THE REPUBLIC OF INDONESIA
REPORT ON THE COOPERATIVE MINERAL EXPLORATION
OF
SOUTHERN SUMATRA

PHASE III

FEBRUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In responce to the request of the Government of the Republic of Indonesia, the Japanese Government decided to conduct a mineral exploration in Southern Sumatra Area and entrusted the survey to the Japan International Cooperation Agency. Concidering its technical aspects, the Agency sought collaboration with the Metal Mining Agency of Japan to accomplish the task.

The Government of the republic of Indonesia appointed the Directorate of Mineral Resources to excuted the survey as a counterpart to the Japanese team. The survey is being carried out jointly by exparts of both Governments.

For the work 1987, the third phase, the Metal Mining Agency of Japan dispatched the survey team consists of one geologist and six drilling engineers to Indonesia during a period from July 21, 1987 to January 7 1988.

This report summarized the result of the third phase, and forms a part of the final report.

We wish to express our heartful gratitude to the agencies of the Republic of Indonesia, and other autholitis concerned for thier kind cooperation and support to the Japanese survey team

February 1987

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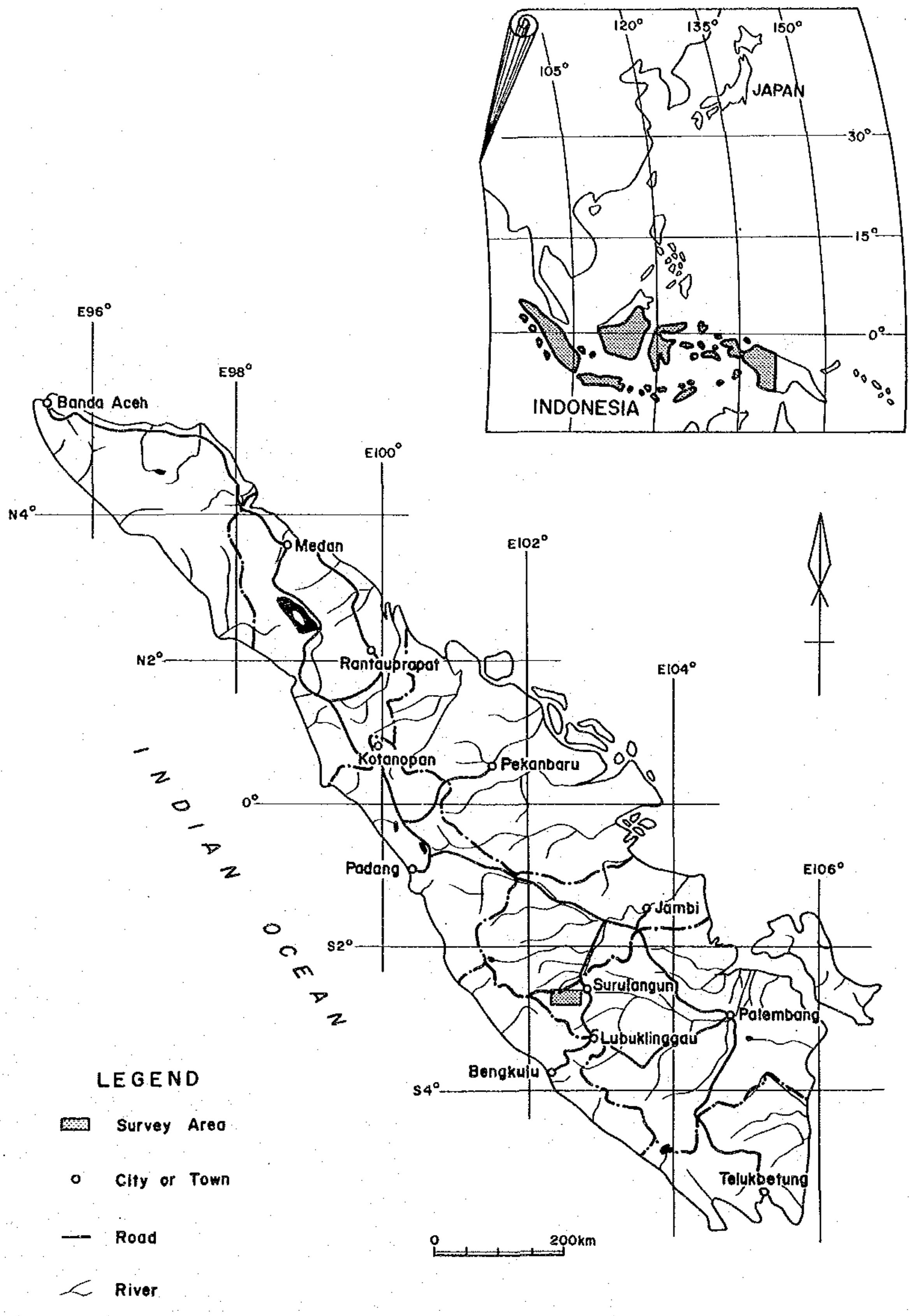

Fig. 1 Index Map of the Surveyed Area

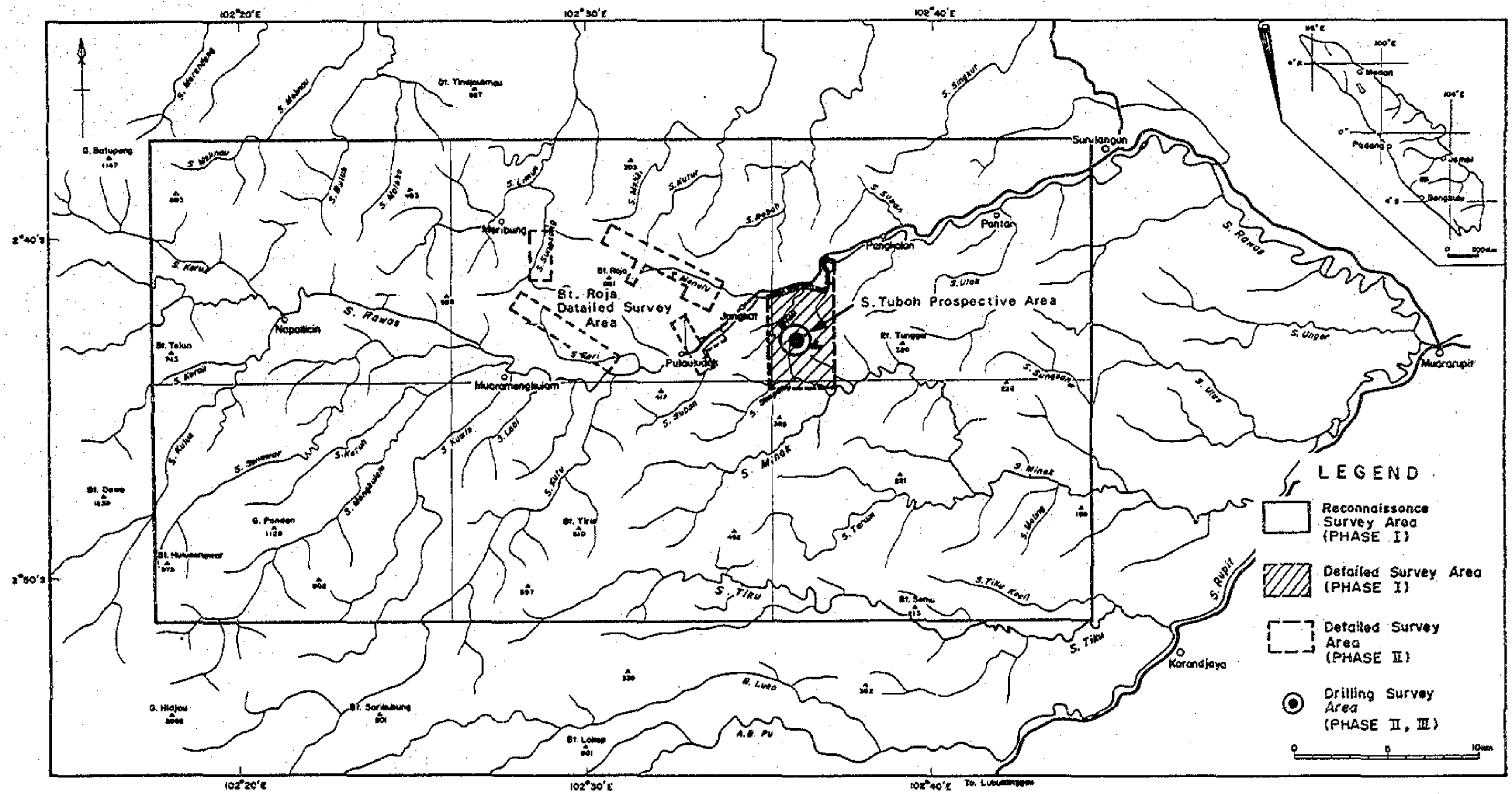

Fig. 2 Location Map of the Survey Area for Third Phase

SUMMARY

Mineral Exploration of Southern Sumatra, drilling survey (13 holes, total 3,170m) has been conducted in the ted on the basis of the result of the second phase survey.

The results reveals that nine skarn type mineralized zone are embedded in the S.Tuboh area, and they contain silver,lead and zinc. A current provisional ore reserves has also been calculated.

The zones consist of three longer-trending mineralized zone(D_1,D_2, and D_3) and other six zones(D_2,D_5,D_7,D_6 and D_9). Their shallow part obtained by the third phase survey have a tendency to contain high grade.

Although these mineralized zone are displaced by several faults trending NNE-SSW. The relationship of the mineralized zones between these fault are indistinct in a some place, following provisional ore seserves is calculated up to the present ;

ore reserves	grade					metal contents				
	Au	Ag	Cu	Pb	Zn	Au	Ag	Cu	Pb	Zn
$\times 10^3$	g/t	g/t	%	%	%	kg	kg	t	t	t
1,762	0.1	130	0.8	1.5	10	192	229.760	1,400	25,600	176.000

The provisional ore reserves and grade are not enough to develop under a commercial standard, objecting the present mineralized zones obtained. In addition, the ore reserves and grade are still undefined in their accuracy up to the result of the survey, and should be improved by detailed survey. Considering the fact that there are other prospecting areas, future exploration is recommended as foffows ;

① Detailed survey continues in order to improve its accurasy for provisional ore reserve, and also increase the ore reserves.

② After the exploration survey for the whole S.Tuboh area, included two mineral indications of S.Kuring, S.Sepang and marble zone of middle reaches of S.Nilau, to obtain additional ore reserves, and confirm the potentiality of the area, the possibility of exploitation in the area is to be investigated.

③ Metallic mineral and marble resources would be investigated together for the exploitation of this area.

Concerning the geology and mineralization in the area, especially genesis of the mineralization, new concept is concluded as follows ;

i) The mineralization of the S.Tuboh area is attributed in movement,

reorganization and redeposion of existed sulfide under temperature condition forming skarn ore deposit. The existed sulfide was presumably embedded in the S.Rawas Formation as strata-bound sulfide ore deposit.

ii) The igneous activity supplied the heat to form the skarn ore deposit took place at 60~50Ma

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Part I General Descriptions

Part I General Descriptions

Chapter 1 Introduction

1-1. Back ground of the survey

The 1987 survey of an area of Southern Sumatra Area in the Republic of Indonesia was the third phase of survey for which the scope of works was agreed between Governments of Japan and the Republic of Indonesia on 31st August 1985.

The first phase survey consisted of aerial photogeological interpretation and investigation on existing data, geological-geochemical reconnaissance survey in the whole area, and geological-geochemical detailed survey in the selected area (18 km^2) where selected by the investigations of above mentioned preliminary investigations of the photogeology and existing data.

On the basis of these results, the Bukit Raja Area and the Sungai Tuboh Area were selected as detailed survey area for the second phase.

The second phase survey consisted of geological, geochemical and ground magnetic surveys carried out in the Bt. Raja area, and a drilling survey carried out in the S. Tuboh area.

From these results the possible existence of a skarn type mineralized zone in the S. Tuboh area was deducted.

In the third phase, a drilling survey (13 holes, total drilled length 1,170 m) was carried out in order to find out the horizontal and vertical extent of the mineralized zone in the S. Tuboh area and to clarify its occurence.

1-2. Conclusions and proposals from second phase survey

1-2-1 Conclusions from the second phase survey

(1) Bt. Raja area

The conclusion drawn from the results of the second phase survey was that "Porphyry copper type mineralization was recognized in the Bt. Raja area, but the grade of mineralized zone was too low to justify further investigation and development".

Namely, porphyry copper type mineralization which related to plutonic igneous activity where took place during the age from 60 to 50 Ma, and samll scale skarn type mineralization consisting of magnetite and hematite apparently formed at the same time were detected in the area. However, both are low grade and small scale.

(2) S. Tuboh area

The second phase survey unreveled the four mineralized zones D-1 to D-4, and indicated that the extension of mineralised zones D-5 and D-6 was inferred with a high degree of accuracy. The survey also concluded as follows ;

1) D-2 and D-3 extend a certain scale to both strike and dip sides.
2) More new mineralized zones might be discovered in the future.
3) If the mineralized zones intersected or joined up each other,they might form a large "ore shoot" and the silver and zinc were of high grade.

The S. Tuboh area was, therefore, designated as suitable for future investigation.

1-2-2 Proposals based on secocnd phase survey

From the results of the second phase survey, it was decided that the third phase survey should be targeted on the skarn type Ag-Zn-Pb mineralized zones in the S. Tuboh area.

The mineralized zones D-2 and D-3, with their excellent grade and extension to both strike and dip sides, seemed to offer the better prospects.

Drilling survey for both mineralized zones would be distributed 70 m to 100 m interval along strike and up to 250 m deep from the ground surface in dip to clarify these occurrences. The mineralized zones strike N45°-50°E and dip 65°-75°SE, and drilling holes would be set up penetrating from southeast (hanging wall) to northwest(foot wall).

1-3. Outline of third phase survey

1-3-1 Survey area

The S. Tuboh area is located in the center of the eastern half of the Southern Sumatra Area, on the upper and middle reaches of the S.Tuboh.

This river is a minor tributary of the S.Simpang which in turn is a tributary of S.Minak, which join the S.Rawas at Muara Rupit, at the eastern edge of the area.

The second and third phase drilling surveys covered an area of NE-SW 900 m and NW-SE 500 m.

The S. Tuboh area is located at 100 km north up the Sumatra Highway from Lubuk Linggau, the capital of the Rawas District of Southern Sumatra

Province. The village of Surulangun (the residence of the Camat, district chief, whose jurisdiction covers the entire S.Rawas basin) can be reached by the highway. From here transport is by river barge, 23 km up the S.Rawas, after which is a further 4 km on foot. The journey from Lubuk Linggau takes about 4 and a half hours. From Surulangun, motor vechicles can travel only 7 km upstream alongside the S.Rawas after that the only transport is the river barge.

1-3-2 The purpose of the survey

The purpose of the survey was to discover the vertical and horizontal extent of the skarn type mineralized zones whose existence in the S. Tuboh area was indicated by the results of the second phase survey, and to assess the ore reserves and its exploitage for the future.

1-3-3 Survey procedure

The third phase survey plan consisted of initially for four 350 m inclined holes(=1,400m) and six 150m vertical holes(=900m) making a toatl of 10 holes (=2,300m). However, the addition of extra inclined holes, one 270m, one 280m and one 300m, totaling 850m, brought the total to 13 holes (=3,150m).

The work was performed by two teams using two drilling machines. The work includes core analyses (assaying, x-ray diffraction analysis, microscopic observations), data interpretation. An estimation of ore reserves and assessment of potential are also included. Making reports of the phase and summary throuth wohle phases, and technical transfer take place on the basis of this work.

1-3-4 Formation of the survey team

Member of the survey team are listed below.

【Japanese side】

Planning and coordination	Atsushi Osame (MMAJ)
	Natsumi Kamiya (MMAJ)
Team leader & General Manager	Yoitsu Oguma (NED)
Drilling	Isamu Nakayama (NED)
	Susumu Horiguchi (NED)
	Soji Kan-nari (NED)
	Tadateru Sugibuchi (NED)
	Mitsuo Nomura (NED)
	Hidemitsu Itoda (NED)

【Indonesian side】

Planning and coordination	Salman Padmanagara (DMR)
	J. Rainir Dhadar (DMR)
	A. Machali Musin (DMR)
General Manager	Sukirno Djaswadi (DMR)
Core logging	Bonifatius Bandi (DMR)
Drilling	Saksono (DMR)
	Agus Muliyadi (DMR)
	Encep Sudjana (DMR)
	Kisman (DMR)

1-3-5 Survey period

Drilling work was started from MJI-13 in case of inclined hole on 27th July 1987 and from MJI-16 in case of vertical hole on 22nd July 1987.

Drilling work was completed on 12th September in case of vertical hole and on 18th November in case of inclined hole.

Whole survey schedule of the third phase is shown in Fig.3 and the amount of work conducted in Table 1.

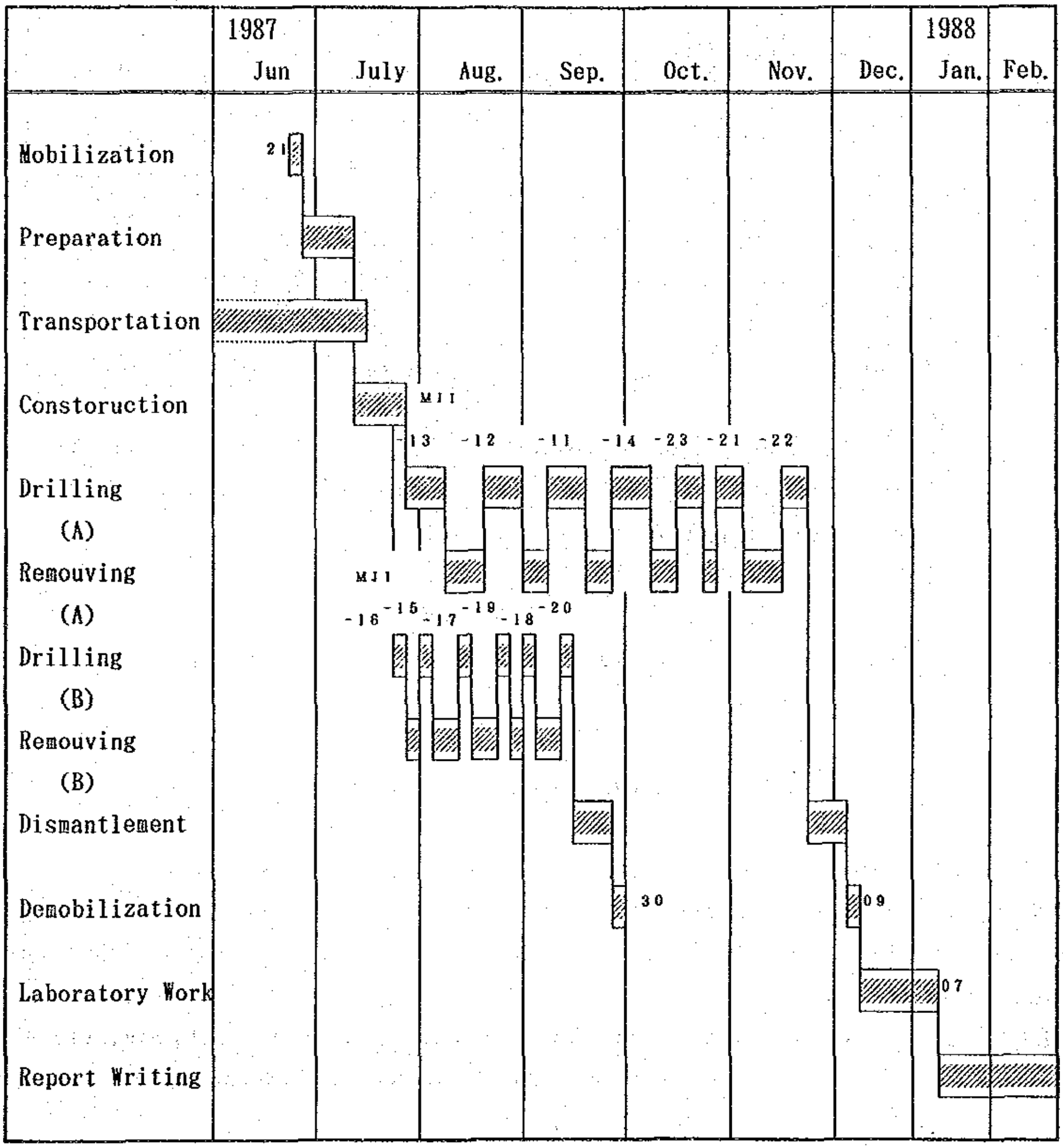

Fig. 3 Progress of Drilling Work

Table 1 Drilling Plan and Amounts Conducted

Hole No.	Length planed (m)	Length drilled (m)	Azimuth (°)	Dip (°)	surface soil (m)	core length (m)	core recovery (%)
MJI-13	350	351.00	340	-50	29.35	313.60	97.5
MJI-12	350	351.00	340	-50	14.70	333.15	99.1
MJI-11	350	351.00	340	-50	13.50	303.15	89.8
MJI-14	350	351.00	340	-50	17.30	335.60	99.1
MJI-16	150	151.00		-90	16.40	133.60	99.3
MJI-15	150	151.10		-90	32.00	104.50	87.7
MJI-17	150	151.00		-90	10.00	141.00	100.0
MJI-19	150	151.00		-90	25.10	118.30	94.0
MJI-18	150	153.70		-90	22.60	75.80	57.8
MJI-20	150	151.00		-90	20.50	124.00	95.0
MJI-23	270	276.30	340	-50	15.40	235.20	90.1
MJI-21	280	281.00	340	-50	36.10	237.35	96.9
MJI-23	300	300.00	340	-50	43.00	242.55	94.4
Total	3,150	3,170.10			295.95	2,597.80	95.4

In addition to the above, the following samples were taken for analysis.

Assaying : 105 pcs, 525 items(Five elements : Au, Ag, Cu, Pb, Zn)
X-ray diffraction analysis : 22 pcs
Polished specimens : 21 pcs
Thin sections : 14 pcs
Sulfur isotope analysis : 10 pcs

Chapter 2 Geography and stream system

2-1 Topography and stream system

The S. Tuboh area consists of a range of low hills, and its height above sea level is no more than 300m at miximum. The level of the S.Tuboh basin is below 100 m.

The S.Tuboh, as mentioned above, is a tributary of the S.Simpang, which in turn is a tributary of the S.Minak, which join the S.Rawsa at the east of the survey area.

There are no population centers in the area, the nearest one being about 6 km away.

2-2 Climate and vegitation

The region belongs to the rain forest, with high temperature and high humidity, and the annual rainfall is over 3,000 mm. From May to September rainy days are not so frequent, but from October to April is rainy season, when it rains almost every days.

As for vegetation, most of area was cultivated by slushing and burning agriculture in the past, and then left alone, resulting in a dense forest about 20 to 30 years old. This forest contains quite a lot of rubber trees from plantings in the past.

Chapter 3 General geology

The results of previous surveys show that the S.Tuboh area is formed mainly of the Mersip Limestone Member(L-T, can be classified into 3 rock facies, descibed in the later) which belongs to the S. Rawas Formation (Late Mesozoic-Jurassic to Early Cretaceous), and consist of a sandy - muddy facies at a lower horizon(A-P) with andesitic tuff and andesitic lava. Sericite-chlorite tuffaceous phyllite facies dominates at a lower half of this horizon. The upper horizon of the S.Rawas Formation is a roughly alternated beds of sandstone and slate(S-S).

The intrusive bodies all of which have penetrated S.Rawas Formation are alkaline rock(60-50 Ma).

The Mersip Limestone Member in the S.Tuboh area is a southwest extension, across the Bt.Raja area from the type-locality at northwest of the Southern Sumatra Area. In the S.Tuboh area the limestone has undergone marble, with its thin layers of sand and mudstone metamorphosed into hornfels, while the layers of tuff are metamorphosed into serpentine and talcum.

However, the structure and composition of the original rock remains, and from this the probable geologic structure can be seen.

The distribution of the alkaline intrusive rocks suggests that the location and direction of elongation of their intrusion was strongly influenced by the geologic structure. They show a strong tendency to extend NE-SW. They are composed of many types of rock, but on the whole, they can be divided into two facies of "Deep" and "Shallow(Volcanic)".

Deep facies has formed rather large rock bodies which seem to be combinations of various sorts of rock bodies. Shallow facies has formed always small scale rock bodies, coexisted frequently with mineralized part and undergone sakrnitization.

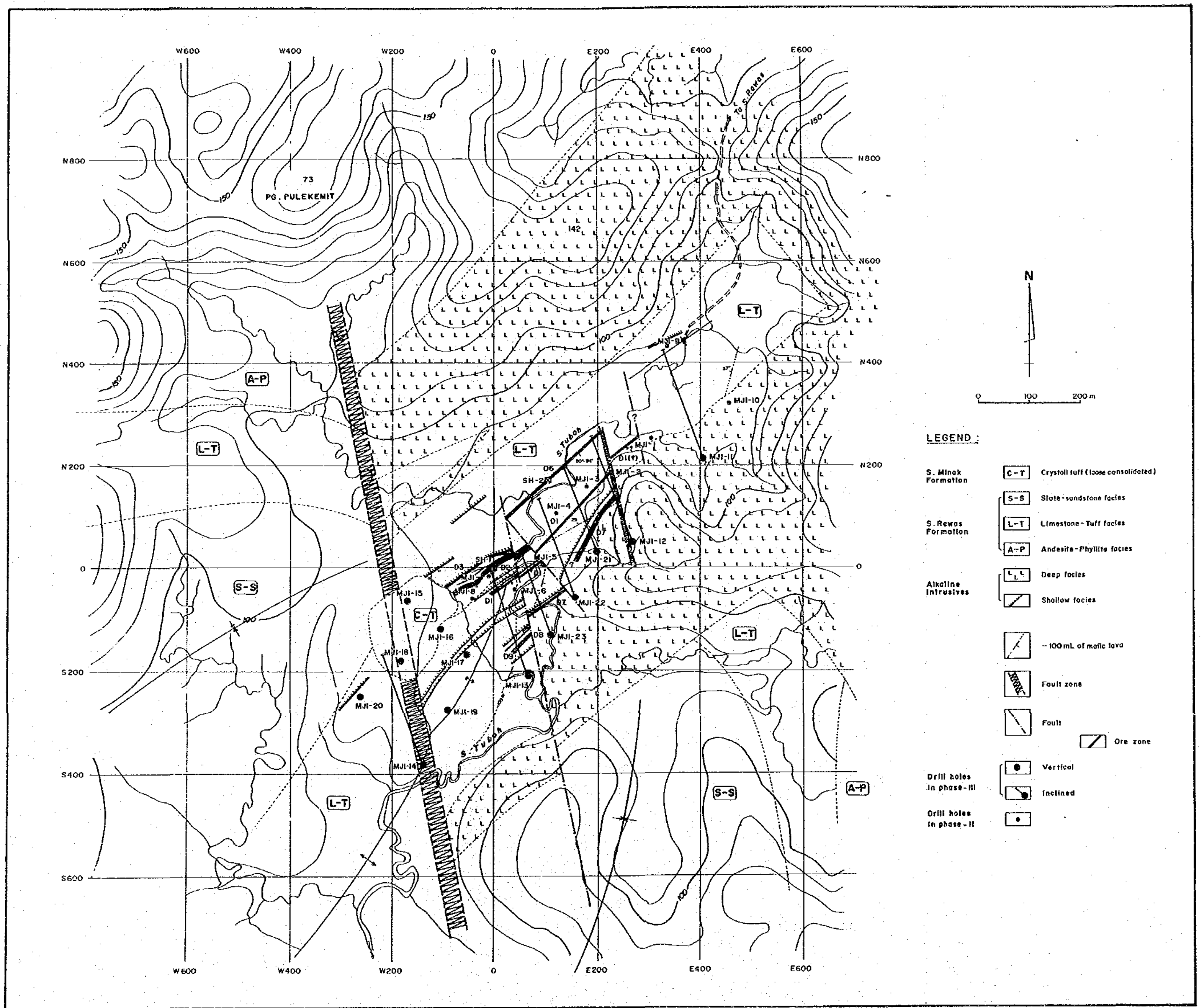

Fig. 4 Geological Map of the S.Tuboh Prospective Area

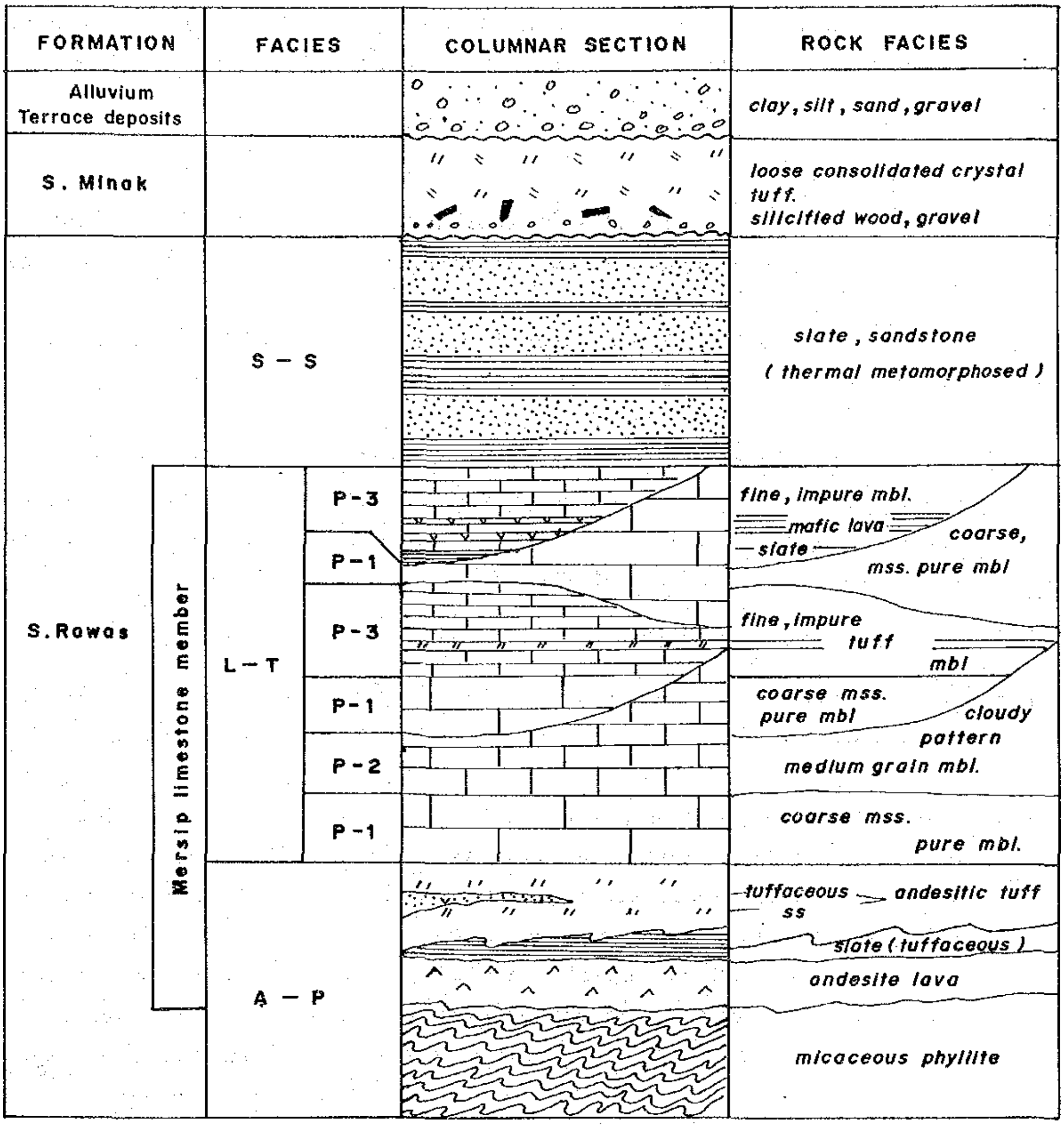

Fig. 5 Schematic Geologic Column of the S.Tuboh Prospective Area

Chapter 4 Survey results and general consideration

(1) Geology and geologic structure

In this two years, drilling surveys covered area of 900 m(NE-SW) - 400 m (NW-SE). By means of these survey, our knowledge of the geology on the S. Tuboh area becomes clear by the data collected in these two years of drilling surveys.

a.) Geology

Most of the drilling survey area is composed mainly of marble, excepting alkaline intrusive rocks (deep facies) extendinmg NE-SW at the south and the north.

This marble seems to be a metamorphosed facies of Mersip Limestone Member, and can be divided into the three facies P-1, P-2 and P-3.

P-1: Colored mainly white, light gray and bright gray. Often coarse-grained and massive. Bands or patterns which may indicate impurities lack, so it is probably P-1 derived from massive pure limestone. It is correlative with PMBL of the second phase.

P-2: Facies between these of the P-1 and P-3 mentioned below. Darker in color than P-1. It is correlative with MBL of the second phase.

P-3: Fine-grained rock facies frequently showing dark color, sometimes red due to biotite hornfels, sometimes banded with yellow and green due to serpentine(tuffaceous part), occures as "laminated marble" with predominant lamination, as "sandy marble" with massive and fine equi-granular, and as "shally marble" with very fine grain and very fine shally lamina. It is correlative with IMBL of second phase.

In some parts of P-3, slumping structure or/and water-escaped structure are found frequently, suggesting a sedimentary enviornment and mode of sedimentation.

Also, the alkaline lava(trachy andesite, trachy basalt etc.)and the alkaline tuff found in the S. Tuboh area are always found as constituents of P-3.

As above mentioned, occurrence of the marble suggests that the carbonate rock which was the original rock of the marble seems to have settled on the shallow sea floor of a slope of the volcano.

The occurrence of alkaline intrusive rock of the shallow facies cutting the marble, and which sometimes accompanies mineralized zones, are the same as those given in the second phase report.

On the other hand, deep facies alkaline intrusive rock on the south side of the marble zone, while appearing to be an one rock body, is regarded as a complex of many different types of alkaline intrusive rocks.

b.) Geologic structure

As shown in Fig. 4 and 18, the prominent geologic features of the S. Tuboh area are the NE-SW-trend which indicates by stratum, intrusions and mineralized zones running almost parallel each other, and fault system running in NNW-SSE (hereinafter simply as the N-S system).

b-1. Folding

The stratum extends ENE-WSW in the northeast part of MJI-1 and seems to have a gentle synclinal structure with SW plunge axis. Between MJI-1 and MJI-5, there appears to be monoclinal structure dipping to NW, but it may be the southeast wing of the synclinal structure on the northeast of MJI-1. There appears to be an anticlinal structure extending NE-SW from MJI-5 in the southwest up to MJI-20 and plunging NE.

b-2. Fault

The first phase report described that there coexists two systems of fault running in NE-SW and NW-SE(or N-S) in the detailed survey area, including S.Tuboh area.

However, when results of the surveys of the last two years were collaborated, it appeared that only the N-S fault systems were prominantly developed, as shown on the geologic map. This is because the N-S fault systems are the most recent geologic features in the S.Tuboh area, and they pass almost at right angles to the trend of the older structures.

The NE-SW fault systems, on the other hand, were formed earlier age, have controlled field of alkaline intrusive rocks, some of them were faded due to activity of alkaline intrusive rocks and also by the fact that it more or less coincides with the strike of the stratum and of the intrusive rock.

(2) Mineralization and constituent minerals of mineralized zone

As shown in Fig. 18, nine mineralized zones have now been recognized in the S.Tuboh area. The mineralized zones in MJI-9 and MJI-18, that is to say D-5 and D_8, are counted as independent two zones.

The mineral assemblage in the mineralized zones seems to indicate skarn type mineralization, but the configuration of the mineralized zones have appearence parallel vein deposits or bedded type deposits.

Two points support the judgement that the mineralization of the S.Tuboh area is skarn type. The first is the fact that the occurrence of the gustavite(Ag_2S-Bi_2S_3-PbS group silver mineral) reported in the second phase is very similar to that found in the Nakatatsu Mine well known as skarn type ore deposit. The other point is that the sulfur isotope data indicates temperature conditions conductive to the formation of galena and sphalerite, which are similar to the conditions for skarn type ore deposits.

The third phase survey made no additions to the list of ores and gangue minerals as the constituents of the mineralized zone.

(3) Mineralization, geologic structure and igneous activity

As can be seen in the geologic map(Fig. 4), the NE-SW geologic elements were an important influence on the formation of the structure of mineralized zones in the S.Tuboh area. The occurrence of the NE-SW geologic elements, perhaps at the later period(probably late Cretaceous) when the S.Rawas Formation was folded, presumably provided space for NE-SW alkaline intrusive rocks.

Heat radiated from the magma which produced these rocks and the solodifying intrusive rocks gradually changed the Mersip Limestone Member into marble.

Igneous activity of a shallow facies intrusive rocks took place about same time to activity of the deep facies intrusive under the strong geologic structural control of NE-SW. As a result of this enviornment, shallow facies intrusives formed parallel dikes in direction of NE-SW.

The mineralization began successively after alkaline igneous activity. The hydrothermal convection flow, which had formed mineralized zones, took place in and near the alkaline shallow facies intrusive rocks through the fissures as suitable field formed by cooling and crystalization. Therefore, the structure of the mineralized zone paralleled to NE-SW structure of the alkaline shallow facies intrusive rock, and it is also a reflection of the geologic movement which formed regional geologic structure of S.Tuboh area. Both area of S.Tuboh and Bt.Raja have situated in a same domain in geology and igneous activity. Age of the granite in Bt.Raja area is almost the same, or they may be 5 Ma older than the alkaline intrusive rocks in S.Tuboh. This suggests that the alkaline intrusive rock in the S.Tuboh area represents later stage of plutonic igneous activity which took place across the S.Tuboh area from the Bt.Raja area.

These processes occurred in the following sequence.

170-140 Ma : Sedimentation of Mersip Limestone Member, formation and precipitation of sulfides from sulfiric acid in Jurassic seawater and trace elements which formed the source of the metals for mineralized zones.

⇩

70-60 Ma : Tectonic movement, formation of NE-SW folding and fault system.

⇩

60-55 Ma : Intrusion of alkaline rock, start of metamorphosis of limestone into mareble.

⇩

55-50 Ma : Later intrusive of alkaline rock, thermal effect on early alkaline intrusive rocks and sedimentary carbonate, formation of barren skarn zone.

⇩

50 Ma ≥ : Skarn type mineralization(movement-reorganization-settling of existing bedded sulfide in Mersip Limestone Member).

Chapter 5 Conclusions and proposals for the future

5-1. Conclusions

The conclusions on the geology, igneous activity, mineralization and resource potential in S.Tuboh area are as follows.

(A) Mersip Limestone Member in S.Tuboh

① This member consists of three rock facies of P-1, P-2 and P-3 well reflecting of composition and texture of original limestone. These three rock facies are regarded as as follows ;

P-1 derived from pure limestone

P-2 derived from intermediate of P-1 and P-3

P-3 derived from impure limestone

② P-3 has a lot of thin beds of sandy/muddy facies and tuffaceous facies. These thin beds represent frequently laminations, slumping structures and water-escaped structures. Tuffaceous facies is mafic, and undergone commonly serpentinized. P-3 has intercalations of mafic lava and yields coral fossiles. These occurrences suggests that P-3 had deposited preliminarily on the shallow sea floor of the slope of mafic volcano, and flowed by submarine sliding to the depositional field of P-1 and deposited secondarily forming rough alternation with P-1.

③ Including marble, sedimentary rocks in S.Tuboh area have NE-SW strike and formed gentle synclinal and anticlinal foldings. However, this strike(trend) where developing only in the S. Tuboh area and its vicinity is in striking contrast to general trend of the S.Rawas Formation at northwest of S.Rawas. A prominent NE-SW strike of the stratum, synorogenic NE-SW fault system and younger N-S fault system have formed present geologic structure in the S.Tuboh area.

④ There are noticeable development of the caves under the surface soil around existing of N-S fault.

(B) Alkaline intrusive rock

⑤ Consisting of comperative large scale deep fcies intrusive rocks and small scale intrusiive rocks coexisting with mineralized zones.

⑥ Deep facies intrusive rocks were brought by the magmatic activity from eraly stage(60 Ma) to later stage(≤ 50 Ma). These are regardes as a complex consisting of alkaline gabbro, tonalite, quartz monzonite, quartz monzonite porphyry, monzonite etc.

⑦ Barren skarn zone found at a rim of deep facies intrusive body were formed at a boundary of limy sedimentary rock and early stage alkaline intrusive rocks consisting of coarse-grained grossular, vesuvianite, diopside etc. The formation of this skarn zone is considered that related to the activity of the later stage alkaline intrusive rocks with thermal metamorphosis and migmatisation.

(C) Mineralized zone

⑧ Consisting of nine mineralized zones and their approximate (possible) ore reserves is 1,760,000 tons, Au 0.1 g/t, Ag 130 g/t, Cu 0.8 %, Pb 1.5 %, Zn 10 %.

⑨ These possible ore reserves have a probability of development in the future in suitable economic enviornment. There is probability of a acqiusition of the new ore reserves by the further exploration.

It is able to also investigate on marble as a objective material for the development in the future in the S.Tuboh area.

⑩ Metal content of mineralized zones has a tendency to decrese toward the deep, but width of mineralized zone including skarn become not so shrinkage.

⑪ Igneous rock and igneous activity related to the mineralization are considered high probability as alkaline magmatic avtivity about ≦ 50 Ma in late Cretaceous to early Paleogene Tertiary.

⑫ NE-SW trend of mineralized zones is reflaction of the structure of shallow facies alkaline intrusive rocks, and its also reflaction of the regional synorogenic fault system.

⑬ Origine of the sulfur as sulfide forming component is regarded as biogenic sulfur derived from sulfiric acid of Jurassic sea water. This hypothesis and data on $Sr^{86}/^{87}Sr$ ratio in second phase survey are suggestive that the mineralization of the S.Tuboh area is movement-reorganization-settling of the existing sulfide in the S.Rawas Formation as a bedded sulfide. The temperature condition of 430 °C in this mechanism well corresponds with the cases of known skarn type ore deposits.

⑭ The target reaches for the futher exploration in the S.Tuboh area are as follows.

Suthwest of MJI-13
Environs of MJI-18
Foot wall reach of D_6
Northwest of the between MJI-9 and MJI-2
Reach of the between MJI-11 and MJI-12

5-2. Proposal for the future

Above mentioned approximate ore reserves 1,760,000 tons and its economic value 125,000,000 $ are a result of a calculation in the plimary stage of the exploration. This means that it is expectative acquisition of additional ore reserves in the future cause of the target reaches to be remain. In the other hand, the accuracy of this ore reserves are still low. Therefore, the proposals for the future are as follows.

1) Ore reserves aquired at a present is a target for the development in the future. However, for up to the judgement of the exploitage, there are neccessary to improve an accuracy of amount and grade of this ore reserves and to acquire of the new more ore reserves.

2) To clarify the total resource potential in the area including S.Tuboh, by means of the exploration in the area of the mineral indication of S. Kering, S.Sepan and also the reach of S.Nilau.

Part Ⅱ Detailed descriptions

Part II Detailed descriptions

Chapter 1 S. Tuboh area

1-1. Survey procedure

The third phase survey of the S. Tuboh area consists of drilling survey, assaying, X-ray diffraction analysis, microscopic observation of rock and ore minerals, sulfur isotope analysis of the core obtained and analysis and evaluation of the resultant data.

1-2. Drilling survey

1-2-1 Purpose of the survey

The purpose of the third phase drilling survey are as follows;

1) To reveal of the extent in both sides of strike and dip of the mineralized zones.
2) To assess the grade of mineralization.
3) To evaluate of the ore reserves and the possibilities of the development for the future.

1-2-2 Methods, equipment used and works carried out

In drilling surveys, an OE-8L drilling machine was used for vertical holes, and an L-38 drilling machine for inclined holes.

The wire-line coring method was used in both cases.

Drilling work commenced in order from MJI-16, MJI-15, MJI-17, MJI-19, MJI-18 and MJI-20 for vertical holes, and from MJI-13, MJI-12, MJI-11, MJI-14, MJI-23, MJI-21 and MJI-23 for inclined holes. A decision of these order depended on the data of the situation of occurrence of the mineralization from the advanced drill holes.

The operation schedule of the third phase survey is shown the Fig.3, bit and casing program is shown Fig. 6, overall results of drilling work is shown Table 2. Equipment used is shown Table 3 and drilling records are shown Table 4. The other records tables are given as appendices at the end of the report.

For the transportation of the drilling equipments from Surulangun to drilling site used a hilicopter and for the movement of hole by hole used catapillar equiped crane carrier.

Table 2. Overall results of drilling survey

Number of holes	13 holes	Working shift(drilling)	303 shift
Total drilled length	3,170.19 m	(Others)	409 shift
Total core length	2,649.00 m	Man power(Engineers)	768 man-day
		(Laborers)	2,833 man-day
Core recovery	92.2 %	Operation time(Drilling)	1,829° 40′
Diamond bit used		(Others)	570° 20′
NQ size 22 pcs		(Recovery)	24° 00′
Drilled length	711.10 m	(Subtotal)	2,424° 00′
Life	32.3 m/pc	(Moving)	538° 00′
BQ size 43 pcs		(Track setting)	310° 00′
Drilled length	2,167.30 m	(Grand total)	3,272° 00′
Life	50.4 m/pc		

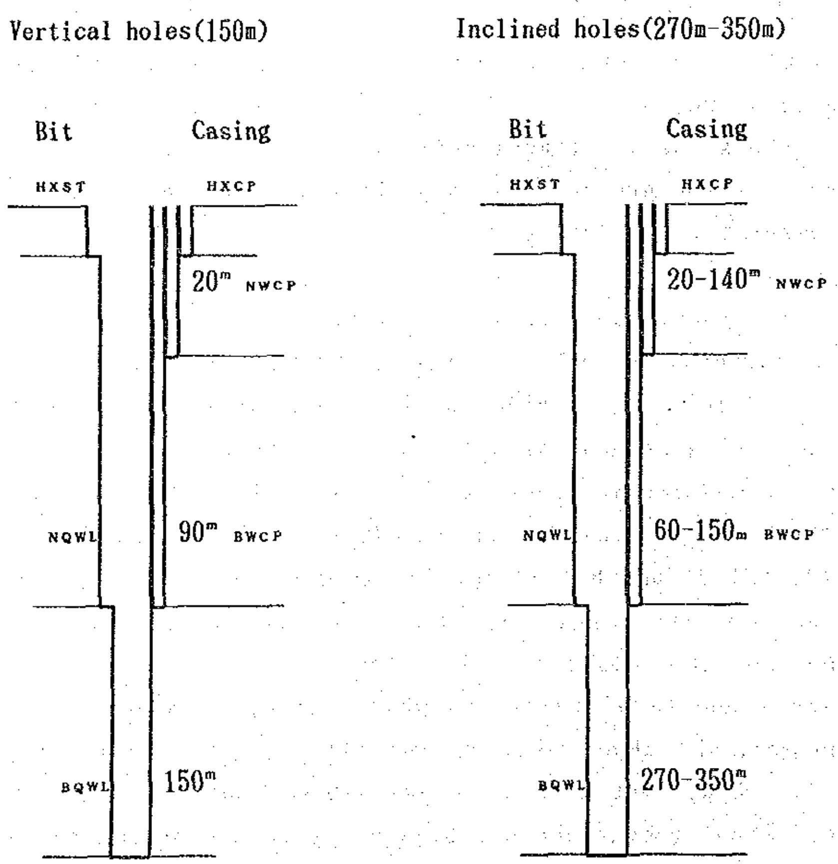

Fig. 6 Bit • Casing Program

Table 3 Specification of Drilling Machine and Equipments Used(3-1)

Drilling machine, Model "L-38"	1-set
【Specification】	
Capacity	600m in BQWL
Dimensions L x W x H	2,150mm x 1,170mm x 1,450mm
Hoisting capacity	4,000kgs
Spindle speed	Forward 70(230), 144(490), 240(900)rpm
Engine, Model F3L912	52Hp/2,500 rpm
Drilling pump, Model "MG-15h"	1-set
【Specification】	
Piston diameter	85mm
Stroke	100mm
Capacity	Discharge capacity 160 l/min
	Max. pressure 25 kg/cm^2
Dimensions L x W x H	2,350mm x 720mm x 1,120mm
Engine, Model NS-130G	13Hp/2,200 rpm
Water supply pump, Model "TA-800"	1-set
【Specification】	
Capacity	Discharge capacity 80 l/min
	Max. pressure 40 kg/cm^2
Engine, Model NF-90K	9Hp/2,200 rpm
Mud mixer, Model "MCE-250"	1-set
【Specification】	
Capacity	200 l/1,000 rpm
Engine, Model NS-50C	5.5Hp/2,400 rpm
Drilling tools	
Drilling rod	NQWL:3m x 80pcs, BQWL:3m x 125pcs
Casing pipe	HW:1m x 5pcs, NW:1m x 5pcs
	NW:3m x 20pcs, BW:1m x 3pcs,
	BW:3m x 80pcs
Drilling mast	1-set Height:9.5m,
	Max. load capacity:6,000kgs
Helicopter, Model "Bell 212B"	1-craft Max. sling load : 4,500 lbs

Table 3 Specification of Drilling Machine and Equipments Used(3-2)

Drilling machine, Model "OE-8BL"	1-set
【Specification】	
Capacity	300m in BQWL
Dimensions L x W x H	1,550mm x 700mm x 1,260mm
Hoisting capacity	2,000kgs
Spindle speed	Forward 100,190,320,530 rpm
Engine, Model NS-130CG	13Hp/2,200 rpm
Drilling pump, Model "MG-10"	1-set
【Specification】	
Piston diameter	68mm
Stroke	100mm
Capacity	Discharge capacity 120 l/min
	Max. pressure 70 kg/cm^2
Dimensions L x W x H	1,690mm x 580mm x 980mm
Engine, Model NS-110C	11Hp/2,200 rpm
Mud mixer, Model "MCE-250"	1-set
【Specification】	
Capacity	200 l/1,000 rpm
Engine, Model NS-50C	5.5Hp/2,400 rpm
Wire-line hoist, Model "WLH-4"	1-set
【Specification】	
Rope capacity	500m(Hoistin speed : 8 ~ 105m/min)
Engine, Model NS-40C	5Hp/2,400 rpm
Drilling tools	
Drilling rod	NQWL:3m x 60pcs, BQWL:3m x 60pcs
Casing pipe	HX:1m x 3pcs, NW:3m x 10pcs
	NW:1m x 3pcs, BW:3m x 40pcs
	BW:1m x 3pcs
Crane carrier, Model "YFC-2"	1-set Max. sling load : 960 kg

Hole	Terms	Drilling				Shift		Man Power		Working Time						
No.	of Drilling	Bit Size	Drilled Length	Core Length	Core Rcv.	Drl.	Ttl.	Eng.	Wkr.	Drilling	Other Works	Rcv. Works	Total	Rmv.	Road/ Others	Total Hour
MJI-11	04.09.87	HX	10.10	0.00	0.0	1										
		NQ	50.90	28.30	55.6	5										
	21.09.87	BQ	290.00	274.85	94.8	27										
	Total		351.00	303.15	89.8	33	42	90	217	185.0	79.0	-	264.0	64.0	8.0	336.0
MJI-12	13.08.87	HX	16.30	0.40	2.5	1										
		NQ	136.80	134.85	98.6	15										
	03.09.87	BQ	197.90	197.90	100.0	21										
	Total		351.00	333.15	99.1	37	48	132	279	210.8	85.2	-	296.0	44.0	44.0	384.0
MJI-13	19.07.87	HX	24.00	0.00	0.0	1										
		NQ	126.10	112.70	89.4	14										
	12.08.87	BQ	200.90	200.90	100.0	22										
	Total		351.00	313.60	97.5	37	49	146	292	234.0	62.0	-	296.0	80.0	16.0	392.0
MJI-14	22.09.87	HX	17.30	0.00	0.0	1										
		NQ	95.90	51.20	53.4	11										
	08.10.87	BQ	237.80	235.60	99.1	27										
	Total		351.00	286.80	85.9	39	47	68	400	232.0	80.0	-	312.0	36.0	28.0	376.0
MJI-15	27.07.87	HX	30.00	0.00	0.0	1										
		NQ	17.80	1.20	6.7	5										
	05.08.87	BQ	103.30	103.30	100.0	9										
	Total		151.10	104.50	87.7	15	20	30	138	88.0	8.0	24.0	120.0	30.0	10.0	160.0
MJI-16	12.07.87	HX	16.40	0.60	3.6	1										
		NQ	10.60	9.20	86.7	1										
	26.07.87	BQ	124.00	123.80	99.8	10										
	Total		151.00	133.60	99.3	12	23	45	167	77.7	18.3	-	96.0	32.0	56.0	184.0

Table 4 Summarized Table of the Drilling Operation (1)

Hole	Terms	Drilling				Shift		Man Power		Working Time						
No.	of Drilling	Bit Size	Drilled Length	Core Length	Core Rcv.	Drl.	Ttl.	Eng.	Wkr.	Drilling	Other Works	Rcv. Works	Total	Rmv.	Road/ Others	Total Hour
MJI-17	06.08.87	HX	10.00	0.00	0.0	1										
		NQ	29.00	29.00	100.0	2										
	17.08.87	BQ	112.00	112.00	100.0	10										
	Total		151.00	141.00	100.0	13	20	36	186	93.0	11.0	-	104.0	32.0	24.0	160.0
MJI-18	29.08.87	HX	22.60	0.20	0.9	1										
		NQ	30.20	9.70	32.1	2										
	05.09.87	BQ	100.90	65.90	65.3	7										
	Total		153.70	75.80	57.8	10	17	23	123	63.0	17.0	-	80.0	48.0	8.0	136.0
MJI-19	18.08.87	HX	25.10	0.00	0.0	1										
		NQ	14.80	7.20	40.4	3										
	28.08.87	BQ	111.10	111.10	100.0	9										
	Total		151.00	118.30	94.0	13	19	33	145	84.0	20.0	-	104.0	40.0	8.0	152.0
MJI-20	05.09.87	HX	25.40	1.20	4.7	1										
		NQ	16.50	13.70	83.0	2										
	16.09.87	BQ	109.10	109.10	100.0	9										
	Total		151.00	124.00	95.0	12	21	36	162	73.0	23.0	-	96.0	48.0	24.0	168.0
MJI-21	27.10.87	HX	36.10	0.00	0.0	2										
		NQ	84.00	76.45	91.0	7										
	03.11.87	BQ	160.90	160.90	100.0	15										
	Total		281.00	237.35	96.9	24	30	36	268	148.8	43.2	-	192.0	24.0	24.0	240.0
MJI-22	09.11.87	HX	43.00	0.00	0.0	2										
		NQ	38.00	23.55	62.0	4										
	18.11.87	BQ	219.00	219.00	100.0	22										
	Total		300.00	242.55	94.4	28	36	45	208	159.0	65.0	-	224.0	24.0	40.0	288.0

Table 4 Summarized Table of the Drilling Operation (2)

Hole No.	Terms of Drilling	Drilling				Shift		Man Power		Working Time						
		Bit Size	Drilled Length	Core Length	Core Rcv.	Drl.	Ttl.	Eng.	Wkr.	Drilling	Other Works	Rcv. Works	Total	Rmv.	Road/ Others	Total Hour
MJI-23	11.10.87	HX	15.40	0.00	0.0	1										
		NQ	60.50	38.55	63.7	6										
	21.10.87	BQ	200.40	196.65	98.1	23										
	Total		276.30	235.20	90.1	30	37	48	251	181.5	58.5	-	240.0	36.0	20.0	296.0
Sum Total		HX	291.70	2.40	0.8	15										
		NQ	711.10	535.60	75.3	77										
		BQ	2,167.30	2,111.00	97.4	211										
			3,170.10	2,649.00	92.2	303	409	768	2,833	1,829.8	570.2	24.0	2,424.0	538.0	310.0	3,272.0

♦ Core recovery = Core length ÷ (Drilled length - Surface soil part) × 100(%)

【Abbreviations】

Core Rcv. : Core recovery(%)
Drl. : Drilling(actual shift for drlling)
Ttl. : Total(total shift for drilling)
Eng. : Number of engineers(man/day)
Wkr. : Number of workers(man/day)
Rcv. Work : Recovering work(hour)
Rmv. : Removing hole to hole(hour)

Table 4 Summarized Table of the Drilling Operation (3)

1-2-3 Drilling condition

Excluding the cementation in MJI-15, by means of application of flexible bit and casing program, and preventive mud water circulate control for a water-escape which depending on the experiences in previous year, drilling work was smooth.

Specially, in case of inclined hole, drill holes penetrated weathered parts, caves and fissured igneous rocks, however, preventive treatments brought good condition of the drilling works.

Mechnical power for transportation brought drilling works on schedule.

1-2-4 Description on geology,mineralization and metamorphism in holes

(1) MJI-11

Drilled Length : 351.00m ; Azimuth : 340° 00′ ; Inclination ; -50°

【Purpose】 The hole was performs to discover the deep extent of the mineralized zone discovered in MJI-9 during the second phase survey.

【Results】 An alkaline intrusive rock (Shallow fafies) occurs at 13.50～39.80m. The rock has undergone thermal metamorphism, partly changed to skarn, and in some part decomposed to soil owing to weathering. Garnet, diopside, quartz, serpentine and mica can be identified through naked eye. A small amount of pyrrohtite disseminate in the skarn.

Several caves apear in the marble zone from 42.20m to 88.90m. Small scale intrusive rocks (deep facies) occur at 113.20m～115.00m, 293.20m～297.20m, 201.70m～305.15m, 345.90m～307.25m. Only filmy thin veins of andradite-quartz-mica-serpentine are recognizable at the contact with the alkaline rock and marble, but the partss are not accompanied by noticeable mineralization.

The marble in the hole consists of aggregation of very coarse-grained calcite, some of calcite has 6cm crystal edge, whereas the usual crystal length is 4cm. The marble is not predominant slumping structure, contains not much sandy and muddy fasies or tuff facies, in comparison to the marble in other holes. At 100.70m～102.75m, alterated beds of slate and tuffaceous rock are present, at 107.50m～107.90m lamina of surpentinized tuff. At 227.00m～229.65m hematite, serpentine and pyrrhotite bearing rock appears to be mafic lava origin. Coarse-grained rock at 281.00m～ 287.40m could be originally rich in sand-mad facies and tuff facies. Thin layers of sand and mud have become spotted black grains like sesame seeds,owing to coarse-crystalization. and probable tuffaceous facies is talcose. At 320.20m～345.90m slumping structure network of black spotted granis and serpentinized part are recognized in the coarse-grained marble.

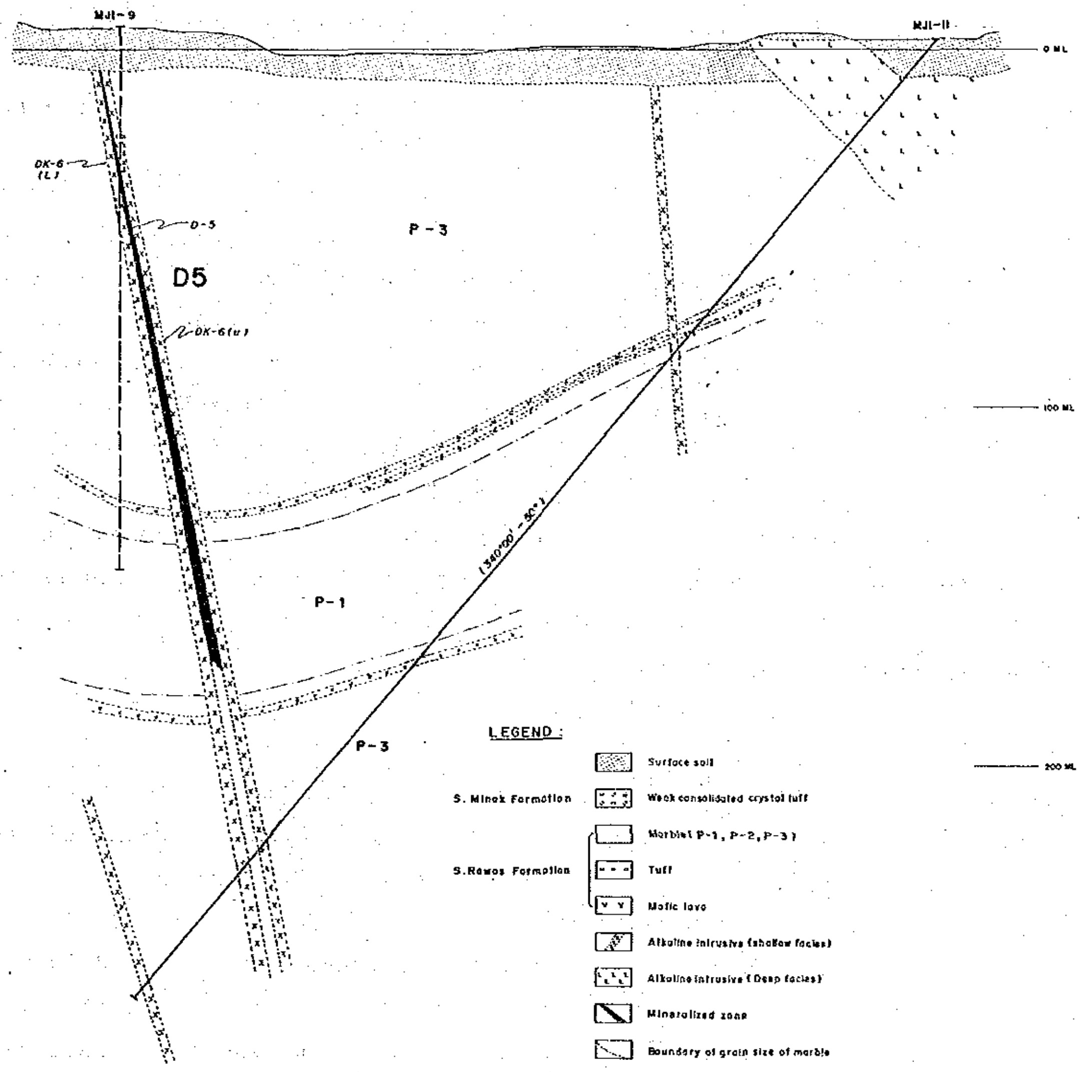

Fig. 7 Geologic Profile by Geologic Columns of Drills

【Consideration】 : Similarity of these rock facies indicates that two intrusive rocks at 293.20m~297.20m and 301.70~305.15m are connected to the rocks in MJI-9 at 29.35m~40.35m and 46.80m~52.90m. This means that this hole caught the zone D5, but they are accompanied by no mineralization.

The coarseness of the marble is probably resulted by extensive intrusion of alkaline intrusive rock(deep facies) in the northeast of this hole. Sand-mud facies and tuffaceous facies in the marble have lost their original texture along with recrystalization to coarse-grain.

Thin section study of a rock taken from 33.00m indicates that the rock is called alkaline gabbro or monzonite, rich in alkaline feldspar, accompanied by aegirine. A rock at 338.50m is composed of olivin and calcite detected by thin section study, and X-ray diffraction analysis, and additionally serpentine and chromite by X-ray diffraction analysis. This rock is probably originated in mafic volcanic products, contained in the limestone. It also has a relationship with the volcanic activity which emplaced the mafic lava at 227.80m~229.50m. Similar rock occur at 285.60m~ 287.00m. Along with marmorization of limestone, the volcanic product as minor materials in the limestone have probably recrystalized and aggregated to spotted green parts.

A cross-section between this hole and MJI-9 shows that a loose synclinal structure exists trending NNE-SSW.

(2) MJI-12

Drill length : 350.00m ; Azimuth : 340° 00′ ; Inclination : -50°

【Purpose】 The hole was conduct to confirm the deeper extent of the mineralized zone discovered at MJI-2 during the second phase survey.

【Results】 Alkaline intrusive rock (Shallow facies) occur at 14.70~33.70m, a skarnitized zone continues, extending 34.79m between 33.70m and 68.79m. The skarnitized rock is composed of quartz, grossular,vesuvianite, aegirine, diopside, calsite, pottasium feldspar, chlorite. Serpentine is sporadically found. Grossular and calcite are prominently contained, and also vesuvianite and calsite remarkably occur in some parts. In the zone, alkaline intrusive rocks(deep facies) are clearly observed. The varying contact between alkali rock and skarnitized rock changes in gradual and indistinct. A small number of pyrrhotite are disseminated throughout. Small-scaled alkaline intrusive rocks appear at 150.50m~152.50m, 153.50m~ 155.00m, 285.54m~283.55m, 283.85m~287.15m, 287.95m~289.40m and 331.30m~ 333.35m. Among the rocks, mineralized zone are found at 149.52m~150.50m (forming in upper part from 150.50m~152.50m), at 285.15m~285.30m, 286.00m~ 287.10m, 288.00m~289.35m and 289.90m~290.15m(forming in upper, middle and lower parts from 283.85m~287.15m). The formar is massive ore consists of

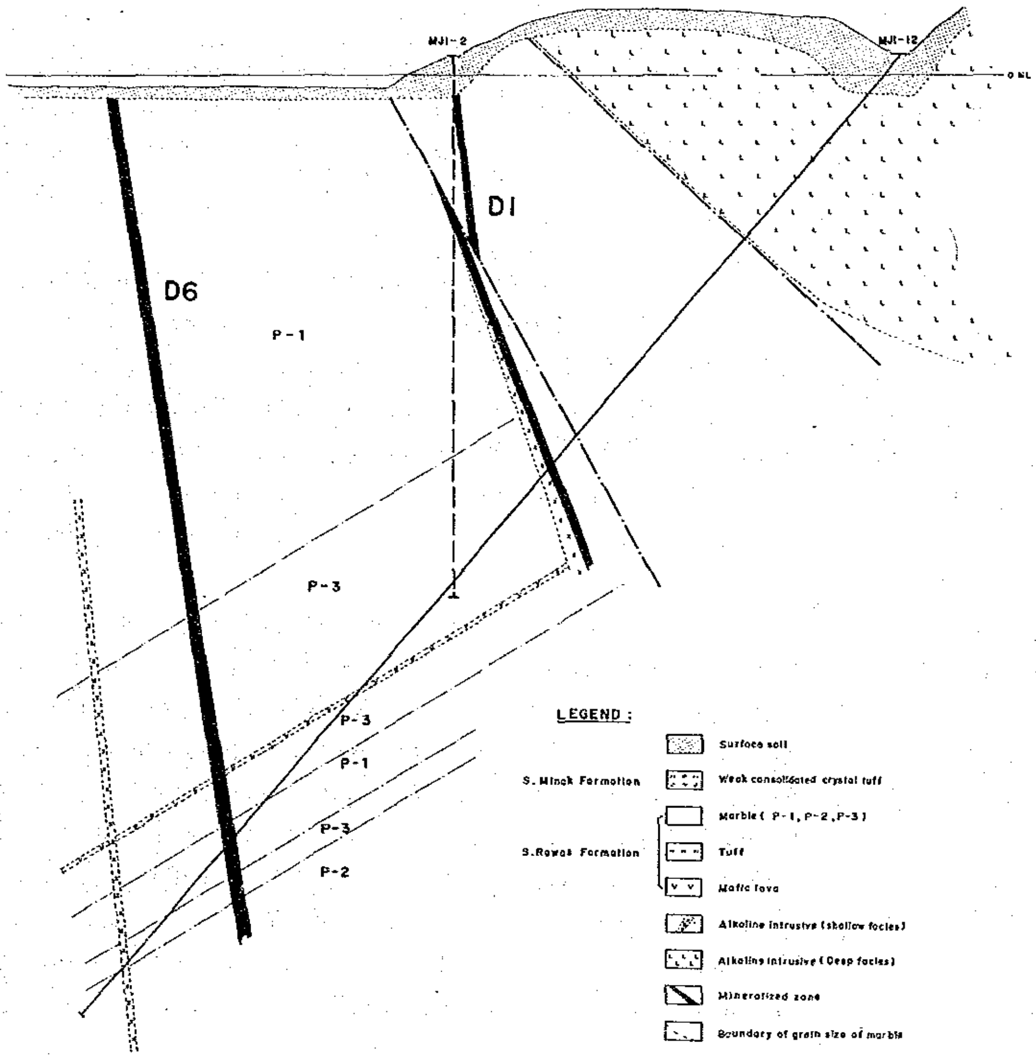

Fig. 8 Geologic Profile by Geologic Columns of Drills

sphalerite,galena,pyrrhotite,and chalcopyrite, associating with a small amount of hedenbergite as skarn, while the latter consists of (red) sphalerite dissemination in skarn containing mainly hedenbergite.

Average ore grades are shown in following table.

depth (m)	core length	Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
149.52-150.50	0.98m	0.14	350	3.78	6.38	25.0
285.15-287.10	1.95m	0.17	34.8	0.12	0.10	4.13
285.15-290.15	5.00m	<0.07	14.0	0.02	0.04	1.69

In the hole, slumping structure occur evidently at 174.30m~179.10m, 201.10m~206.95m,238.10m~241.00m,and 257.00m~259.10m. A part from 155.00m to 271.80m including this slumping structure part contains prominently thin layers of mud and tuffaceoud facieses. The tuffaceous facies has partially undergone serpentine mineral, and most of the muddy facies were changed to hornfels. At 106.80m~108.45m, lava is apparently affected by the thermal metamorphism, and it is accompanied by 15cm thick tuffaceous above and below.

【Consideration】 From location of the hole, the mineralized zone (D_1) of 150m down is correlative with the existing mineralized zone D-4, the zone (D_6) of 226m with D-6. The D-4 appears to be two mineralized parts containing spharelite and quartz in MJI-2, but these parts were not clear their relation in shallow, because of existance of cave above and below.

This hole reveals that the D-4 has been cut by fault running NNW-SSE across MJI-2, and the mineralized zone of 39.17m~39.50m in MJI-2 occurs as draged ore in the fault. The mineralized zone of 39.17m~39.50m in MJI-2 probably continues to a mineralized zone of 150m down in MJI-12. The cave was supposedly formed owing to leaching by permeation of underground water along the fault.

The mineralized zone D-6, as same as D-4 was indistinct mineralization, supposing its existence from waste ore scattering around shaft SH-2 of the old mine. However the information gained from rsult of the hole confirms that it is independent mineralized zone, in spite of low-graded dissemnated ore.

The mineral occurence is similar aspect in the second phase survey, but pyrrohtite is newly observed from ore around 150m of this hole through naked eye. Chalcopyrite occurs as laminar form within the pyrrhotite and also rimming form around the pyrrotite.

(3) MJI-13

Drill length : 381.00m ; Azimuth : 340° : Inclination ; -50°

【Purpose】 The hole was carried out aiming at discover the deeper extent of the mineralized zones obtained by MJI-6,MJI-7 and MJI-8 of the second phase survey.

【Results】 Four mineralized zoned were found, along with 13 intrusive rocks and 15 skarn zones.

85.35~85.85m (width : 0.50m) ; Banded ore consisting of hedenbergite, sphalerite,garena and hematite. Magnetism in this zone is probably due to magnetite, since no pyrrhotite is found. The upper part, 84.50~ 85.35m, is a skarn zone rich in epidote with a small amount of hematite, and in more above part, 80.80~84.58m, intrusive rock is characterized by grayish green(skarnitized part) and gray(discoloured part) in colour.

101.13~101.53m(width : 0.40m) ; High-graded massive ore is embedded in the marble. Massive ore consisting of sphalerite, galena, and garnet (andradite) contains sporadically small amount of chalcopyrite in disseminated distribution.

222.75m~223.10m(width : 0.35m) : Intrusive rock occurs from 222.80m to 223.00m, and two ore parts at 222.75m~222.80m and 223.00m~223.10m. In the upper ore part disseminated red sphalerite is contained in hedenbergite and calcite. The upper ore consists of chain-banded red sphärerite, rimming the ore at top, and dissemination of sppoted black sphärerite in hedenbergite and calcite skarn at lower. The lower ore is also composed of hedenbergite, calcite, red sphalerite, and also rim of red sphalerite as same the upper ore.

255.60m~264.43m : This mineralized zone is composed of the following 5 parts.

1. 255.60m~257.15m(width : 1.55m) : green skarn and sphalerite
2. 257.15m~259.50m(width : 2.35m) : epidote rich intrushive rock
3. 259.50m~260.80m(width : 1.30m) : Andradite, hedenbergite and sphalerite
4. 260.80m~261.50m(width : 0.70m) : marble
5. 261.50m~264.43m(width : 2.93m) : Andradite, hedenbergite and sphalerite

These boundaries vary gradually esch other, except boundary with the marble. Red sphalerite rims occur at the top and bottom of the mineralized zone. The intrusive rock have been completely undergone skarnitization as same as that at 56.20m~56.98m of MJI-7. Grade of the mineralized zone is shown as follow ;

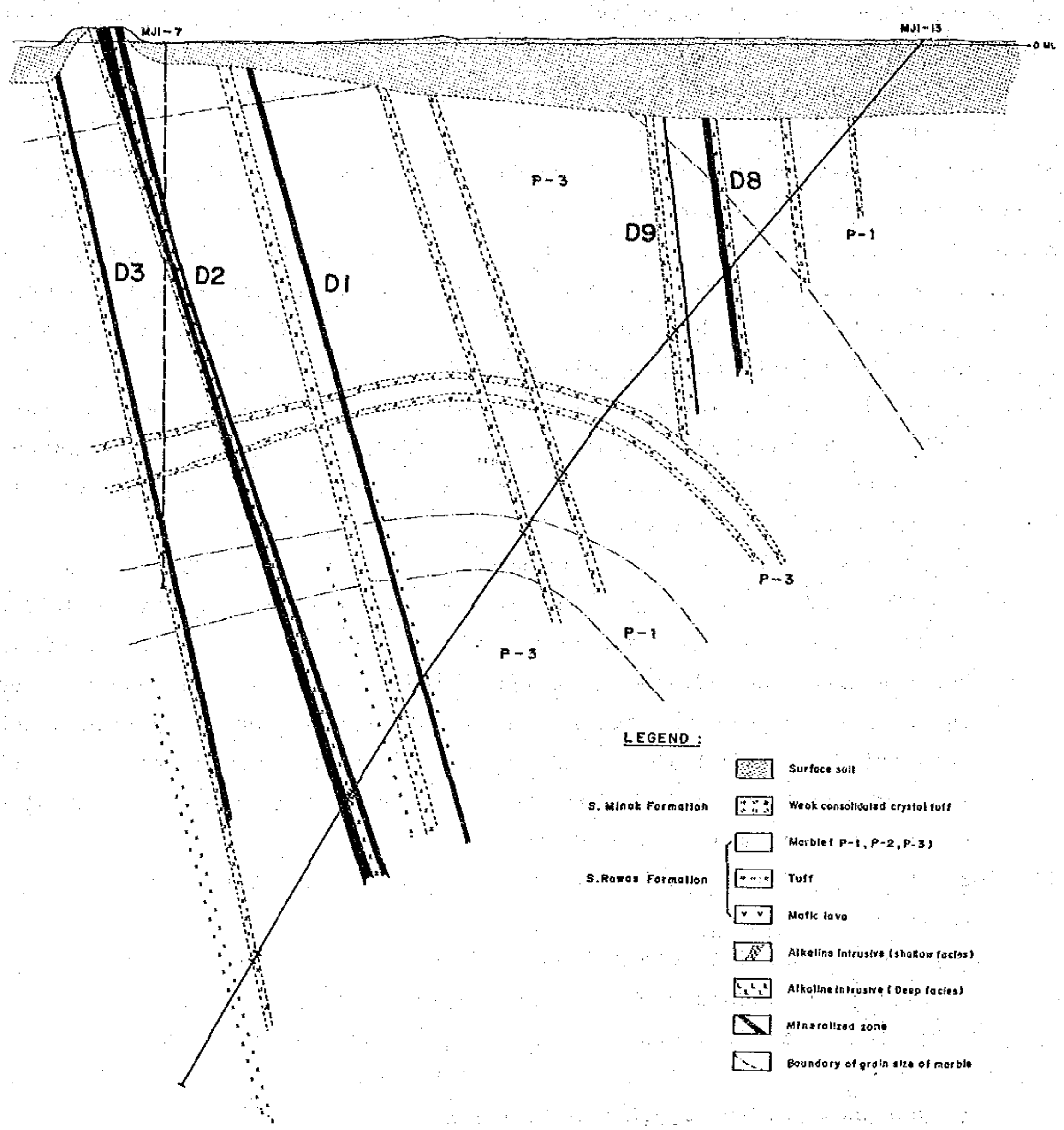

Fig. 9 Geologic Profile by Geologic Columns of Drills

depth (m)	core length	Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
85.35- 85.85	0.50m	0.14	378	3.20	4.20	14.50
101.13-101.53	0.40m	0.21	1,220	0.79	5.42	36.40
222.75-223.10	0.35m	0.07	62.0	1.42	0.15	5.22
255.60-257.15	1.55m	0.07	15.6	0.34	0.08	3.81
259.50-260.80	1.30m	0.07	6.8	0.26	0.04	1.85
261.50-264.43	2.93m	0.07	16.0	0.17	0.06	9.49
255.60-264.43	8.83m	0.07	7.7	0.16	0.05	4.94

The geology is the same as for the holes discussed above. Circulation water run off at 138.80m and 143.40 during drilling, and slumping structure is observed at 129.75m~139.80m.

【Consideration】 : The occurence of the ores reveals that the mineralized zone at 255.60~264.43m is correlative with the D_2 (D-2 in previous report). Accordingly, mineralized zone at 222.75m~223.10m is probably correlative with D_1 (D-1 in previous report), and also mineralized zone(although containing only a samll amount of skarn in the hole) at 309.00m~311.30m with D_3 (D-3 in previous report).

In the contrary, The upper mineralized zones at 85.35m~85.85m, 101.13m~101.53m, skarn zones around 134.40m and 144.45m, and skarn bearing intrusive rocks at 153.73m~155.95m and 170.95m~172.70m were previously unknown. The fact suggests a possibility that new mineralized zones are embedded at further southeast area from D_1 and D_2.

Refering to ore analysis, 2 small scale mineralized zone in shallow are very high grade, but mineralized zone below 255.60m which is probably correlative with D_2 is quite low grade, lower than that in MJI-8, The deep mineralized zone has a tendency to decrease the grade.

As shown in cross-section of Fig 9, the hole bent downward several degrees from about 150m.

(4) MJI-14

Drilled length : 350.00m, Azimuth : 340° , Inclination : -50°

【Purpose】 The hole was performed to unreveal the deep extent of the mineralized zone discovered in MJI-18, and southeast extent of the zone discovered in MJI-13. The location was to decided by the results of the MJI-15 ~ MJI-20. This hole was set turning a bit toward MJI-20 for targeting to deeper part of mineralized zone caught by MJI-18.

【Results】 This hole was expected to confirm the deeper extention of the mineralized zone found in MJI-18, but failed it. Namely Intrusive rocks occur at 14 parts below 72.10m, but no mineralized zone occur, although

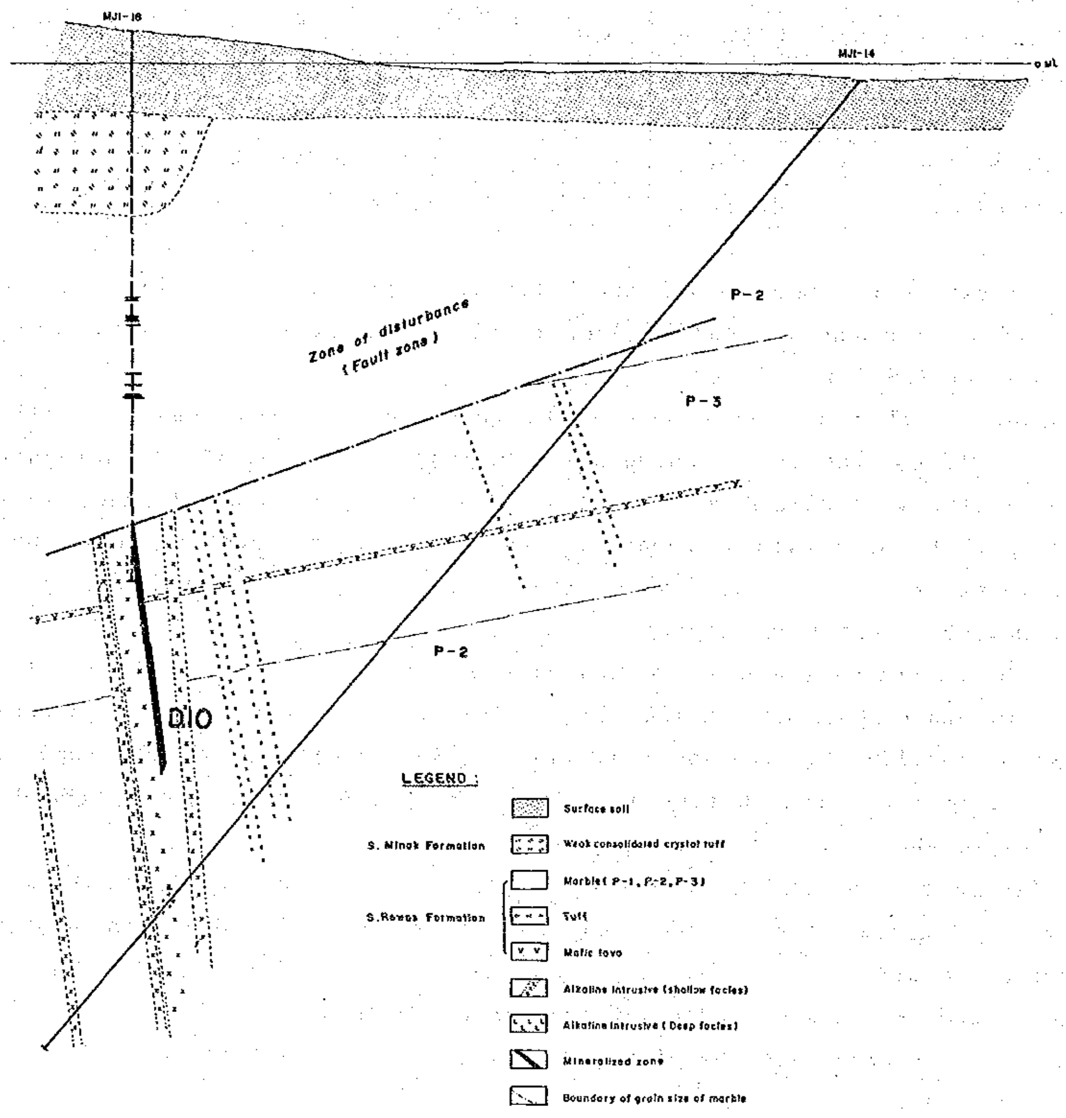

Fig.10 Geologic Profile by Geologic Columns of Drills

garnet bearing rocks are embedded at margin of some intrusive rock.

These intrusive rocks are hard without phenocryst, as same that in other hole, but a rock at 295.70m~304.95m could be slightly of different lithologic character from others, and contains many phenocrysts, although it is difficult to identified its original rock owing to strong alteration. This intrusive rock occurs too in MJI-18.

There are many caves from 17.30m to 314.65m. Especially, 31 caves occur from 17.30m to 113.20m, and largest one has 6.75m in width among them. Trace of erosive dissolving is clearly evident at cave surface of marble, and limonite-stained fractures reach to 341.10m(about 260m vertical below the ground surface). Most marble is fine-grained facies(p-3) with dark in colour.

【Consideration】 The results from this hole and MJI-15, MJI-16, MJI-17, MJI-19 indicate that the mineralization in MJI-18 is embedded as remarkable ore shoot, centering the hole. In MJI-18 hole, many caves are present, and limonite-staining extends to deep. In MJI-18, caves are also frequent, fragment ores occur, as if the fragments sank into the marble of host rock, and kaoline appears as a altered mineral. These facts show that both mineralized zones in MJI-14 and MJI-18 could be emplaced in same geological situation, namely under same moving and crushing processes. It suggests that a fault zone extends in direction linking the two holes, and mineralized zone occuring at the upper part of MIJ-18 has been draged into, and emplaced in the fault as brecciated ore. Most of the caves in MJI-14 and MJI-18 were probably made by weathering and dissolution of carbonaceous rock and mineralized zone(MJI-18) caused by underground water circulation to the deep through the fault.

The intrusive rocks at 297.70m~304.95m connects to the intrusive rocks of 145.20m~the hole botton in MJI-18, but it is accompanied by no mineralization. Accordingly, the mineralized zone below 140.60m is embedded in situ, despite it was dislocated and brecciated. This matter is discussed again in the section of MJI-18.

(5) MJI-15

Drill length : 151.10m, Inclination -90°

【Purpose】 The hole was performed to find out the southeast extention of the mineralized zone discovered at MJI-8 in the second phase, and and to reach the mineralized zone D-6 inferred to extend southeast from the old mine shaft SH-2.

【Results】 A Intrusive rock occurs from 100.20m to 108.75m, bounding on skarn margins composing of garnet, epidote, hematite, chlorite and (or)

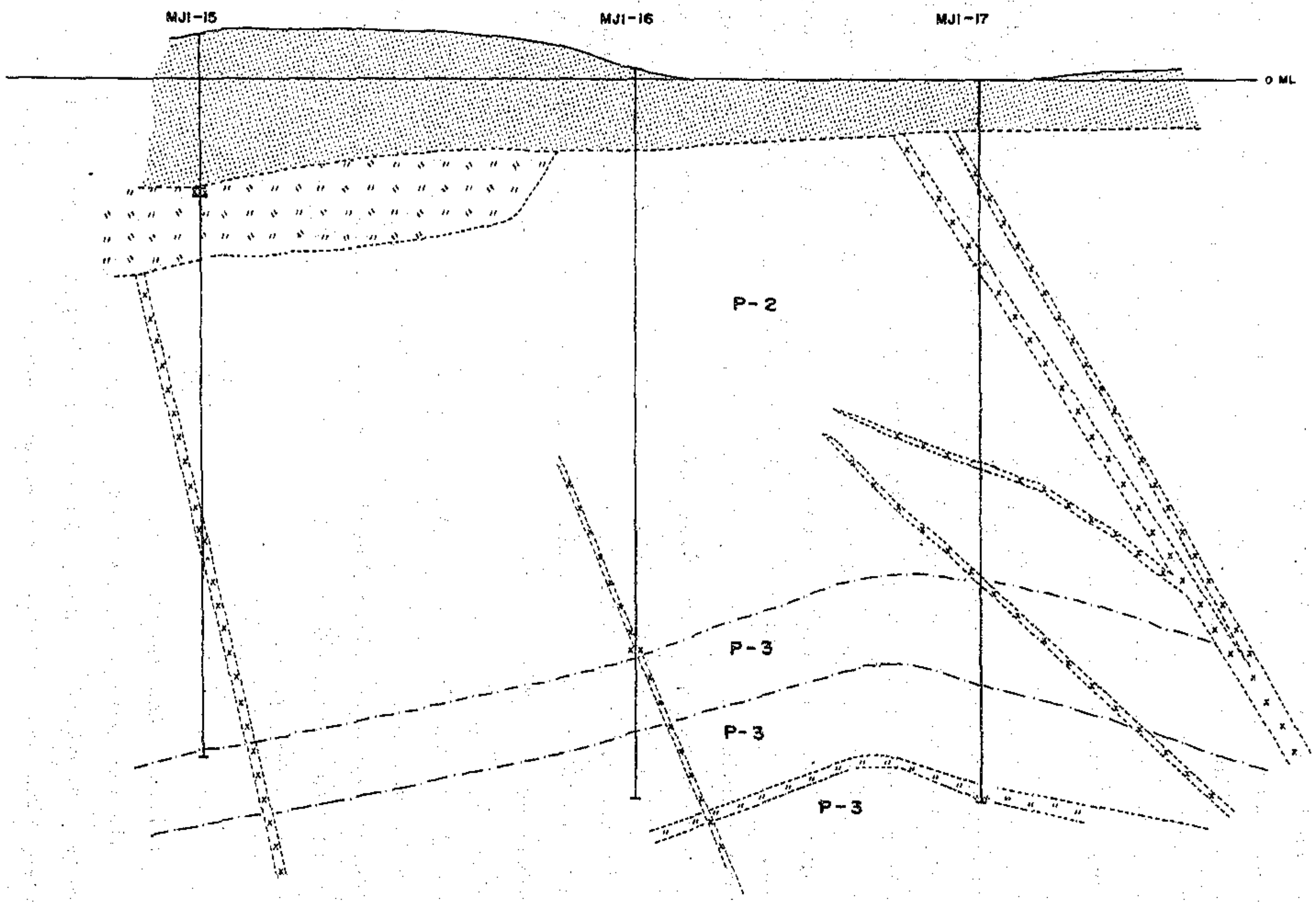

Fig.11 Geologic Profile by Geologic Columns of Drills

hedenbergite, but there is no mineralization.

In this hole, silicified and decomposed rock, probably igneous rock in original, occur from 32.00m to 33.20m, and weathered and decomposed soil-like rock from 33.20m to 47.80m. It was not made clear what kind of rock or part it is in that time,(but later correlation with result of MJI-18 reveals that the part is correlative with low-consolidated tuffaceous facies, called previously crystal tuff of S.Minak Formation).

The marble below 47.80m is mainly fine-grained and coloured from dark to gray.

【Consideration】 This hole is located at northewest extention of inferred mineralizae zone D-2 on a line joining MJI-7 and MJI-8. The location was chosen so that even if the mineralized zone D-2(and D-3) changes its direction to northwest, this hole ought to catch it, and also if the mineralized zone does not changed its direction, it ought to catch the mineralized zone D-6. In fact, the hole terminated without catching any mineralization. The result could be simply due to no mineralization in the area, not the locational relationship between this hole and the mineralized zone.

(6) MJI-16

Drilled length : 150.00m, Inclination : -90°

【Purpose】 This hole was performed to find out the southwest extention of mineralized zones(D-2 and D-3) discovered in MJI-8 in the second phase survey.

【Results】 From 120.39～120.69m, a intrusive rock occurs, ranging from dark gray to black in colour. At the upper and lower boundary, green skarn consisting mainly of epidote is present, with a width of 10cm. The marble facies is the same as in MJI-15.

【Consideration】 The hole was decided its location, taking into consideration the most favorable to catch the southwest extention of the mineralized zone D-2, but the hole did not succeed, namely the mineralized zone D-2 does not extend into this part, and it pinchs sharply out with only 40m extention between MJI-8 and MJI-16.

(7) MJI-17

Drilled length : 151.00m, Inclination : -90°

【Purpose】 The mineralized zone D-1 is a small outcrop locating between MJI-5 and MJI-6, as known by the second phase survey. The hole aimed at finding out D-1 and a new mineralized zone.

【Results】 Altered and discoloured intrusive rocks were found at 18.40m～18.60m, 19.35m～19.70m, 19.80m～21.80m, 36.95m～40.60m, 80.70m～81.35m, and

104.14m~ 104.90m Among them andradite-pyrite ores occur as rim-form at the top and below part of the intrusive rock from 80.70m~ 81.35m. The thickness of the rim are 2cm at the top, and 1~ 4cm at the below. Other andradite band with 1cm thickness is present at upper margin of intrusive rock of 104.15m~ 104.90m. As a result, only poor mineralization occurs without ore minerals in the area.

In the marble with fine dark-gray lamina at 107.35m~ 128.80m in the hole, the lamina are found whose deformed-shape suggests slumping structure. The part from 148.10m to the bottom of the hole contains alkaline lapilli tuff, tuff breccia, hyaloclastite lava(indistinct due to alteration), and blocks of marmorized limestone.

Contrary to expectation, the hole did not succeed to confirm emplacement of intrusive rock and skarn zones occured from 54.20m to 108.35m, and at 172.70m in MJI-13. That result means that either these zones are located further to the southwest, or the mineralized zone pinchs out rapidly to the southwest extention as happened with MJI-16. In the case of D-1, D-2, and D-3, mineralized zones probably pinch out in the hole.

(8) MJI-18

Drilled length : 153.70m, Inclination : -90°

【Purpose】 The hole was performed to find out southwest extent of mineralized zones D-2 and D-3 discovered by MJI-16

【Results】

0.00m~ 22.60m : Surface bed

22.60m~ 51.30m : semiconsolidated tuffaceous facies

51.30m~ 153.70m(bottom) : Marble, intrusive rock and mineralized zone

Above 125.80m, there are many non-core parts and caves. Semiconsolidated tuffaceous facies is correlative with crystal tuff of S.Minak Formation as mention in MJI-15. A piece of core obtained yields a pertrified wood.

The mineralized zone is as follows.

74.03m~ 74.50m : galena, phalerite, assive chalcopyrite. Caves contacts at upper and lower parts.

79.60m~ 80.20m : galena, sphalerite, massive chalcopyrite. Cave contacts at upper.

81.60m~ 81.75m : galena, sphalerite, massive chalcopyrite. The ore is embedded in marble.

95.15m~ 95.45m : grey clay and ore pebbles. Cave occur at lower part.

98.25m~ 98.55m : grey clay and a small amount of ore pebbles. Cave occur at lower part.

101.20m~ 101.50m : grey clay and sphalerite pebbles, for 30cm below the

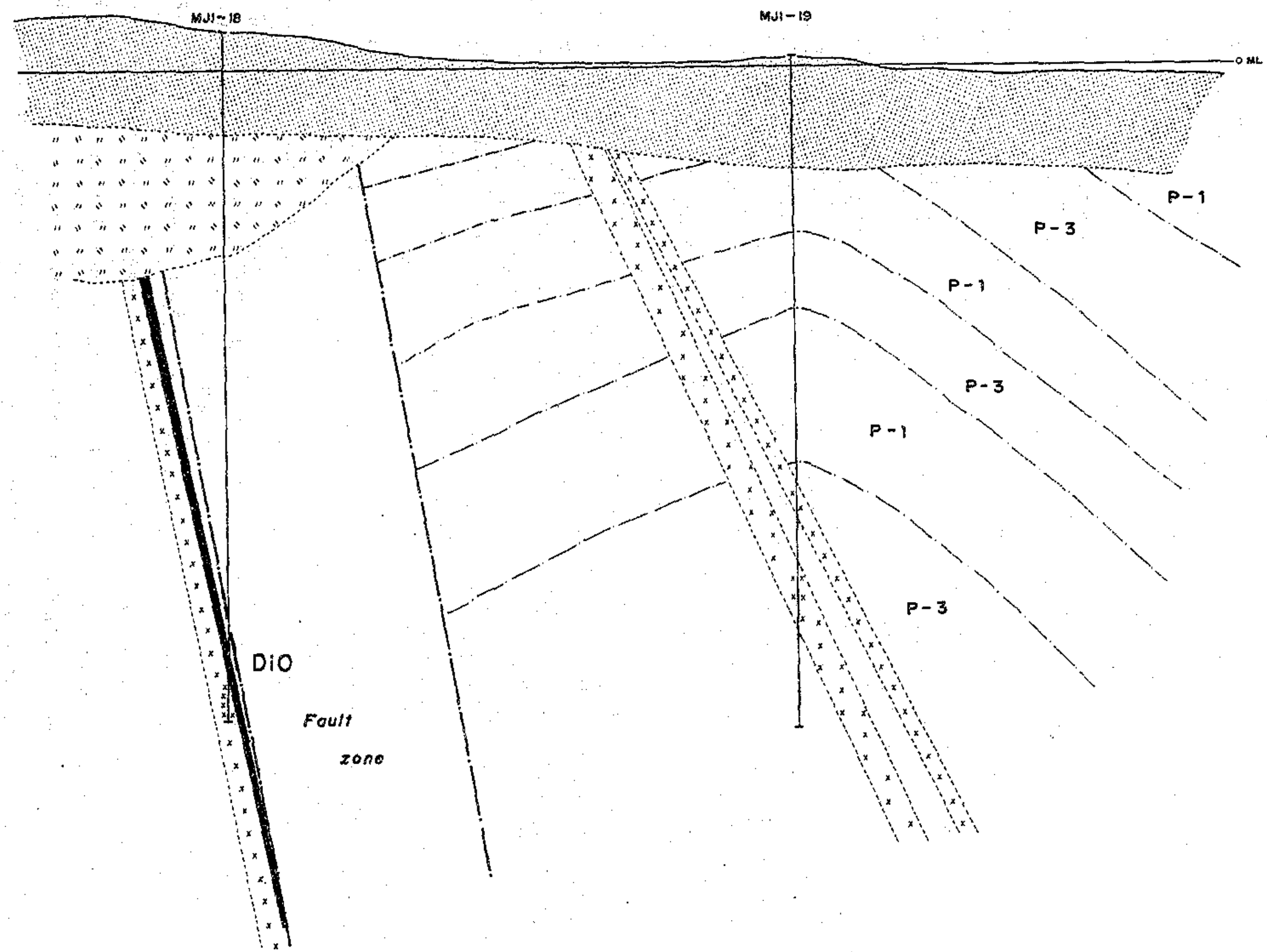

Fig.12 Geologic Profile by Geologic Columns of Drills

zone(101.50m~ 101.80m) brown caly, and further below to 125.20m mostly cave.

125.20m~ 137.70m : decoloured, argillic and silicified intrusive rock and pyrite-disseminating marble.

140.65m~ 140.75m : Sphalerite ore accompanying by a small amount of pyrite.

142.92m~ 144.05m : massive ore of sphalerite and galena.

144.25m~ 144.55m : silicified marble associating with brecciated massive ore of sphalerite and galena.

144.75m~ 145.15m : silicified marble associating with brecciated massive ore of sphalerite and galena.

Intrusive rocks are emplaced in contact with or near the mineralized zone of 125.20m~ 137.70m and 142.65m downwards.

The assay result are shown below. The distinct ore are quite high grade.

depth (m)	core length	Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
74.03~ 74.50	0.47m	0.35	1,730	2.52	16.10	34.7
78.60~ 80.20	0.60m	0.21	780	7.00	15.70	11.30
81.60~ 81.75	0.15m	0.07	590	6.10	27.8	14.40
101.20~ 11.50	0.30m	<0.07	265	1.38	4.68	7.05
140.60~ 140.75	0.15m	1.27	276	0.04	2.96	33.1
142.70~ 145.15	2.45m	0.11	263	0.09	11.27	15.76

The marble in this hole is generally fine-grained, but the rock facies is not clear owing to its severe argillization, silicification and brecciation. At 144.05m~ 144.25m,there is evidence of slumping structure.

[Consideration] The occurence of the mineralized zone embedding in this hole is somewhat different to other cases. Namely, selicitization, kaolinization and silicification occur characteristically from 125.20m downward, and brecciated ore from 144.25m downward in the hole, in comparison with other holes. Especially, it may be inferred from occurence of brecciated ore that primary ore was brecciated by fracturing, and then sank into the soft limeston. This hole is located in fault zone, which suggests the possibility of deformation and brecciation. On the other hand, even if this mineralized zone is skarn type, evidence of sericitization, kaolinization and silicification instead of skarn indicates that following geological process happened ;

Fracturing and brecciation ⇨ alteration by penetratation of surface water ⇨ retrogressive alteration

The numeraou caves are mostly doline, and it appears that exsisting of many fracturings and faults in the area is attributed to make these numerous caves. Besides as mentioned previously, MJI-14 toward deep of this hole confirmed a fault-disturbing zone trending north-south direction.

The mineralization is supposed to be whether new bonanza of mineralized zone which pinchs out on the line of MJI-15 ~ MJI-16~MJI-17 as mentioned before, or new mineralized zone.

(9) MJI-19

Drilled length : 151.00m, Inclination : -90°

【Purpose】 The hole was carried out to confirm mineralized zone southwest of MJI-17.

【Results】 Intrusive rocks occur at 96.75m~104.60m and 96.75m~104.65m. A thin andradite-hemetite layer is found at upper contact with the rock, but no consistent mineralized zone occurs.

A fine-grained marble with slumping structure occurs from just below the surface. The rock belongs to fine-grained facies(p-3). A assay result of weak mineralization at 113.70m are shown below ;

depth (m)	core length	Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
113.70~113.85	0.15m	0.07	5.5	0.01	0.33	0.31

【Consideration】 The hole was aimed at catching southwest extention of ores discovered in shallow through MJI-13. Contrary to the expectation, only skarnitized intrusive rock with weak mineralization was found continuing from MJI-13.

(10) MJI-20

Drilled length : 151.00m, Inclination : -90°

【Purpose】 THe hole was performed to confirm a mineralized zone southwest of D-2 and D-3.

【Results】 From 39.30m to 85.30m, eight intrusive rocks were found, some is accompanied by skarn, but any mineralized zone were not discovered.

A rock can be clearly identified its original rock owing to weak metamorphism, in comparison with that in other holes. For example, the marble yields probable coral fossils at 123.10m~123.30m, and reverse grading of dark gray slate and limestone in 10m thickness at 128.30m~131.30m. Below 135.85m, original rock of the marble(P-3) are assumed to be originally limy slate and mudy limestone.

【Consideration】 A extention of mineralized zone discovered by MJI-18 was not found in this hole, contrary to expectation. The intrusive rock at 81.70m~

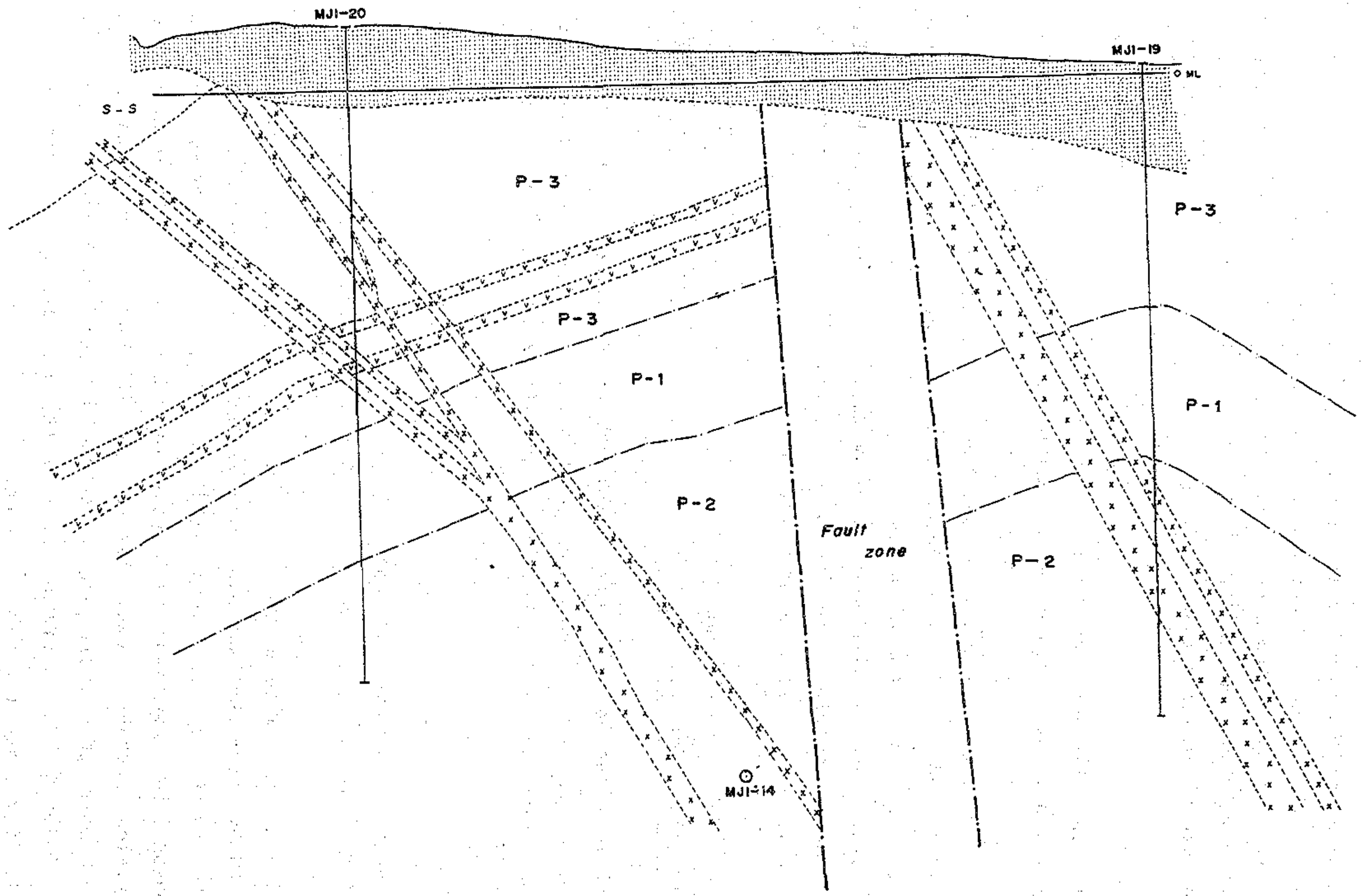

Fig.13 Geologic Profile by Geologic Columns of Drills

85.30m is geologically correlative with the rock(lower part of mineralized zone) of 142.92m and below in MJI-18, but there is only alteration without any mineralized zone.

(11) MJI-21

Drilled length : 281.00m, Azimuth : 340° 00′ , Inclination : -90°

【Purpose】 This hole was performed to unreveal distribution of mineralized zone between MJI-12 and MJI-13.

【Results】 Following mineralized zones were found ;

49.80m~50.50m, 52.20m~52.60m, 52.80m~53.70m, 54.15m~54.20m : Hedenbergite- bearing massive sphalerite.

47.15m~48.80m : fine-grained intrusive rock

48.80m~49.80m : associating with skarn

50.50m~52.20m and 52.60m~52.80m : caves

52.20m~52.60m : weathered(discoloured) and cream-coloured hedenbergite

133.20m~133.60m : hedenbergite-andradite-calcite-sphalerite-galena ore accompanying by a small amount of chalcopyrite.

131.30m~131.70m : compact intrusive rock

131.70m~133.20m : fine-grained andradite-epidote, accompanied by hematite with minor amount of sphalerite although invisible to naked eye.

248.90m~249.20m : hedenbergite-sphalerite-andradite.

249.20m~250.70m : slightly skarnitized intrusive rock

260.30m~260.70m : hematite-sphalerite-calcite-hedenbergite(?).

260.70m~261.30m : altered intrusive rock

261.30m~261.50m : fine-grained andradite

261.50m~262.05m : quartz veins filled in brecciated marble.

Skarns occur at marginal part of the alkaline intrusive rock (deep facies) as same found in MJI-12. The skarn consists of grossular, vesuvianite, quartz, diopside and k-felspar. Their occurrence are as same as that in MJI-12.

The mineralized zone is emplaced at contct of small-scaled intrusive rocks and marble. The marble occured in the hole is mostly coarse-grained, except fine-grained in 96.90m~123.90m.

Average grade of the mineralized zones are shown below ;

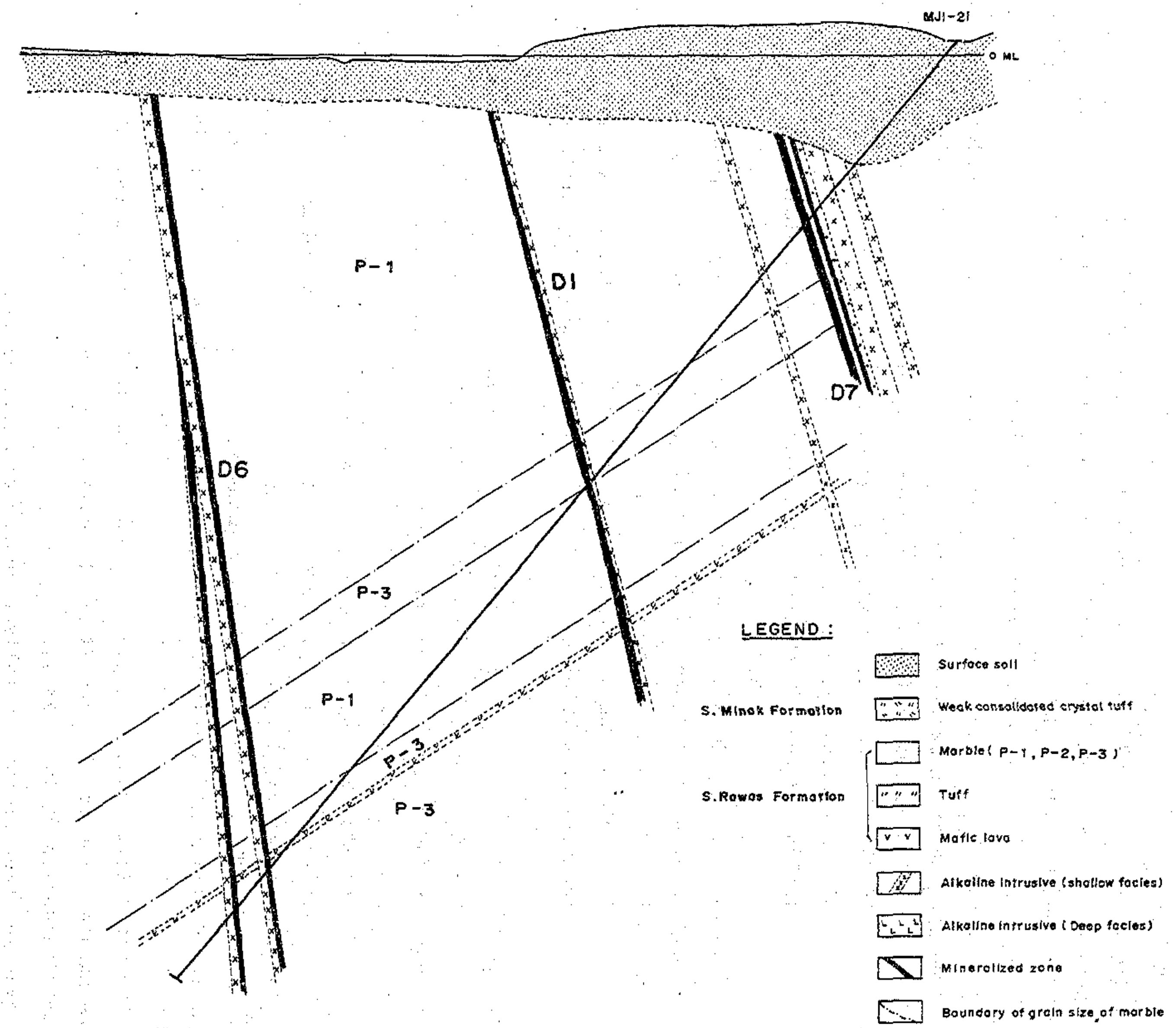

Fig.14 Geologic Profile by Geologic Columns of Drills

depth (m)	core length	Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
48.60～54.20	5.60m	< 0.07	56.5	0.23	0.24	6.10
131.30～133.60	2.30m	< 0.07	18.8	0.03	0.10	1.32
248.90～250.70	1.80m	< 0.07	1.9	0.02	0.01	0.13
260.30～261.70	1.40m	< 0.07	7.1	0.09	0.02	1.94

【Consideration】 The three holes,MJI-21,MJI-22 and MJI-23, were additionally performed.

The hole discovered new mineralized zone at the shallow from 49.80m to 54.20m. The zone resembles in occurrence to that at 65.95～66.35m in MJI-23. The mineralized zone at 131.30m～3.60m is correlative with D-4, and other 2 zones at 248.90m～250.70m and at 260.30m～262.05m with D-6.

(12) MJI-22

Drill length : 300.00m, Azimuth : 340° 00′, Inclination : -50°

【Purpose】 The purpose is same as for MJI-21 and MJI-23. This hole was positioned between these two holes in order to investigate their continuity and ore grade between mineralized zones of MJI-12, MJI-21,MJI-22 and MJI-23.

【Results】 Mineralized zones were found in the following three places, but as the assay results, none is of a notably high grade.

125.60m～130.35m : A mineralized zone consisting of sphalerite-hedenbergite -andradite is embedded along lamina(tuffaceous facies), or as fine veins in the marble.

125.60m～128.85m : somewhat serpentinized greenish dark-gray, hard rock(probably ignious rock in origin), accompanied a small amount of red sphalerite and hematite.

128.85m～130.35m : sphalerite-hedenbergite-andradite showing a form permeating along lamina of tuffaceou facies, and veinlets of sphalerite-andradite. The same occurrence is found in the marble with tuffaceous lamina at two parts of 131.80m～131.90m and 133.05m～1333.15m.

140.86m～143.00m : Composed of following parts ;

140.86m～141.06m : coarse-grained sphalerite-quartz-(calcite)

141.06m～141.60m : silicified part rich in andradite

141.60m～143.15m : silicified intrusive rock

280.85m～287.55m : Composed of following parts ;

280.85m～282.13m : hematite-sphalerite-andradite-hedenbergite

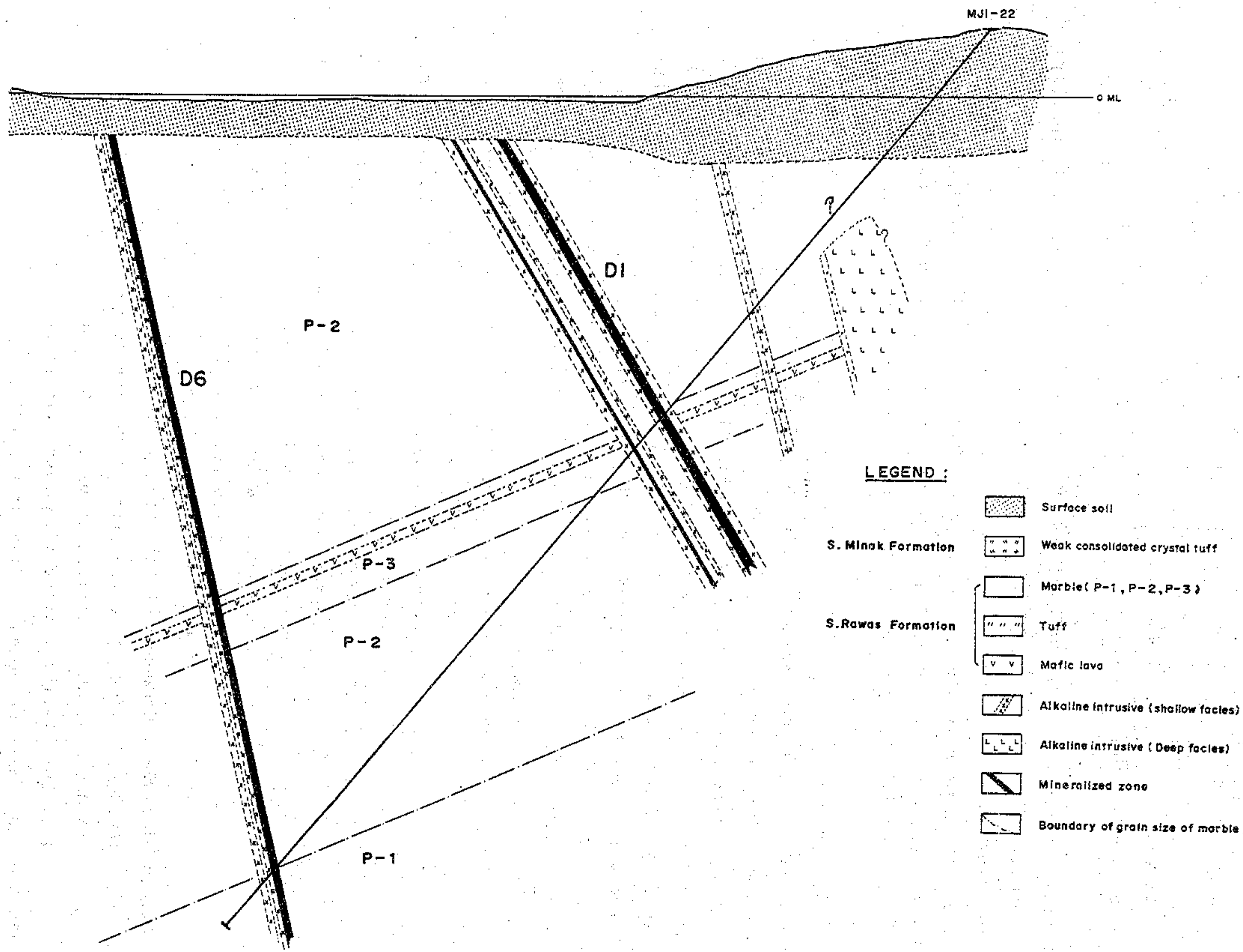

Fig.15 Geologic Profile by Geologic Columns of Drills

282.13m～283.13m : skarnitized igneous rock(?)

283.13m～285.65m : marble

285.65m～287.55m : skarnitized igneous rock

depth (m)	core length	Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
128.85～130.35	1.50m	< 0.07	3.9	<0.01	0.02	1.34
140.86～143.15	2.29m	0.08	4.0	0.01	0.02	1.80
280.85～283.13	2.28m	< 0.07	13.3	0.28	0.03	5.47

Shallow part of this hole is composed of surface soil bed at 0.00m～43.00m, and weathered and cave(filled up by soil) parts at 43.00m～68.60m.

【Consideration】 Two zones of 125.60m～130.35m and 140.86m～141.60m, regarding as a mineralized zone, is correlated with D-2, while other zone of below 280.85m with D-6. This hole did not reach the mineralized zone discovered at shallow by MJI-21 and MJI-23, because it passed through the ore horizone being weathered.

(13) MJI-23

Drilled length : 276.30 : Azimuth : 340° .00′ : Inclination : -50°

【Purpose】 The hole was performed to aimed at reaching the deeper part of the mineralized zone found in MJI-7 and MJI-6, between MJI-13 and MJI-12, and northwest extent of the mineralized zone of MJI-13.

【Results】

Above 33.60m : Alkaline intrusive rock(Shallow facies)

33.60m～65.95m : Complex of alkaline intrusive rock(deep facies),compact intrusion rock and marble. Sporadic distribution of garnet of 2～10mm and diopside of 7～25mm in size at 38.50m～39.50m within the rock.

65.95m～66.35m : massive ore accompanied rich sphalerite and galena.

93.70m～94.35m : Mineralized zone. The zone is divided into as follows :

93.70m～93.80m : marble mineralized with disseminated sphalerite

94.80m～94.20m : skarn(andradite and epiddote),sphalerite and hematite

94.20m～94.35m : fine-grained skarn

(94.35m～96.75m) : decoloured compact aphyric intrusive rock)

160.37m～164.48m : Mineralized zone composing of following parts ;

160.37m～160.52m : andradite-sphalerite-chalcopyrite

160.52m～160.60m : andradite

160.60m～160.70m : andradite with small amount of sphalerite

160.70m～160.85m : limonite-stained quartz-sphalerite

160.85m～161.50m : sphalerite massive rock

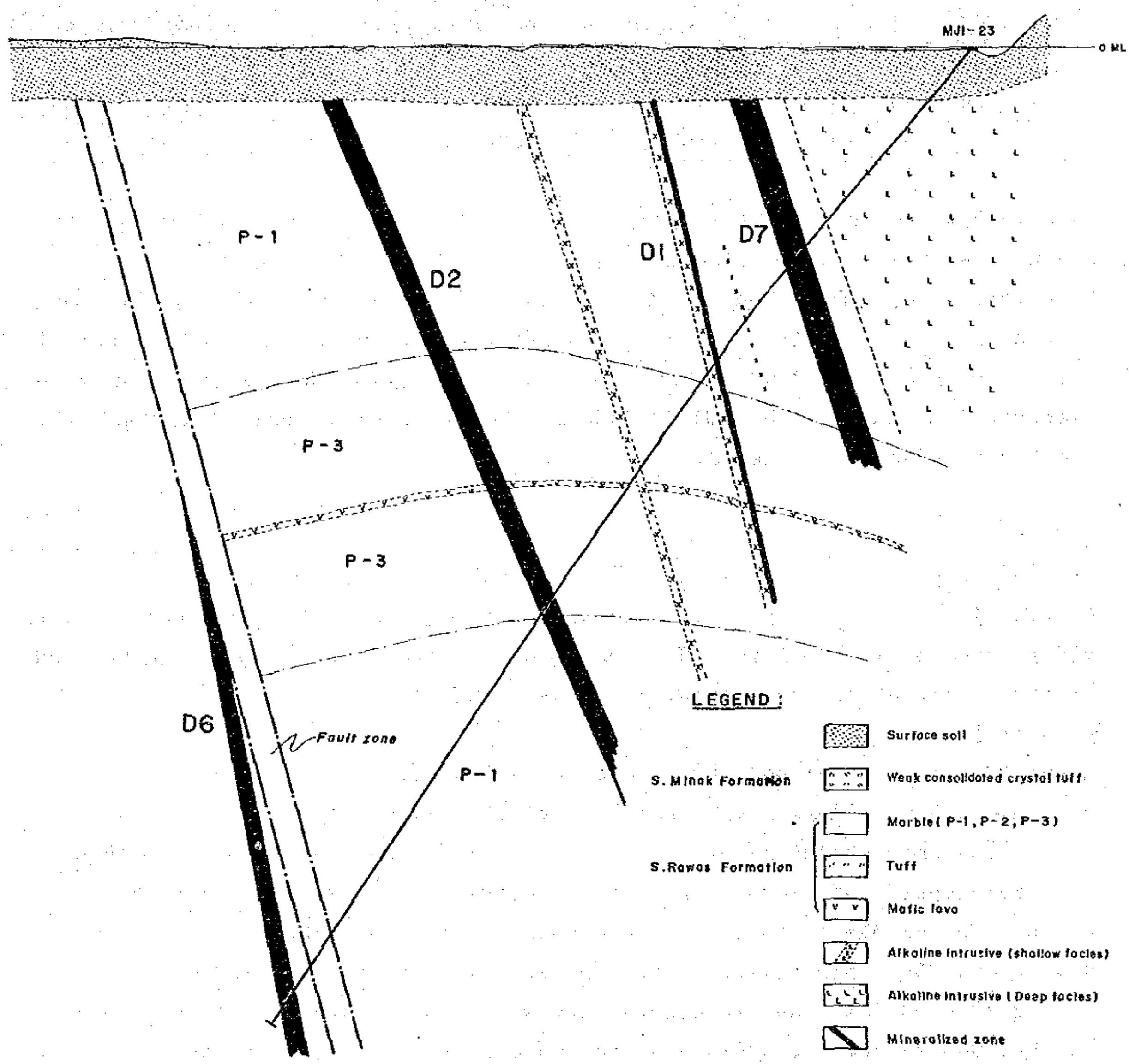

Fig.16 Geologic Profile by Geologic Columns of Drills

161.50m~163.35m : chlorite-epidote with hematite

163.35m~164.30m : calcite-quartz with small amount of disseminated sphalerite

267.15m~272.55m : Mineralized zone consisting of followinf parts ;

267.15m~267.95m : hedenbergite with a small amount of sphalerite

267.95m~268.85m : hedenbergite

268.85m~269.65m : andradite(?)-epidote

269.65m~270.95m : hedenbergite

(270.95m~273.10m : marble)

270.95m~272.55m : compound of hedenbergite and andradite

273.10m~273.20m : spherical aggregattion of hedenbergite-sphalerite

depth (m)	core length	Au(g/t)	Ag(g/t)	Cu(%)	Pb(%)	Zn(%)
65.95~66.35	0.40m	< 0.07	383.0	0.05	1.90	29.2
93.70~94.35	0.65m	< 0.07	13.3	0.15	0.04	4.26
160.37~164.48	4.11m	< 0.07	17.6	0.18	0.05	7.34
267.15~268.85	1.70m	< 0.07	22.8	0.89	0.05	6.56
267.15~272.55	5.40m	< 0.07	9.2	0.31	0.02	2.30

【Consideration】 As mentioned in the article at MJI-21, the mineralized zone at 65.95~66.35m is a new discovery. It appears to be connected to the shallow mineralized zone in MJI-13. However, there are several facts which argue against the relation, namely the fault striking NNW-SSE runs between this hole and MJI-13,the mineralization at MJI-13 and this hole is different in composition of ore and skarn minerals, the mineralized zone in MJI-13 is not accompanied by alkaline intrusive rock(deep facies) in contact with it, or by skarn zone mixing with the intrusive rock.

As for the other mineralized zone, the one at 93.70m~94.35m is correlative with D-1(D_1), one at 160.37m~4.48m with D-2(D_2), and one at 267.15m~272.55m with D-6(D_6).

1-2-5 Laboratry studyes and analysis results

(1) Ore Analysis

The 150 ore samples collected from drilled core were chemically analyzed on 5 elements, Au, Ag, Cu, Pb, Zn. The results are shown in App-table 1. The result indicates that the small-scaled shallow mineralized zones are mostly of a high grade, while the deeper mineralized zones tend to be a low grade.

(2) Study of thin section, polished specimen and Xray-diffraction analysis

The samples tested are shown in App-table 2. The results of these study are shown in App-table 3~8.

Thin section study reveals that alkaline intrusive rocks are a complex composing from quartz diorite to alkaline gabbro, and X-ray diffraction analysis detected interesting minerals, namely vesuvianite, chromite, serpentine(partially altered to talc), olivin and natrolite from marble.

(3) Sulfur isotope analysis

Sulfur isotope analysis of ten ores collected from drilled core and outcrop was performed. Sulfur isotope ratio ($^{34}S/^{32}S$) of mineral obtained by isotopic analysis clarifies origin of sulfur and thermal condition to form sulfide minerals through calculation of distribution ratio of the sulfur isotope during the forming process.

Samples assayed and results are shown in Table 5.

Table 5 Results of Sulfur Isotopic Analysis

mineral	place collected	$\delta^{34}S$ value(‰)	remarks
sphalerite	MJI-8 64.20m	-2.5 black	massive ore
	MJI-13 101.50m	-3.4	〃 〃
	MJI-12 150.00m	-3.1	〃 〃
	D_1	-3.5	outcrop of D_1
	D_2-1	-5.2	ore from waste outcrop of D_2
	D_2-2	-4.7	〃 〃
galena	MJI-12 150.00m	-4.0	above sphalerite
	D_1	-6.6	outcrop of D_1
	D_2-1	-4.1	outcrop of D_2
	D_2-2	-5.3	ore from waste outcrop of D_2

As mentions later, the ore sulfur had originated from sulfuric acid in sea water during sedimentation of host rock.

(4) Calculation of ore reserves

A total of 9 mineralized zone were discovered by drilling survey of 23 holes (a total length : 4,680m) implemented in the S.Tuboh area over 2 years in the second and the third phases. The longituginal section of the zones is shown in Fig. 17. The figures show ore block for calculation of reserves, taking geologically their scale, and continuation into consideration, excluding unminable part, such as weathering and leached part. This is estimated as possible reserves(inferred reserve), using only data obtained by drilling through following condition.

【Condition of ore reserves calculation】

① A ore block is delineated the area confirmed at least two holes, or estimate considerable strike and ore shoot, even though it is estimated by a hole.

② The calculation width should be more 1 meter in drilled width, or value of grade × drilled width should be satisfied over the cut of limit memtioned in ④

③ Calculation depth differs for each zone, but it should be up to a maximum of -300m level, as the base level(om level) is set at surface of MJI-7

④ The calculated components are Au,Ag,Cu,Pb,and Zn. These cut-off limit grades are shown as follow, and a ore block is calculated provided at least a component in average satisfies over the cut-of grade .

Au≧ 0.5g/t, Ag≧ 5g/t, Cu≧ 0.5%, Pb≧ 1%, Zn≧ 1%.

⑤ A specific gravity of rock and skarn used is $3.5g/cm^3$.

The specific gravity of the ore normally changes with the amount of metal content(grade), so the value should be used depending on the grade. However, all that required here is an approximate estimnate, so these value are adequate.

Results of the calculation is shown in Table 6. And each zone's rserves and grade-width of hole used are also shown in Fig 17.

Among these zones, D_2 (D-2) is the most valuable zone, in terms of both ore reserves, the main mineralized zone in S.Tuboh area. D_7 (D-7) has high grade, and D_6 (D-6) has good continuity.

Teble 6 Calculation of Ore Reserves

Ore Bodies	Square m^2	Width m	Volume m^3	Sp.	Reserves t	Ore grade Au(g/t)	Ag(g/t)	Cu %	Pb %	Zn %
D_1	126,575	0.90	113,917	3.5	398,709	0.09	105.2	1.10	1.69	8.05
D_2	50,400	4.43	223,272	3.5	781,452	0.13	117.7	0.78	0.90	8.58
D_3	25,200	0.54	13,608	3.5	47,628	0.07	441.2	0.76	14.58	18.58
D_6	84,000	0.90	75,600	3.5	264.600	0.11	26.3	0.47	0.07	6.29
D_7	96,350	0.68	65,518	3.5	229,313	0.07	187.9	0.60	0.84	18.47
D_8	13,000	0.35	4,550	3.5	15,925	0.14	378.0	3.20	4.20	14.50
D_9	13,000	0.28	3,640	3.5	12,740	0.20	1,220.0	0.79	5.42	36.40
D_{10}	7,000	0.50	3,500	3.5	12,250	0.11	263.2	0.09	11.72	15.76
Total		1.21			1,762,617	0.11	130.4	0.80	1.45	9.98

Metal Content

Element	Contents
Au	192.1 kg
Ag	229,768.1 kg
Cu	14,084 t
Pb	25,622 t
Zn	175,868 t

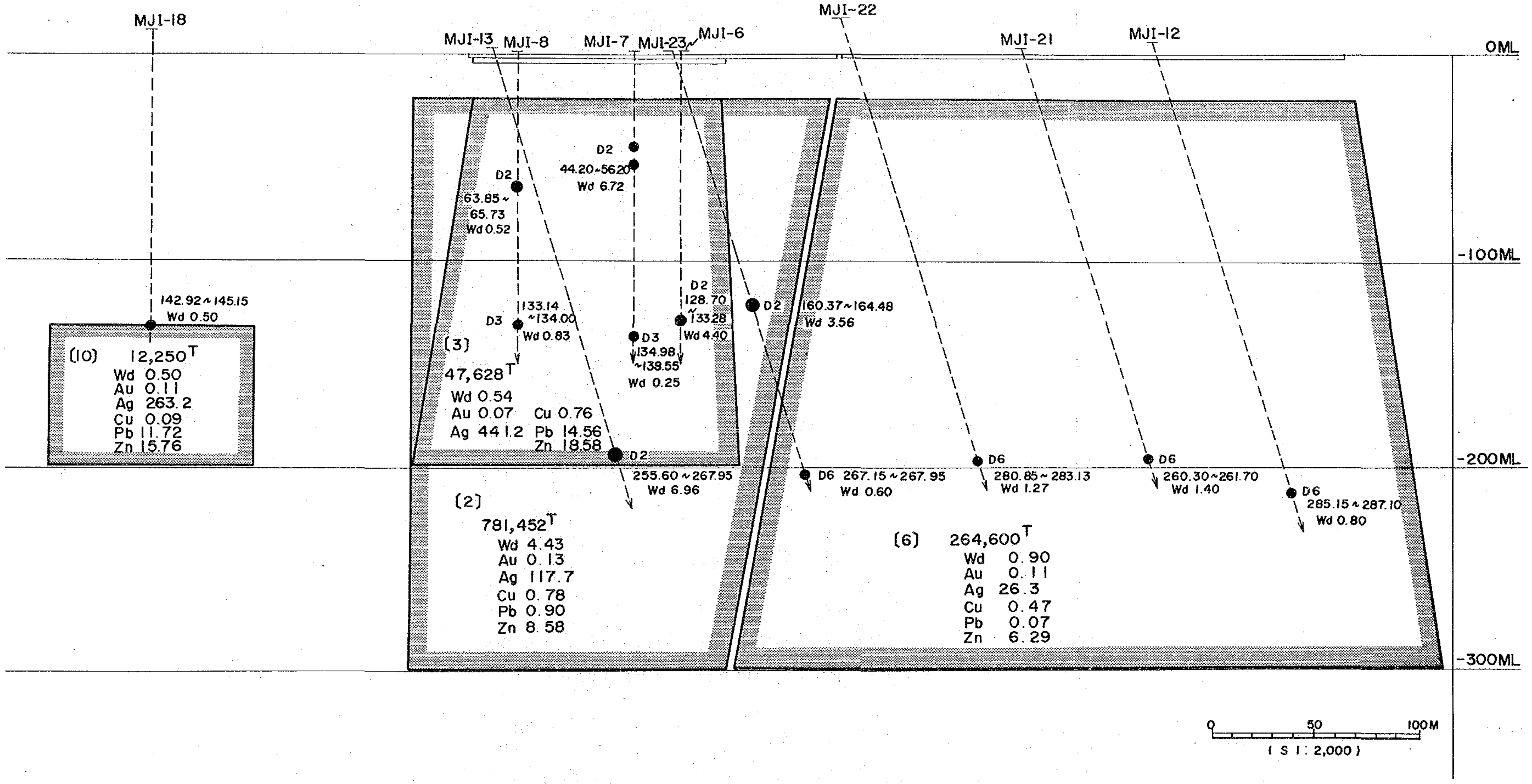

Fig.17 Cross Section for Ore Reserves(1)

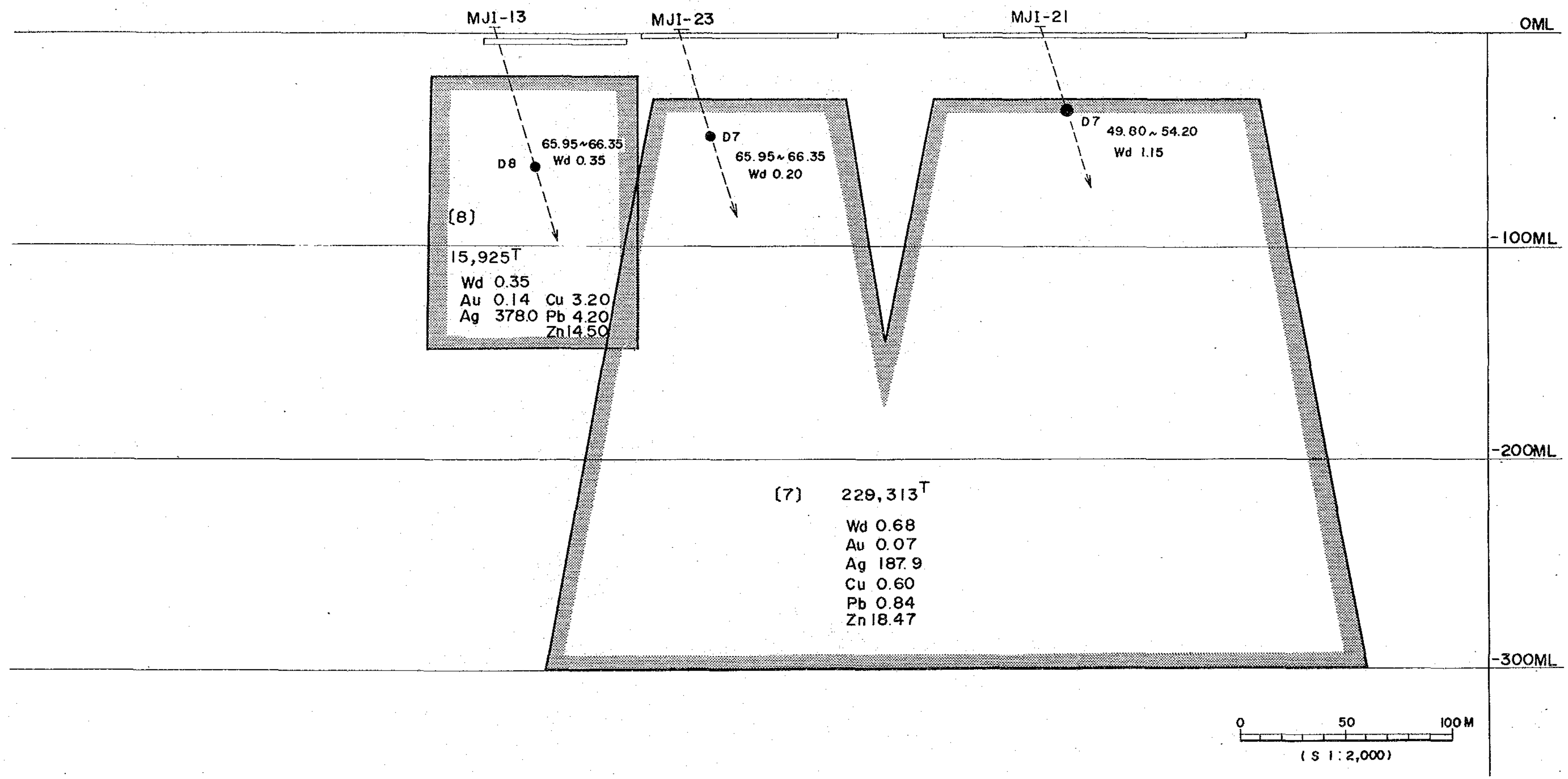

Fig.17 Cross Section for Ore Reserves(2)

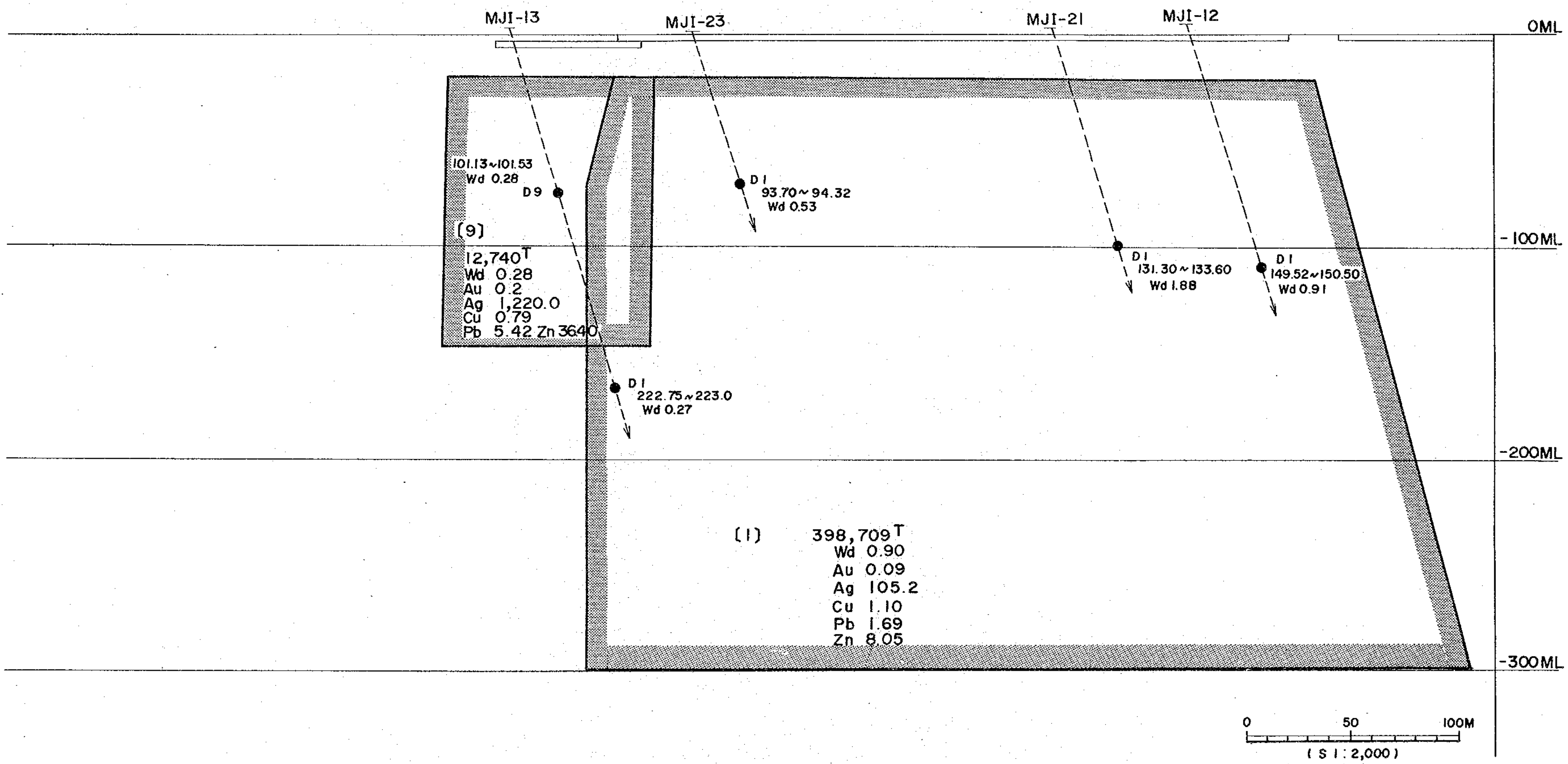

Fig.17 Cross Section for Ore Reserves(3)

I -2-6 Discussion of Results

(1) Geology and Geologic Structure

The drilling survey area covers virtually marble, aparting from alkaline intrusive rocks(deep facies) extending NE-SW at south part, as shown in Fig 18(distribution map of mineralized zone). The marble is a metamorphosed facies of the Mersip Limestone Member, and is widely distributed from Bt.Bulang in the north of Southern Sumatra area to S. Tuboh area, via Mersip (type locality area) and Bt.Raja.

The marble is divided into three facieses, P-1,P-2, and P-3. P-3 contains laminated marble, sandy marble, and shally marble facieses, and slumping structure and water-escaped structure occur in it. The facts indicate that the sediments of P-3 slided by subaqueous sliding, and deposited secondaly with P-1 and P-2. P-3 sometimes is intercalated into P-1.

P-3 intercalates alkaline lava and tuffaceous fasies, and it probably has sedimented on the shallow sea with volcanic products of alkaline volcanic eruption. Sedimentation of P-1 has also sediment not far away from that of P-3.

In the case of alkaline intrusive rock(deep facies), the survey reveals that the rock is complex rock composing of quartz diorite, quartz monzonite, quartz monzoninite porphyry, diorite, monzonite, tonalite, and alkaline gabbro. Some of these have undergone considerble thermal metamorphism, and intrusion probably occured at differnt time.

A barren skarn zone distributing along boundary between alkaline rock (deep facies) and marble is product of contamination and metasomatism between both rocks. The existence of the similar skarns are also known within the alkaline intrusive rock. This suggests that the alkaline intrusive rock is composed of small size intrusives, if the skarns are regarded as boundary of the rock bodies, and these rocks were formed by substantial contamination and metasomatism.

At locations of MJI-15,16 and 18, there are small distrinbution of smi-consolidated pyrocrastic rock. The existence of the facies was already known from the trench survey in the initial phase, and it was called crystal tuff. The drilling result of of MJI-18 reveals that the facies is correlative with S.Minak Formation from its rock facies and mineral composition. The facies which is unwelded pyroclastic flow has presumably deposited into depressed groung caused by existence of large-scale doline or N-S fault.

(2) Geological structure

a.) Fold structure

A syncline structure trending ENE-WSW and plunging to southwest at low

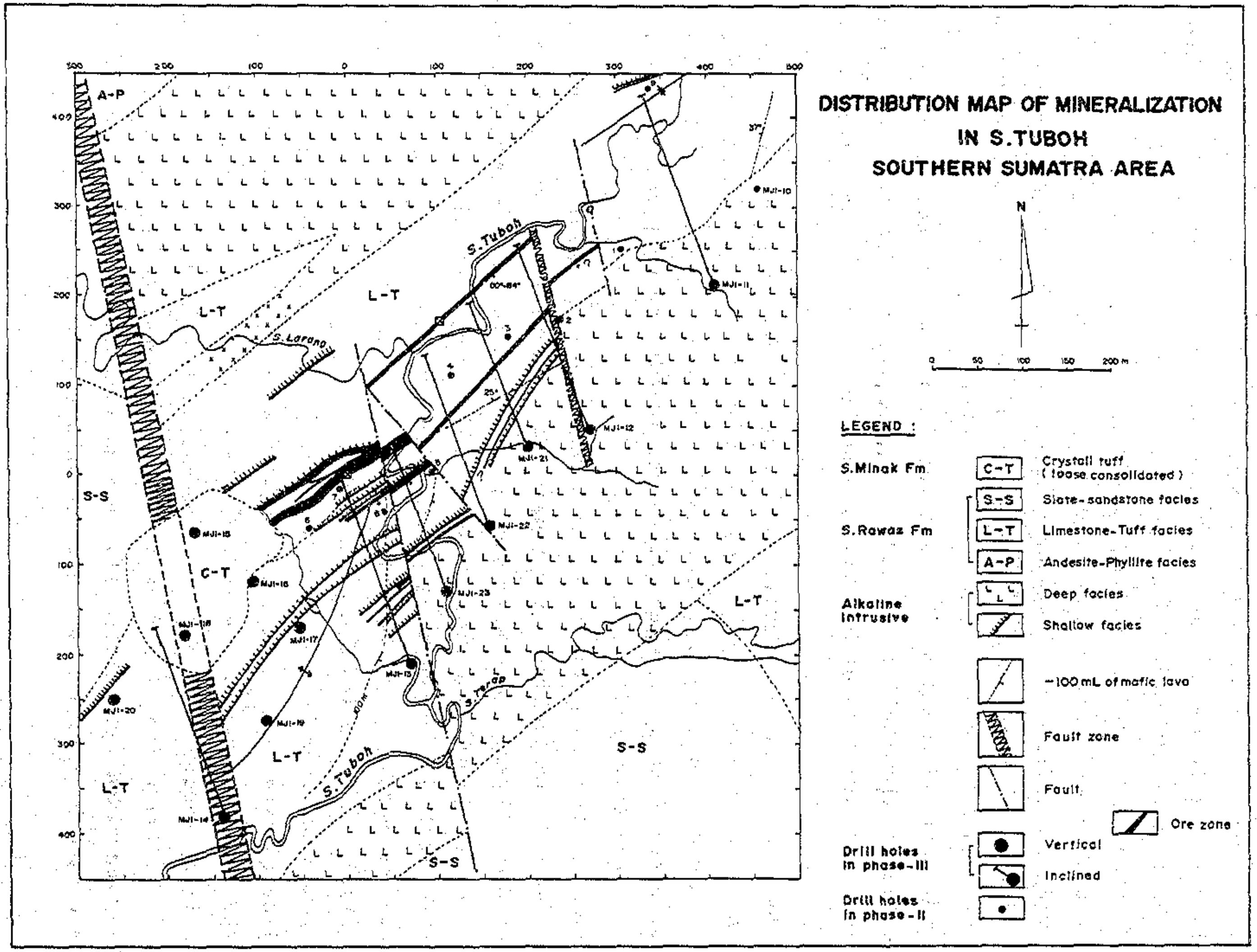

Fig.18 Distribution Map of the Mineral Indications in S.Tuboh Prospective Area

angle exists at northeast MJI-1. The ares from MJI-1 to MJI-5 is possibly located at southeast wing of the syncline, although there appears to be a monoclinal structure dipping NW. There is also a anticlinal structure trending NE-SW and plunging NE from MJI-5 up to MJI-20 toward southwest. The synclinal structure is cut by a fault striking N10° W at its northeastern part between MJI-5-MJI-6 and MJI-23-MJI-13. These structures were obteined by tracing key bed of Lava intercalating in P-3, namely interpretating strike of S.Rawas Formation of NW-SE at northwestern from S.Rawas (grneral trend of Sumatra Island) and NW-SE (perpendicular to the former) at S.Tuboh area.

However, a structure trending NW-SE occurs again at south part of S.Tuboh, and it could be a local structural disturbance. Alkaline intrusive rocks also extend NE-SW, so the NE-SW striking of the stratum presumably corresponds to deep fructure controlled the intrusion. Accordingly, the structure is one of essential structure in the Sumatra Island, even though it is in local.

b.) Faults

The initial phase report described two fault systems of NE-SW and NW-SE(orN-S) in the detailed survey area, including S.Tuboh area. The N-S faults exist prominently in the recent geological map compiled by second and third phase surveys, in comparison with the NE-SW faults, because the N-S fault is a most young structure cutting older structure, while the NE-SW fault controls emplacement of the intrusion.

In the S.Tuboh area, there are many caves covered by surface soil bed. The caves are doline structure. The drilling survey during two phases have proved their presence interpreted by photogeological interpretation in the initial phase. It may be inferred that the N-S faults have caused the doline structure by penetration of water through it.

(3) Mineralization and constituent minerals

As shown in Fig. 18, nine mineralized zones have been recognized in the S.Tuboh area in present. Two mineralized zones(D_5 and D_8) in MJI-19 and MJI-18 are counted a zone.

The mineralized zones are regarded as skarn type, looking at them from constituent minerals, on the contrary look like paralleled ore vein or bedded types from their emplaced form.

Although these mineralized zones can not be strata-bound type (bedded sulfide), considering their inclination point of view, the results of $^{87}Sr/^{86}Sr$ ratio reveals that materials of the mineralized zones are possibly sedimentary origine, in terms of that ore sulfur of the mineralized zone are of sulfuric acid origin in sea water. To put differnt terms, ready-existed sulfide moved, reorganized and deposited under a physical condition to form a skarn ore. Besides, mineralizatin of the S.Tuboh area is characterized in existence of quartz(rock-crystal), alteration with silicification, sericitization and kaolintization, fine-grained gangue mineral.

Occurrence of gustavite(silver mineral Ag_2S-Bi_2S_3-PbS) reported in the second phase survey is similar to that in Nakadatsu Mine(typical skarn ore deposit), and isotopic temperature obtained by sulfur isotope analysis shows 430℃ in average, as same as that in ordinary skarn ore deposit. These evidences of the mineralization in the S.Tuboh area coincide with skarn type mineralization.

As to the constitution of mineral, no additional ore and gangue minerals are described by the third phase survey. This means that no change have been recognized in the constitution of minerals in either strike or dip direction. On the other hand, a volume ratio of ore and gangue minerals, viz ore grade, changes in the dip direction, and the ore grade decreeses toward deeper in the dip. Hematite considerably occurs in deep part of the mineralized zone.

(4) Mineralization, Geological Structure and Igneous Activity

Geological structure trending NE-SW has strongly affected forming of mineralized zone of S.Tuboh area, as can be seen in the geological map. NE-SW trending fault, perhaps at the folding period of the Rawas Formation (probably end of Cretaceous), provided presumably place for intrusion, and alkaline rocks(deep facies) extending NE-SW were successively emplaced along the faults. The limestone of the Mersip Limestone Member was marmorized by thermal metamorphism of the intrusion.

The alkaline rock(shallow facies) co-existed with the mineralized zone started its activity before and after intrusion of the deep facies, and was emplaced as paralelled dykes, structurally controled along the NE-SW direction.

During the mineralization succeeding the igneous activity, a ore-forming fluid was favorably embedded in a number of fissures within the intrusive rock and contact with marble and intrusive rock. Therefore the mineralized zone in the S.Tuboh area are also embedded in the structure line of NE-SW, resulted by the regional geological structure.

It supposed that the source of the metallic mineral could be come from the Mersip Limestone Member of Rawas Formation (upper Jurassic 170～140Ma) as already mentioned. The intrusive rocks have been dated as 51.7Ma and 51.9Ma from 2 samples(alkaline gabbro and trachy dolerite). The alkaline rock intrusion in the S.Tuboh area took place at the later stage of the igneous activity in the Bt Raja area, taking these age dating into consideration. Considering these information, it may be inferred that the mineralized zones in the Bt.Raja and S.Tuboh areas were formed, associating with igneous activity of the alkaline intrusive rocks(deep facies), namely, the activity had prepared a heat source, causing movement, reorganization and deposition of existed strata-bound sulfide in Mersip Limestone Member to form skarntype ore deposit in the S.Tuboh area.

The mineralized zones in the S.Tuboh area consist of several mineralized units, paralleling and trending NE-SW. However the areas concentrated the units and bonanza having good grade and large-scale are located around MJI-8 and MJI-18, especially around MJI-5～MJI-8. The bonanza trends rather to NW-SE, in opposition to NE-SW trending of the mineralized zone, supposing a some reason to emplace the bonanza to the trending.

In the marble widely distributed around in the middle of S.Nilau to north west, there are no igneous rock(intrusive rock). The heat source which formed the coarce marble here may have been a concealed plutonic rock, and such a igneous rock body influenced the rich and pinch of the mineralized zone in the S.Tuboh. In addition, a old deep fracture trending NE-SW which is unable to recognize in present may have also taken part the mineralization.

(5) Mineralization in terms of sulfur isotope

i) Origin of the ore sulfur

The $\delta^{34}S$ values given in Table 7 show clear distinction in terms of isotope from igneous fulfur($\delta^{34}S \fallingdotseq 0$ ‰). The reason for this is as follows;

Sea water sulfide in Jurassic period $\delta^{34}S$ = ca. 16 ‰ ------ A

Average sulfide value of mineralized zone

in S Tuboh area $\delta^{34}S$ = ca. -4 ‰ ------ B

⇩

Isotope fraction between these ($\Delta\delta A - \delta B$)= ca. 20 ‰

The isotope fraction value between A and B (20 ‰) coincides very well with typical value (20 ± 5 ‰) (20± 5 ‰) for the isotope fraction from SO_4^{2-} to S^{2-} produced by reduction process of sulfate by bacteria. Accordingly, ore sulfur in the mineralized zone of S.Tuboh area is essentially biogenic, and was produced through fixing the sulfide produced by bacterial reduction of sea water sulfate during Jurassic. This value also agrees well with the average value for Jurassic crude oil sulfur(Fig 19).

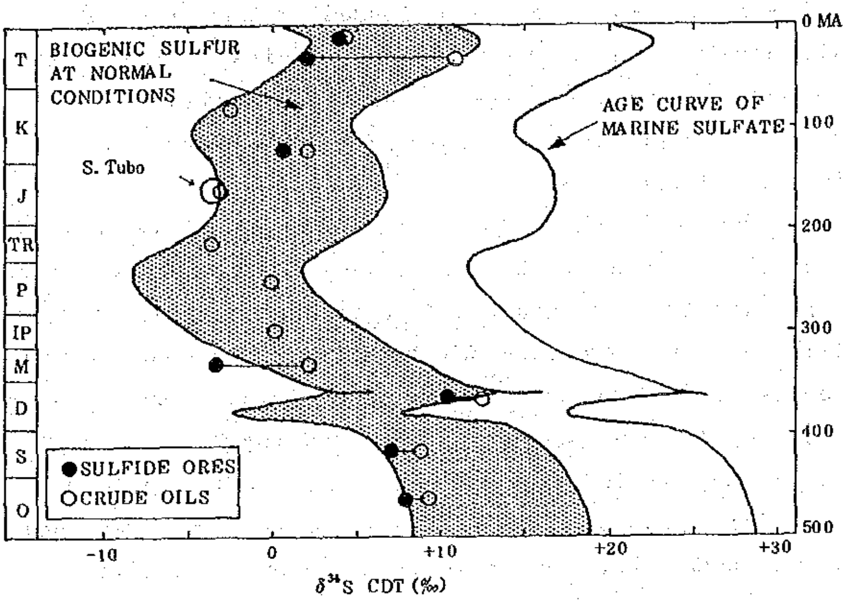

Fig.19 Sulfur isotopic fraction of S.Tuboh on a chart of stratabound massive sulfide and crude oil in phanerozoic eons

ii) Isotope temperature

If, as described above, the origin of the ore sulfur in the mineralized zone of S.Tuboh area is biogenic, deriving from sea water sulfate in Jurassic, a temperature obtained by geothermometer must be seen as the recrystalization temperature (or metamorphose temperature) at the time of skarn formation.

The sulfur isotope temperatures obtained from the $\delta^{34}S$ values are shown in Table 7. There is no constant agreement. That is because there is usually noticeable isotope zoning in the coarse crystal, and even with the sample of sphalerite and galena taken from the same specimen, there is no gurantee that these values are of simultaneously deposited parts.

Consequently, the value of 430℃ obtained from the average value of $\delta^{34}S$ is taken as a guide to the recrystallization temperature(Table 7). This value matches well with the temperature measured for most skarn deposits.

Table 7 Sulufur isotopic temperature by $\delta^{34}S$ values

sample	$\delta^{34}S$ values		isotopic temperature	remarks
	sphalerite	galena		
D-1	-3.5	-6.6	180°C	
D_2-1	-5.2	-4.1	unequilibrium	
D_2-2	-4.7	-5.3	760°C	
MJI-8	-2.5	-		
MJI-12	-3.1	-4.0	570°C	
MJI-13	-3.4			$\Delta\delta$ Sp-Gn =
				$(0.8\times 10^3)/T(°K^1/_2)$
Ave.	-3.7	-5.0	430°C	

This "recrystallization temperature" is also expressed by oxygen partial pressure-temperature relationship(Fig 20) of skarn minerals, and of andradite-hedenbergite in particular.

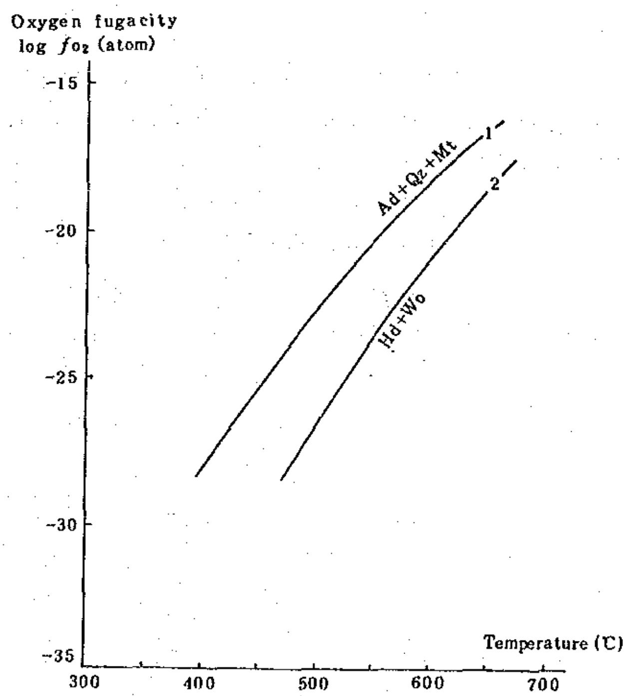

Fig.20 Relations of the between oxygen fugacity and temperaure for the paragenesis

The figure shows that in area where the oxygen partial pressure is high, the iron becomes Fe^{3+} and andradite is stable, while in area where it is low, the iron becomes Fe^{2+} and hedenbergite is stable. However the mineralized zones in the S.Tuboh area normally have both andradite and hedenbergite, and also magnetite and quartz. They should be a paragenesis on Ad + Qz + Mt line. However, in the slightly deeper mineralized zone in the S.Tuboh, combinations of magnetite-hematite, pyrrhotite-pyrite-magnetite also occur. These combinations are stable in area where the oxigen partial pressure is higher, and those sorts of condition have been maintained at the time of mineralization. What is important at this point is that the deeper part only differs by around 200m vertically, and so this show that incline grade in physical and chemical condition of mineralization in the S.Tuboh area is substantially large.

Character of these mineralization is generalized as shown in Fig.21

(6) Calculation of ore reserves and reserve potential

The ore reserves and grades are shown in Table 6. It is satisfying amount and grade for the first step of the exploration, expecting that S.Tuboh area has high potential in the ore deposit. Additional ore reserves is expected by the future exploration because there are many prospect area in and around the mineralized zones obtained.

A marble area from two mineral indications of S.Karing and S.Sepan to middle S.Nilau is also geologically promising mineralized area. More ore reserves might be obtained by survey covering in the area.

On the other hand, it is necessary to consider that the possible ore reserves is calculated by some undefined factors, such as continuation,width of mineralized units, variation range of grades, specific gravity of ore, and correlation of grade and specific gravity, because of first step calculation of the survey.

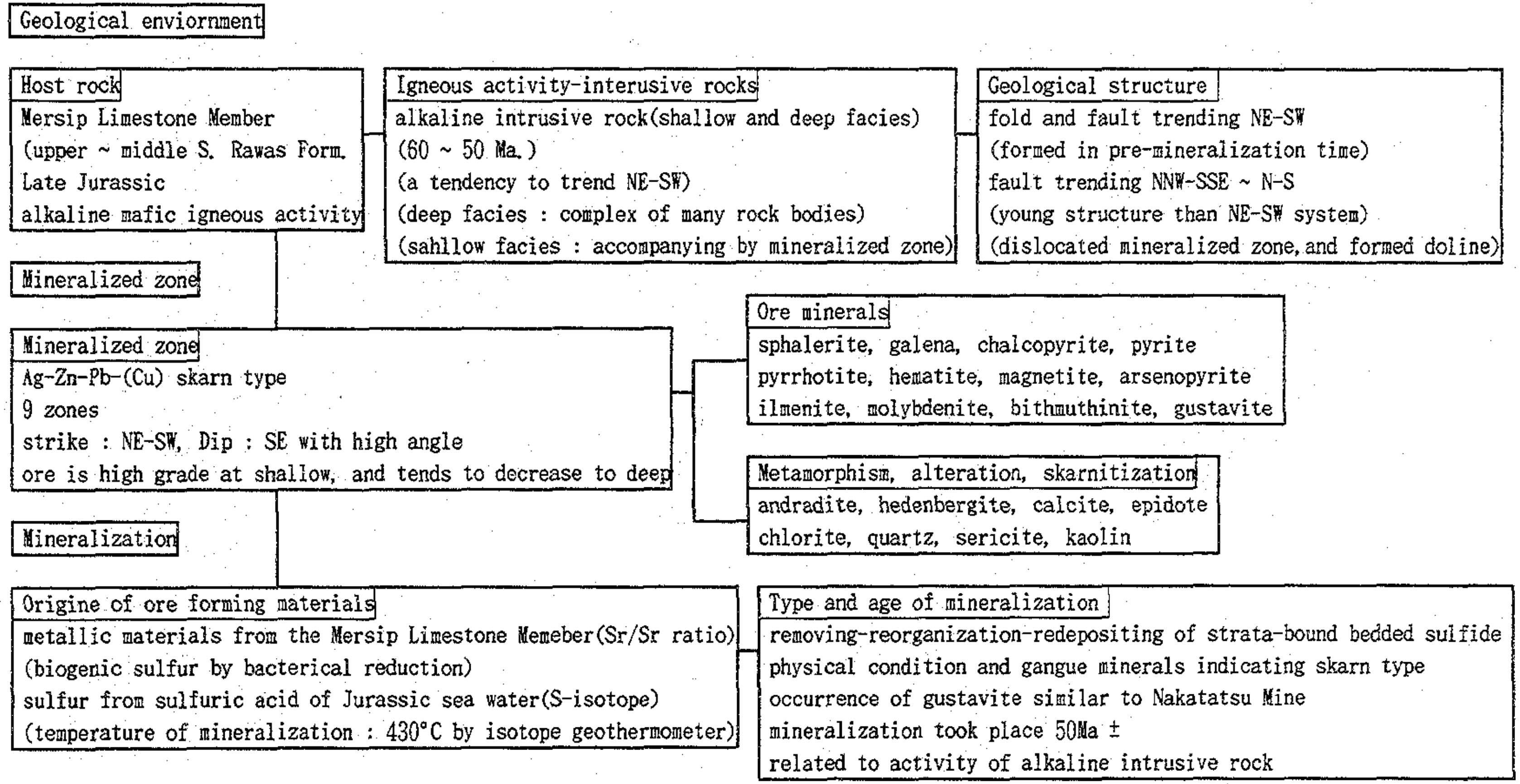

Fig. 21 Overall characteristics of mineralization in the S. Tuboh area

Part Ⅲ CONCLUSIONS AND RECOMMENDATION

PartⅢ CONCLUSIONS AND RECOMMENDATION

Chapter 1 Conclusion

The suevey results of geology, igneous activity, mineralization and ore reserves potential are concluded as follows ;

(A) The Mersip Limstone Member

① The Member is divided into three facies of P-1,P-2 and P-3, on the basis of their original composition. Namely P-1 is highly pure limestone, P-3 impure limestone, and P-2 composition in between P-1 and P-3.

② P-3 intercalates many thin layers of sandy, muddy and tuffaceous facieses, and contains often laminae and slumping structure, also water-escaped structure. The tuffaceous facies is mafic, and has frequently undergone serpentinization. P-3 contains also mafic lava, and yields coral-like fossil. From these facies and occurence, it may be inferred that P-3 sedimented on a shallow sea slope of mafic volcano, flowed by subaqueous sliding, and re-sedimented with P-1.

③ The sedimentary rock which be composed of mainly marble strikes NE-SW, and forms low-plunged syncline and anticline structure. The strike of NE-SW occurs within S.Tuboh and around area, in contrast to general strike of NW-SW in S.Rawas Formation in northwest part from S.Rawas. S.Tuboh area is structurally characterised by the NE-SW strike, cocurrent fault trending NE-SW, and young fault of N-S trend.

④ Around N-S-trend fault, caves are predominant under surface soil bed.

(B) Alkalline intrusive rocks

⑤ The alkaline intrusive rocks are divided into large-scale deep facies and small-scale shallow facies. The latter coexists with mineralized zone.

⑥ The deep facies intruded by the igneous activity from early stage(60Ma) to later stage(≦ 50Ma). The rock is complex composing of alkaline gabbro, tonalite, quartz diorite, quartz monzonite and so on.

⑦ A barren skarn zone distributing along contact with the deep facies was emplaced at boundary between limestone and deep facies of early intrusive through metamorphism, metasomatism with contaminationn caused by later stage intrusion. This skarn is composed of grossular,vesuvianite,and diopside etc.