REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE KHUZDAR AREA OF BALUCHISTAN
THE ISLAMIC REPUBLIC OF PAKISTAN

PHASE III

NOVEMBER 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Islamic Republic of Pakistan, the Japanese Geovernment decided to conduct geological survey, geochemical survey and other work relevant for confirming the mineral potential of the Khuzdar Area and entrusted the survey to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Islamic Republic of Pakistan a survey team of four technical personnel headed by Mr.T.Ichinose from January 17, 1989 to August 4, 1989. The team conducted field work with the excellent cooperation of the Geological Survey of Pakistan and other concerned agencies of the Government of the Islamic Republic of Pakistan. The work was completed in accordance with the original plan.

This is the third and the last year since the project started in 1986 and the present report constitutes a part of the final report.

We wish to express our deep appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the team.

November 1989

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

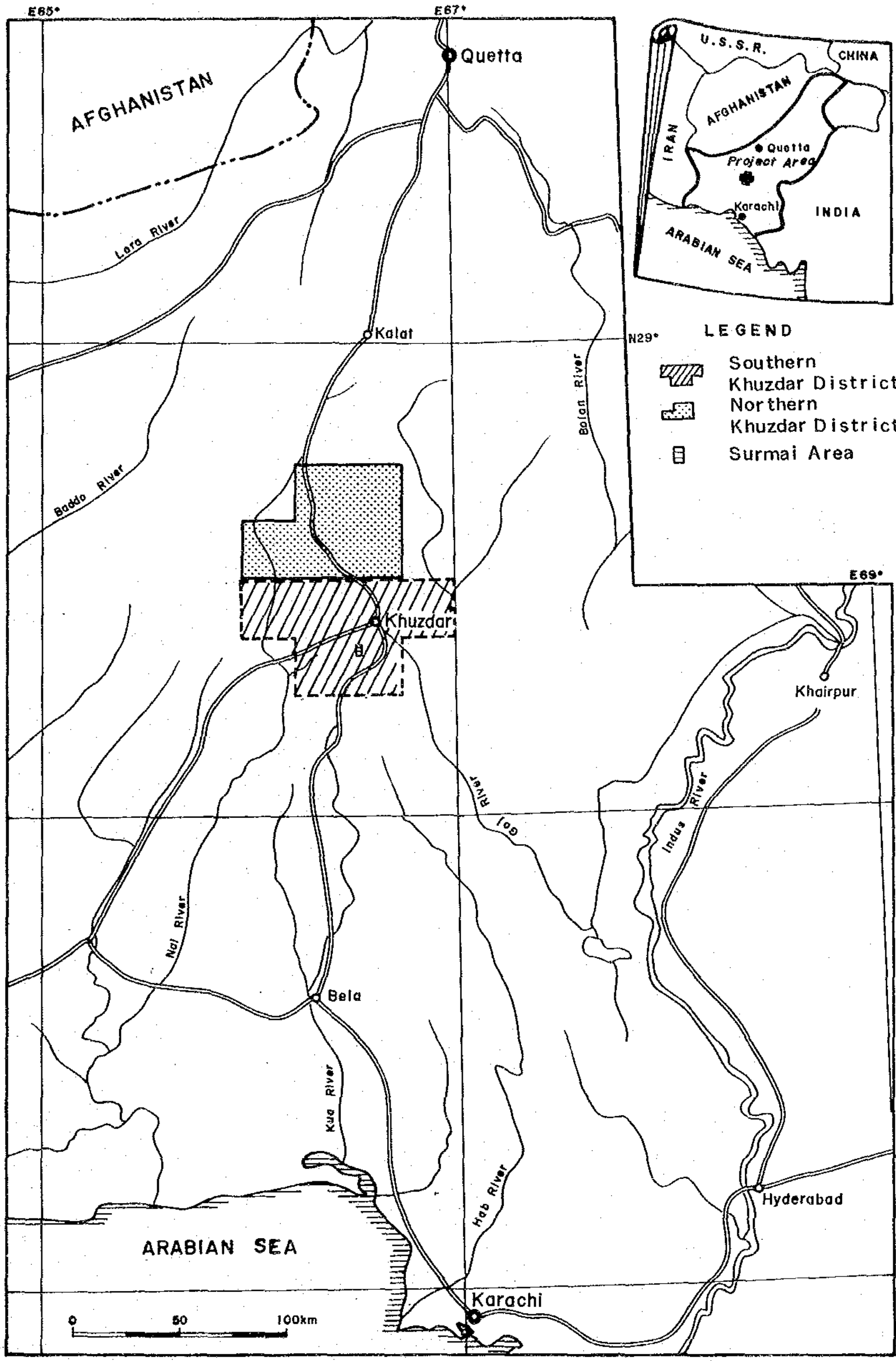


Fig. 1 Index Map of the Survey Area

SUMMARY

This report embodies the results of the work conducted during the third phase of the cooperative mineral exploration in the Khuzdar District of the Islamic Republic of Pakistan. The objective of the work is to clarify the state of the Mississippi Valley type lead-zinc deposits distributed in the area by geological survey, geochemical survey, geophygical survey and drilling.

During the first phase, geological and geochemical survey was conducted in the Southern Khuzdar District and also detailed geological survey and gephysical prospecting were carried out in the Surmai Area. During the second phase, geological and geochemical survey was carried out in the Northern Khuzdar District and drilling was carried out in the Surmai Area. This drilling confirmed the existence of lead-zinc sulphide ores below the surface gossan (lead-zinc oxide zone).

During the third phase, drilling was continued in Surmai-I and III. Field work was carried out from January to August 1989. The results obtained are as follows.

(1) The horizons confirmed by the third phase drillng range from the lower part of Unit-I of Loralai Member to the upper part Unit-II of Anjira Member. The lithology of these units is mainly limestone and shale. They form alternation of unit beds of 0.2～10m thickness. The structure of the survey area is complex with folds and faults of varying dimensions.

(2) Of the nine holes drilled during the third phase, lead-zinc sulfide mineralization was confirmed in eight holes. The mineralized horizons are classified into three, namely A, B and C Horizons from the uppermost one. These horizons all occur in Units-II～III of Loralai Member. The mineralized zones are distributed in these horizons with varying vertical positions. The mineralized zones which are evaluated to be promising from

both size and grade occur in the A-Horizon.

(3) The mineralization is composed of powdery to granular sphalerite and galena which are disseminated replacing the limestone host rock and of siderite and calcite veins and veinlets which intersect the disseminated ore. Minor amount of pyrite and chalcopyrite is associated. Microscopic studies confirmed the existence of lead-zinc carbonates and electrum and also, although too minute to identify with certainty, indicated the probable existence of Pb-Bi and Pb-Sb silver minerals.

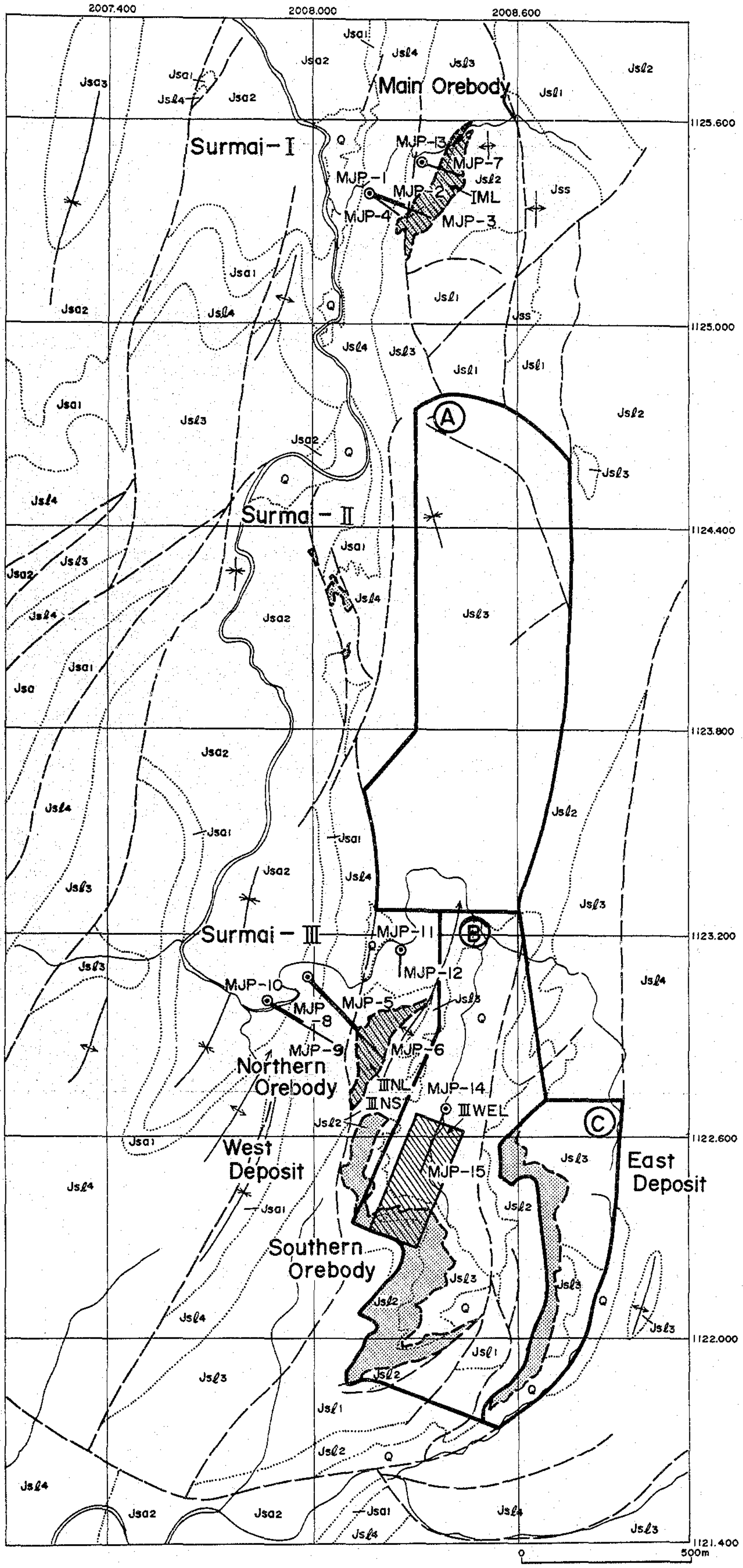
(4) The level of the water table is estimated to be approximately 100 m below the surface. The boundary between the oxide and sulfide ores is inferred to be at approximately 50 m below the surface.

(5) The location of the mineralized zones confirmed by the drilling of the present phase coincides with the geophysical (IP,SIP) PFE anomaly zones which were detected during the first phase with the exception of the traverses where the electrode intervals were excessive.

(6) Mining blocks were drawn and reserves calculated for the Surmai-I Main Orebody, Surmai-III Northern Orebody of West Deposit and Surmai-III Intermediate Orebody between West and East Deposits. These are in the possible reserve category and the total is 30,513,000t (Pb:0.66%, Zn: 2.13%, Ag:7.4g/t) of which 22,700,000t are sulfide and the balance of 7,813,000t oxide ores. The reserves sulfide of the small blocks within the above are 870,000t (Pb:2.03%, Zn:6.51%, Ag:23.4g/t). These reserves and grades are considered to be insufficient for commercial development at current world metal markets.

(7) There are three promising zones which warrant further exploration. They are vicinity of Surmai-III East Deposit, the zone between Surmai-III West and East Deposits and the area east of Surmai-II.

(8) The economic feasibility of the reserves calculated on the basis of the work of the past three years and laid out in (6), is cosidered to be low at present, but there are possibilities of more high grade ores being found by future prospecting. Therefore, it is desirable that drilling be continued in the mining blocks in order to ascertain the shape, grade, continuity and spatial extension of the mineralized zones and also that exploration with emphasis on drilling be carried out in the three zones with high resource potential laid out in (7). It is concluded that gold should be added to the objective of exploration.



Summary of the Survey in the Surmai Area

Methods	Contents
Geological Survey	10 Km^2
Geochemical Prospecting	10 Km^2, 205 samples
Geophysical Prospecting	IP : Line ; 7.8 Km, Points ; 420
	SIP : Line ; 8.2 Km, Points ; 410
Drilling	15 holes, Total Length : 5,012.8 m

Ore Reserve

Surmai- I

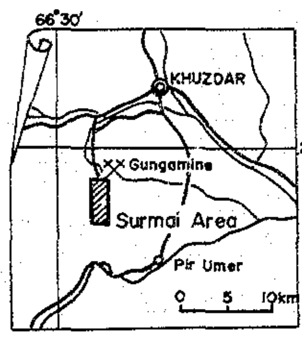
Name of Block	Tonnage (1,000 t)	Grade			
		Pb (%)	Zn (%)	Ba (%)	Ag (g/t)
I ML	6,531	0.40	1.51	<0.01	6.6

Surmai-Ⅲ

Name of Blocks	Tonnage (1,000 t)	Grade			
		Pb (%)	Zn (%)	Ba (%)	Ag (g/t)
ⅢNL, ⅢNS	9,321	0.68	3.06	0.02	6.8
ⅢWEL	14,661	0.76	1.98	<0.01	8.1

Promising Zone for Future Prospecting

Ⓐ East of Surmai-II
Ⓑ Zone between West and East Deposits
Ⓒ Vicinity of East Deposit



LEGEND

LOWER JURASSIC Shirinab Formation

Q	Alluvium
Jsa_3	Anjira member-Ⅲ
Jsa_2	Anjira member-II
Jsa_1	Anjira member- I
Jsl_4	Loralai member-Ⅳ
Jsl_3	Loralai member-Ⅲ
Jsl_2	Loralai member-II
Jsl_1	Loralai member- I
Jss	Spingwar member

Minaralization

Anticline

Syncline

Fault

Bedding traces

Drilling site

Area of Ore Reserve

Fig. 2 Generalized Map of Survey Results in Surmai Area

CONTENTS

Note

"DISTRICT" will be use instead of "AREA" for Khuzdar in order to avoid confusion with area of Surmai area.

Figures

Tables

Photographs

Appendices

Plate

Phot. -1 Survey Team

1. Mr. Subhani
2. Mr. Bhagwandas
3. Mr. Ichinose
4. Mr. Kawamura
5. Mr. Sasaki
6. Mr. Wakamatsu

PART I

O V E R V I E W

PART I OVERVIEW

CHAPTER 1 INTRODUCTION

1 - 1 Background of the Survey

The Japanese Government, in response to the request of the Government of the Islamic Republic of Pakistan (henceforth Pakistan) to conduct mineral exploration, sent a mission to consider the ways and means of implemen-tation and upon its recommendations, concluded the Scope of Work (S/W) with the Pakistan Government regarding mineral exploration in Khuzdar District of the State of Baluchistan in October 1986. The S/W stipulates that the objective of the survey is to determine the mineral potential of the area with work comprising geological survey, geochemical prospecting, geophysical prospecting and drilling.

On the basis of this S/W, it was agreed that the work of the first phase would consist of the following activities. Geological and geochemical reconnaissance survey of Jurassic limestone area in the vicinity of Khuzdar Town•••1,350 km^2 (Southern Khuzdar District, in six 1:50,000 topo-graphic sheets; the total area of the six maps 3,900 km^2) together with detailed geological survey and geochemical prospecting of Surmai Area (10 km^2) where the occurrence of lead-zinc mineralization is known. Also geophysical prospecting of the Surmai Area and its vicinity was planned. MMAJ organized a survey team consisting of seven experts and conducted field work from December 1986 to April 1987 and completed the report of the first phase in June 1987.

During the second phase, field work was conducted in accordance with the conclusions and recommendations of the first phase. Geological, geochemical investigation and drilling (six holes, 2,250 m) of the Jurassic limestone area of 940 km^2 (Northern Khuzdar District, in five 1:50,000 topographic sheets; the total area of the five sheets, 3,250 km^2) was planned. The area is located to the north of the survey area of the first phase in the Khuzdar District. The work was carried out from November 1987 to August 1988 and the report of the second phase was completed in October 1988.

On the basis of the results of the second phase survey, drilling nine holes totaling 2,750 m in length in the Surmai Area was recommended for the third phase. This was carried out during January to August 1989.

The summary of survey results in the Surmai Area is shown in Fig.2.

1 - 2 Conclusions and Recommendations of the Phase I Survey

1 - 2 - 1 Conclusions of the Phase I Survey

1 - 2 - 1 - 1 Southern Khuzdar District

(1) The Jurassic limestone in this area is the Shirinab Formation which is of Early Jurassic age. This formation comprises, in ascending order, Spingwa Member consisting mainly of calcareous sandstone, Loralai Member composed of limestone-shale alternation and Anjira Member.

(2) The general trend of the geologic structure of Shirinab Formation is N-S to NNW~SSE in the southern and eastern parts and it changes to E-W to NE-SW in the northern and western parts. This trend is strongly affected by the large-scale structhure of the Khuzdar Knot. The members have complex folded structure of anticlines and synclines with the trend of their axes conforming to the general geology.

(3) Mine prosepects Malkhor, Ranj Laki, East Sekran and Sekran as well as Gunga and Surmai occur in a narrow zone extending 25 km in the central part. It is considered that these were formed by Mississippi Valley type mineralization associated with ophiolite activities. All of these showings crop out as gossan, but it is inferred that primary sulfide ores exist below the water table. The major constituents are lead-zinc-barite in Gunga and lead-zinc in other prospects.

(4) All mineral showings are combinations of bedded mineralization replacing the host rock along the bedding planes and those filling the fissures and faults. Of the bedded mineralization, that of Gunga occur in the Anjira Member and those of other areas in Loralai Member, while the fissure-filling type occur throughout the Shirinab Formation. From the grade and size, the bedded type seems more promising.

(5) There are four mineral showings in the Malkhor～Sekran mineralized zone. These all show evidences of intense mineralization and some parts appear to have promising lower portions. But the structures are very complex and the subsurface continuity is not clear.

(6) The results of geochemical prospecting show that elements Pb, Zn, Hg show high positive correlation to each other and form anomalous zones around gossan while Ba forms anomalous zone outside of the Pb, Zn, Hg zone. This fact indicates, that geochemical prospecting is effective for delineating the promising zones regarding the occurrence of Mississippi Valley type lead-zinc mineralization in this area. Lead, zinc, mercury anomalous zones of A-rank were found in Surmai Area and also in the vicinity of Malkhor～Sekran showing. It is concluded, therefore, that further detailed geological and geophysical investigation of the Malkhor～Sekran mineral showing is warranted.

1-2-1-2 Surmai Area

(1) In this area, three members of the Shirinab Formation are distributed and the Loralai Member is divided into I～IV Units and the Anjira Member into three, I～III Units.

(2) The structural trend of this area is north-south and the eastern half is the uplifted zone with anticlinal structure while the western part is the subsided zone with synclinal structure.

(3) There are three mineral showings consisting of gossan, the weathered

product of lead-zinc mineralization, along the uplifted zone. They are called Surmai-Ⅰ, Ⅱ, Ⅲ from the north. These showings are considered to be of Mississippi Valley type mineralization. The mineralization of these showings is a combination of replacement along the bedding of host rock and fissure filling. The bedded type is seen in Surmai-Ⅰ, Ⅲ and large-scale mineralization is developed in Loralai Units Ⅱ and Ⅲ. The fissure filling type is distributed in Surmai-Ⅱ and in the vicinity of the bedded type, but they are of small scale and are not promising. The mineralized parts with good structural and geochemical indications on the surface and in deeper parts are located in the lower parts of the Main Orebody of Surmai-Ⅰ and at the northernmost part of the westward dipping west ore deposit (henceforth: Northern Orebody of West Deposit) of Surmai-Ⅲ.

(4) The results of geochemical prospecting showed high positive correlation among Pb, Zn, Hg in the high anomalies around gossan and with Ba on its outerside. This is similar to the results of the Southern Khuzdar District.

(5) Geophysical prospecting showed A-rank anomalies believed to be caused by sulfide minerals in the lower parts of the Main Orebody of Surmai-Ⅰ and the Northern Orebody of West Deposit of Surmai-Ⅲ.

(6) From the above results, the lower parts of the Main Orebody of Surmai-Ⅰ and the Northern Orebody of West Deposit of Surmai-Ⅲ are the two localities where ore deposits, particularly the lead-zinc sulfide deposits are anticipated.

1-2-2 Recommendations of the Phase Ⅰ Survey

1-2-2-1 Southern Khuzdar District

(1) Geological reconnaissance and geochemical prospecting in the Jurassic limestones outside of the designated area : It was proven by the work of the first phase that geochemical prospecting is very effective for exploration of the Mississippi Valley type mineralization in this area.

It was recommended that geological reconnaissance together with geochemical prospecting be conducted in the Jurassic limestone area not included in the survey of the first phase. This would delineate new promising areas.

1 - 2 - 2 - 2 Surmai Area

(1) Drilling in Surmai-I and III : The geological survey showed that the surface indications of the Main Orebody of Surmai-I and the Northern Orebody of West Deposit of Surmai-III were the most promising in the area. And continuation of the mineralized zones to the lower parts can be expected from the geological structure. Also the geophysical work showed A-rank results for the lower parts of these two prospects. It was recommended that drilling aimed at the lower parts of the two prospects be carried out in order to confirm the continuation of the mineralization and the change from oxide to sulfide mineralization.

1 - 3 Conclusions and Recommendations of the Phase II Survey

1 - 3 - 1 Conclusions of the Phase II Survey

1 - 3 - 1 - 1 Northern Khuzdar District

(1) The Jurassic limestone of this district consists of the Early Jurassic Shirinab Formation. This formation is subdivided into Spingwar Member consisting of calcareous sandstone, Loralai Member consisting of limestone and shale alternation, and Anjira Member in ascending order.

(2) The Shirinab Formation is distributed largely in eight zones, and it extends in east-west direction gently protruding northward, in conformity with the large scale structure of Khuzdar Knot. The members of this formation show complex anticlinal and synclinal structure with axes along the above direction.

(3) The mineral showings are distributed around the ophiolite zone in

the Surmai~Sekran Zone. This zone is located in the southwestern part of the Southern Khuzdar District. The area surveyed during this second phase lies on the outerside of the Surmai~Sekran Zone, and mineral showings were not observed.

(4) The results of the second phase geochemical prospecting did not yield promising anomalous zones. The highest rank for the overlapping anomalous zones was C for barium and the lead-zinc zones were ranked the lowest E. The lead-zinc anomalous zones, which include the mineral showings of the Surmai~Sekran Zone, are distributed around the ophiolite zone and the barium anomalous zones occur on the outer side of the lead-zinc zones. These are in the southwestern part of the first phase area. The lead-zinc zones with rank E in the southernmost part of second phase area are located in the northernmost part of the anomalous zone.

(5) The study of all geochemical data, obtained by this project during the last two phases, clearly shows that the promising geochemical anomalies all exist in the first phase area, the Surmai~Sekran Zone.

(6) Thus, it is concluded that the mineral potential of the Northern Khuzdar District is very low.

1-3-1-2 Surmai Area

(1) The units confirmed by drilling to contain mineralized zones range from the lower Loralai Unit-I to the higher Anjira Unit-I. The rocks of these units are mainly limestone and shale with minor amount of two types of limestone, shale and marly shale alternation. These four types of rocks form alternation with individual beds of 0.2~10 m thick.

(2) The geologic units of the drilled area dip 60°~70° westward with gentle folding in both Surmai-I and III areas. Also the central part dips steeply westward and a fault with 300~400 m displacement intersects the formation.

(3) Mineralized zones of lead-zinc sulfides considered to be of Mississippi Valley type were confirmed by five drill holes MJP-2～6 aimed at the lower parts of the oxide outcrops. The only hole which did not intercept a mineralized zone was MJP-1. The mineralization consists mainly of disseminated powdery to granular sphalerite and galena in limestone, and siderite and calcite vein～veinlets which intersects the above.

(4) The stratigraphic horizon of lead-zinc mineralization is the same in all drill cores as well as for the outcrops. Thus it is clear that the mineralization is stratigraphically controled. The mineralized horizons confirmed by drilling are all in Loralai Unit-II and are divided into A, B, C in descending order.

(5) The distribution of the lead-zinc sulfides is controled by the water table at about 100 m depth and the fault mentioned in (2).

(6) The promising mineralization confirmed in Surmai-I area is that located by MJP-3, at depth 169.1～172.9 m (approximately 180 m below surface) in A Horizon, it is 3.8 m wide with grade of Pb+Zn 5.11 %. Those in Surmai-III occur at two depths in MJP-6, in A Horizon, 168.5～172.4 m and 185.6～188.1 m (approximately 140 m below surface) and they are 3.9 m wide, Pb+Zn 9.60 % and 2.5 m wide, Pb+Zn 6.87 %.

(7) In the Surmai-I area, the mineralization zone confirmed by MJP-3 corresponds to the PFE anomaly detected in geophysical traverse C(IP,SIP) carried out during the first phase. Also mineralized zone was con-firmed by MJP-6 in Surmai-III area at a location where geophysical anomalies were not very clearly detected. It is inferred that the reason for not detecting this mineralized zone is that the length of the inter-vals in Surmai-III was too long (100 m in Surmai-III and 50 m in Surmai-I areas).

(8) The mineralization in the A Horizon of both Surmai-I and III is promising in both grade and scale. Their development is anticipated. The mineralization in B and C Horizons is small and discontinuous, but as high grade parts exist, we recommended the prospecting to be continued.

1 - 3 - 2 Recommendations of the Phase II Survey

1 - 3 - 2 - 1 Surmai Area

(1) Drilling in Surmai-I and III : During the work of the second phase, lead-zinc sulfide mineralized zones were confirmed by drilling in the lower parts of the Main Orebody of Surmai-I and of the Northern Orebody of West Deposit of Surmai-III. It was recommended that drilling be carried out in the vicinity of the findings of this year to confirm the shape, grade, continuity and the feasibility of developing these zones.

1 - 4 Outline of the Phase III Survey

1 - 4 - 1 Survey Area

The area of the Phase III Survey is located to the south of the central part of Pakistan as shown in Figure I and Figure I -1-1. The coordinates are as follows.

(1) Surmai Area

[Latitude]	[Longitude]
27° 43′ 17″ N	66° 31′ 26″ E
27° 43′ 17″	66° 32′ 41″
27° 40′ 37″	66° 31′ 38″
27° 40′ 37″	66° 32′ 51″

The area of the Surmai Area is included in five topographic sheet (1:50,000 scale), No.35-I/10, published by the Survey of Pakistan.

1 - 4 - 2 Objective of the Survey

During the second phase, lead-zinc sulfide mineralization was confirmed by drilling below the surface gossan at Surmai-I Main Orebody and Surmai-III the Northern Orebody of West Deposit. The objective of the drilling of the third phase is to confirm the mode of ore occurrence in the vicinity of the above zones and also of the intermediate zone between the West and the East Deposit. Also the examination of the mineralization processes by detailed study of the geochemical characteristics and the detailed geologic structure of the Surmai Area is a matter of great relevance to the project.

1 - 4 - 3 Methods and Contents of the Survey

(1) Surmai Area

Drilling, MJP-7～15 (9 holes) total length	2,757.0 m

(2) Laboratory studies

Thin sections	10 samples
Polished sections	30 samples
Chemical analysis (ores)	141 samples
Elements: Pb, Zn, Ba, Ag (564 analysis)	

1 - 4 - 4 Organization of the Survey Team

(1) Planning and Coordination

Japanese Side		Pakistan Side	
Name	Office	Name	Office
Hiroshi Shimotori	MMAJ	A.H.Kazmi	Director General of GSP
		M.Ishaque Durrazai	GSP

(2) Field Survey

Japanese Side			Pakistan Side		
Name	Work	Off.	Name	Work	Off
Tsutomu Ichinose	Team Leader	NED	A.Mahmood Subhani	Team Leader	GSP
Yukio Kawamura	Dril.	NED	S.Mukhtar Zaidi	Geol.,Geoc.,Dril.	GSP
Mitsuo Sasaki	Dril.	NED	Bhagwandas	Geol.,Geoc.,Dril.	GSP
Masaya Wakamatsu	Dril.	NED	M.Dawood Khan	Geol.,Geoc.,Dril.	GSP

(NB) GSP : Geological Survey of Pakistan
MMAJ : Metal Mining Agency of Japan
NED : Nikko Exploration & Development Co., Ltd.
Off. : Office Geol.: Geological survey
Dril.: Drilling Geoc.:Geochemical survey

1 - 4 - 5 Period of the Survey

The Phase III Survey was conducted from 11 January 1989 to 20 November 1989. The field work was carried out during the following period.

Drilling survey; from 7 January 1989 to 4 August 1989

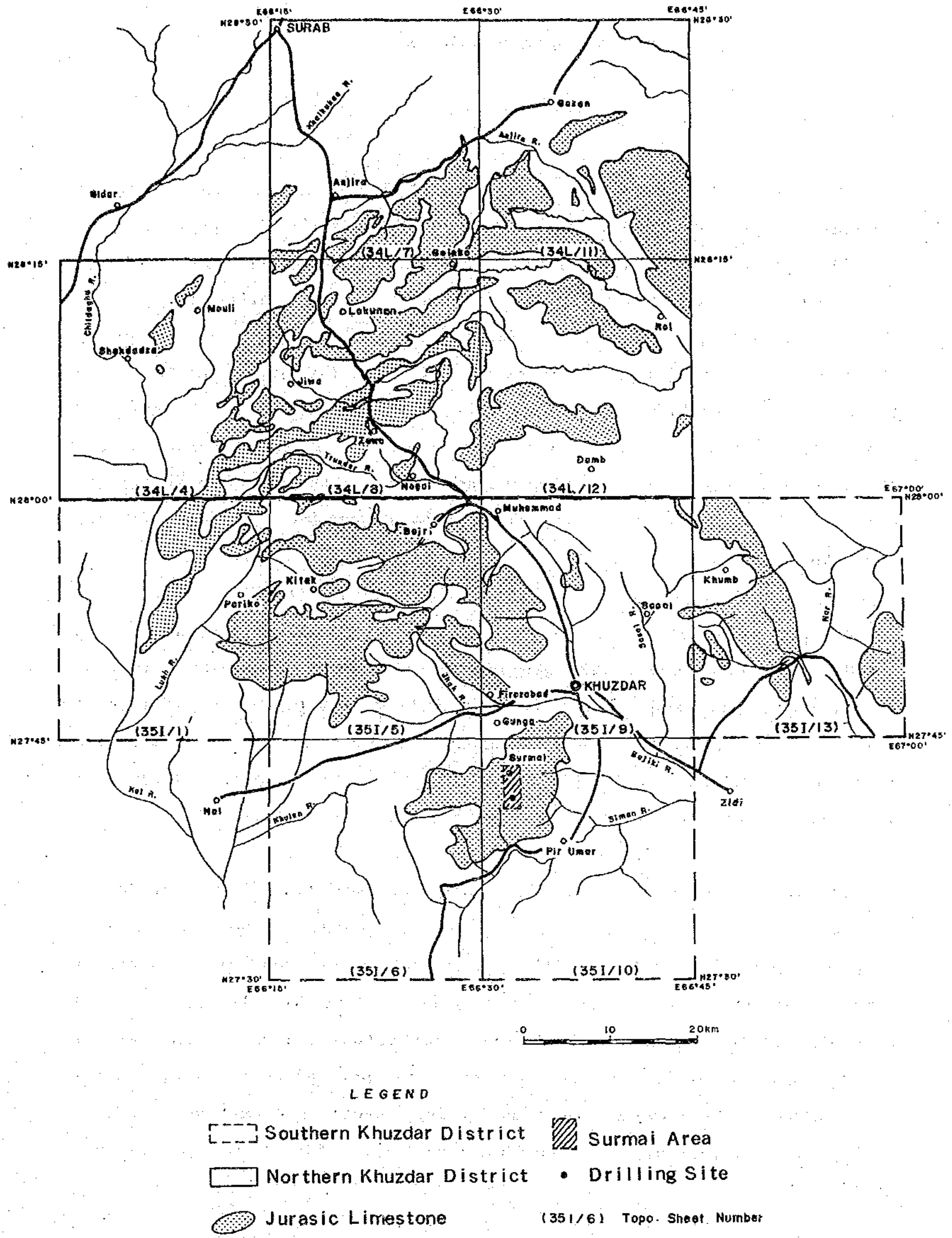


Fig. I-1-1 Location Map of the Survey Area

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

2 - 1 Morphology and Drainage

The Khuzdar District is located near the centre of the State of Baluchistan of western Pakistan. The Town of Khuzdar with a population of 20,000 is located at the centre of the southern Khuzdar District. Daily provisions are available in this town. Surmai Area is located approximately 15 km southwest of Khuzdar Town and it takes approximately 45 minutes by car. Quetta, the capital of the State is about 270 km to the north and Karachi lies approximately 350 km to the south. Travel time is about five hours to Quetta and seven hours to Karachi by car. Karach-Khuzdar-Quetta air route was opened since 1988 and there are three frights per week. The fright time from Khuzdar is 1 hour 40 minutes to Karachi and 1 hour 10 minutes to Quetta.

The elevation of the plains is around 1,200 m and the highest peak is 2,100 m above sea level. The geology of the vicinity consists mainly of Jurassic and Cretaceous calcareous sedimentary rocks. The topography is steep reflecting the intense folding and faulting. The Cretaceous limestone overlying the Jurassic limestone often forms small mountains of 300～500 m in height and their peripheries are steep cliffs.

The Khuzdar District is located in the vicinity of the uppermost stream of Nal, Kua, Hab, Goji and several other rivers which flow southward for 300～400 km into the Arabian Sea. The trend of the drainage system in the eastern part of the survey area is north-south consisting of the tributaries of the Nal River while that of the central to the western part is east-west formed by Anjira River, the upstream Goji River, and its tributaries. The rivers are usually dry, wadi, but during rain they become muddy streams in very short time.

The official language is Urdu and English. The mountain people speak Buluchi, and Urdu is often not understood. The people are pious Moslems and are honest.

2 - 2 Climate and Vegetation

The climate is largely divided into summer, April～October, and winter, November～March. During the hottest season of May～August, the temperature exceeds 40°C in the shade and reaches 50°C in the sun. The minimum temperature drops below freezing during December～January. Mid June～mid August is the monsoon season and it often rains heavily with strong winds, but other seasons are dry. The annual rain fall is around 150 mm and the humidity is about 50 %. Meteorological data are not available for the area. Those of Jacobabad which has similar climate and is located about 150 km east of the survey area, are laid out in Table I-2-1. The survey area is rock desert and vegetation consists of sparse and small shrubs along wadis and sparse grass on the flat land and mountains.

Table I-2-1 Average Monthly Temperature and Rainfall at Jacobabad

Month	1	2	3	4	5	6	7	8	9	10	11	12	Av./Y
Temp. (°C)	14.9	18.3	24.2	30.3	34.7	37.0	35.0	33.6	31.9	27.9	22.0	16.8	27.2
Rf. (mm)	7.8	3.8	6.2	1.6	4.6	4.6	38.5	5.9	0.3	3.3	1.3	2.9	93.9

By Rika nenpyo(1988), Average of 1951～1980 (NB) Av. Average

Temp. Temperature

Rf. Rainfall

CHAPTER 3 GENERAL GEOLOGY

3 - 1 Geologic Setting

3 - 1 - 1 Outline of the Geology of Pakistan

The Indian Subcontinent which separated from Gondowana in Late Cretaceous drifted northward and collided with the Asian Continent during Eocene. This formed a vast fold zone represented by the Himalayas and a thrust zone extending parallel to the folding causing the most violent diastrophism in earth's history. The geology of Pakistan clearly reflects this diastrophic event.

The east-west trending fault and the fold zone between the two continents in the Himalaya region forms syntaxis protruding northward and at Kashmir of Pakistan in the west and Nepha of India in the east and curves southward in between. The western fault and fold zone which extends southward along the western side of Pakistan is divided into the marginal zone called the Pakistan Axial Belt and the Major Fold Belt. The Axial Belt is connected to the Owen Fracture Zone which is the transform fault extending north-south in the Arabian Sea. The geology of Pakistan is largely divided into the Indo-Pakistan Plate, namely the Indian shield and the overlying shelf sediments to the east, and the Lut-Afghan Block consisting mainly of Tertiary flysch sediments to the west of the Axial Belt.

The Khuzdar District belongs to the Kirthar Fold Belt which is a branch of the Major Fold Belt in its southern part. The geology consists of Mesozoic to Tertiary sediments and ophiolite. The Kirthar Fold Belt extends from near Karachi in the south to the vicinity of Khuzdar in the north for approximately 400 km. This fold belt has a general north-south trend, but it changes abruptly to east-west direction at Khuzdar. Thus,the vicinity of Khuzdar is called Khuzdar Knot in structural classification. Low temperature hydorothermal lead-zinc-barite deposits (Mississippi

Valley type) controled stratigraphycally occur in the Mesozoic carbonates near the above ophiolite. The geology, geologic structure and the distribution of Mississippi Valley type lead-zinc-barite deposits are shown in Figure I -3-1.

3 - 1 - 2 Outline of the Geology of Khuzdar District and Surmai Area

(1) Khuzdar District

The major geologic units of the Khuzdar District are Jurassic~ Cretaceous calcareous sedimentary rocks. The Jurassic system consists of Shirinab Formation said to be Early-Middle Jurassic. It is subdivided, in ascending order, into Spingwar Member, mainly calcareous sandstone; Loralai Member, mainly alternation of limestone and shale; and Anjira Member. The Cretaceous system of the area consists of, in ascending order, Goru and Sembar Formations of the early stage and the Parh Formation and Pab Sandstone of the later stage. The Goru and Sembar Formations are limestone containing marl and the Parh Formation is chert containing limestone. The Tertiary system consists of the Jamburo Group made up of limestone and shale with sandstone in the basal part. This group is considered to be Eocene. Also melangé is distributed in a limited area and it is considered to be a part of ophiolite belt. A simplified geological map including the mineral showing of the northern and southern Khuzdar District is laid out in Figure I -3-3 and the stratigraphy of the vicinity of Khuzdar is shown in Figure I -3-2.

The geology of the Khuzdar District, reflecting the structure of Khuzdar Knot, show an east-west structure with northward protrusion at the central part of southern Khuzdar. The Jurassic Shirinab Formation which is the target of the present survey is distributed in the above structural direction in the northern and southern Khuzdar District in eleven rock bodies numbered I ~ XI. It is intensely folded locally, but these rock bodies each have anticlinal structure with lower horizons exposed at the central part.

Showings of Mississippi Valley type lead-zinc deposits occur in eight localities within a narrow zone 2 km wide and approximately 25 km long (Surmai～Sekran zone). They are in the above Ⅳ to Ⅱ rock bodies.

(2) Surmai Area

Three members of the Shirinab Formation are distributed in the Surmai Area. The Loralai Member was divided into Ⅰ～Ⅳ and the Anjira Member into Ⅰ～Ⅲ from the characteristics of the stratigraphy of the area. The stratigraphic column of this area is shown in Figure Ⅰ-3-4 and the geological map and cross sections including the drilling site are laid out in Figures Ⅰ-3-5～7.

There are three mineral showings, Surmai-Ⅰ, Ⅱ, Ⅲ in a 4 km zone in north-south direction. These showings consist of dark reddish brown gossan and occur in all members of Shirinab Formation with the exception of Anjira Ⅲ (Figs. Ⅰ-3-5～7). Gossan consists of porous to massive oxide composed mainly of limonite. The gossan occurs in thick bedded form replacing the host rock along the bedding. It occurs from the upper part of Unit-Ⅱ to the lower part Unit-Ⅲ of Loralai Member. Large scale gossan occurs in Surmai-Ⅰ and Ⅲ. Many small gossans occur along faults in Surmai-Ⅱ, but they are not promising.

3-2 Previous Surveys

The published systematic geologic map of the State of Baluchistan is the "Reconnaissance Geology of Part of West Pakistan" a 1:253,440 scale geologic map published by Hunting Survey Co., Ltd. in 1961 [henceforth HSC map (1961)]. In this map, the Jurassic limestone accompanied by shale and sandstone was lumped together as Zidi Formation.

In 1977, the GSP correlated the Jurassic system of the area to Early-Middle Jurassic and named it the Shirinab Formation and further subdivided it to Spingwa, Loralai and Anjira Members in ascending order (Geology of Pakistan; GSP, 1977) and is using this as the basis for geologic mapping of the State.

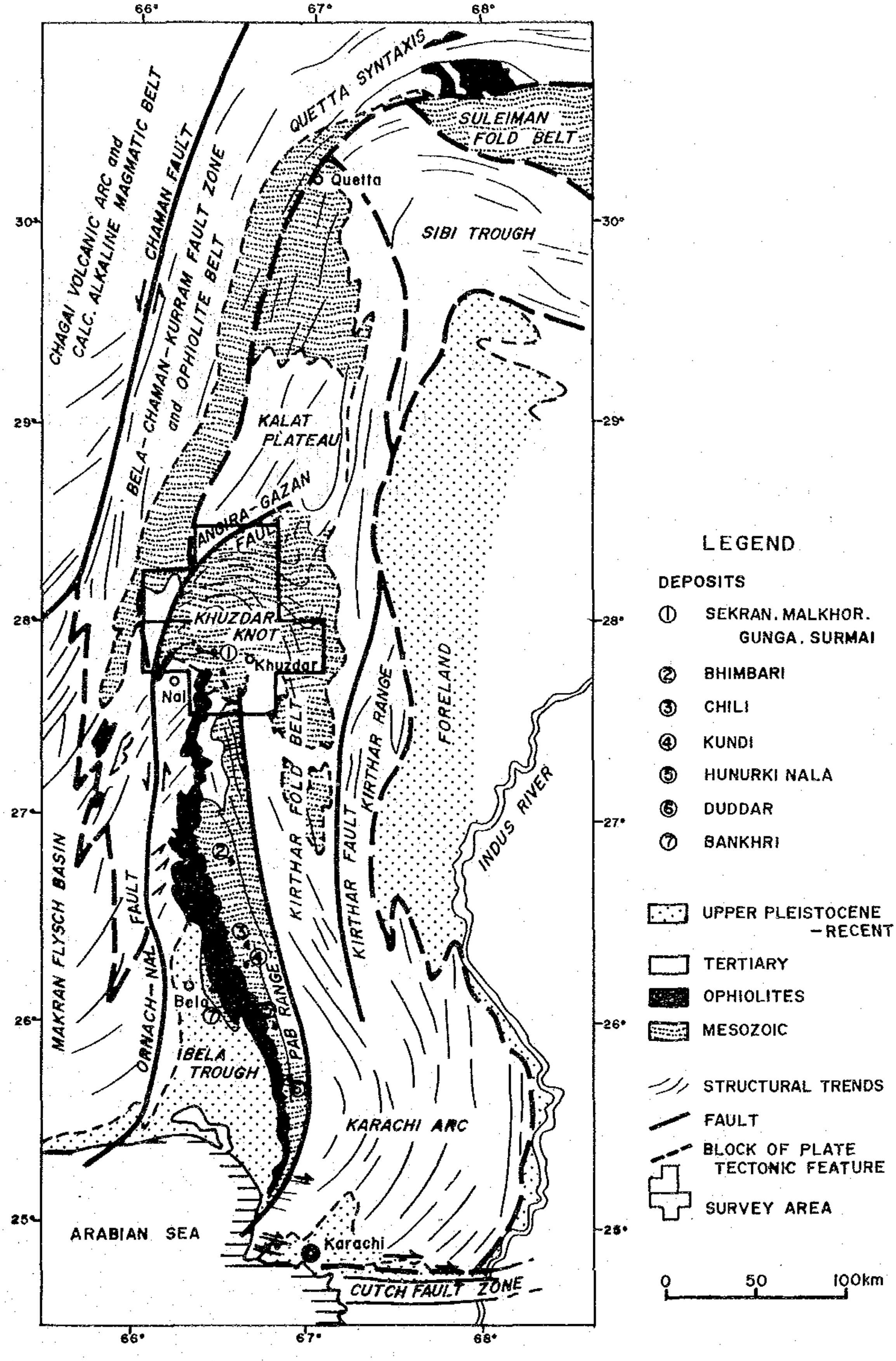


Fig. I-3-1 Geology, Structural Features and Distribution of Mississippi Valley Type Pb-Zn-Ba Deposits in the Vicinity of the Survey Area

Fig. I-3-2 Geological Stratigraphy of Khuzdar District

Geologic age		Hunting Survey Corp. (1961)		Cooperative Exproration (1987)		Thick-ness	Lithology
Tertiary		Jamburo group		Jamburo group		+100	Ls, shale, ss
Cre-taceos	Late	Parh series	PabS. s.	Pab Sandstone		+490	Sandstone
	Late	Parh series	Parh group	Parh Limestone		+270	Ls, chert
	Early	Parh series	Parh group	Goru formation & Sembar formation		+540	Marl, ls
Jura-ssic	Late	Zidi formation					
	Mid	Zidi formation					
	Early	Zidi formation		Shirinab formation	Anjira member	+290	Ls, shale
	Early	Zidi formation		Shirinab formation	Loralai member	+380	Ls, shale
	Early	Zidi formation		Shirinab formation	Spingwar member	+240	Ss, shale, ls

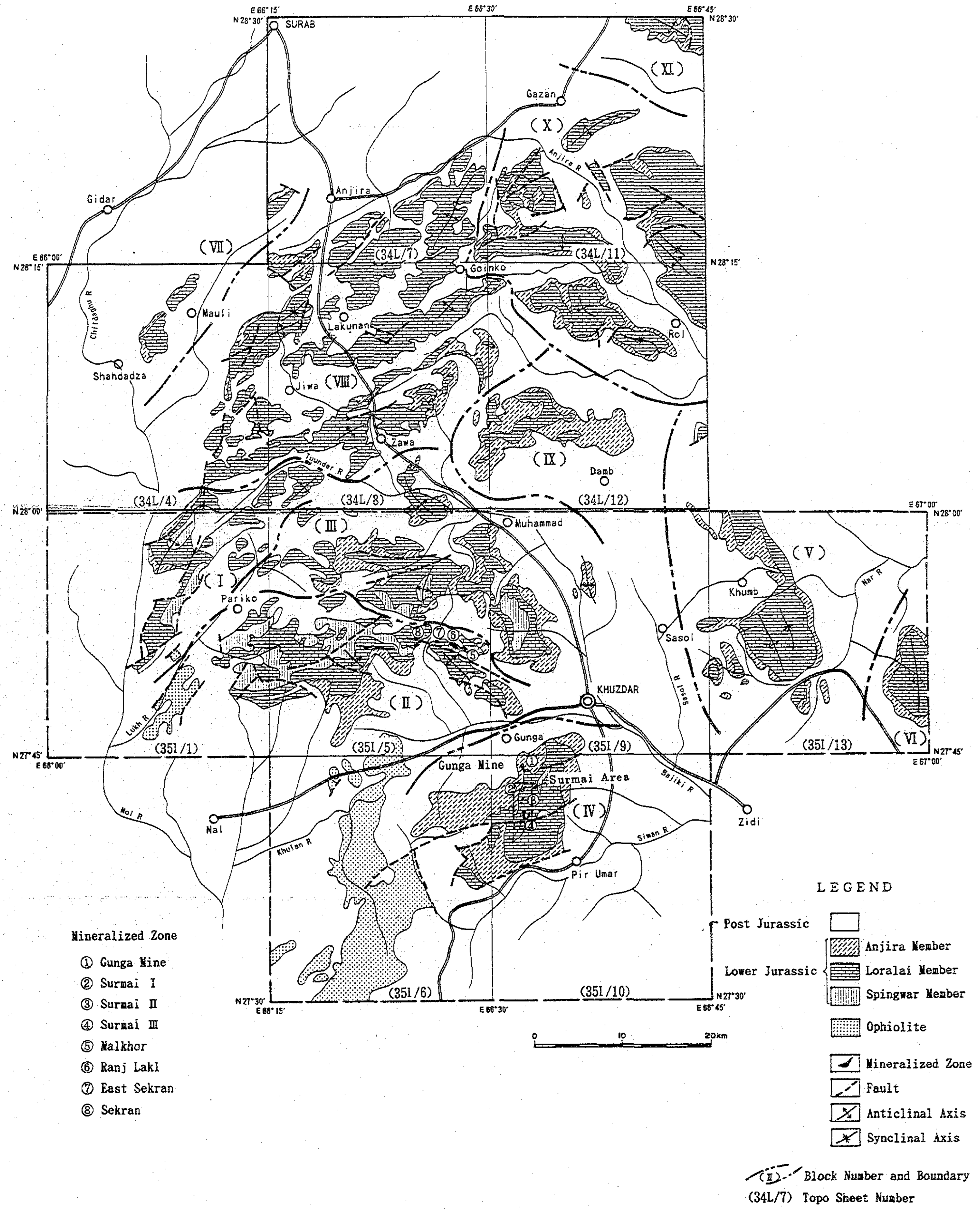


Fig. I-3-3 Geological Map of Khuzdar District

Geologic age	Group			Lithology	Thickness (m)	Columnar Section	Mineralization
	Formation	Member	Unit				
Quaternaly			Stream bed deposits	Boulder, cobble, pebble, sand, silt.			
			Alluvial deposits	Sand, silt, clay, detritus.			
			Terrace deposits	Boulder, pebble sand, silt clay			
	Unconformity						
Early Jurassic	Shirinab	Anjira	Ⅲ	Limestone. thick bedded	+50		Gu
			Ⅱ	Interbedded limestone and shale, contains ammonites.	100~180		SⅡ
			Ⅰ	Interbedded limestone and shale. Limestone thin to thick bedded contains ammonite.	30 ~ 50		
		Loralai	Ⅳ	Limestone grey, thick to massive, mottled with a zone of thin interbedded limestone and shale.	80 ~ 100		
			Ⅲ	Limestone and shale interbedded. Limestone dark grey, thin to med bedded, mottled, fossiliferous.	100 ~ 150		SⅢ
			Ⅱ	Limestone with very minor shale. Limestone grey thick to massive with some oolitic bed.	100 ~ 120		
			Ⅰ	Interbedded limestone and shale with minor marl. Limestone grey, thin bedded, mottled and ooloitic occaisionally. Shale of black colour.	100 ~ 150		
	Spingwar			Interbedded sandstone and shale.	+200		SⅠ

Note Gu: Gunga, SⅠ: Surmai-Ⅰ, SⅡ: Surmai-Ⅱ, SⅢ: Surmai-Ⅲ

Mineralization

┃ : Large bedded type mineralization.

┆ : Small mineralization in faults, fractures, joints and bedding planes.

Fig. Ⅰ-3-4 Stratigraphy of Surmai Area

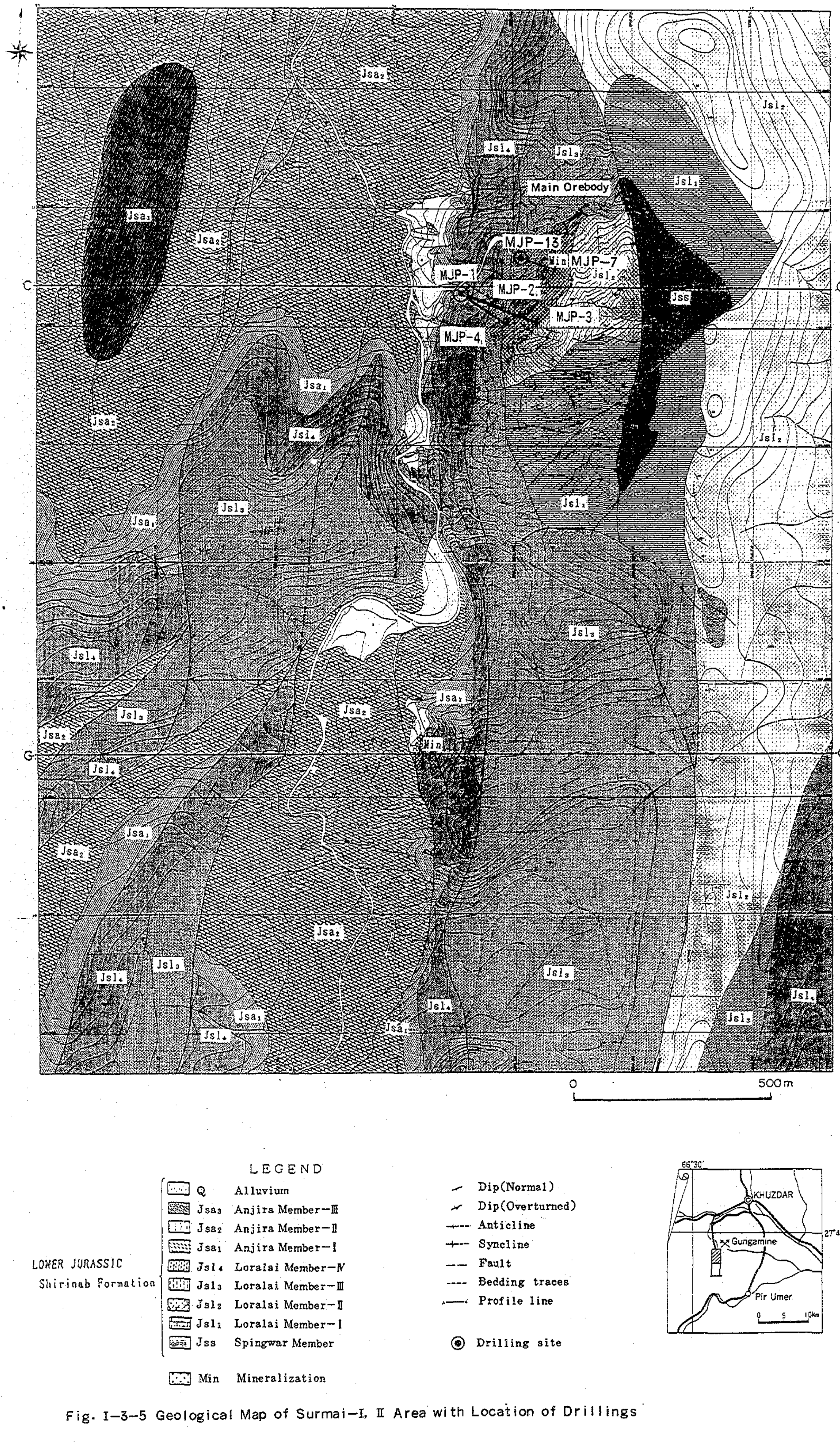


Fig. I-3-5 Geological Map of Surmai-I, II Area with Location of Drillings

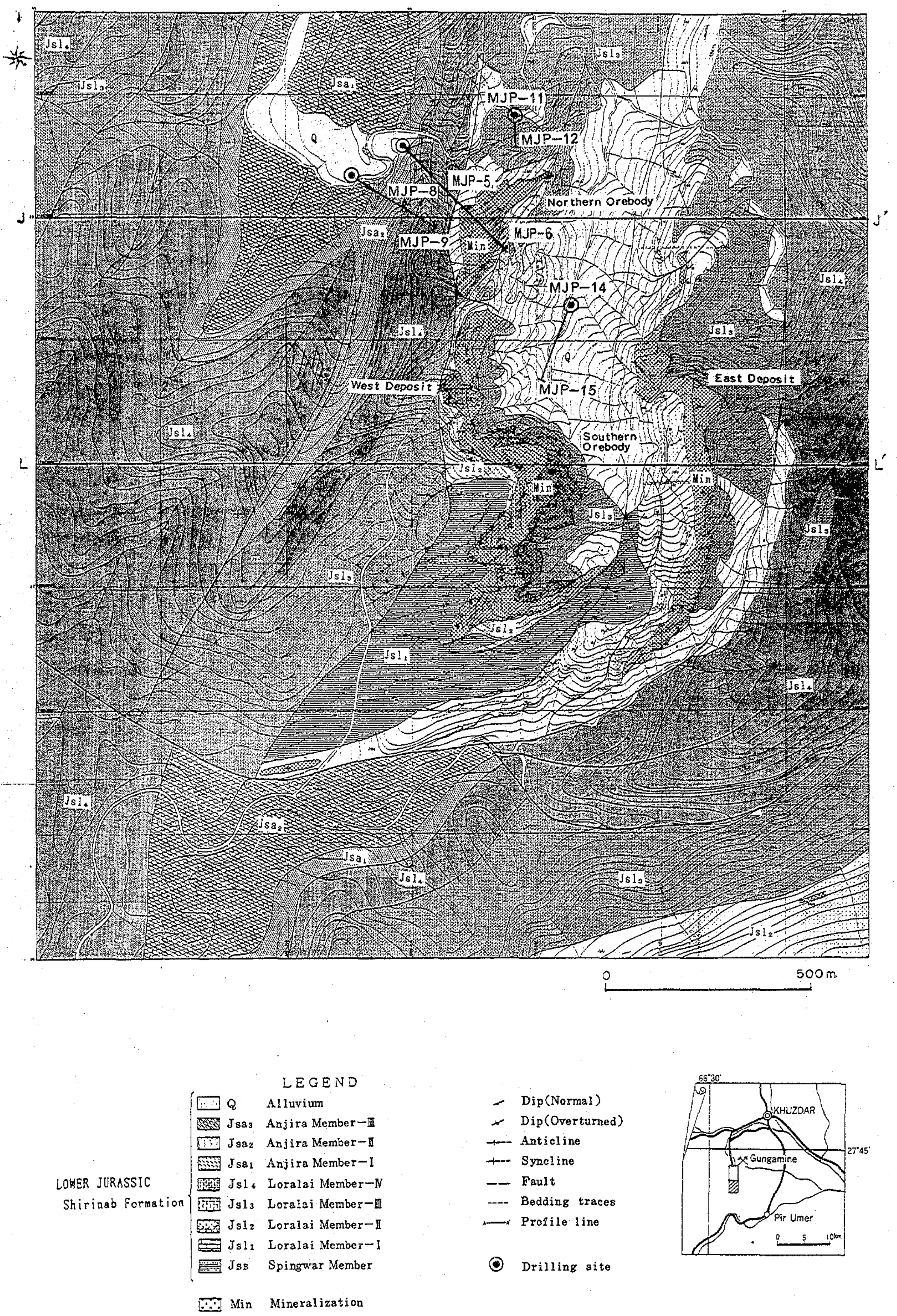


Fig. I-3-6 Geological Map of Surmai-Ⅲ Area with Location of Drilling

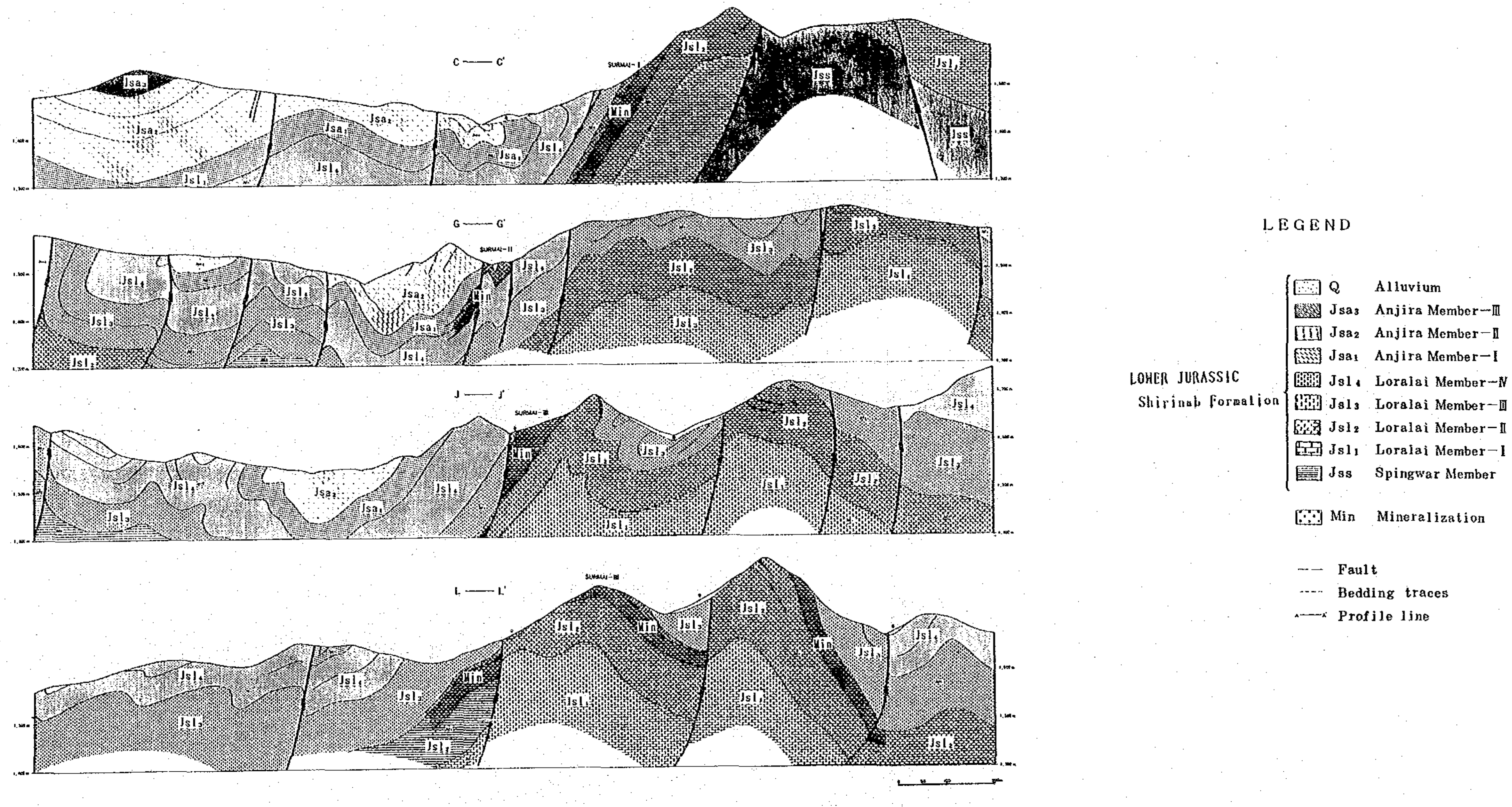


Fig. I-3-7 Geological Profiles of Surmai Area

CHAPTER 4 RESULTS OF THE SURVEY

4 - 1 The Characteristics of Geologic Structure and Mineralization and Factors which Control Mineralization

It was clarified by the first phase survey that the mineralization of the Surmai district occurred along the bedding replacing the host rocks and also filling the faults and fractures. It was also revealed that the mineralization which was considered to be promising for both continuity and grade formed bedded deposits. And the bedded deposits of larger scale were developed in Units Ⅱ～Ⅲ of Loralai Member of Surmai-Ⅰ and Ⅲ showings and were accompanied by samller fissure filling types. The mineralized horizons confirmed by drilling during the second and third phases largely corresponded with the horizon of the surface gossan derived from the bedded deposits. Thus it is concluded that the assumption from the results of the first phase that the gossan distributed on the surface was derived from the primary sulphide deposits which were controled stratigraphically during their formation.

It is inferred that the ground water table of the Surmai district is approximately 100 m deep from the zone of lost circulation during drilling and also from the distribution of *hematitization of limestone*. The transition from oxidized to sulphide zone was confirmed by MJP-7 and the boundary between the two zones is believed to be shallower than the water table at approximately 50 m below the surface.

A *normal* fault *with westward* dip and 300～400 m displacement intersects the whole area in N-S direction at the central part of the area and it cuts through the mineralized horizon. The drilling for Surmai-Ⅰ Main Orebody and Surmai-Ⅲ Northern Orebody confirmed the mineralized zone at the footwall side of the fault while the deepest drilling MJP-10 (-90°, 500 m) into the hanging wall side of the fault did not encounter the mineralized zone. In the intermediate zone between the West and East Deposits, the mineralized zone is cut and separated by several faults with N-S and E-W trends.

Thus the distribution of the mineralized zone is controled stratigraphically and bounded by the faults.

The nature of the lead-zinc mineralization of the Surmai district generally correspond to that of the Mississippi Valley type deposits. The main deviation of this mineralization from that of the general Mississippi Valley type is the relatively higher Fe content of sphalerite judged from the colour of the mineral and particularly the higher Ag content. The average Ag content of the total reserve calculation is 7.4 g/t, that for small blocks is 23.4 g/t and the highest assay value is 670 g/t, while that of most Mississippi Valley type deposits is 1～3 g/t. Detailed microscopic study of 30 polished sections of drill core samples revealed the existence of electrum in 21 samples of which one contained gold grains. Also Ag minerals of Pb-Bi, Pb-Sb series were inferred to exist in five samples. It is therefore, concluded that most of the silver associated with the lead-zinc mineralization of this district occurs as electrum and the possibility of containing gold is high for these ores. The gold-silver ratio of the electrum is estimated from the colour to be 1:5～10.

The Mississippi Valley type deposits in North America are generally mined by large scale underground mining method (Room and Pillar) with high efficiency of 30～50 t/man•shift and the crude ore grade is Pb+Zn: 10 %. The evaluation of the reserves and grade of deposits is carried out on the basis of a cut-off grade which is decided by considering various factors such as the planned operational mode of the mine, the price of the metals and others. The cut-off grade of the deposits at Surmai district has not been calculated and thus accurate estimation cannot be made, but it is considered that the economic feasibility of developing these ores at the present knowledge of the deposits and the current metal markets, however, is concluded to be low. The present knowledge of the deposits, as mentioned above, is grand total reserves of 30,513,000 t at the average grade of Pb: 0.66 %, Zn: 2.13 %, Ag: 7.4 g/t of which higher grade small mining blocks contain a total of 870,000 t of at the average grade of Pb: 2.03 %, Zn: 6.51 %, Ag: 23.4 g/t.

The large blocks were set for larger areas with emphasis on the continuity of the mineralization and thus the lower grade parts were included. Future drilling between the present drill holes would clarify the continuity of the high grade parts and will enable more accurate reserve evaluation. Also increase of drilling would add more small blocks and will provide data for more accurate calculation.

4 - 2 Mineralization and Geophysical Anomalies

The location of the geophysical (IP/SIP) anomalies measured during the first phase survey and the location of the mineralized zones confirmed by the drilling of the third phase agrees relatively well as shown below. It is expected that the accuracy of the geophysical work will increase significantly if re-analysis of the model simulation using the physical data measured from the drill cores would be carried out. And thus IP/SIP is a very effective method for prospecting for Mississippi Valley type lead-zinc deposits.

4 - 3 Resource Potential

Of the three zones drilled, the mineralization of Surmai-I Main Orebody is limited by faults to the west and east and thus the possibility of its extension outside of the block established for evaluation is small. Regarding Surmai-III Northern Orebody, there is a possibility of the deposit extending northward at a gentle dip and the wide area east of Surmai-II showing can be identified as a target for further prospecting Unit-III of Loralai Member is distributed in this area. Also this is outside of the geophysically prospected area of the first phase. Regarding the Surmai-III West-East Deposit area, the deposit could be cut by faults, but the grade is relatively high and the concentration of the ores is not bad. There-fore, together with the fact that there are wide areas outside of the blocks set for evaluation, this is considered as a promising zone for further prospecting.

The three zones with high potential for locating mineralization by future prospecting are, vicinity of East Deposit, Surmai-Ⅲ ; between West and East Deposit, Surmai-Ⅲ ; and east of Surmai-Ⅱ .

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5 - 1 Conclusions

(1) The horizons confirmed by the third phase drillng range from the lower part of Unit-Ⅰ of Loralai Member to the upper part Unit-Ⅱ of Anjira Member. The lithology of these units is mainly limestone and shale. They form alternation of unit beds of 0.2～10m thickness. The structure of the survey area is complex with folds and faults of varying dimensions.

(2) Of the nine holes drilled during the third phase, lead-zinc sulfide mineralization was confirmed in eight holes. The mineralized horizons are classified into three, namely A, B and C Horizons from the uppermost one. These horizons all occur in Units-Ⅱ ～ Ⅲ of Loralai Member. The mineralized zones are distributed in these horizons with varing vertical positions. The mineralized zones which are evaluated to be promising from both size and grade occur in A-Horizon.

(3) The mineralization is composed of powdery to granular sphalerite and galena which are disseminated replacing the limestone host rock and siderite and calcite veins and veinlets which intersect the disseminated ore. Minor amount of pyrite and chalcopyrite is associated. Microscopic studies confirmed the existence of lead-zinc carbonates and electrum and also although too minute to identify with certainly, indicated the probable existence of Pb-Bi and Pb-Sb silver minerals.

(4) The level of the water table is estimated to be approximately 100 m below the surface. The boundary between the oxide and sulfide ores is inferred to be at approximately 50 m below the surface.

(5) The location of the mineralized zones confirmed by the drilling of the present phase coincides with the geophysical (IP,SIP) PFE anomaly zones detected during the first phase with the exception of the traverses where the electrode intervals were excessive.

(6) The mining blocks were drawn and reserves calculated for the Surmai-I Main Orebody, Surmai-III Northern Orebody of West Deposit and Surmai-III Intermediate Orebody between West and East Deposits. These are possible reserves and the total reserves are 30,513,000t (Pb:0.66%,Zn:2.13%, Ag:7.4 g/t) of which 22,700,000t are sulfide and the balance of 7,813,000t oxide ores. The reserves (sulfide) of the small blocks within the above are 870,000t (Pb:2.03%,Zn:6.51%,Ag:23.4g/t). These reserves and grades are considered to be insufficient for commercial development at current world metal markets.

(7) These are three promising zones which warrant further exploration. They are vicinity of Surmai-III East Deposit, the zone between Surmai-III West and East Deposits and area east of Surmai-II.

5 - 2 Recommendations for the Further Survey

The economic feasibility of the reserves calculated on the basis of the work of the past three years and laid out in 5-1-(6), is cosidered to be low at present, but there are possibilities of more high grade ores being found by future prospecting. Therefore, it is desirable that drilling be continued in the mining blocks in order to ascertain the shape, grade, continuity and spatial extension of the mineralized zones and also that exploration with emphasis on drilling be carried out in the three zones with high resource potential, vicinity of Surmai-III East Deposit, the zone between Surmai-III West and East Deposits and area east of Surmai-II. It is concluded that gold should be added to the objective of exploration.

PART II

DETAILED DISCUSSIONS

PART Ⅱ DETAILED DISCUSSIONS

CHAPTER 1 DRILLING

1 - 1 Background and Details of Drill Holes

The mineral showings in this area were long known, but systematic survey started with the sheet mapping of the area by GSP in 1984～1985 (maps unpublished). Three lead-zinc showings (gossan) of Mississippi Valley type occur in three localities arranged in north-south direction. They are called Surmai-Ⅰ, Ⅱ and Ⅲ.

During the first phase, geological survey at 1:2,000 scale, geochemical and geophysical prospecting were carried out for an area of 2 km E-W and 5 km N-S in the vicinity of the mineral showings. Drilling was recommended for Surmai-Ⅰ and Ⅲ as the result of the above survey. On the basis of this recommendation, a total of six holes (MJP-1～6, 2,255.8 m) were drilled in Surmai-Ⅰ and Ⅲ during the second phase.

During the third phase, a total of nine holes were drilled following the recommendations of the second phase. They were at one site in Surmai-Ⅰ and at four sites in Surmai-Ⅲ. The locality, direction and lengths of each hole are shown Table Ⅱ-1-1. The locality of the holes is plotted in Figs. Ⅱ-1-1 and Ⅱ-1-2. The sequence of the holes drilled is from MJP-9, 8 for Surmai-Ⅲ, MJP-7, 13 for Surmai-Ⅰ and MJP-15, 14, 12, 11, 10 for Surmai-Ⅲ.

The core section (column) was prepared in 1:200 scale and the whole core was photographed in colour. The results of ore assay, x-ray powder diffraction, ore microscopy and other laboratory work of the cores of the mineralized parts encountered by drillings were fully utilized in considering the drilling results.

Table II-1-1 Location, direction and lengths of drilling

Drill No.	Area, Coordinates (X,Y), Altitude(H)				Direction from T.N.	Angle	Length
	Area	X	Y	H			
				m			m
MJP- 7	Surmai-I	2,008,315	1,125,475	1,477	108°	-50°	150.5
MJP-13	ditto	ditto	ditto	ditto	-	-90°	351.0
MJP- 8	Surmai-III	2,007,858	1,123,002	1,542	121°	-70°	401.0
MJP- 9	ditto	ditto	ditto	ditto	121°	-40°	301.0
MJP-10	ditto	ditto	ditto	ditto	-	-90°	500.3
MJP-11	ditto	2,008,247	1,123,150	1,567	-	-90°	251.0
MJP-12	ditto	ditto	ditto	ditto	180°	-60°	151.0
MJP-14	ditto	2,008,382	1,122,689	1,641	-	-90°	351.0
MJP-15	ditto	ditto	ditto	ditto	200°	-50°	300.2
Total							2,757.0

1 - 2 Targets for Surmai-I and III

(1) Surmai-I

The survey carried out during the first phase indicated the mineral potential below the surface gossan of the Main Orebody of Surmai-I and the existence of Mississippi Valley type lead-zinc deposits was anticipated. The geophysical results also revealed indications which were believed to be the A-ranking manifestations of sulfide bodies below the Main Orebody.

During the second phase, four holes (MJP-1～4) were drilled with the purpose of locating the sulphide deposit, confirming the continuity, and the characteristics of the deposits and also clarifying the subsurface geologic structure. This drilling located the existence of lead-zinc sulfide ores approximately 180 m below the surface.

Two holes (MJP-7, 13) were drilled during the present phase in order to confirm the existence of sulfide deposit, its extent, the nature of the ore and the subsurface geologic structure of the zone to the north of the above newly discovered body.

(2) Surmai-Ⅲ

The survey carried out during the first phase indicated the potential below the high-grade surface gossan of the Northern Orebody of Surmai-Ⅲ West Deposit and the existence of Mississippi Valley type lead-zinc mineralization was anticipated. The geophysical results also revealed indications which were believed to be the A-ranking manifestations of sulfide bodies below the above orebody.

During the second phase, two holes (MJP-5～6) were drilled with the purpose of locating the sulfide deposit, confirming the continuity and the characteristics of the ores and also clarifying the subsurface geologic structure. This drilling located the existence of lead-zinc sulfide ore approximately 140 m below the surface.

During the present phase two holes (MJP-11～12) were drilled for the northern extension and three (MJP-8～10) for the southern extension of the above newly discovered sulfide body. Also two holes (MJP-14～15) were drilled at sites between the West Deposit and the East Deposit. These were all carried out with the purpose of confirming the existence of sulfide deposit, it characteristics, its extent and the subsurface geological structure of the zone in question.

1 - 3 Geology and Mineralization

1 - 3 - 1 Geological Setting

Three members of the Shirinab Formation are distributed in the Surmai area. The Spingwa Member occurs a small zone in northwestern part, Anjira Member in three localities with N-S trend in the western half of the area, and Loralai Member is distributed in the remaining zones. The Loralai Member is divided into Ⅰ～Ⅳ units and Anjira into Ⅰ～Ⅲ units considering the characteristics of this formation. The survey area is situated in the western limb of a N-S trending anticline and has a general westward dipping structure, but locally, there are intense folding. Particularly in Surumai-Ⅲ, there are two anticlinal structures with N-S trend and has complex structure (Figs. I -3-4~7).

1 - 3 - 2 Mineralization

In the Surmai area, there are mineral showings in three localities, namely in Surmai-Ⅰ, Ⅱ, Ⅲ in 4 km zone with N-S trend. The showings consist of dark reddish brown gossan and occur in all the members of the Shirinab Formation with the exception of Anjira-Ⅲ (Figs. I -3-5~7). These gossans are believed to have formed by weathering of the primary replacement lead-zinc sulphide deposits and they consist of porous-massive oxide ore. The large gossans occur replacing the host rocks along the bedding planes. They are thick, bedded and occur from the upper part of unit-Ⅱ to the lower part of unit-Ⅲ of the Loralai Member. Large gossans are distributed in Surmai-Ⅰ and Ⅲ. In Surmai-Ⅱ, many small gossans are distributed along faults, but they are not promising.

The gossans of the mineral showings in Surmai-Ⅰ occur in a zone of 900 m N-S and 300 m E-W. In the northern half of the mineral showing zone, the gossans of the Main Orebody occur in a subzone of 450 m N-S and 60~80 m E-S. The strike and dip of the gossans are the same as the host rock, N30°E, 50~70°W. In the Southern half, many small gossans occur along the fissures, bedding planes and small faults, but they are not important.

The gossans of the Surmai-Ⅲ mineral showing occur in a zone of 1.5 km N-S, and 0.7 km E-W and they are grouped into the West Deposit and the East Deposit. The West Deposit extends 1.5 km in strike direction, 50~60 m thick and consists of the Northern Orebody and the Southern Orebody. The Northern Orebody is situated at the western limb of the western anticline and dips 40~60°W, extends 400 m in strike direction and is 60~70 m thick. The Southern Orebody lies on the eastern limb of the anticline and has wide distribution but the grade is low and is dispersed. The East

Deposit is located at the eastern limb of the eastern anticline, dips 50～80°E, extends 1.1 km in strike direction and is 30～50 m thick. Both deposits are believed to extend under the Quaternary formations in the central part of the zone and to continue with the same anticlinal structure as the host rocks.

The constituent minerals of the gossans are, by the unaided eyes, as follows. Limonite (goethite), calcite, siderite and quartz are common and marcasite, pyrite, galena are less common and also white powder with the possibility of smithonite occurs in small druses. Sphalerite was not found. X-ray diffraction was carried out during the second phase. The results were; aside from quartz, calcite, geothite, marcasite, pyrite and galena, hematite, dolomite and hemimorphite were found to occur in minute amounts.

1 - 4 Methods, Equipment, System

1 - 4 - 1 Methods

For soil containing gravel (1～4 m thick), operation was as follows; drilled by HX single bit (φ 114.3 mm), reamed by HX casing metal bit, inserted HX casing. For the bedrock, wireline method was used with NQ (φ 79 mm) and BQ (φ 62 mm) oversized bit. Fractures are developed in rocks (particularly limestone), thus the fluid was often lost and this was prevented by injecting Tel-stop (lost circulation material) and cement milk.

1 - 4 - 2 Equipment

The rig used was Longyear L-38 and the specifications of the major equipment are shown in Appendix-1. The use of diamond bit and the expendable items are listed in Appendices-2～3 respectively.

1 - 4 - 3 Working System

(1) Working system

The construction, transfer and withdrawal of the drilling equipment were carried out by one shift per day and the drilling operation by three shifts (8 hours per shift) per day. Each shift consisted of one Japanese and three Pakistani personnel. Both Japanese and Pakistani teams each rented a house in Khuzdar, used them as camps and commuted by Jeep to the site.

(2) Transportation of equipment and material

Most of the equipment were transported from Japan by sea and landed at Karachi. From here, they were transported overland by truck to Khuzdar and the material dismounted. From Khuzdar to Gunga, for 16 km, the equipment was transported by truck using existing road. The 6 km between Gunga and Surmai-I ~ III was negotiated by truck using a road newly constructed by GSP. Also during the monsoon season, the road was destroyed at several localities and the supply of water was hindered several times by heavy rain.

(3) Water for drilling

The water necessary for drilling was transported by trucks from near Gunga for 6~8 km to the drilling site.

(4) Withdrawal

After the completion of the operation, usable equipment was shipped to Japan. The cores were stored by the GSP at Quetta and Karachi.

1 - 5 Progress of Drilling

The progress made at each drilling site was as follows. Various relevant data are laid out in tables and charts, namely working time analysis of the drilling operation (Appendix-4), record of the drilling operation (Appendix-5), summary of the drilling operation (Appendix-6), chart of drilling progress (Appendix-7).

(1) MJP-7

HX diamond bit and bentonite mud were used for soil and weathered horizon down to 3.10 m, the hole was reamed by HX casing metal shoe to 3.10 m and HX casing pipe inserted. For the bedrock, NQ wireline with bentonite mud and mud oil were used. Since the limestone in the shallower parts often caused total loss of water, the hole was reamed by NX casing diamond shoe every 3～6 m, and casing pipe inserted at 40.10 m. As measures countering the loss of fluid after inserting the casing pipe, Tel-stop and cement milk were injected and drilled to 150.50 m.

(2) MJP-8

HX diamond bit and bentonite mud were used for soil and weathered rocks down to 9.10 m, the hole was reamed by HX casing metal to 6.10 m and HX casing pipe inserted. Then, NQ wireline was used with bentonite mud and mud oil. Reaming by NX casing diamond shoe was done parallel to the drilling. NX casing pipe was set at 38.10 m. After attaining 240.40 m, BX casing pipe was inserted. Below that depth, BQ wireline with bentonite mud and mud oil was used down to 401.00 m. During limestone penetration, total fluid was often lost and Tel-stop and cement milk were injected at each loss.

(3) MJP-9

HX diamond bit and bentonite mud were used for soil and weathered rocks to the depth of 12.00 m. The hole was reamed by HX casing metal shoe to 10.00 m and HX casing pipe inserted. Below that depth down to 24.10 m, NQ wireline with bentonite mud and mud oil were used, reamed by NX casing diamond shoe and NX casing pipe was inserted. Circulation was often lost below this depth and the loss was stopped successfully except at 90.70 m. Here the fracture was large and the milky agents were completely lost. Thus cement pellets in plastic bags were thrown in, pounded by rods, drilled and washed after hardening. This process was repeated, but was not effective. Therefore, blind drilling was done, and the water supply could not cope with it, and BX casing pipe was inserted at 99.10 m. Then BQ wireline method was used with bentonite mud and mud oil. At 106.90 and 110.90 m, circulation loss could not be prevented and the hole was reamed with BX casing diamond shoe to 111.10 m and the casing was set. Circulation was often lost, but the loss was prevented and attained the depth of 301.00 m.

(4) MJP-10

HX diamond bit and bentonite mud were used for soil and weathered rocks to the depth 10.10 m. The hole was reamed by HX casing metal to 9.10 m and the HX casing pipe inserted. Below the depth down to 48.10 m, NQ wireline with bentonite mud and oil were used, reamed by NX casing diamond shoe and NX casing pipe was inserted. Then down to 298.00 m, BX casing pipe was inserted after drilling with circulation loss prevention. Below this,BQ wireline was used with bentonite mud and mud oil to 500.30m.

(5) MJP-11

HX diamond bit and bentonite mud were used for soil and weathered rocks to the depth of 4.10 m. The hole was reamed by HX casing metal to 3.10 m and HX casing pipe inserted. Below that depth down to 24.10 m, NQ wireline with bentonite mud and mud oil were used, reamed by NX casing diamond shoe and the NX casing pipe inserted. After drilling down to 150.10 m, BX casing pipe was inserted. Then BQ wireline with bentonite mud and mud oil was used to the depth of 251.00 m. Tel-stop and cement milk were injected whenever fluid was lost. The fluid was often completely lost when penetrating limestone, it was stopped by the injection of Tel-stop and cement milk.

(6) MJP-12

HX diamond bit and bentonite mud were used for soil and weathered rocks to the depth 3.10 m. The hole was reamed by HX casing metal shoe to 1.60 m and HX casing pipe inserted. Below that depth down to 27.10 m, NQ wireline with bentonite mud and mud oil were used, reamed by NX casing diamond shoe and NX casing pipe was inserted. After drilling to 39.10 m, heavy rain on 7 June caused flooding and the suction pit was washed away and the base of the derrick became unstable. Thus, the drilling was temporarily halted. Later the drilling was completed at 151.00 m depth.

(7) MJP-13

HX diamond bit and bentonite mud were used for soil and weathered rocks to the depth 4.10 m. The hole was reamed by HX casing metal shoe to 3.10 m and HX casing pipe inserted. Below this depth, down to 63.10 m, NQ wireline with bentonite mud was used, reamed by NX casing diamond shoe and NX casing pipe was inserted. Then, NQ wireline drilling method was used and BX casing pipe inserted at 210.40 m. BQ wireline with bentonite mud and mud oil was used to 351.00 m.

(8) MJP-14

HX diamond bit and bentonite mud were used for soil and weathered rocks to the depth of 6.10 m. The hole was reamed by HX casing metal shoe to 5.10 m and HX casing pipe inserted. Below that depth down to 36.10 m, NQ wireline with bentonite mud and mud oil were used, reamed by NX casing diamond shoe and NX casing pipe was inserted. After drilling down to 210.40 m with measures for circulation loss, BX casing pipe was inserted. The BQ wireline with bentonite mud and mud oil was used to the depth of 351.00 m. Tel-stop and cement milk were injected when the fluid was often lost in the limestone beds. In this hole, the recovery of BX casing pipe became difficult and the pipe below 181.00 m was abandoned.

(9) MJP-15

HX diamond bit and bentonite mud were used for soil and weathered rocks to the depth 4.00 m. The hole was reamed by HX casing metal shoe to 3.10 m and HX casing pipe inserted. Below that depth down to 48.10 m, NQ wireline with bentonite mud and mud oil were used, was reamed by NX casing shoe and HX casing pipe was inserted at 7.60 m and NX casing pipe at 48.10 m. Wireline drilling continued below that depth to 180.10 m and BK casing pipe was inserted. But the drill was often jammed in the shale beds because of argillization and fluid was often lost in the limestone beds and preventive measures were taken. After this, BQ wireline with bentonite mud and mud oil were used. Tel-stop and cement milk were injected whenever loss of fluid occurred. At 232.60 m and 234.40 m, however, the fractures of the rocks were large and the measures were not effective.

Therefore, cement pellets were thrown in and hardened by pounding by rod. This was done for 15 shifts. Later at 254.30 m, the circulation was lost completely and Tel-stop was applied. During this operation, the upper part of the hole collapsed and the rod was raised to 250.60 m by hydraulic system of the drilling rig. After this jacking up and knocking would not move the rod. Thus, BX casing pipe was recovered and 180.10～250.60 m was reamed by BX casing diamond shoe and then recovered the trapped rod. BX casing was inserted at 253.96 m after reaming. Drilling continued to 300.20 m.

After the completion of the drilling operation, BX casing was recovered and the work was suspended during 7～11 May, the Islam holiday festival (Eid). The rig was dismantled on 12 May.

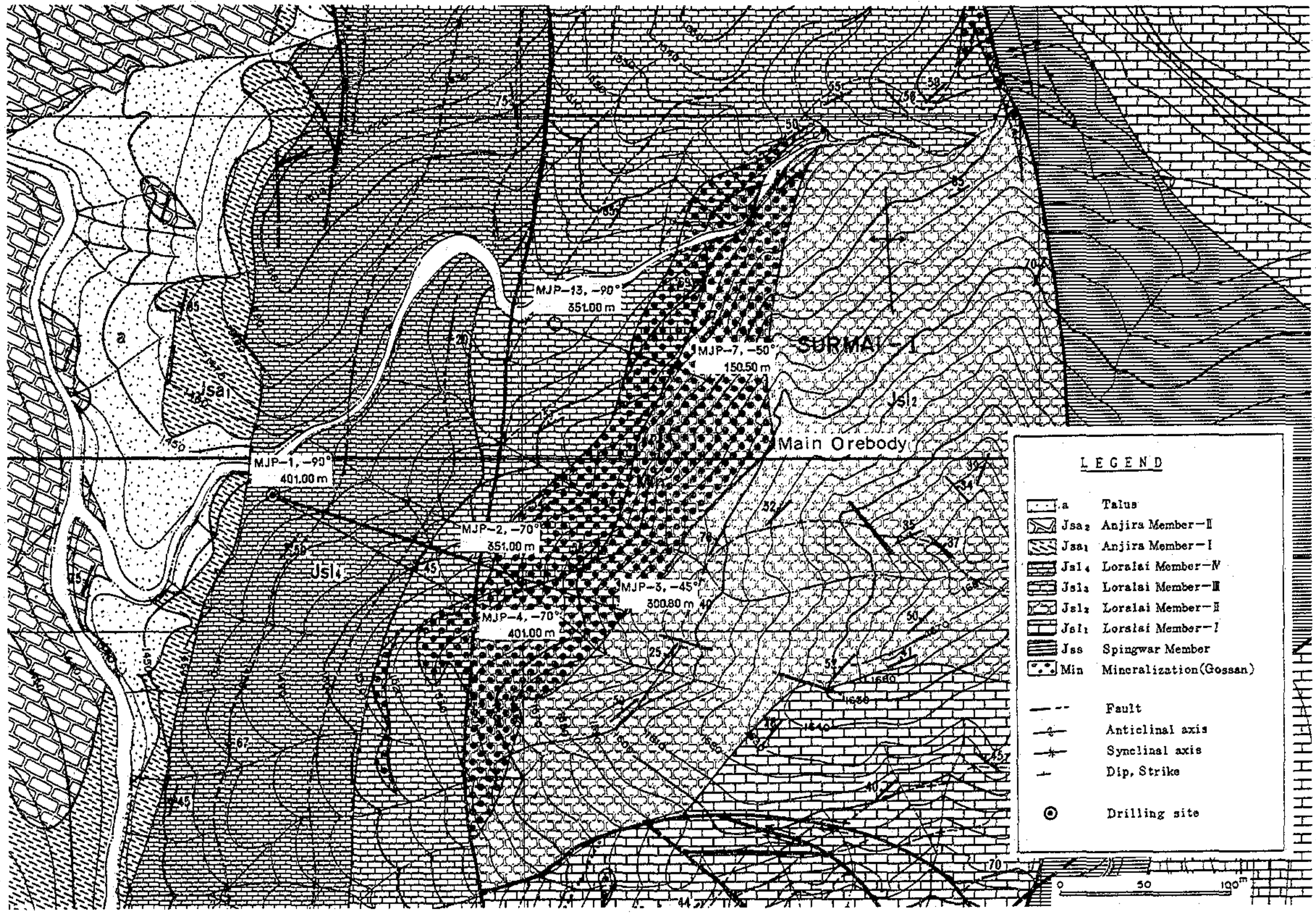


Fig. II-1-1 Geological Map of Surmai-I Area with Locations of Drilling(scale 1:2,000)

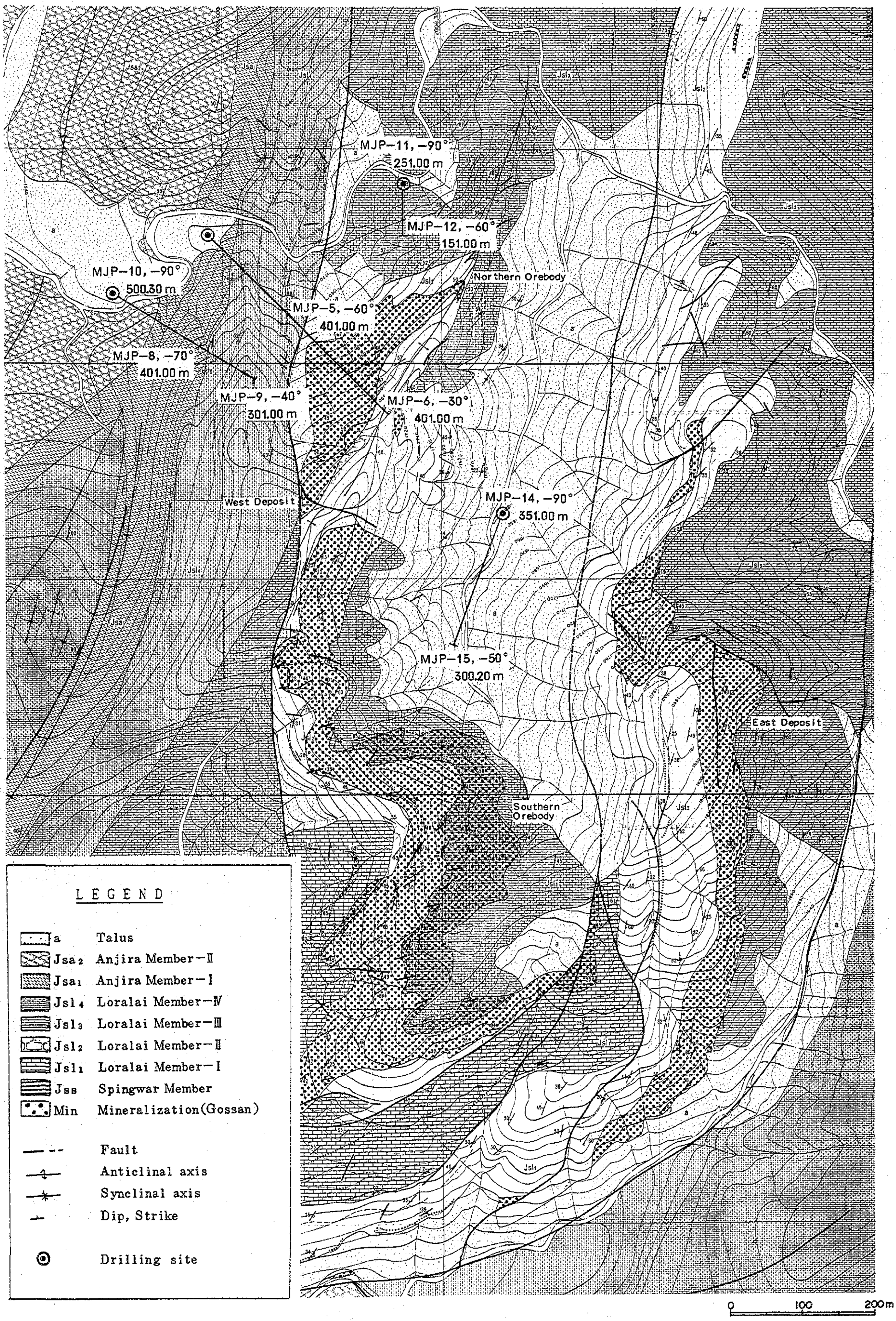


Fig. II-1-2 Geological Map of Surmai-III Area with Locations of Drilling(scale 1:5,000)