	.194904	1.00	23.00	6.14	9.61
Hg	152	34.517060	1.538034	.025682	.160257	10.00	220.00	49.92	72.20
Li	152	16.248830	1.210822	.018126	.134633	8.00	54.00	22.15	30.21
Au	152	2.055590	.312936	.576072	.758994	.50	2300.00	11.80	67.75

Table 13 Statistic Values of Geochemical Analysis Correlated to the Geologic Units(3)

GEO CODE: 5

	N	MEAN	MEAN(LOG)	VARIANCE	ST. D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	562	15.468300	1.189443	.069952	.264484	3.00	102.00	28.44	52.29
Mo	562	1.015369	.006624	.006438	.080239	1.00	22.00	1.22	1.47
Pb	562	6.674714	.824433	.079731	.282367	1.00	200.00	12.79	24.50
Zn	562	55.575840	1.744886	.044876	.211840	5.00	149.00	90.52	147.42
Ag	562	.101415	-.993898	.003284	.057306	.10	.70	.12	.13
Ni	562	13.947960	1.144511	.081545	.285560	1.00	280.00	26.92	51.96
Co	562	7.892619	.897221	.095510	.309047	1.00	53.00	16.08	32.76
Cr	562	54.084670	1.733074	.035390	.188122	9.00	720.00	83.41	128.62
As	562	4.271303	.630560	.073573	.271243	1.00	105.00	7.98	14.90
Hg	562	33.915200	1.530394	.014383	.119929	10.00	110.00	44.70	58.92
Li	562	20.142510	1.304114	.030093	.173473	5.00	94.00	30.03	44.78
Au	562	1.784513	.251520	.613731	.783410	.50	4130.00	10.84	65.82

GEO CODE: 6

	N	MEAN	MEAN(LOG)	VARIANCE	ST. D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	35	7.686682	.885739	.085665	.292686	1.00	24.00	15.08	29.59
Mo	35	1.000000	.000000	.000000	.000000	1.00	1.00	1.00	1.00
Pb	35	6.896351	.838619	.093984	.306568	1.00	26.00	13.97	28.30
Zn	35	61.177200	1.786590	.088479	.297454	21.00	285.00	121.35	240.71
Ag	35	.100000	-1.000000	.000000	.000000	.10	.10	.10	.10
Ni	35	1.924084	.284224	.127850	.357561	1.00	11.00	4.38	9.98
Co	35	3.536292	.548548	.231493	.481137	1.00	28.00	10.71	32.42
Cr	35	18.732300	1.272591	.047679	.218354	6.00	58.00	30.97	51.20
As	35	2.663933	.425523	.090076	.300127	1.00	11.00	5.32	10.61
Hg	35	38.198840	1.582050	.015734	.125437	20.00	110.00	50.99	68.06
Li	35	14.165550	1.151233	.011157	.105627	8.00	22.00	18.07	23.04
Au	35	3.413121	.533152	1.473564	1.213905	.50	7000.00	55.85	914.03

Table 13 Statistic Values of Geochemical Analysis Correlated to the Geologic Units(4)

GEO CODE: 7

	N	MEAN	MEAN(LOG)	VARIANCE	ST.D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	78	13.730380	1.137683	.070397	.265325	2.00	45.00	25.29	46.59
Mo	78	1.000000	.000000	.000000	.000000	1.00	1.00	1.00	1.00
Pb	78	4.369774	.640459	.096709	.310981	1.00	13.00	8.94	18.30
Zn	78	34.884330	1.542630	.086739	.294515	6.00	101.00	68.73	135.41
Ag	78	.102324	-.990024	.004033	.063502	.10	.30	.12	.14
Ni	78	5.364479	.729528	.269458	.519093	1.00	27.00	17.73	58.58
Co	78	4.604026	.663138	.189045	.434793	1.00	19.00	12.53	34.10
Cr	78	39.206300	1.593356	.146837	.383193	6.00	260.00	94.74	228.95
As	78	2.774124	.443126	.097232	.311820	1.00	24.00	5.69	11.66
Hg	78	29.731660	1.473219	.028053	.167492	10.00	60.00	43.72	64.30
Li	78	14.376060	1.157640	.037344	.193245	4.00	30.00	22.43	35.01
Au	78	1.468567	.166894	.608225	.779888	.50	2230.00	8.85	53.29

	N	MEAN	MEAN(LOG)	VARIANCE	ST.D	MINIMUM	MAXIMUM	M+σ	M+2σ
Cu	1600	11.723410	1.069054	.128307	.358199	1.00	119.00	26.75	61.02
Mo	1600	1.013640	.005884	.003538	.059478	1.00	22.00	1.16	1.33
Pb	1600	6.418661	.807444	.086939	.294855	1.00	340.00	12.66	24.95
Zn	1600	54.294940	1.734759	.076290	.276206	4.00	775.00	102.56	193.72
Ag	1600	.109110	-.962137	.043202	.207850	.10	22.00	.18	.28
Ni	1600	6.416527	.807300	.252310	.502305	1.00	280.00	20.40	64.85
Co	1600	5.645774	.751723	.188137	.433748	1.00	53.00	15.33	41.61
Cr	1600	38.046430	1.580314	.091498	.302486	6.00	720.00	76.35	153.21
As	1600	3.588832	.554953	.082362	.286988	1.00	105.00	6.95	13.46
Hg	1600	36.180040	1.558459	.021013	.144957	10.00	260.00	50.52	70.53
Li	1600	17.270260	1.237299	.028638	.169228	2.00	94.00	25.50	37.65
Au	1599	1.781485	.250782	.761730	.872772	.50	9999.00	13.29	99.16

frequency (distribution) diagram have been constructed (Table 13, Fig. 22, Fig. 23).

(2) Frequency distribution characteristics of elemental contents

Distribution characteristics of each elemental content are outlined as follows.

a) Cu : The values range from 1 to 119 ppm, with 12 ppm in mean value, and distribute almost close to a logarithmic normal distribution. The maximum value of 119 ppm is not remarkably high in comparison with the average crustal abundance (55 ppm)

b) Mo : The values range from 1 to 22 ppm, but many samples (1,578 pieces) show the value of detection limit (1 ppm). The other higher values are distributed at random.

c) Pb : The valued range from 1 to 340 ppm, with 6 ppm in mean value, showing a distribution close to logarithmic normal distribution. Significantly-high values (higher than 50 ppm) as compared with the average crustal abundance (13 ppm) are recognized in samples from 3 locations in the visinity of the detailed survey area.

d) Zn : The values range from 4 to 775 ppm ,with 54 ppm in mean value and shows a distribution closed to logarithmic normal distribution. Significantly-high values (greater than 200 ppm),as compared with the average crustal abundance (70 ppm), are recognized from 18 samples.

e) Ag : The values range form 0.1 to 22.0 ppm, but many samples (1,520 pieces) are the value of detection limit 0.1 ppm, and show no logarithmic normal distribution.

f) Ni : The values range from 1 to 280 ppm, with two frequency peaks at < 3 ppm and 10~20 ppm, and is not along with logarithimic normal distribution.

This bimodal nature is consistent with that the samples from the S. Minak Formation, and the Hulusimpang Formation are mostly of low values and part from the S. Kuwis Formation and the S. Rawas Formation are mostly high values exceeding 10ppm. This fact reveals that Ni content of the stream sediments is largely affected by basement rocks of back ground rock.

g) Co : The values range from 1 to 53 ppm. Its frequency distribution is similar to those of Ni, showing no logarithmic normal one.

h) Cr : The values range from 6 to 720 ppm with 38 ppm in mean value. The distribution is more close to logarithmic normal distribution in comparison with Ni and Co. Only three samples show significantly higher values (exceeding 500 ppm) as compared with the average value in basalt (200 ppm).

i) As : The values range from 1 to 105 ppm, and mostly higher than the average crustal abundance (2 ppm). Of these, 14 samples show significantly high values (higher than 20 ppm) as compared with the average shale abundance(7 ppm).

j) Hg : The values range from 10 to 260 ppm, showing similar behaviors to Ag. Only 6 samples are significantly high values (higher than 200 ppb) as compared with the average crustal abundance (80 ppb).

k) Li : The values range from 2 to 94 ppm, with 17 ppm in mean value, being rather close to a logarithmic normal distribution. Only 12 samples are significantly high values (higher than 50 ppm) as compared with the average crustal abundance (20 ppm).

l) Au : The values are mostly less than the detection limit (1 ppb). On the other hand, the maximum value is over 10,000 ppb, and the variation range between the maximum and minimume values are quite large. Other samples are randomly distributed in this variation range, showing no logarithmic normal distribution.

2-2 Difference of the Contents being due to Back-Ground Rocks

As described above, the elemental contents of the stream sediments seem to differ depending on their back-ground rocks. It has been examined by means of disintegration analysis whether such a difference is statistically significant or not. The back-ground rocks of collected samples are generally composed of various rocks. Therefore, for conveniences sake, the rocks have been grouped into geologic formations and intrusive rocks based on stratigraphy by the geological survey, and the samples have been treated in one lot as a geochemical "level" corresponding the rock group.

The following seven "levels" have been grouped ;

Level 1……Quaterary System : Surulrangum Formation
Tertiary System : S. Minaku Formation
Level 2……Tertiary System : Hulusimpang Formation
Level 3……Tertiary System : Napallicin Formation
Level 4……Mesozoic Formations : S. Kuwis Formation
Level 5……Mesozoic Formations : S. Rawas Formation
Level 6……Intrusive rocks : granites, quartz monzonite
Level 7……Intrusive rocks : quartz diorite, basalt, andesite, dacite

On the basis of the above classification, respective mean values and standard deviations have been calculated, the frequency diagrams and accumulated frequency diagrams have been constructed, and then they have been processed throgh variance analysis (Table 14).

Table 14 Results of Variance Analysis

	Sb	Sw	Vb	Vw	Vb/Vw	φ b	φ w
Cu	72.95	132.22	12.16	.08	146.48**	6	1593
Mo	.01	5.64	.00	.00	.70	6	1593
Pb	10.62	128.39	1.77	.08	21.97**	6	1593
Zn	27.27	94.77	4.54	.06	76.39**	6	1593
Ag	1.43	67.65	.24	.04	5.61**	6	1593
Ni	198.47	204.97	33.08	.13	257.07**	6	1593
Co	104.71	196.12	17.45	.12	141.75**	6	1593
Cr	55.63	90.70	9.27	.06	162.82**	6	1593
As	11.01	120.68	1.84	.08	24.23**	6	1593
Hg	2.22	31.39	.37	.02	18.80**	6	1593
Li	7.43	38.36	1.24	.02	51.40**	6	1593
Au	14.10	1203.15	2.35	.76	3.11**	6	1592

** : significant at 1 % level

The results of the variance analysis reveal that all the elements except for Mo generally differ

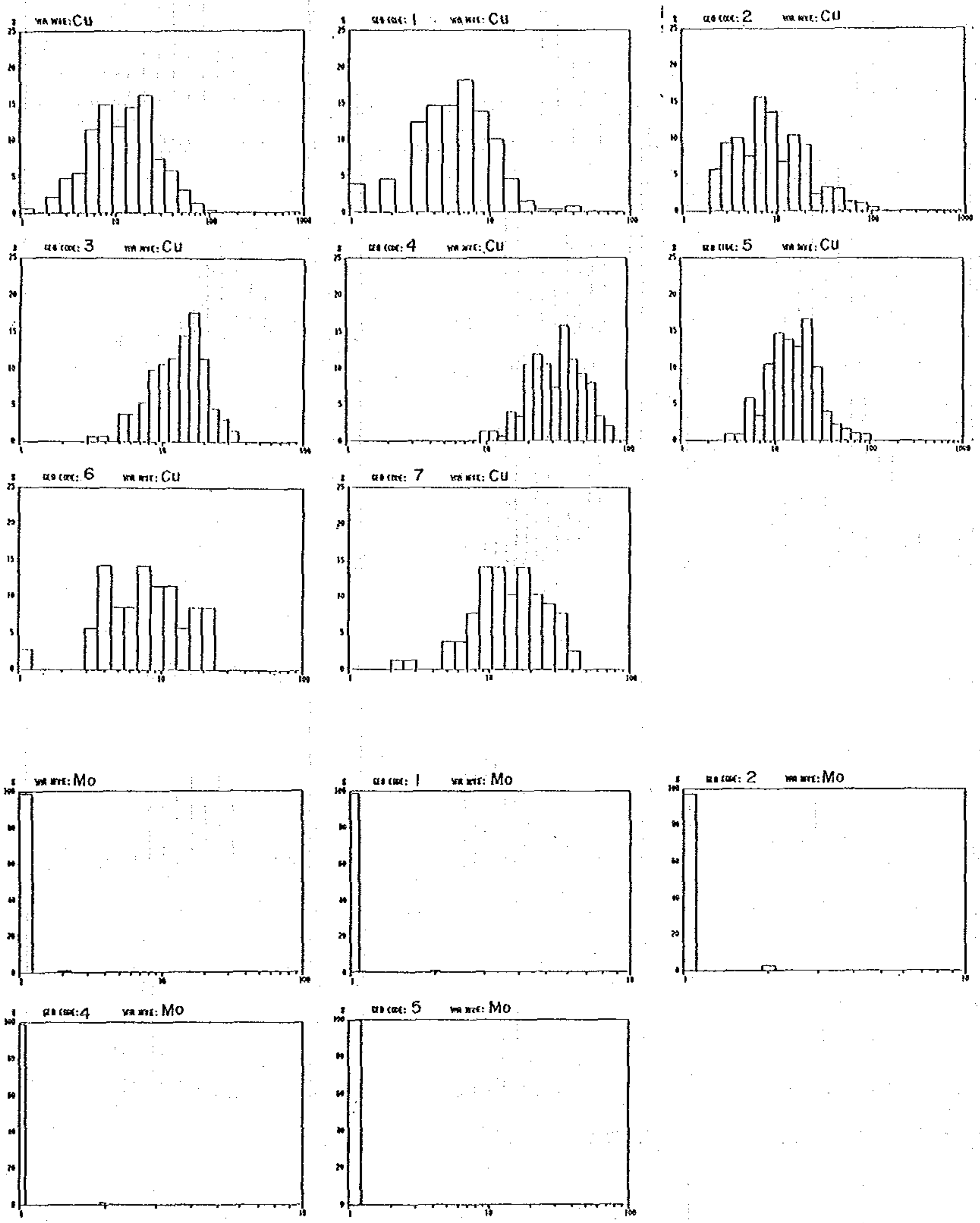


Fig. 22 Histogram of the Contents in Stream Sediments in the Reconnaissance Survey Area (1)

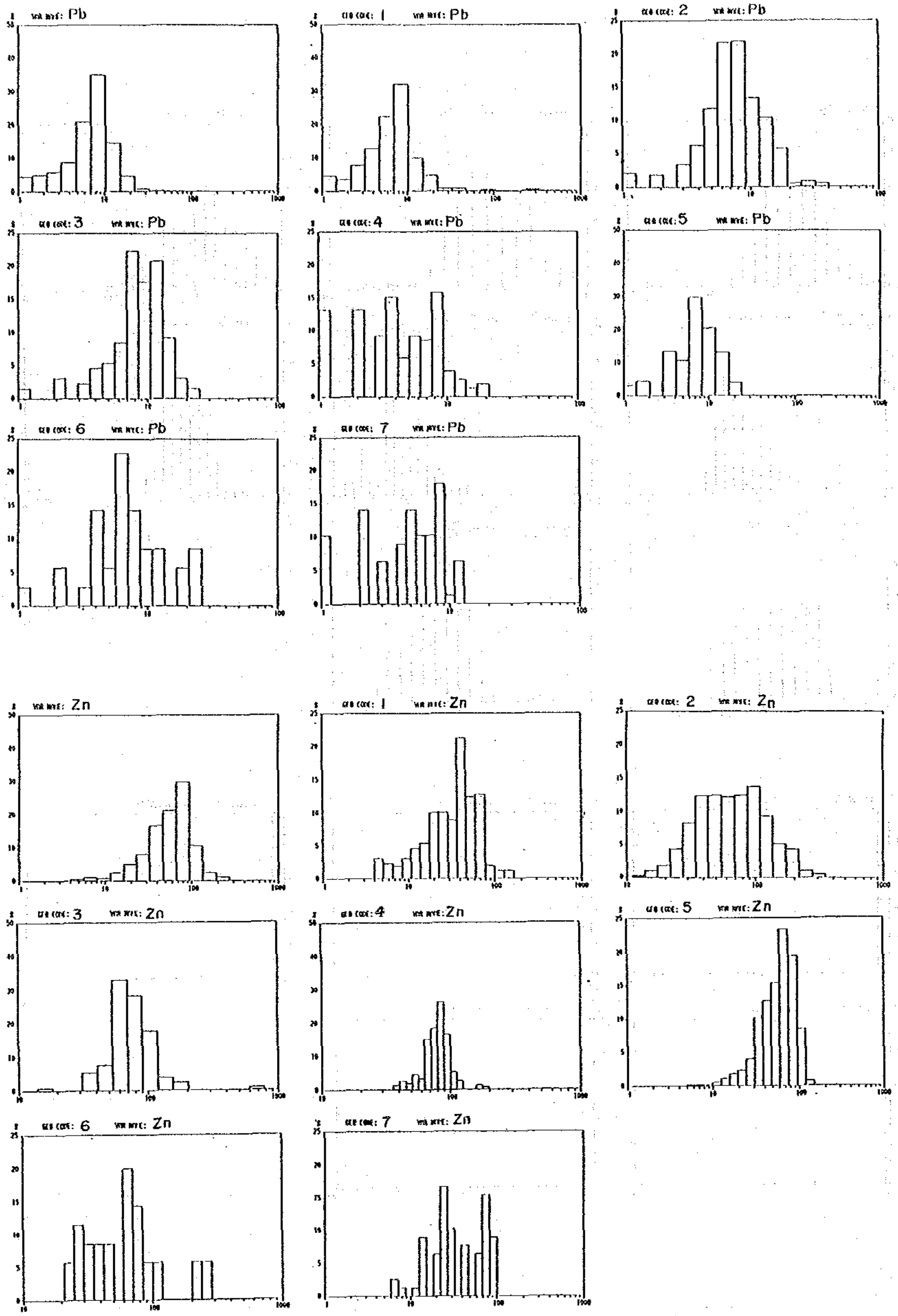


Fig. 22 Histogram of the Contents in Stream Sediments in the Reconnaissance Survey Area (2)

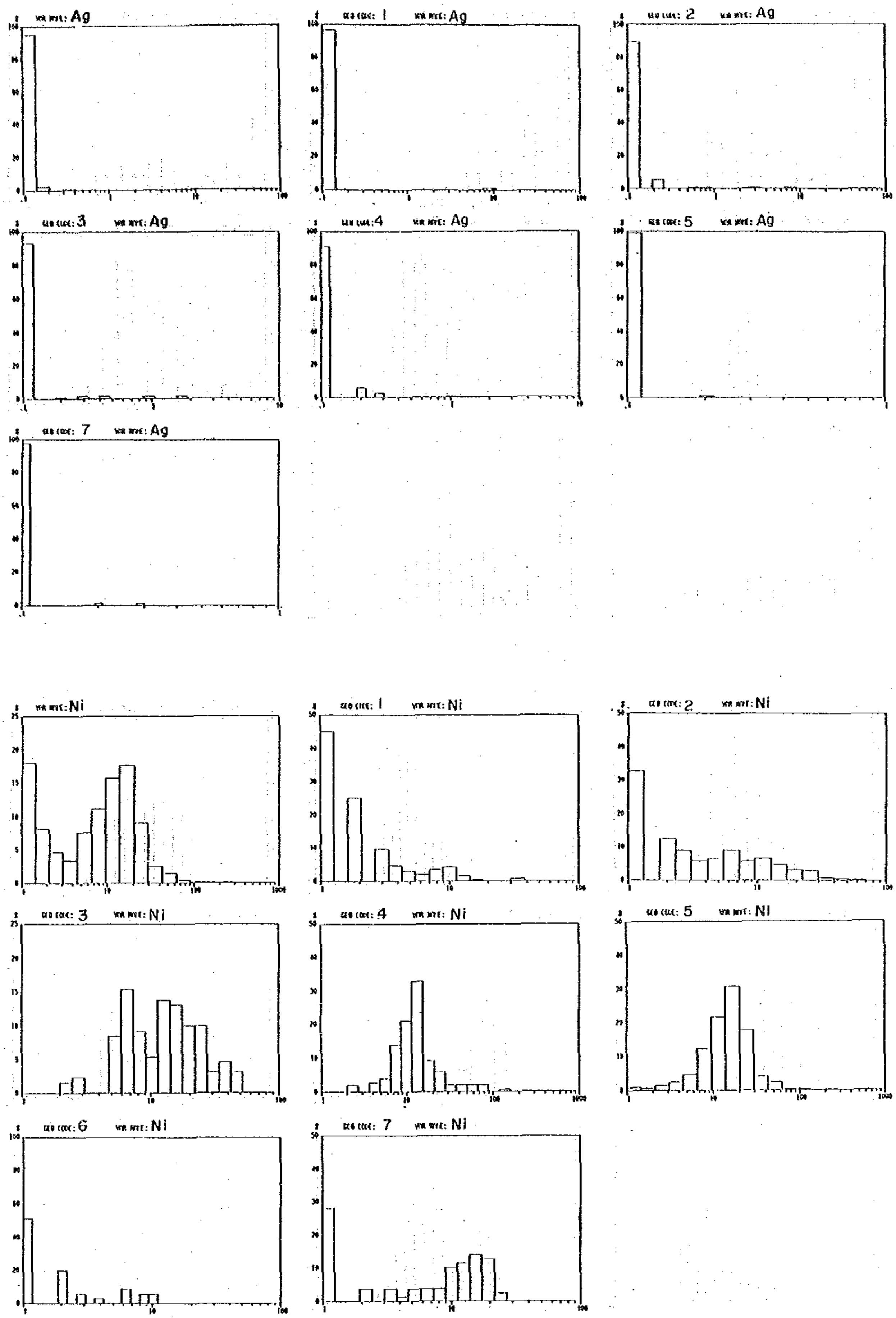


Fig. 22 Histogram of the Contents in Stream Sediments in the Reconnaissance Survey Area (3)

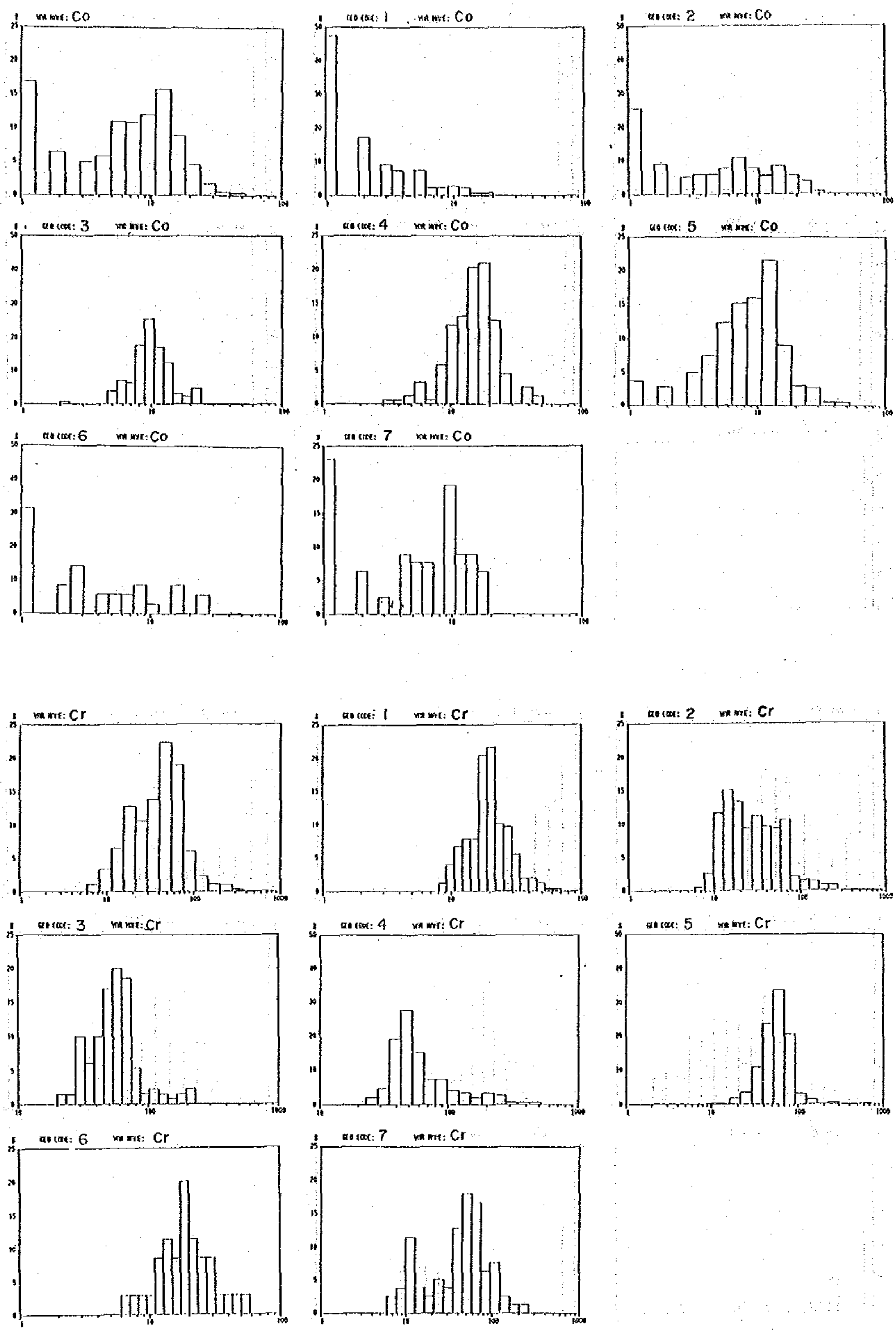


Fig. 22 Histogram of the Contents in Stream Sediments in the Reconnaissance Survey Area (4)

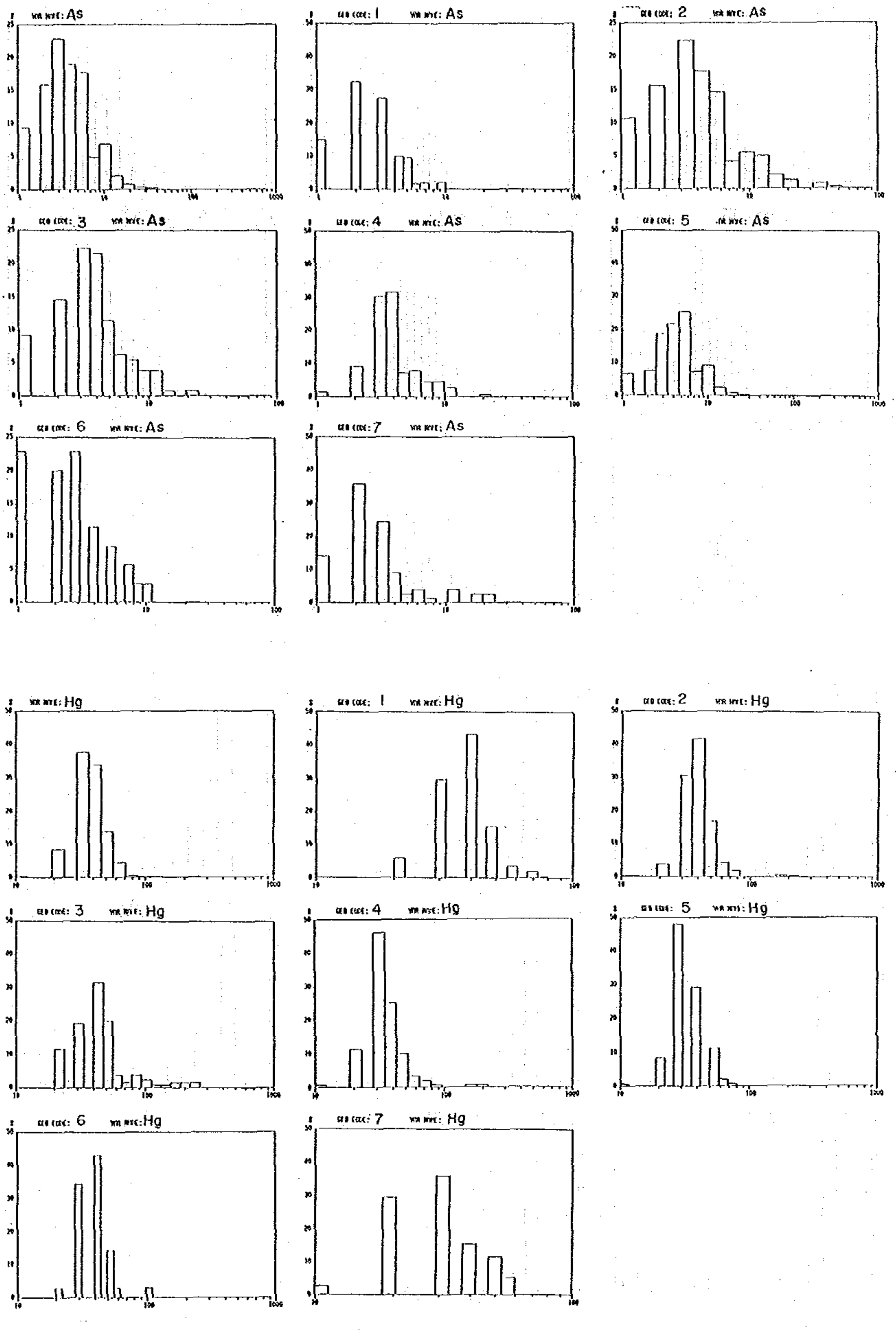


Fig. 22 Histogram of the Contents in Stream Sediments in the Reconnaissance Survey Area (5)

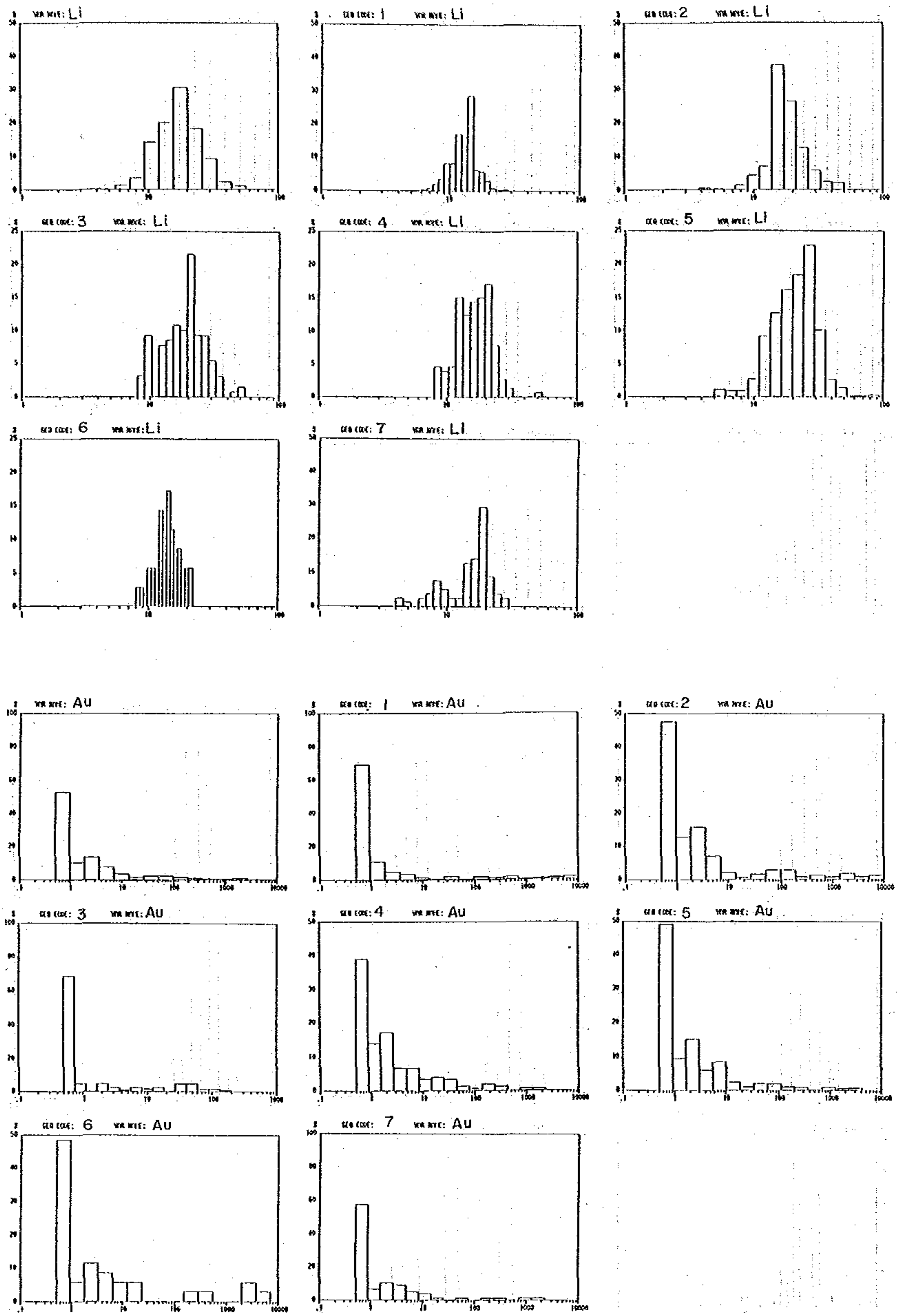
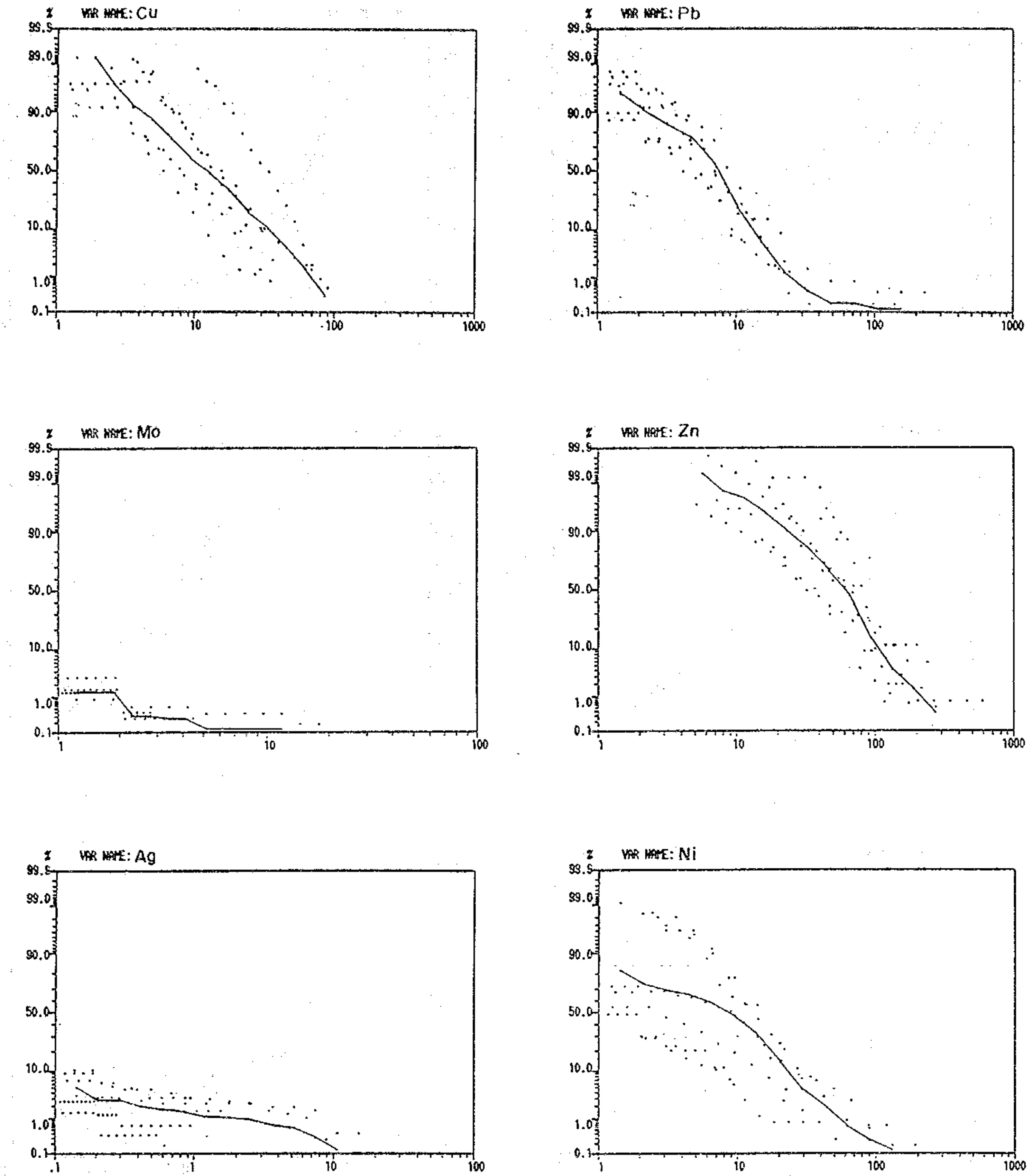


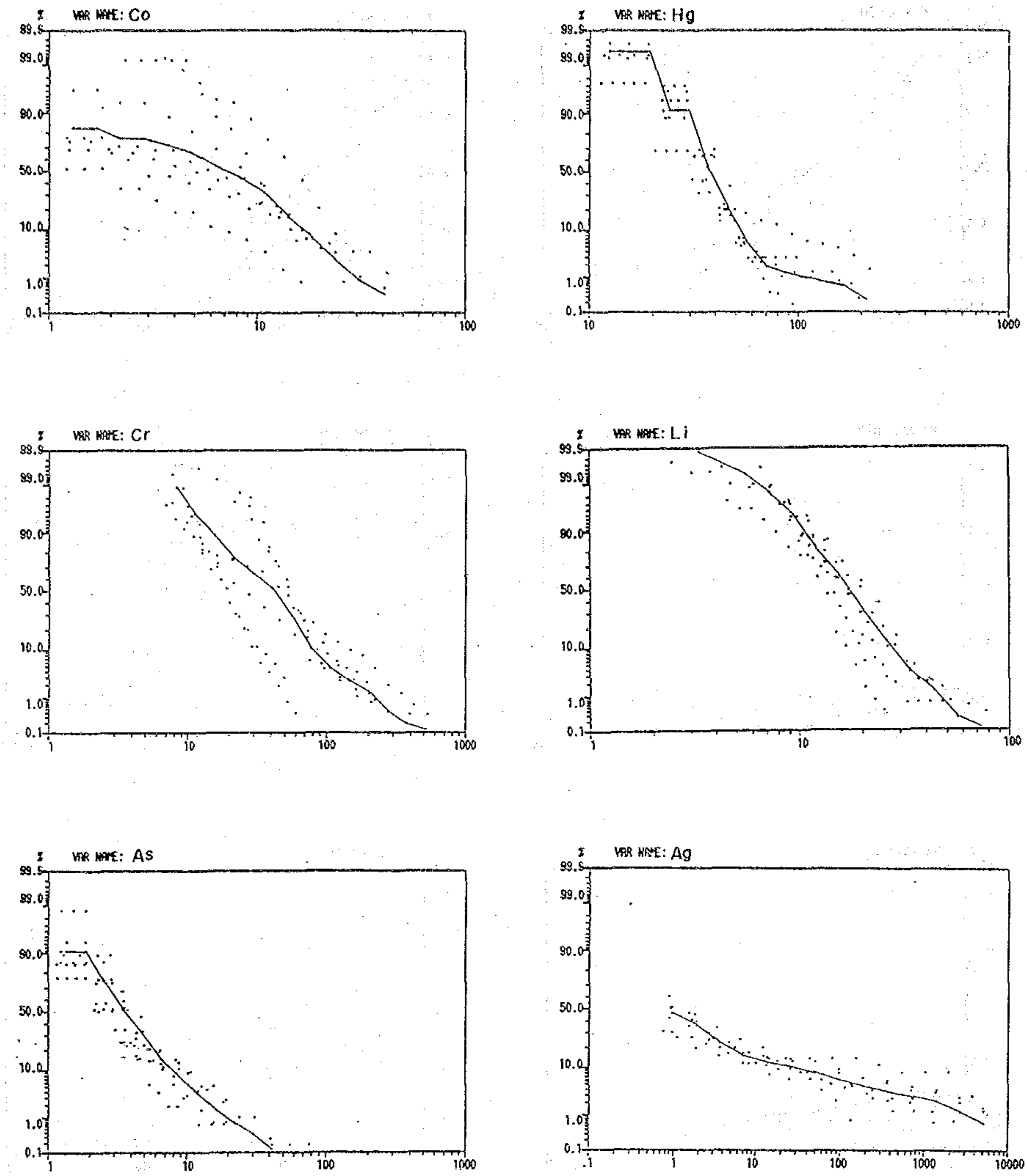
Fig. 22 Histogram of the Contents in Stream Sediments in the Reconnaissance Survey Area (6)



——— whole samples

······ values correlated a geologic unit

Fig. 23 Cumulative Frequency of the Contents in Stream Sediments in the Reconnaissance Survey Area (1)



——— whole samples

∴∵∴ values correlated a geologic unit

Fig. 23 Cumulative Frequency of the Contents in Stream Sediments in the Reconnaissance Survey Area (2)

in their content depending on the back-ground rocks. Therefore, the threshold values have been calculated respectively to determine geochemical anomalies on the basis of the "level"classification. However, in case of specific rock mineralized selectively, the present method, namely determination of the threshold value by the "level", may not be very suitable to detect the geochemical anomalies. This problem is to be examined by comparing the geological data with the geochemical anomalies extracted.

2-3 Relation among Elements

Many elements are involved in a mineralization, therefore it is necessary to unravel the relationship between the elements prior to extracting and evaluating the geochemical anomalies. For this purpose, the correlation matrixes have been constructed, and on the basis of these data the principal component analyses have been processed.

As seen from the correlation matrixes (Table 15), following elemental pairs exceed 0.5 of the correlation coefficients ; Cu-Zn, Cu-Ni, Cu-Co, Cu-Cr, Zn-Co, Zn-Cr, Ni-Co, Ni-Cr and Co-Cr.

The accumulated proportion reaches 81.9% by up to the sixth principal components, and it may indicate that the behaviors of all the elements can roughly be explained by six factors (Table 15). The accumulated proportions are generally not high except for the first principal component showing 0.35, and those from the fourth principal components to the sixth principal components are less than 0.1, and therefore it is hard to assume that the behaviors of many elements are intensively explicable.

It is found from the factor loading (Table 15) that the first principal components are strongly correlated with Cu, Zn, Ni, Co and Cr. The second principal components are rather strongly correlated with Pb, Ag, As and Hg, and the third principal components are correlative with Au and Ag. What the respective principal component means is presumed by only comparing respectively the results of the geolgical survey and the factor scores. From the behaviors of the elements involved in the mineralizations and the elemental contents of various kinds of rocks (Table 22), the following things may be speculated, Namely the first principal components are considered to represent the degree of "basicity" of the back ground rocks rather than owing to the mineralization. On the other hand, the second principal components are considered to indicate the Ag-Pb mineralizations, and As and Sb also are assumed to have been added from the mineralizations. The third principal components may probably represent the Au mineralizations, and Ag might also have behaved together with Au.

2-4 Extraction and Evaluation of Anomaly Areas

(1) Determination of threshold values

The threshold value of each element can be determined by several methods such as Lepeltier method(1969), calculation of $m + 2\sigma$ and others. In Table 16 are tabulated the values for m+

Table 15 Results of Principal Component Analysis for the Reconnaissance Survey Area

CORRELATION MATRIX

	Cu	Mo	Pb	Zn	Ag	Ni	Co	Cr	As	Hg	Li	Au
Cu	1.000	.022	-.009	.623	-.084	.717	.831	.728	.363	.023	.274	-.010
Mo	.022	1.000	.030	.030	.029	-.015	.021	-.003	.128	.024	.092	-.017
Pb	-.009	.030	1.000	.337	.018	-.008	.071	.003	.198	.178	.317	-.024
Zn	.623	.030	.337	1.000	-.055	.476	.717	.534	.296	.140	.318	-.048
Ag	-.084	.029	.018	-.055	1.000	-.107	-.111	-.103	.055	.133	-.023	.366
Ni	.717	-.015	-.008	.476	-.107	1.000	.780	.865	.327	-.002	.321	-.045
Co	.831	.021	.071	.717	-.111	.780	1.000	.788	.342	.053	.292	-.075
Cr	.728	-.003	.003	.534	-.103	.865	.788	1.000	.242	-.002	.259	-.052
As	.363	.128	.198	.296	.055	.327	.342	.242	1.000	.118	.371	.120
Hg	.023	.024	.178	.140	.133	-.002	.053	-.002	.118	1.000	.092	.070
Li	.274	.092	.317	.318	-.023	.321	.292	.259	.371	.092	1.000	.004
Au	-.010	-.017	-.024	-.048	.366	-.045	-.075	-.052	.120	.070	.004	1.000

	EIGENVALUE	ACCUMULATED PROPORTION
1	.4213818E+01	.351
2	.1622820E+01	.486
3	.1311642E+01	.596
4	.1027531E+01	.681
5	.8985191E+00	.756
6	.7522253E+00	.819
7	.6287444E+00	.871
8	.5964895E+00	.921
9	.4532211E+00	.959
10	.2386618E+00	.979
11	.1392070E+00	.990
12	.1172570E+00	1.000

EIGENVECTOR

	1	2	3	4	5	6
Cu	.426021E+00	-.996182E-01	.141521E+00	.173809E-01	.554377E-01	-.173966E-01
Mo	.237072E-01	.168044E+00	-.121548E+00	.837896E+00	.412208E+00	-.237136E+00
Pb	.867966E-01	.449225E+00	-.470834E+00	-.239663E+00	-.172922E+00	-.429391E+00
Zn	.372374E+00	.121237E+00	-.132219E+00	-.175036E+00	.981564E-01	-.377391E+00
Ag	-.587468E-01	.412761E+00	.514905E+00	-.294562E-01	.534670E-01	-.332574E+00
Ni	.421579E+00	-.153386E+00	.138094E+00	.171390E-01	-.223210E-01	.999544E-01
Co	.450033E+00	-.979016E-01	.622321E-01	-.406450E-01	.963633E-01	-.100894E+00
Cr	.420786E+00	-.179027E+00	.140494E+00	-.204696E-01	.500963E-01	-.448189E-01
As	.236989E+00	.345979E+00	-.113827E-01	.261085E+00	-.239798E+00	.486331E+00
Hg	.432733E-01	.392619E+00	-.521542E-01	-.347850E+00	.719958E+00	.423791E+00
Li	.228417E+00	.322638E+00	-.267991E+00	.130952E+00	-.382452E+00	.259607E+00
Au	-.276938E-01	.363119E+00	.586135E+00	.260947E-02	-.224077E+00	-.191150E-01

FACTOR LOADING

	1	2	3	4	5	6	7	8	9	10	11	12
Cu	.875	-.127	.162	.018	.053	-.015	-.081	-.043	-.153	-.374	.115	-.067
Mo	.049	.214	-.139	.849	.391	-.206	-.023	.117	.042	-.000	-.003	-.008
Pb	.178	.572	-.539	-.243	-.164	-.372	-.109	.011	.315	-.118	-.011	.003
Zn	.764	.154	-.151	-.177	.093	-.327	-.180	-.035	-.346	.241	.065	-.080
Ag	-.121	.526	.590	-.030	.051	-.288	.400	-.338	-.009	-.007	-.003	-.001
Ni	.865	-.195	.158	.017	-.021	.087	.144	.064	.294	.085	-.102	-.225
Co	.924	-.125	.071	-.041	.091	-.088	-.047	-.030	-.077	-.039	-.265	.165
Cr	.864	-.228	.161	-.021	.047	-.039	.119	.094	.261	.115	.201	.166
As	.486	.441	-.013	.265	-.227	.422	-.281	-.427	.058	.064	.021	.020
Hg	.089	.500	-.060	-.353	.682	.368	.031	.106	.024	-.011	.004	-.001
Li	.469	.411	-.307	.133	-.363	.225	.442	.277	-.211	-.007	.002	.019
Au	-.057	.463	.671	.003	-.212	-.017	-.324	.426	.012	.010	-.013	.005

Table 16 Threshold Values Correlated to the Geologic Units

unit : ppb for Hg and Au
ppm for other elements

Lithological unit		1	2	3	4	5	6	7	total
Number of samples		259*	384	130	152	562	35	78	1600
Element	Cu	20	48	32	76	52	30	47	61
	Mo	1	1	1	1	1	1	1	1
	Pb	27	22	25	20	25	28	18	25
	Zn	136	221	169	131	147	241	135	194
	Ag	0.4	0.5	0.3	0.2	0.1	0.1	0.1	0.3
	Ni	9	27	48	46	52	10	59	65
	Co	10	35	21	35	33	32	34	42
	Cr	40	116	134	193	129	51	229	153
	As	7	16	13	10	15	11	12	14
	Hg	64	70	124	72	59	68	64	71
	Li	20	37	40	30	45	23	35	38
	Au	102	216	37	68	66	914	53	99

* for gold 258 samples

Table 17 Threshold Values by Lepeltiers' Method

Unit : ppb for Hg and Au
ppm for the other elements

Element	Lithological Unit							Total	D.S.A.
	1	2	3	4	5	6	7		
Cu	19	55	29	70	58	19	36	55	94
Mo	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Pb	22	19	18	16	18	20	11	35	201
Zn	92	190	160	130	105	102	82	102	600
Ag	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)	1.2
Ni	10	25	43	18	46	10	22	52	27
Co	11	21	14	37	27	22	16	25	27
Cr	43	102	82	55	95	50	160	105	86
As	7	18	13	10	15	10	19	14	44
Hg	61	70	56	62	57	59	53	71	66
Li	16	24	37	28	40	21	27	56	42
Au	2,200	1,080	72	260	420	18	10	700	57

D.S.A. : Detailed Survey Area

2σ (m: mean value, σ : standard deviation). On the other hand, in Table 17 are shown the values obtained by the Lepeltier's method. The accumulated frequency distribution on the probability sheet (Fig. 23) gives quite few examples of simple straight line or of bended line towards high-content side. Therefore, the values in Table 17 mostly corespond to those for the content of 2.5 % on the accumulated frequency diagram, and in comparison with the values in Table 16 with those in Table 17, there is generally small differences between the both. Accordingly, the data in Table 16 have been used principally as the threshold. However, the slight differences have also been taken carefully into considerations for extracting anomaly areas on the basis of anomaly values. As compared the threshold values ($m+2\sigma$) determined for every geologic unite in the back-ground ("level" in the proceeding section 2-2) with those ($m+2\sigma$) obtained from the whole samples, the former ones are in general set up at higher levels than the latter ones for all the elements concerned ; namely more than five cases in the seven threshold values (corresponding to the data for seven "levels") exceeding the values obtained from the whole samples.

Therefore, using the threshold values obtained from the whole samples, there would be a possibility of missing anomaly values. In view of this, the threshold values detarmined for every geologic unite have been accepted in the present investigation to extract anomaly values.

(2) Extraction of Anomaly Areas

When anomaly values are obtained from more than two neighbouring sampling spots, the whole drainage area of these sampling spots is defined to be an anomaly area. Furthermore, when a Pb-anomaly and a Zn-anomaly are neighbouring to each other, the area including the both is also defined as an anomaly area (Table 18, Fig. 24). In Figure 24, in the detailed survey area anomaly values are based on the threshold values for the S. Rawas Formation (Level 5) determined in the same way as mentioned before in 2-4.

(3) Distribution Characteristic of Anomaly Area

47 anomaly areas have been extracted from the reconnaissance survey area. Among them, 11 areas are concerned with at least one or more of Cu-Pb-Zn, 18 areas with at least one or more of Au-Ag-Hg, 4 areas with As, 4 areas with at least one or two of Mo-Li and 9 areas with Ni-Co-Cr. The Cu-Pb-Zn anomalies are distributed widely over the detailed survey area and its eastern part 42 in Fig.24, and they are not concentrated in any specified area and geologic formation.

The Au-Ag-Hg anomalies also extend over the whole areas and whole stratigraphical horizons, but they seem to be a tendency of being rather concentrated in the areas underlain by the Hulusimpang Formation. Among them, the areas showing rather extensive anomalies are up-stream of the S. Kulus ②, S Minak㊱, ㊲ and S.
Menalu ㉗. The anomalies are found in S.Limum ②, S.Minak㊸, S.Tarum ㊹ and S.Kuwis ⑰. There are no remarkable charecteristics in distribution on geological back ground throughout the

areas. The Mo-Li anomalies are restricted to S. Maloko ⑬, S.Senawar ⑫ and S.Kutu ㉟. The Ni-Co-Cr anomalies are widely scattered in S.Kulus ③, S.Senawar-Seni ⑩, S.Mengkulam⑯, S.Labi ㉚, S.Ulak ㊵, S.Tiku ㊺ and S.Minak downstream ㊼. Although no conclusive observations are available as to the relations of these anomalies to the geological back ground, some of them (e. g., ③, ⑪, ㉚, ㊺, ㊼) may be presumed to be related, at least to some extent, with the basic igneous rocks.

(4) Evaluation of Anomaly Areas

Paying attention to the concentration and magnitude of the anomalies extracted, and the duplication degree of the components, the anomaly areas have been assessed and evaluated. The extracted anomalies are merely the products of statictical treatment, namely the anomalies are essentially depend on the frequence distribution of each element, and hence no geochemical factors are taken into considerations. Therefore, in the present investigation, the evaluation has been made mainly by comparing the magnitude of the anomalies with the average crustal abundances in addition to the information obtained from the geological survey.

At first, the anomaly areas have been ranked as three grades of A, B and C.

The rank A is applied to the case where more than five anomalies are neighbouring together, and further, more than two samples are two times or more higher in content than the average content of one of the rocks listed in Table 22. The rank B is applied to the case where one of the above two necessary conditions is satisfied, and the rank C to the case where the both conditions are all not satisfied. In addition to these, the Ni-Co-Cr anomaly areas are assumed to be of rank C. As a result of the rankings of the extracted anomalis in such a classification, 4 areas of rank A and 14 areas of B rank are obtained. According to the rough cclassification, the Cu-Pb-Zn anomalies are supposed to lack those of rank A and to comprise only 4 areas of rank B. The Au-Ag-Hg anomalies are divided into 4 areas of rank A and 8 areas of rank B. The Mo-Li anomalry provides only 1 area. Among those of rank B, four Cu-Zn-Pb anomely areas and one Mo anomaly area are outlined below.

S. kerali anomaly-area (①): The area contains four Zn anomalies (173 ppm~775 ppm) together with a Pb anomaly (25 ppm) and a Co anomaly (20 ppm). At the S. Kerali, the pyrite-dissemination zone is known to occur associated with the silicified alteration zone in the Napallicin Formation, though its distribution is narrowly limited and no zinc-and lead-mineralizations are recognized.

Napallicin anomaly-area (⑧): The area contains 6 anomalies of Cu, but the maximun value only reaches 81 ppm, which is not very high as compared with the value of basalt. This anomaly is presumed to be due to the basaltic rocks in the Napallicin Formation.

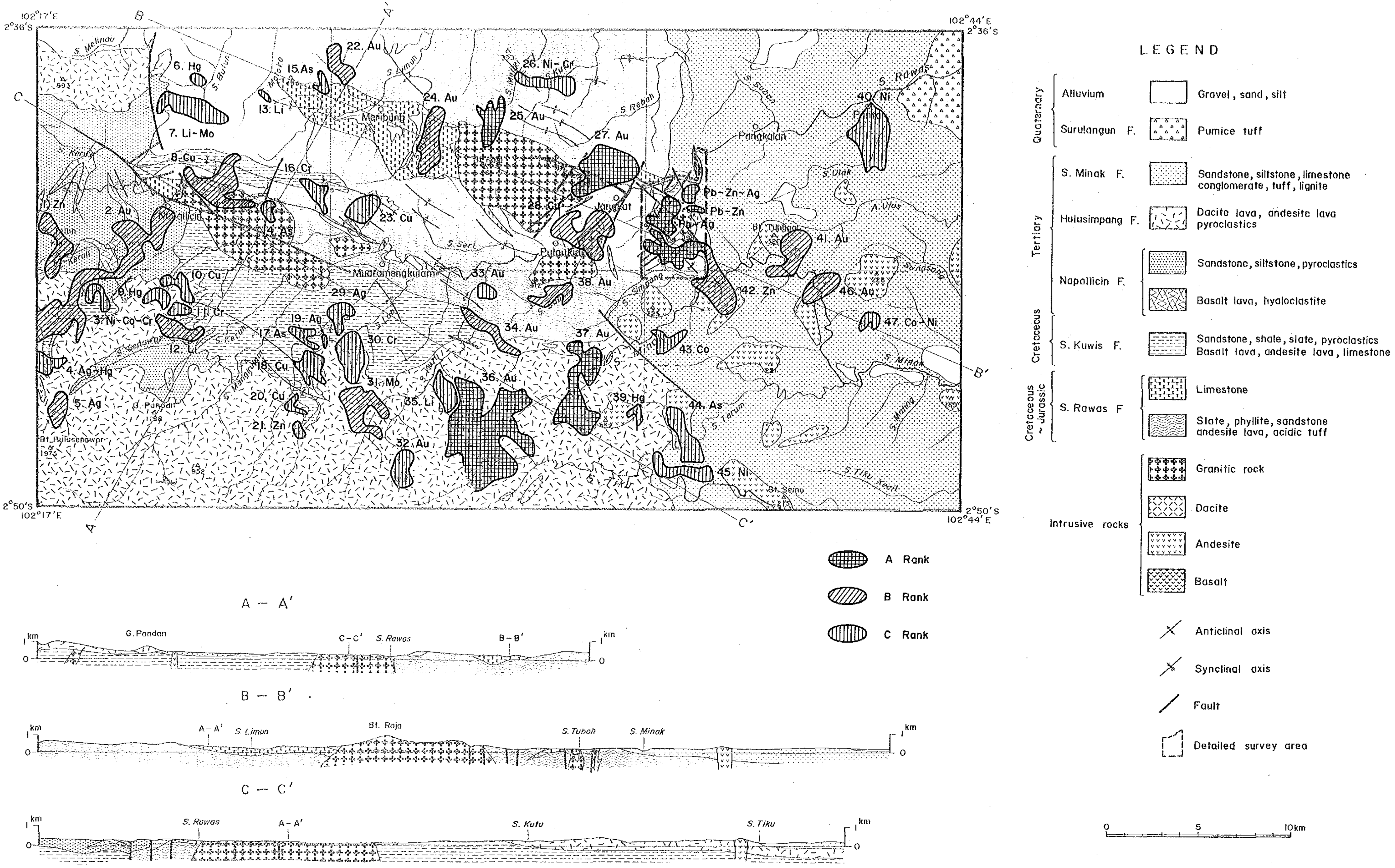


Fig. 24 Geochemical Anomalous Area in the Reconnaissance Survey Area

Table 18 List of the Geochemical Anomalous Areas (1)

No.	Location	Number of Anomalous Samples	Main anomalous element and the range	Subordinate Anomalous element and the range	Inferred Mineralization	Rank
1	S. Kerali	4	Zn: 173 ∿ 775(4)	Pb:25(1), Co:22(1)	(Pb)-Zn 24	B
2	S. Kulus	20	Au:38 ∿ 141(13) Ag:0.3 ∿ 1.9 (10) Hg:80 ∿ 260(12)	Co:21(1) Li:48(1) Cr:124 ∿ 180(2) Zn:176(1) Cu:60 ∿ 67(2)	Au-(Ag)-(Hg) 32	B
3	S. Kulus	4	Ni:52 ∿ 74(3) Co:23 (3) Cr:220 ∿ 270(3)		Ni-Co-Cr	C
4	S. Kulus	4	Hg:70 ∿ 180(3) Ag:0.2 ∿ 1.8(2)	Cu:48(1) Pb:23(1) Cr:118(1)	Ag-Hg	C
5	S.Senawar	3	Cu:73 ∿ 119(2) Au:356 ∿ 390(2)		(Cu)-Au	B (for Au)
6	S. Buluh	2	Hg:60(2)		Hg	C
7	S. Susup	8	Li:48 ∿ 92(7) Mo:2 ∿ 22(3)	As:20 ∿ 105(2)	Li-Mo 28	C
8	Napallicin	13	Cu:55 ∿ 81(6)	As:16 ∿ 81(3) Hg:60(1) Ni:82 ∿ 104(2) Co:38 ∿ 41(2) Cr:290(2)	Cu	B
9	S.Senawar Seni	2	Hg:70 ∿ 80(2)		Hg	C
10	S.Senawar Seni	4	Cu:35 ∿ 81(4)		Cu 17	C

Table 18 List of the Geochemical Anomalous Areas (2)

No.	Location	Number of Anomalous Samples	Main anomalous element and the range	Subordinate Anomalous element and the range	Inferred Mineralization	Rank
11	S.Senawar Seni	3	Cr: 118 ∿ 270(3)	Mo:2 (1), Ni:30(1)	Cr	C
12	S. Senawar	5	Li 32 ∿ 54(5)		Li	B
13	S. Maloko	2	Li 46 ∿ 52(2)		Li	C
14	S. Sosokan	2	As: 12 ∿ 20(2)		As	C
15	North of Bt.Bulan	2	As: 17 ∿ 30(2)	Ni: 55(1)	As	C
16	Mengkulam	3	Cr: 140 ∿ 162(3)	Cu: 53(1), Ni:59(1)	Cr	C
17	S. Kuwis	2	As: 10 ∿ 11(2)		As	C
18	S. Kuwis	6	Ag: 0.2 ∿ 0.3 (3) Cu: 74 ∿ 91 (2)	Pb:21(1) Au:91(1)	Cu [31]	C
19	S. Kuwis	2	Ag: 0.2 ∿ 0.3(2)		Ag [II] zone	C
20	S. Kuwis	3	Cu: 50 ∿ 82(2)	Pb:25(1), Cr:195(1) Mo:45(1), As: 36(1)	Cu [31]近	C
21	S. Kuwis	2	Pb: 34(1) Zn:345(1)		(Pb)-Zn	C
22	North of Meribung	4	Au:568 ∿ 4,130(3)	Ag:0.2(1)	Au	B
23	S.Tunbuk	3	Cu: 56 ∿ 60(2)	Hg: 70(1)	Cu	C
24	S.Pangi	4	Cu: 29 ∿ 52(2) Au:158 ∿ 1,230(2)		(Cu)-Au [6] [9]	B (Au)
25	S. Meliki	5	Au: 76 ∿ 1,200	Pb: 200	Au [1]	A

Table 18 List of the Geochemical Anomalous Areas (3)

No.	Location	Number of Anomalous Samples	Main anomalous element and the range	Subordinate Anomalous element and the range	Inferred Mineralization	Rank
26	S. Meliki ∿ S. Kutur	4	Ni: 61 ∿ 280 (4) Cr:160 ∿ 720 (4)		Ni-Cr	C
27	S. Menalu	7	Au:102 ∿ 2,060 (7)		Au [3] [4] [5]	A
28	S. Temiang	8	Cu: 71 ∿ 102 (6)	Co: 34 ∿ 53(4) Mo: 12 (1) Pb: 28 (1)	Cu [8]	B
29	S.Kuwis (lower)	3	Ag:0.2 (3)		Ag [29]	C
30	S. Kuwis (lower)	10	Ni: 34 ∿ 160 (7) Co: 37 ∿ 51 (5) Cr:205 ∿ 520 (8)	As: 23 (1) Cu: 48 ∿ 58(2) Ag: 0.2 ∿ 0.3(2)	(Ni)-(Co)-Cr [23]	C
31	S. Kutu (upper)	7	Mo: 2 (6)	Li:39 ∿ 41 (2)	Mo	B
32	S. Kutu (upper)	2	Au: 56 ∿ 1,710 (2)	As: 33(1) Ag: 0.6(1)	Au	C
33	S. Kutu	2	Au: 71 ∿ 96 (2)	Ag: 0.2(1)	Au	C
34	S. Kutu	4	Au: 850 ∿ 2,100(3)	Ag: 0.2(1)	Au	B
35	S. Kutu	3	Li: 48 ∿ 50(3)		Li	C
36	S. Kutu - S. Minak	17	Au: 70 ∿>10,000 (16) Ag: 0.5 ∿ 12.3 (11)	As: 22(1)	Au-(Ag) [37]	A
37	S. Minak	7	Au: 144 ∿ 2,420 (7) Aq: 6.8 (1)	As: 38(1)	Au-(Ag) [36]	A
38	S. Suban	3	Au: 84 ∿ 1,250 (3)		Au [12] [13] [14]	B

Table 18 List of the Geochemical Anomalous Areas (4)

No.	Location	Number of Anomalous Samples	Main anomalous element and the range	Subordinate Anomalous element and the range	Inferred Minerali-zation	Rank
39	Bt. Telunmerangin	2	Hg: 70 ∿ 110(2)		Hg	C
40	S. Mejaja	3	Ni: 11 ∿ 38(3)		Ni	C
41	S. Minak	3	Au:596 ∿ 9,730(3) Ag:7.6 ∿ 10.2 (3)		Au-(Ag) [41]	B
42	Bt:Ipuh	6	Cu: 22 ∿ 45(2), Zn: 165 ∿ 285(2) Co: 11 ∿ 16(3) Cr: 40 ∿ 44 (3)	Li: 20 ∿ 22(2) As: 7 ∿ 9 (2) Au: 205 (1)	(Cu)-Zn-(Co)-(Cr) [S.Tuboh]	B
43	Bt:Meru	3	Co: 10 ∿ 13(3)	Au:3,630 (1)	Co	C
44	S. Tarum	3	As: 7 ∿ 11 (3)	Pb: 38 (1), Hg: 80(1)	As [45]	C
45	S. Tiku	3	Ni: 10 ∿ 13(3)	Cr: 70 (1) Zn:141 (1)	Ni [46]	C
46	S. Minak	3	Au: 584 ∿ 7,000 (2)	Ag: 7.0(1)	Au [42]	B
47	S. Minak	2	Co: 18 ∿ 20(2) Ni: 33 (1)	Pb: 83 (1) As: 7 (1) Hg: 70 (1)	Co-Ni	C

□ : Number of indication to be correlated with in Table 9

( ): Element of lower rank anomaly compared to ones without parenthesis