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

FINAL

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

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

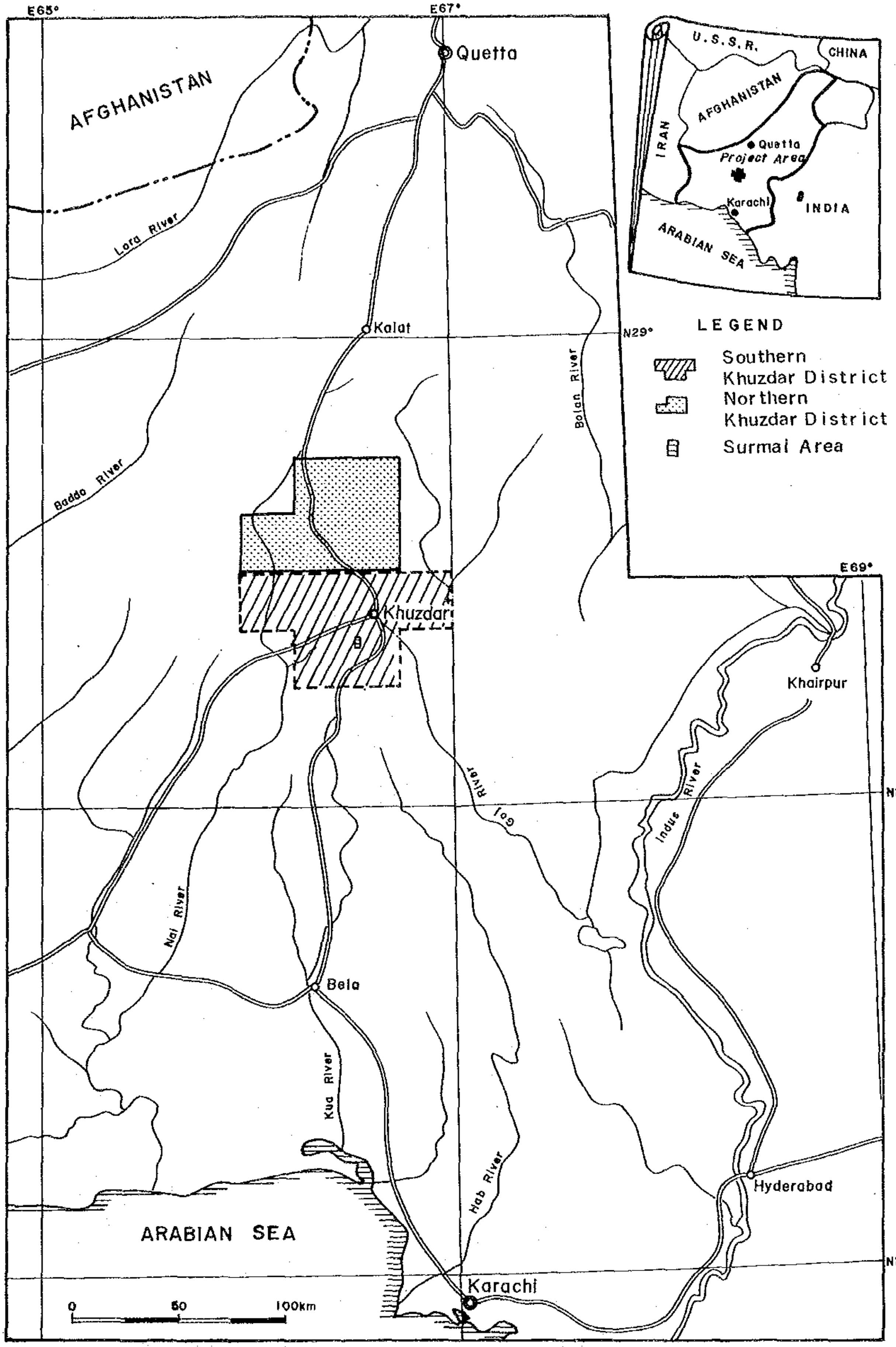


Fig. 1 Index Map of the Survey Area

S U M M A R Y

This report embodies the results of the works conducted during the three phases of the cooperative mineral exploration in the Khuzdar Area 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, geophysical 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 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 lead-zinc oxide zone (gossan). During the third phase, drilling was continued in Surmai-I and III.

The results obtained are as follows.

1. Southern and Northern 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 Shirinab Formation is distributed largely in 11 zones, and the rock bodies consisting the zones extend in east-west direction protruding northward. The members have complex folded structure of anticlines and synclines.

(3) Eight Mississippi Valley type Pb-Zn-Ba prosepects, aside from the already developed Gunga are distributed in this district. They are, four in the Malkhor～Sekran mineralized zone (Malkhor, Ranj Laki, East Sekran and Sekran) as well as in Surmai-I ～III mentioned later. Those prospects occur in a narrow zone (Surmai～Sekran Zone) extending 25 km around the ophiolite area in the southwestern part of the Southern Khuzdar District.

All of these showings crop out as gossan, but it is inferred that primary sulfide ores exist below, near the water table. All mineral showings are combinations of bedded mineralization replacing the host rock along the bedding planes and those filling the fissures and faults.

(4) The four mineral showings in the Malkhor～Sekran mineralized zone 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.

(5) 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. Lead, zinc,mercury anomalous zones of A-rank were found in Surmai Area and also in the vicinity of Malkhor～Sekran mineralized zone. The study of all geochemical data, obtained by this project clearly shows that the promising geochemical anomalies all exist in the Surmai～Sekran Zone and the vicinity of it, in the Southern Khuzdar District .

(6) It is desirable that exploration with emphasis on geophysical prospecting and drilling be carried out in the Malkhor～Sekran mineralized zone that has high resource potential. It is concluded that gold should be added to the objective of exploration.

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 and the wea-

thered 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. Considering grade and scale of mineralization the former is more promising for development than the latter. The bedded type is seen in Surmai-I, III and large-scale mineralization is developed in Loralai Units II and 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 and Northern 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. The location of the mineralized zones confirmed by the drilling coincides with the geophysical (IP,SIP) PFE anomaly zones with the exception of the traverses where the electrode intervals were excessive.

(6) 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.

(7) Of the 15 holes drilled during the project, lead-zinc sulfide mineralization was confirmed in 13 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 A-Horizon.

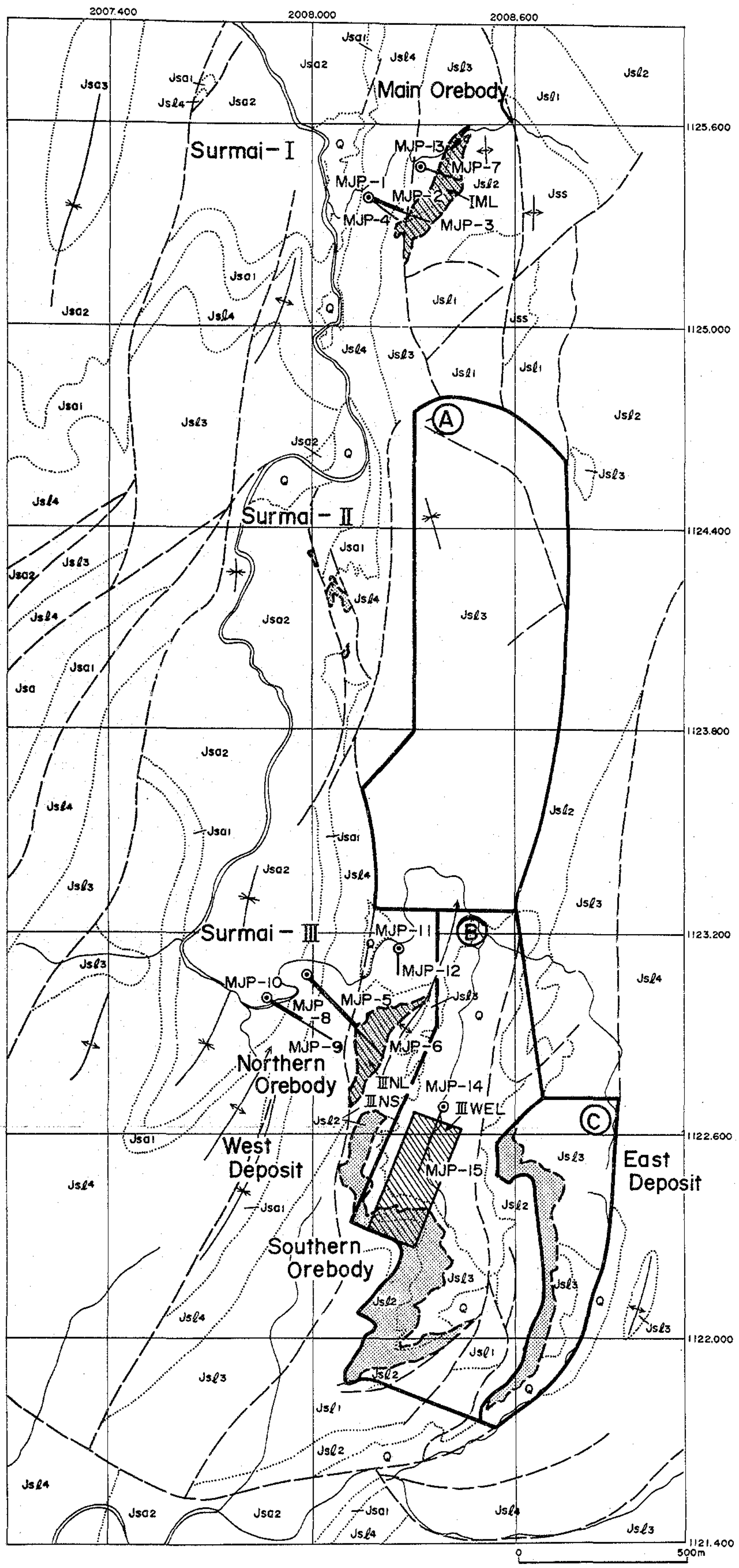
(8) The mineralization is composed of powdery to granular sphalerite and galena which are disseminated replacing the limestone host rock and siderite and calcite veins and veinlets which intersect the disseminated ore. Minor amount of pyrite and chalcopyrite is associated. Microscopic studies confirmed 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.

(9) 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.

(10) 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 30,513,000 t (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 of the small blocks (sulfide) within the above are 870,000t (Pb:2.03%,Zn:6.51%,Ag:23.4g/t). These reserves and grades are cosidered to be insufficient for commercial development at current world metal markets.

(11) 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 area east of Surmai-II.

(12) The economic feasibility of the reserves calculated on the basis of the work of the past three years and laid out in (10), 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 (11). 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

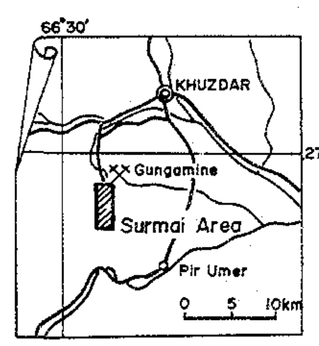
Name of Block	Tonnage (1,000 t)	Grade Pb (%)	Zn (%)	Ba (%)	Ag (g/t)
I ML	6,531	0.40	1.51	<0.01	6.6

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

PART I OVERVIEW

PART II REGIONAL DISCUSSIONS

PART III CONCLUSIONS AND RECOMMENDATIONS

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

Figures

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PART I

O V E R V I E W

PART I OVERVIEW

CHAPTER 1 OUTLINE 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 implementation and upon its recommendations, concluded the Scope of Work (SW) with the Pakistan Government regarding mineral exploration in Khuzdar District of the State of Baluchistan in October 1986. The SW 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 SW, 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 6 sheets of 1:50,000 topographic maps; the total area of the 6 sheets 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 carried out 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 sheets of 1:50,000 topographic maps; 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 and the report of the third phase was completed in November 1989.

This is the final report compiled as the result of the three phase survey. The flow sheet of the Survey is shown in Figure I -1-2.

1 − 1 Survey Area and Objective of the Survey

1 − 1 − 1 Survey Area

The area of the 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) Khuzdar District

【Southern Khuzdar District】

[Latitude]	[Longitude]
28° 00′ N	66° 00′ E
28° 00′	67° 00′
27° 45′	66° 00′
27° 45′	66° 15′
27° 45′	66° 45′
27° 45′	67° 00′
27° 30′	66° 15′
27° 30′	66° 45′

【Northern Khuzdar District】

[Latitude]	[Longitude]
28° 30′ N	66° 15′ E
28° 30′	66° 45′
28° 00′	66° 45′
28° 00′	66° 00′
28° 15′	66° 00′
28° 15′	66° 15′

(2) 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 Southern Khuzdar District is included in six topographic sheets (1:50,000 scale), Nos.35-I/1,35-I/5,35-I/9,35-I/13,35-I/6,35-I/10, published by the Survey of Pakistan and that of the Northern Khuzdar District in five topographic sheets Nos.34-L/4,34L/7,34-L/8,34-L/11,34-L/12 and that of the Surmai Area No.35-I/10.

1 − 1 − 2 Objective of the Survey

The objective of the survey is to clarify the state of ore occurrence of the survey area through geological investigation. The important subject of each prospecting is as follows.

(1) Geological Survey and Geochemical Prospecting

Carry out integrated interpretation of the relationship between the Mississippi Valley type lead-zinc mineralization and the geologic structure, geochemical characteristics of mineralization and other relevant factors in order to identify the promising zones of the survey area.

(2) Geophysical Prosprcting

Carry out IP, SIP survey for alteration zones of the Surmai Area and estimate the downward continuation of mineralization by resistivity, FE, spectral analysis and extract anomalous zones and clarify the nature of mineralization.

(3) Drilling

Clarify the detailed characteristics and geologic structure of the mineralized zones of the Surmai Area and thus provide the basis for evaluating the mineralization.

1 − 2 Methods and Contents of the Survey

The survey consisted of geological survey (reconnaissance,detailed), geochemical and geophysical (IP,SIP) prospectings, drilling and laboratory studies. The methods and contents of each phases are shown in Table I -1-1.

1 − 3 Survey Period and Organization of the Survey Team

The period of the field work and the organization of the survey team in each phase are shown in Table I -1-2.

Table I-1-1 Methods and Contents of the Survey

Phase	Survey	Area	Contents
Phase-I	Geological survey reconnaissance detailed	Southern Khuzdar District Surmai Area	1,350 km^2 (Map scale 1:50,000) 10 km^2 (Map scale 1:2,000)
	Geochemical prospecting	Southern Khuzdar District Surmai Area	2,700 samples 205 samples
	Geophysical prospecting	Surmai Area Gunga Mine Area	IP : Line;7.8km, Points;420 SIP : Line;8.2km, Points;410 SIP : Line;1.2km, Points;80
	Laboratory studies	Thin sections Polished sections X-ray powder diffraction Chemical analysis Total rock Ore assay Geochemical analysis SIP analysis	20 samples 20 samples 100 samples 5 samples (SiO_2, TiO_2, FeO, Fe_2O_3, MnO, MgO, K_2O, BaO, Na_2O, Al_2O_3, P_2O_5, LOI) 20 samples (Pb, Zn, Ba, Ag) 2,905 samples (Pb, Zn, Ba, Mg, Hg, S) 40 samples
Phase-II	Geological survey reconnaissance	Northern Khuzdar District	940 km^2 (Map scale 1:50,000)
	Geochemical prospecting	Northern Khuzdar District	1,883 samples
	Drilling	Surmai-I & III Area	6 holes (MJP-1~6) Total length : 2,255.8 m
	Laboratory studies	Thin sections Polished sections X-ray powder diffraction Chemical analysis Total rock Ore assay Geochemical analysis	10 samples 15 samples 10 samples 5 samples (SiO_2, TiO_2, FeO, Fe_2O_3, MnO, MgO, K_2O, BaO, Na_2O, Al_2O_3, P_2O_5, LOI) 78 samples (Pb, Zn, Ba, Ag) 1,883 samples (Pb, Zn, Ba, Mg, Hg, S)
Phase-III	Drilling	Surmai-I & III Area	9 holes (MJP-7~15) Total length : 2,757.0 m
	Laboratory studies	Thin sections Polished sections Chemical analysis Ore assay	10 samples 30 samples 141 samples (Pb, Zn, Ba, Ag)
Total	Geological Survey reconnaissance detailed	Khuzdar District Surmai Area	2,290 km^2 10 km^2
	Geochemical Pros.	Khuzdar Dsct., Surmai Area	4,788 samples
	Geophysical Pros.	Surmai Area	IP : Line;7.8km, Points;420 SIP : Line;9.4km, Points;490
	Laboratory studies	Thin sections Polished sections X-ray powder diffraction Chemical analysis Total rock Ore assay Geochemical analysis SIP analysis	40 samples 65 samples 110 samples 10 samples (SiO_2, TiO_2, FeO, Fe_2O_3, MnO, MgO, K_2O, BaO, Na_2O, Al_2O_3, P_2O_5, LOI) 239 samples (Pb, Zn, Ba, Ag) 4,788 samples (Pb, Zn, Ba, Mg, Hg, S) 40 samples
	Drilling	Surmai-I & III Area	15 Holes (MJP-1~15) Total length : 5,012.8 m

Table I-1-2 Survey Period and Organization of the Survey Team

<table>
<tr><th rowspan="2">Phase
(Year)</th><th rowspan="2">Work</th><th rowspan="2">Term</th><th colspan="2">Name</th></tr>
<tr><th>Japanese Side</th><th>Pakistan Side</th></tr>
<tr><td rowspan="3">Phase-I
(1986~1987)</td><td>Planning &
Coordinating</td><td></td><td>K. Orita ※1
R. Kamiki ※2
M. Ishida ※4
Y. Endo ※4
Y. Kita ※4
Y. Hosoi ※4</td><td>Waheeduddin Ahmed ※3
A. H. Kazmi ※3
M. I. Durrazai ※3</td></tr>
<tr><td>Geological Survey &
Geochemical Survey</td><td>Dec. 15,'86~
Mar. 22,'87</td><td>K. Shuto ※6, ※※
T. Ichinose ※6
H. Suzuki ※6
K. Sato ※6</td><td>A. M. Subhani ※3, ※※
Asad. Jalil ※3
C. Ferozuddin ※3
S. M. Zaidi ※3
M. Ashfaq ※5</td></tr>
<tr><td>Geophisical Survey</td><td>Feb. 5,'87~
Apr. 19,'87</td><td>M. Yoshizawa ※6
T. Fujimoto ※6
N. Sugiura ※6</td><td>A. Khurshid ※3
S. W. H. Nagvi ※3
H. Z. Khan ※3</td></tr>
<tr><td rowspan="3">Phase-II
(1987~1988)</td><td>Planning &
Coordinating</td><td></td><td>N. Adachi ※4</td><td>A. H. Kazmi
M. I. Durrazai
Waheeduddin. A.</td></tr>
<tr><td>Geological Survey &
Geochemical Survey</td><td>Nov. 16,'87~
Feb. 14,'88</td><td>T. Ichinose ※※
H. Suzuki
T. Yoshie ※6</td><td rowspan="2">A. M. Subhani ※※
C. Ferozuddin
S. M. Zaidi
Bhagwandas
M. Dawood Khan</td></tr>
<tr><td>Drilling</td><td>Feb. 15,'88~
Aug. 16,'88</td><td>Y. Kawamura ※6
M. Sasaki ※6
M. Wakamatsu ※6</td></tr>
<tr><td rowspan="2">Phase-III
(1988~1989)</td><td>Planning &
Coodinating</td><td></td><td>H. Shimotori ※4</td><td>A. H. Kazmi
M. I. Durrazai</td></tr>
<tr><td>Drilling</td><td>Jan. 17,'89~
Aug. 4,'89</td><td>T. Ichinose ※※
Y. Kawamura
M. Sasaki
M. Wakamatsu</td><td>A. M. Subhani ※※
S. M. Zaidi
Bhagwandas
M. Dawood Khan</td></tr>
</table>

Remarks
※1 : Ministry of International Trading and Industry (MITI)
※2 : Japan International Cooperation Agency (JICA)
※3 : Geological Survey of Pakistan (GSP)
※4 : Metal Mining Agency of Japan (MMAJ)
※5 : Pakistan Mineral Development Corporation (PMDC)
※6 : Nikko Exploration & Development (NED)
※※ : Team Leader of Field Wook

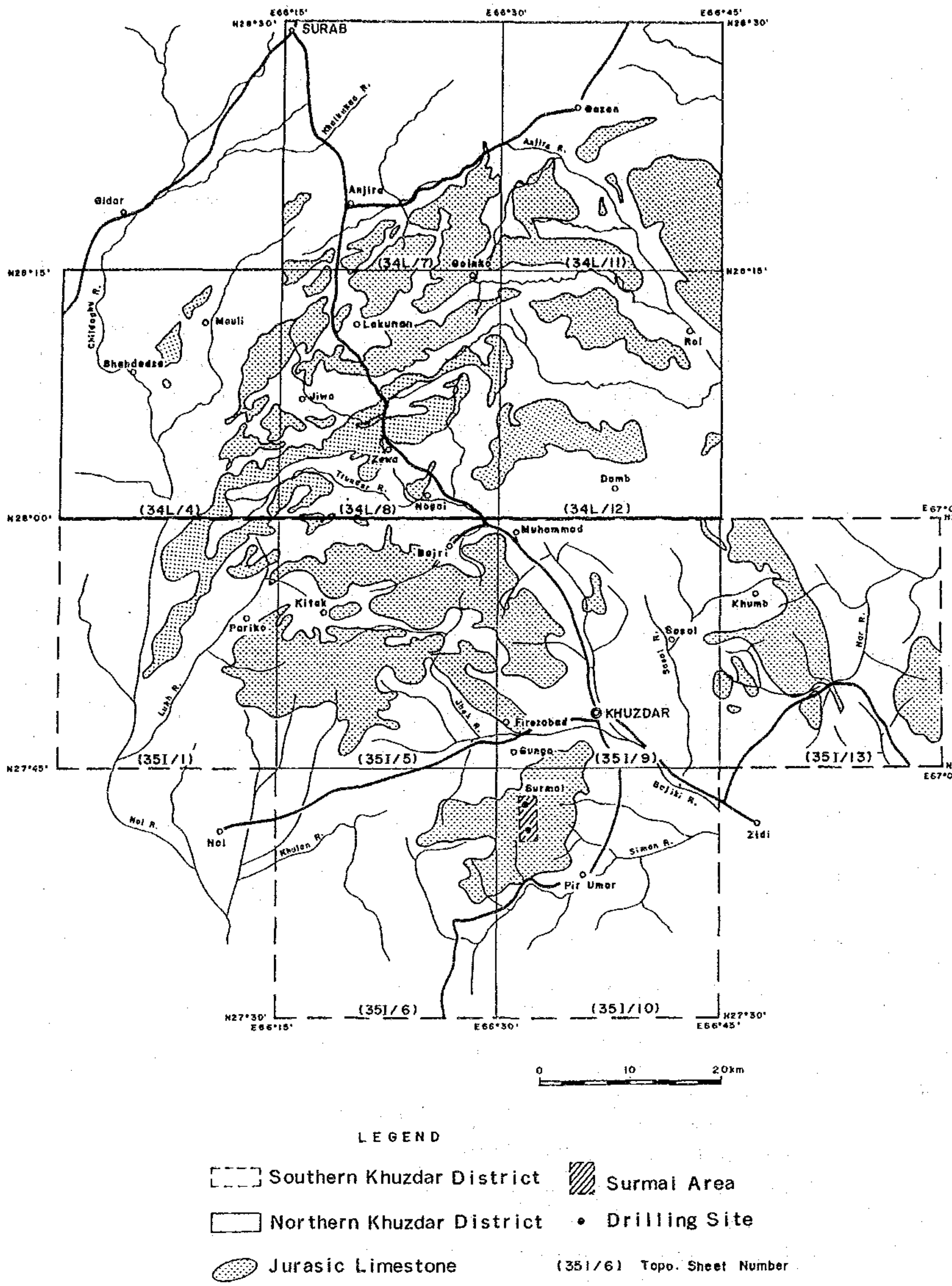


Fig. I-1-1 Location Map of the Survey Area

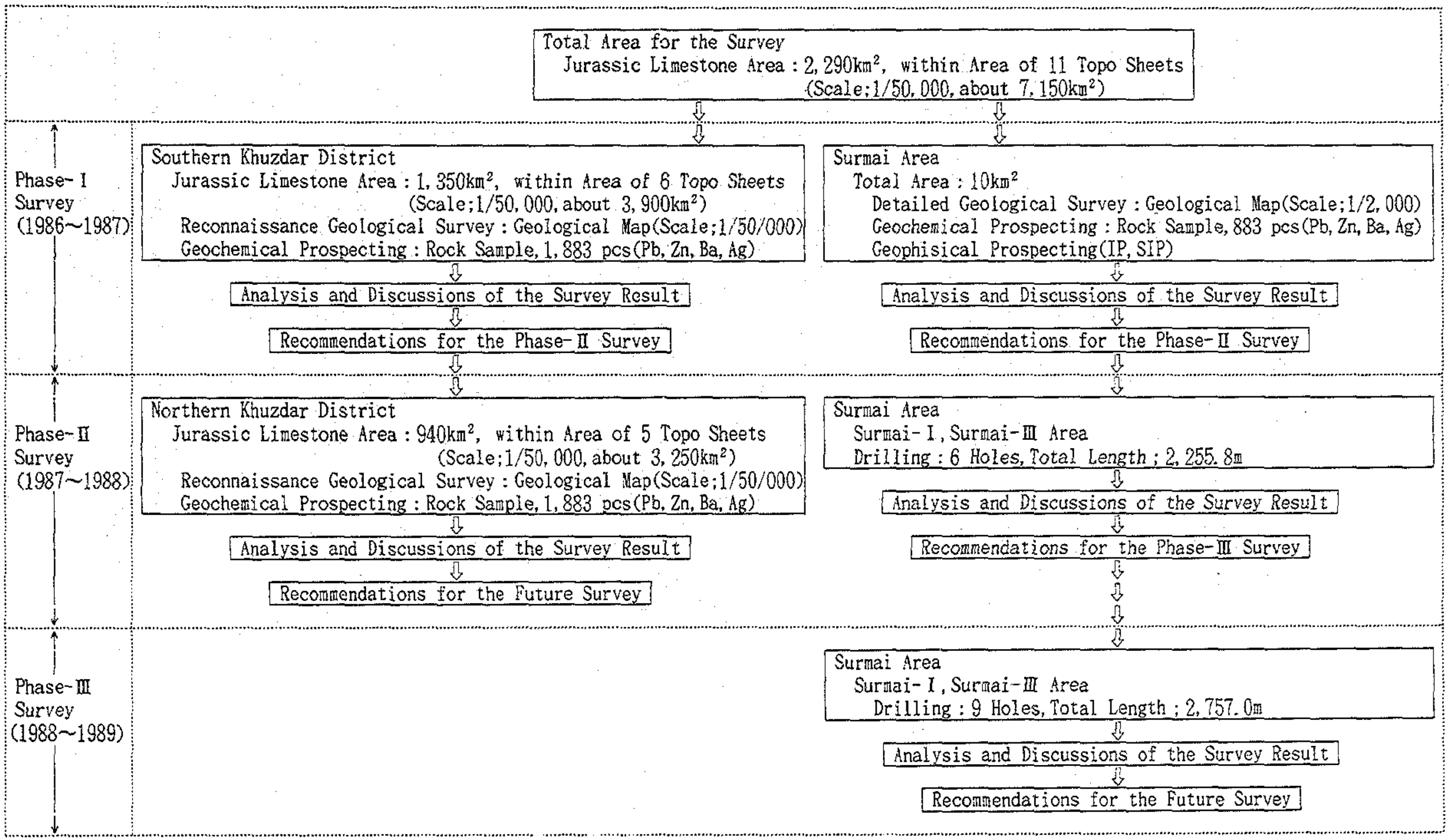


Fig. I-1-2 Flow Sheet of the Survey

CHAPTER 2 CIRCUMSTANCES OF THE SURVEY AREA

2－1 Access, 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 drainage system of 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 GEOLOGICAL SETTING AROUND THE SURVEY AREA

3 − 1 Geological Setting 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 (Fig. I -3-1).

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 hydrothermal 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 -3-2.

3－2 Geological Setting of Khuzdar District and Surmai Area

3－2－1 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 -3-4 and the stratigraphy of the vicinity of Khuzdar is shown in Figure I -3-3.

The geology of the Khuzdar District, reflecting the structure of Khuzdar Knot, show a 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.

3 - 2 - 2 Surmai Area

Three members of 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 -3-5 and the geological map and cross sections including the drilling site are laid out in Figures I -3-6~ 8.

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 . Gossan consists of porous to massive oxide composed mainly of limonite. The gossan occurs in thick bedded form replaceing the host rock along the bedding. It occurs from 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.

CHAPTER 4 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-3-3 Stratigraphy of Khuzdar District

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

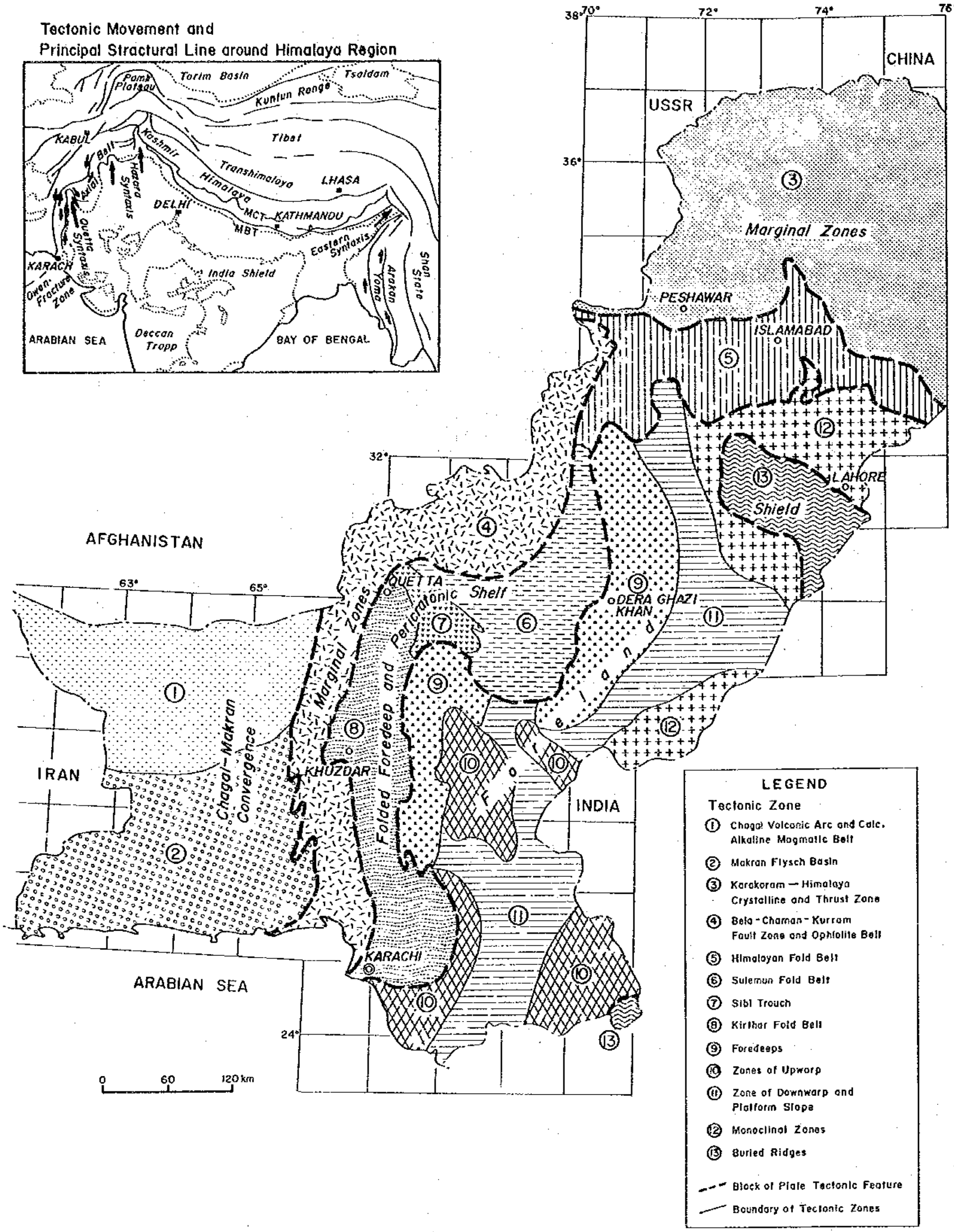


Fig. I-3-1 Tectonic Zones of Pakistan

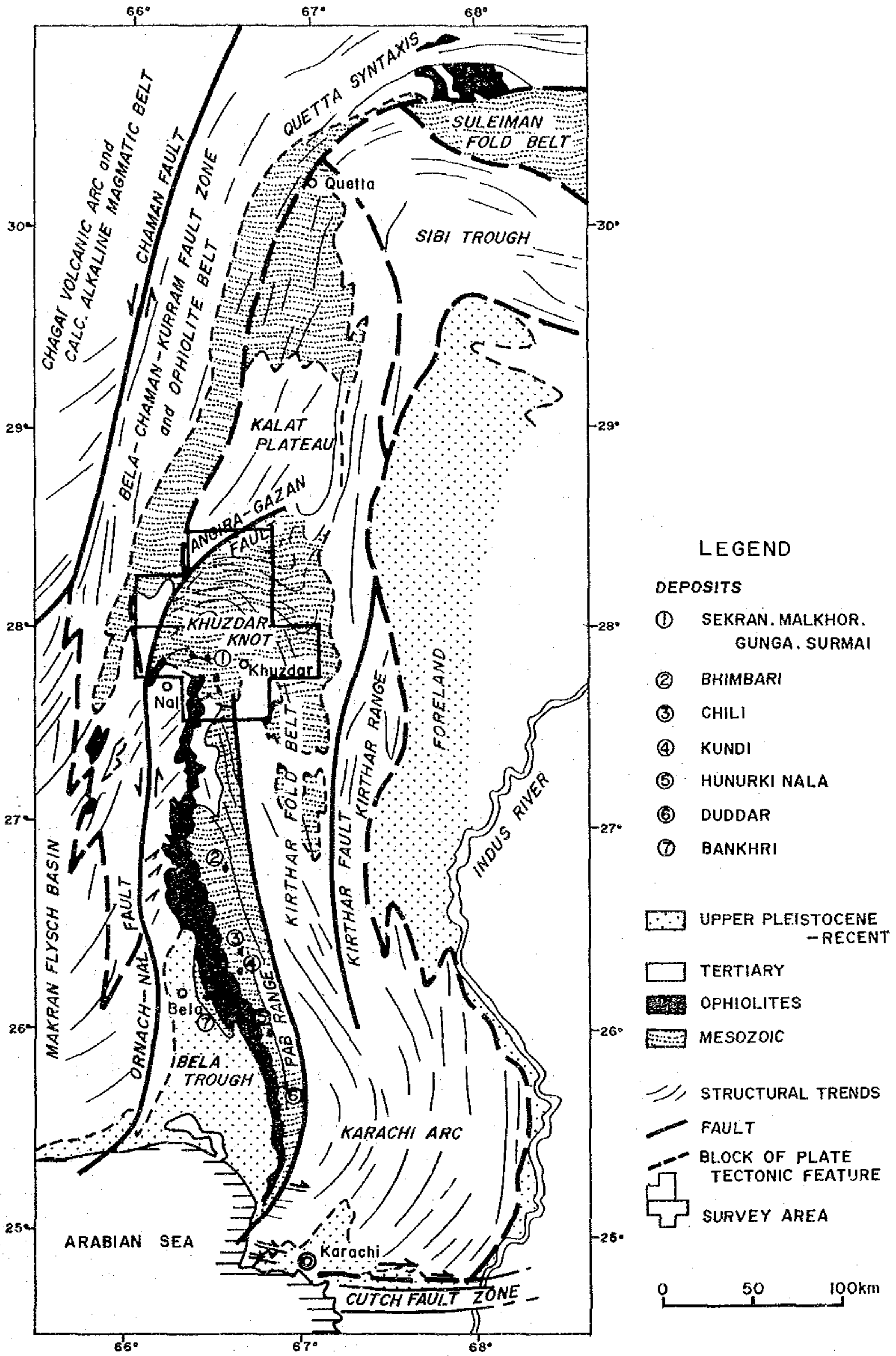


Fig. I-3-2 Geology, Structural Features and Distribution of Mississippi Valley Type Pb-Zn-Ba Deposits in the Vicinity of the Survey Area

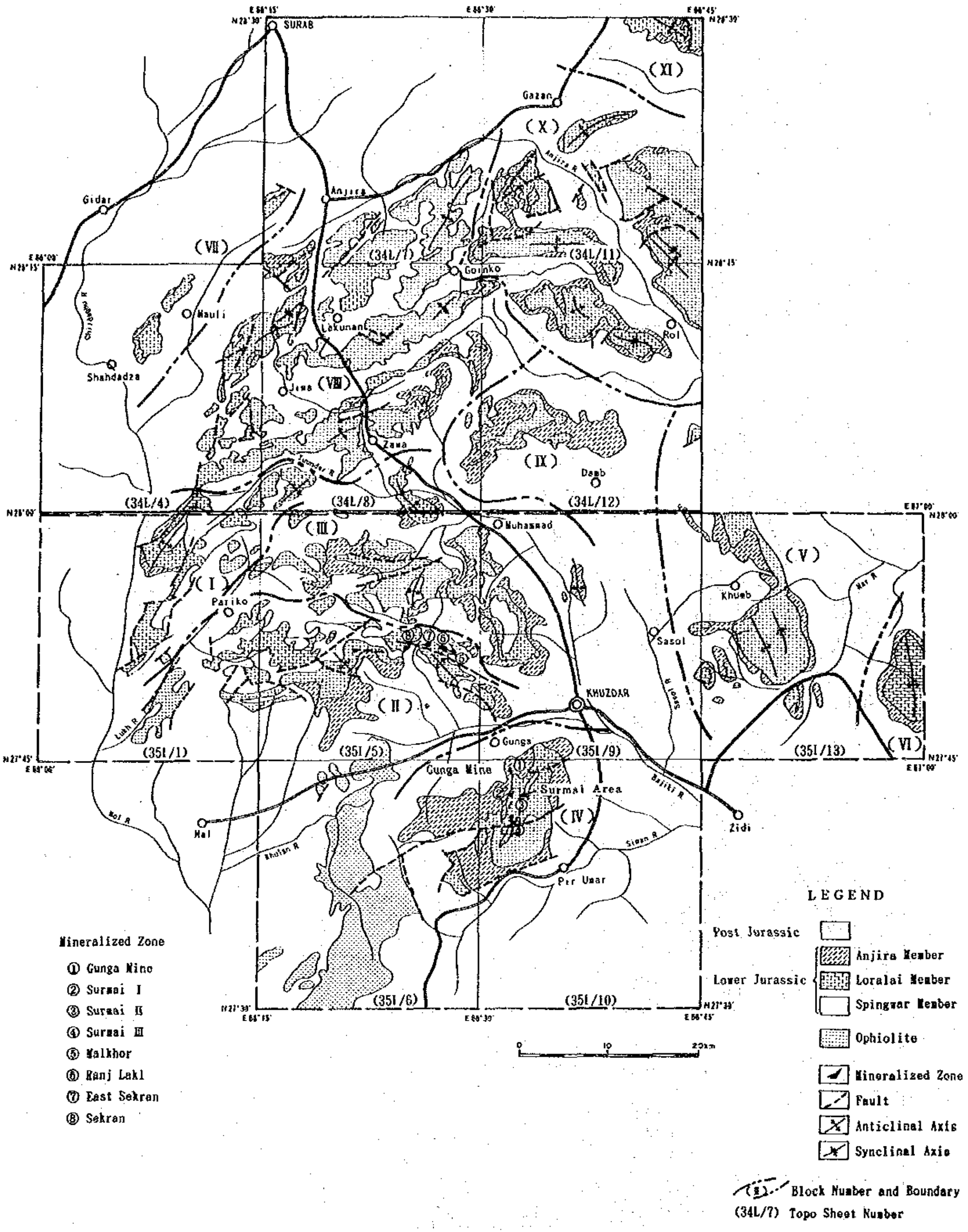


Fig. I-3-4 Geological Map of Khuzdar District

Geologic age	Group			Lithology	Thickness	Columnar	Mineralization
	Formation	Member	Unit		(m)	Section	
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 coloitic 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-3-5 Stratigraphy of Surmai Area

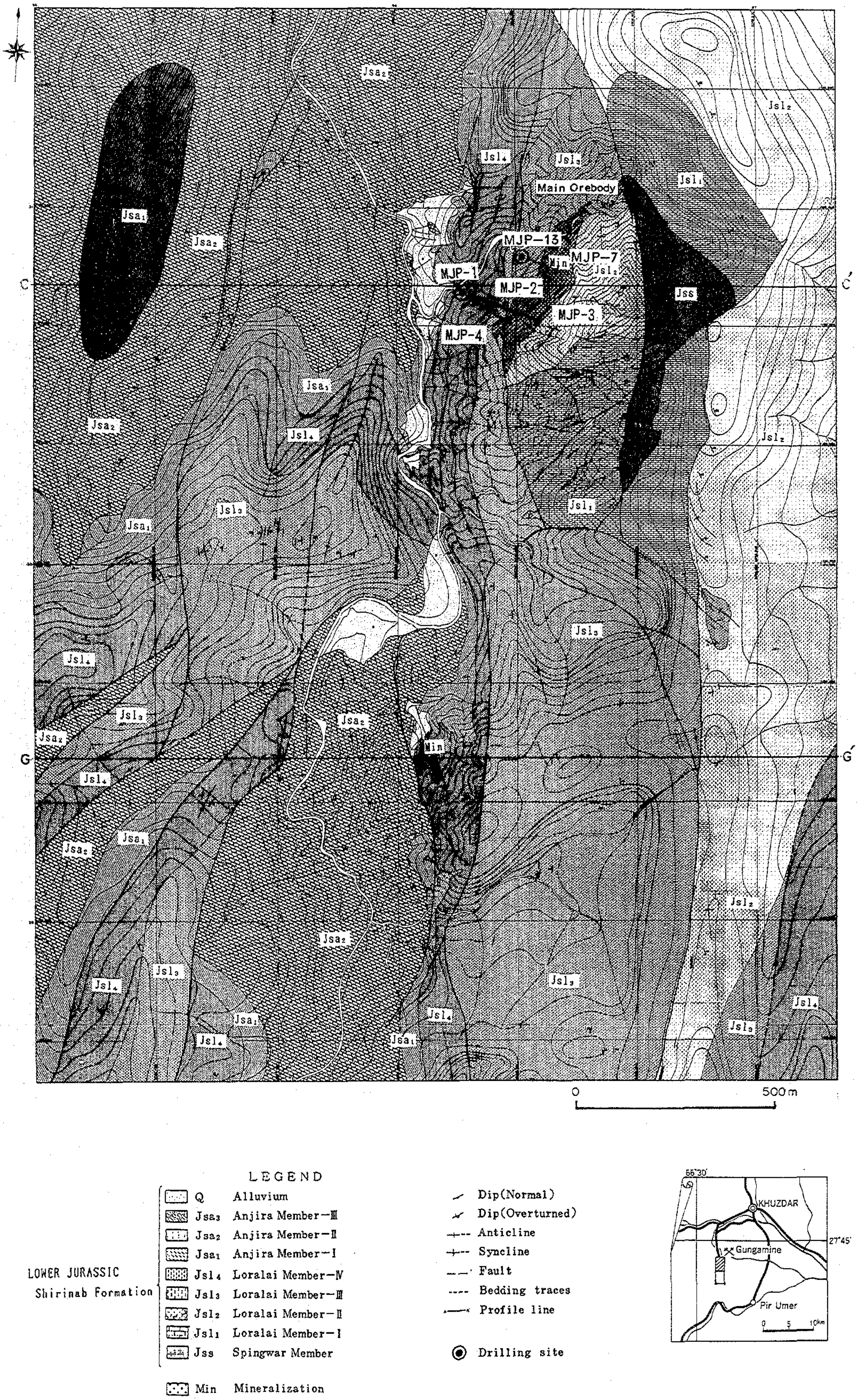


Fig. I-3-6 Geological Map of Surmai-I, II Area with Location of Drilling

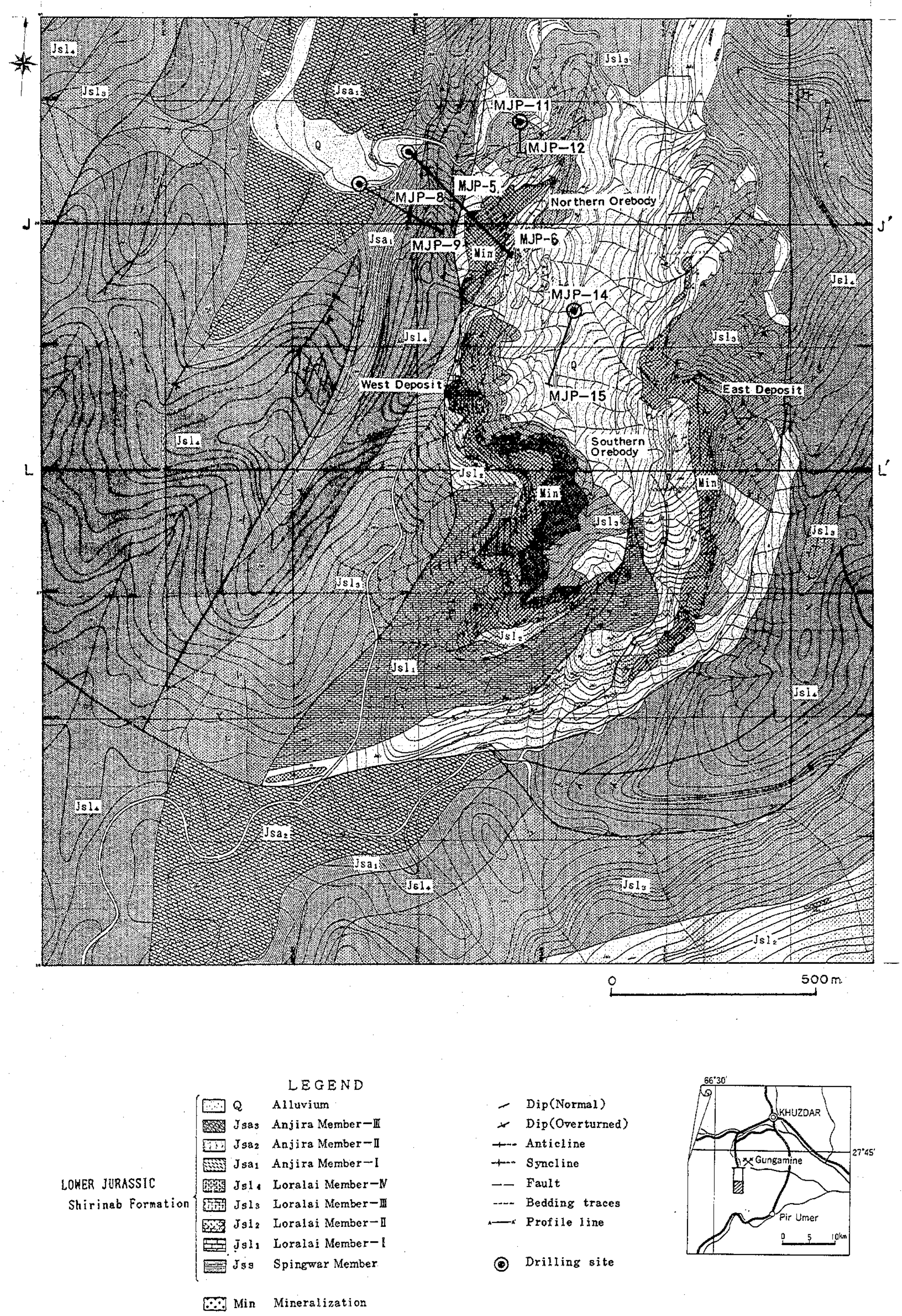
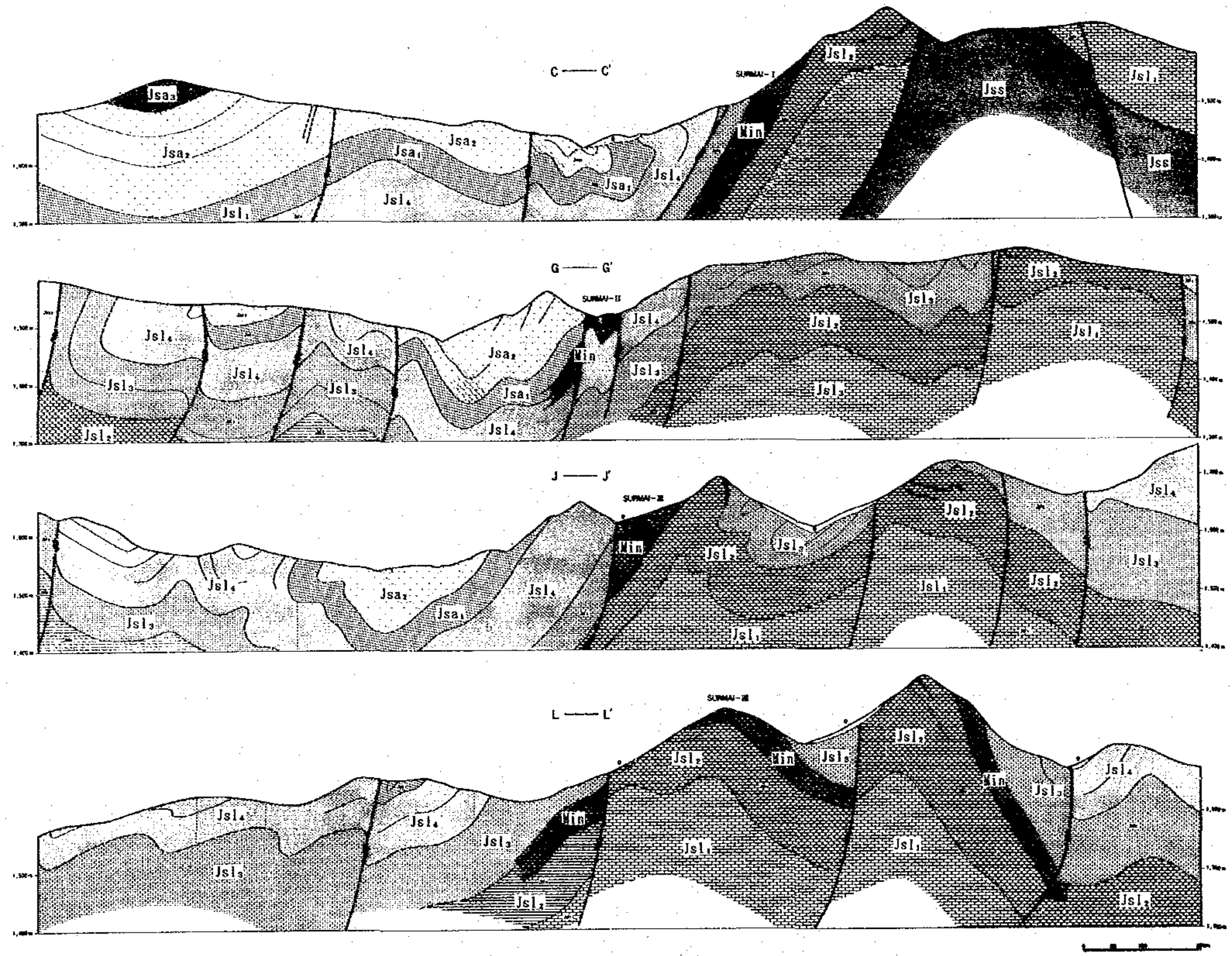


Fig. I-3-7 Geological Map of Surmai-III Area with Location of Drilling



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

- Min — Mineralization

- Fault
- Bedding traces
- Profile line

Fig. I-3-8 Geological Profiles of Surmai Area

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5－1 Conclusions

5－1－1 Southern and Northern Khuzdar District

5－1－1－1 Geological Survey

(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 Shirinab Formation is distributed largely in 11 zones, and the blocks making the zones extends in east-west direction protruding northward. The members have complex folded structure of anticlines and synclines.

(3) 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. All of these showings crop out as gossan, but it is inferred that primary sulfide ores exist below the water table. 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.

(4) 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.

(5) The mineral showings in the Southern and Northern Khuzdar District are distributed around the ophiolite zone in the southwestern part of the Southern Khuzdar District in the Surmai～Sekran Zone. The Northern Khuzdar District lies to the north, outside, of this zone.

5－1－1－2 Geochemical Prospecting

(1) The results of geochemical prospecting show that elements Pb, Zn, Hg have high positive correlation to each other and form anomalous zones around gossan while Ba forms anomalous zone outside of the Pb, Zn, Hg zone. Lead, zinc, mercury anomalous zones of A-rank were found in Surmai Area and also in the vicinity of Malkhor～Sekran mineralized zone. The study of all geochemical data, obtained by this project clearly shows that the promising geochemical anomalies all exist in the Surmai～Sekran Zone and the vicinity of it, in the Southern Khuzdar District .

5－1－2 Surmai Area

5－1－2－1 Geological Survey

(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 not promising.

5 − 1 − 2 − 2 Geochemical Prospecting

(1) The results of geochemical prospecting show 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 and Northern Khuzdar District.

5 − 1 − 2 − 3 Geophysical Prospecting

(1) 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.

(2) The location of the mineralized zones confirmed by the drilling coincides with the geophysical (IP,SIP) PFE anomaly zones with the exception of the traverses where the electrode intervals were excessive.

5 − 1 − 2 − 4 Drilling

(1) The horizons confirmed by the 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 varing dimensions.

(2) Of the 15 holes drilled during the project, lead-zinc sulfide mineralization was confirmed in 13 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 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 of the small blocks (sulfide) 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.

(6) 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 area east of Surmai-II.

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

5-2 Recommendations

5-2-1 Southern and Northern Khuzdar District

It is desirable that exploration with emphasis on geophysical prospecting and drilling be carried out in the Malkhor～Sekran mineralized zone that has high resource potential. It is concluded that gold skould be added to the objective of exploration.

5 - 2 - 2 Surmai Area

The economic feasibility of the reserves calculated on the basis of the work of the past three years and laid out in 5-1-(5), 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

REGIONAL DISCUSSIONS

PART II REGIONAL DISCUSSIONS

CHAPTER 1 SOUTHERN AND NORTHERN KHUZDAR DISTRICT

1 − 1 Geological Survey

1 − 1 − 1 Geology

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 -3-4 and the stratigraphy of the vicinity of Khuzdar is shown in Figure I -3-3.

The three members of the Shirinab Formation are descrived as follows. The results of microscopic studies for rock samples are shown in App.1～2, and the results of hole rock analysis are shown in App.3～4.

(1) Spingwar Member

This member is composed mainly of calcareous sandstone with minor intercalation of shale and limestone. Spingwar Member occurs in very small parts of Blocks-I and VIII. The sandstone is pinkish gray to white and becomes brown upon weathering. It consists of medium to fine-grained quartz with minor amount of feldspars with calcareous matrix and is orthoquartzitic to calcareous. The quartz is rounded to subrounded and the sorting is not very good. The matrix is composed of transparent coarse-grained calcitic cement and argillaceous fine clastics. Also dissemination of idiomorphic to hypidiomorphic magnetite altered to limonite is locally observed. The thin beds of shale intercalated in sandstone are gray to pale brown and becomes brownish gray by weathering. This shale is composed mainly of fine-grained, rounded to subrounded and partly corroded quartz and of brown microcrystals of calcite. Also magnetite grains mostly altered to limonite and acicular to fibrous illite are associated. Limestone is micritic and is poor in fossils.

(2) Loralai Member

This member consists mainly of alternation of limestone and shale. The beds are a 0.2～5 m thick. The limestone is hard and occurs as beds of varying thickness as well as in massive form. The shale is soft and forms the topographic depressions on the surface. It is often covered by weathered sediments. This member often forms mountains with anticlinal structure and is distributed throughout the survey area. Limestone is gray to dark gray and becomes brownish gray by weathering. Calcite veinlets occur in the limestone. Irregular reddish brown to orange patches of 2～10 cm in diameter occur along the bedding and the rock as a whole often has a mottled appearance. The limestone is mostly micrite and partly biomicrite, oomicrite and intramicrite. The allochem of the biomicrite consists of fossil fragments filled by mostly round, egg-shaped, oblong or acicular calcite spar. Gastropods, brachiopods (Spiriferina sp.), bivalves (Pecten Weyla, Girvillia), crinoids (Isocrinus) and corals occur in this member. In the upper parts of this member, 0.1～0.5 m thick coquina layers often occur. Also several layers of oomicrite and intramicrite are observed in the lower parts. Calcite, rounded to subrounded fine quartz, disseminated or irregular patches of limonite are observed microscopically. This member is generally cut by coarse sparry calcite veinlets.

(3) Anjira Member

This member is mostly composed of regular alternation of limestone and shale. The unit beds are 0.3～1 m thick. This overlies the Loralai Member conformably and is distributed around the periphery of the mountains. The limestone is hard, greenish gray to dark gray and becomes yellowish gray by weathering. Schlieren texture is often observed. Shale is soft, friable and gray to black changing to pale yellowish gray by weathering. Limestone is mostly micrite, partly biomicrite, and pelmicrite. Well-preserved brachiopods (Spiriferina, Terebratula) and corals (Montlivaltia sp) and other fossils filled by calcite spar occur in the allochem of the biomicrite. Ammonites and nautiloids (Protogrammocera, Dactylioceratids, Cenoceras) of Toarcian stage occur in the shale.

1－1－2 Geologic Structure and Sedimentary Circumstances of the Shirinab Formation

The geology of the Southern and Northern Khuzdar District, reflecting the structure of Khuzdar Knot, show a east-west structure with northward protrusion at the central part of Southern Khuzdar District. 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 (Fig. I -3-4).

The limestone of this formation is mostly micrite. Most of the micrite is said to be formed by rapid chemical or biochemical precipitation from sea water in quiet environment. The limestone of the Loralai Member forms alternations with shale and the limestone also has patches of shale. Also in some of the limestone beds of this member, concretions are found. This indicates low rate of sedimentation. Thus we see that there were significant variation of sedimentation rate during the deposition of Loralai Member. Also the limestone with patches of shale are believed to have been formed by slow supply of argillaceous material and rapid deposition of micrite occuring simultaneously.

Oolitic limestone is developed into very thick beds in the central part of the Loralai Formation. These oolitic limestones are said to be formed under high energy conditions with rapid movement of sea water, thus in shallow marine environment. Crawling traces are found in the Loralai Formation and this also is an evidence of shallow sea facies.

The above evidences indicate the following depositional environment for the Shirinab Formation of this area. During the early phase (Spingwar Member), the deposition of detrital material (sandstone) of the unstable shallow sea prevailed. The deposition of the middle phase (Loralai Member) occurred first in quiet marine environment - limestone and shale - then limestone in shallow seas and again limestone and shale in quiet waters. The late phase (Anjira Member) limestone and shale alternation containing ammonites and radiolarian fossils was formed under quiet marine environment. Thus this area became shallow marine during a brief period, but during most of the time it had stable conditions similar to that of the continental shelf.

1 − 1 − 3 Mineralization

Eight Mississippi Valley type Pb-Zn-Ba prosepects, Malkhor, Ranj Laki, East Sekran and Sekran as well as Surmai-Ⅰ ～ Ⅲ mentioned later and Gunga developed already, are distributed in the Suothern and Northern Khuzdar District. Those prospects occur in the 25 km long and 2 km wide narrow zone (Surmai～Sekran Zone) extending from Blocks Ⅳ to Ⅱ. All of these showings crop out as dark redish brown colour gossan, and occur in the limestone of Loralai Member.

The gossans are considered to be the weathered and oxidized products of primary lead-zinc replacement deposits. They consist mostly of limonite and other oxides. The mode of emplacement of mineralization is classified into the following four types, A-type: strata-bound replacement associated with fracture fillings, B-type: open-space fillings in solution collapsed breccia, C-type: replacement in fault zones, and D-type: veinlets associate to A,B and C types. The gossans are composed by combinations of above four types of mineralization. The geological maps of the four prospects in the Malkhor～Sekran mineralized zone are shown in Fig. II-1-1～3. The results of chemical analysis of samples from gossans in Surmai, Malkhor, Ranj Laki and Sekran are shown in App.5.

In gossans, limonite, hematite, calcite, siderite and quartz are generally found and smaller amount of marcasite, pyrite and galena, together with white powdery material in small druses which could be smithonite are observed by the unaided eyes. The result of x-ray diffraction is shown in App.6.

1－2 Geochemical Prospecting

Geochemical prospecting was carried out parallel with geological survey in the first and second phases. It was decided that the geochemical samples for analysis would be rocks. An average of two samples per square kilometer was used so that the sampling density would be uniform. And care was taken to collect specimens representing the geology of the area. Total number of 4,788 rock samples were collected. The samples were crushed, about 50 g were extracted by quartering, ground to under 80 mesh and 10 g were extracted for analysis. Analysis was done for six elements, namely Pb, Zn, Hg, Ba, Mg, S. A total of 4,633 samples, combining 4,583 samples from Southern and Northern Khuzdar District and 50 samples selected from those of Surmai Area except gossans, were used for the investigation on the whole survey area.

1－2－1 Basic Statistical Analysis

The interpretation of these results were conducted for each geologic member and blocks for the whole survey area. The statistical values of the district are listed in App.7. The results of the interpretation are as follows.

(1) 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. Lead, zinc, mercury anomalous zones of A-rank were found mainly in Blocks II and IV area centered by the Surmai～ Sekran Zone (App.8, Fig. II -1-4～5).

(2) Anomalous zones of several elements usually occur overlapping one upon another. Thus in order to evaluate the geochemical anomalous zones, they are grouped into Pb-Zn and Ba complex anomalous zones, and ranked A to E by the standards shown in Table II -1-1. The distribution of A rank Pb-Zn complex anomalous zones agrees with Markhor～Sekran Zone as well as with Surmai showings and B rank complex anomalous zones occur in the vicinity of A rank zones. A rank Ba complex anomalous zones occur in the vicinity of Pb-Zn complex anomalous zones (Fig. II -1-6).

1 - 2 - 2 Principal Component Analysis

Analysis was carried out for the six elements analysed for geochemical prospecting. The coefficient of determination of the first principal component is 32.0 %, of the second principal component 26.9 % and of the third principal component is 17.3 %. Seventy six percent of all relevant information for variation is included in the data up to the third principal component (App.9). The results of the analysis are as follows (Fig. II -1-7).

The first principal component: The eigenvectors of lead and zinc are very large and those of sulfur and mercury follow. Lead, zinc and sulfur are all variants related to the lead-zinc mineralization and thus the first principal component is considered to represent the intensity of the lead-zinc mineralization. The high score areas for the first pricipal component are most concentrated in the Surmai～Sekran Zone and small high score areas are scattered in other areas.

The second principal component: The absolute values of the eigenvectors is highest for barium and then mercury. The former has positive value and the latter negative. The second principal component shows the intensity of barium mineralization. The high score areas are concentrated in Blocks II, IV, and V. They tend to surround the high score areas of the first principal component in Blocks II and IV. There are small scale high score areas scattered in other Blocks.

The third principal component: The absolute values of the eigenvectors is large for magnesium. The high score parts of the third principal component are distributed widely from Block I to VIII and their distribution is clearly different from the first and second principal component. *In other words, it is shown that magnesium is not related to* lead-zinc and barium mineralization.

The fourth principal component: The absolute values of the eigenvectors is in the order of those for sulfur and magnesium. That for sulfur is positive and is negative for magnesium. The high score parts are of relatively small scale for this component, and there is no correlation with the high score areas of the first to third components. They are distributed widely and suggest the primary nature of the elements. Since they are seen to occur in the vicinity of the high score areas of the first and second components, this could be related to lead-zinc and barium mineralization.

Table II-1-1 Ranking of Complex Anomalous Areas in Khuzdar District

rank	element	Classification Standards of Complex Anomalous Areas
A	Pb + Zn	① Anomalous area consisting of two or more neighbouring Pb or Zn anomalous values overlapping or close to each other, and associated with an overlapping or neighbouring anomalous area of another element. ② Anomalous area consisting of one Pb or one Zn anomalous value. The anomalous value overlaps or is close to an anomalous area consisting of two or more other kinds of elements formed by two or more neighbouring anomalous values.
	Ba	Anomalous area consisting of two or more neighbouring Ba anomalous values, and overlapping or near an anomalous area of another element with two or more neighbouring anomalous values
B	Pb + Zn	Anomalous area consisting of two or more continued Pb or Zn anomalous values. In addition, the anomalous area overlaps or is close to another anomalous area of a different element.
	Ba	Anomalous area consisting of two or more neighbouring Ba anomalous values, and associated with an anomalous area of anomalous values for another element. These anomalous areas are distributed overlapping or near each other.
C	Pb + Zn	Anomalous area consisting of more than two neighbouring anomalous values of Pb and Zn, surrounded by a low anomalous margin ranging from (M + σ) to threshold values. Anomalous areas of other elements accompany with overlapping or close distribution.
	Ba	Anomalous area of Ba consisting of two or more neighbouring Ba anomalous values, surrounded by a low grade anomalous margin of other elements, ranging from (M+σ) to threshold values.
D	Pb + Zn	The Anomalous area consists of several anomalous values of Pb or Zn which are discontinuously distributed with respect to each other. Their low values surround the anomalous area. Anomalous values of another element also overlaps with or are close to the Pb-Zn anomalous area.
	Ba	Anomalous area consisting of discontinuous anomalous values. Other low anomalous values are distributed overlapping or close to the anomalous area.
E	Pb + Zn	Anomalous area consists of several anomalous~low grade anomalous values of Pb or Zn which are discontinuously distributed. Low grade anomalous values of another element are clos to it.

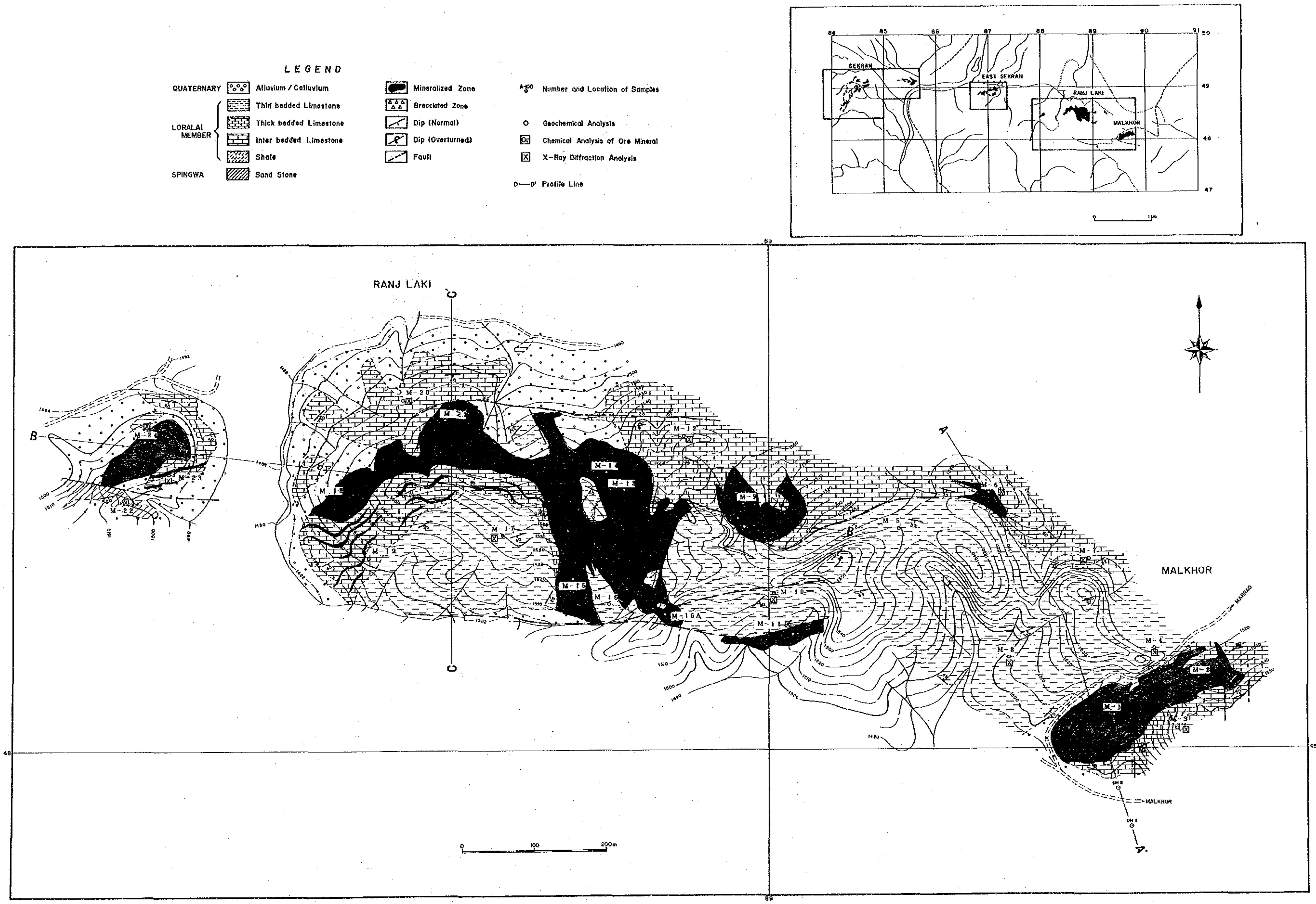


Fig. II-1-1 Geological Map of Malkhor and Lanj Laki

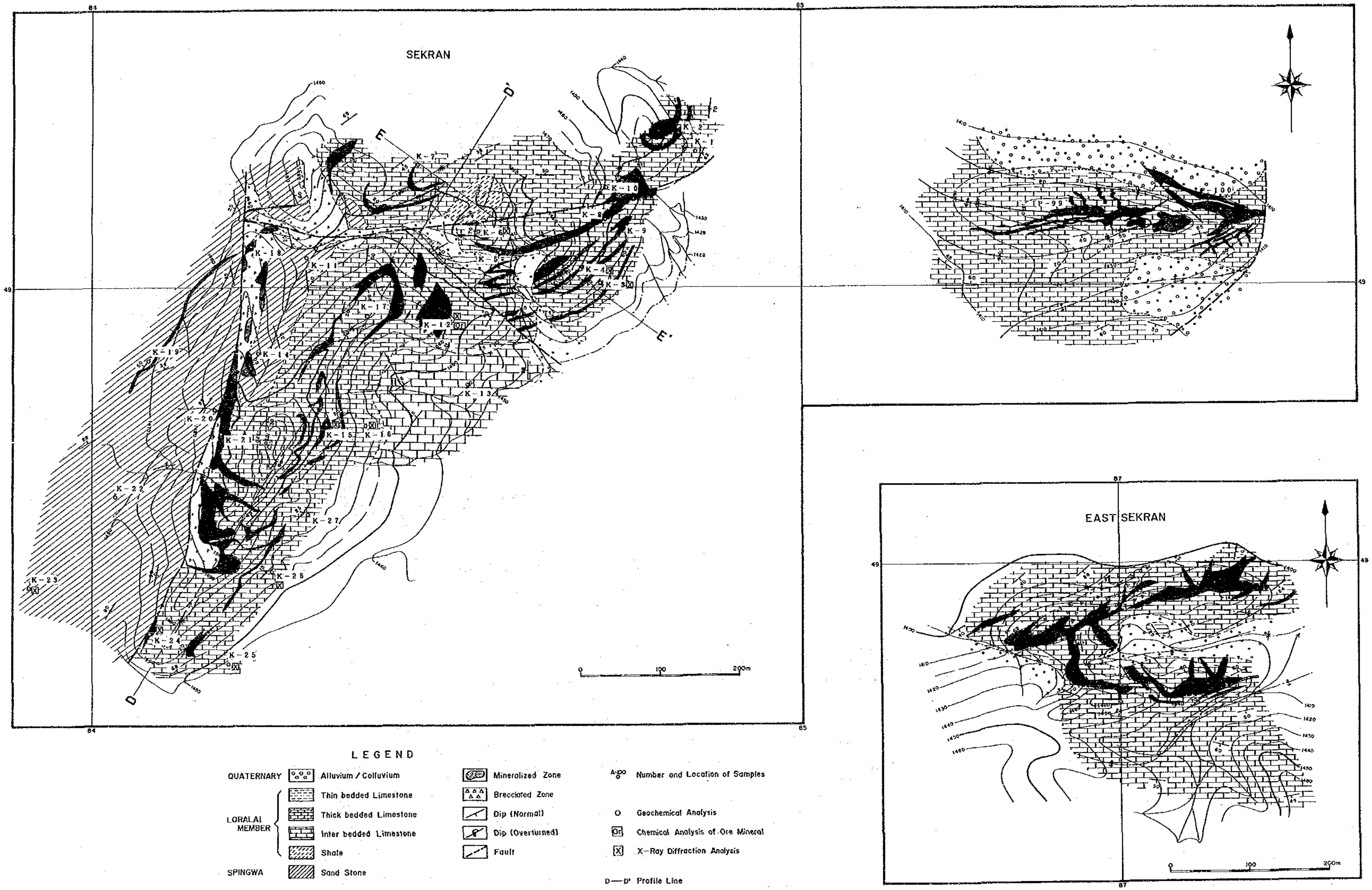


Fig. II-1-2 Geological Map of the East Sekran and Sekran

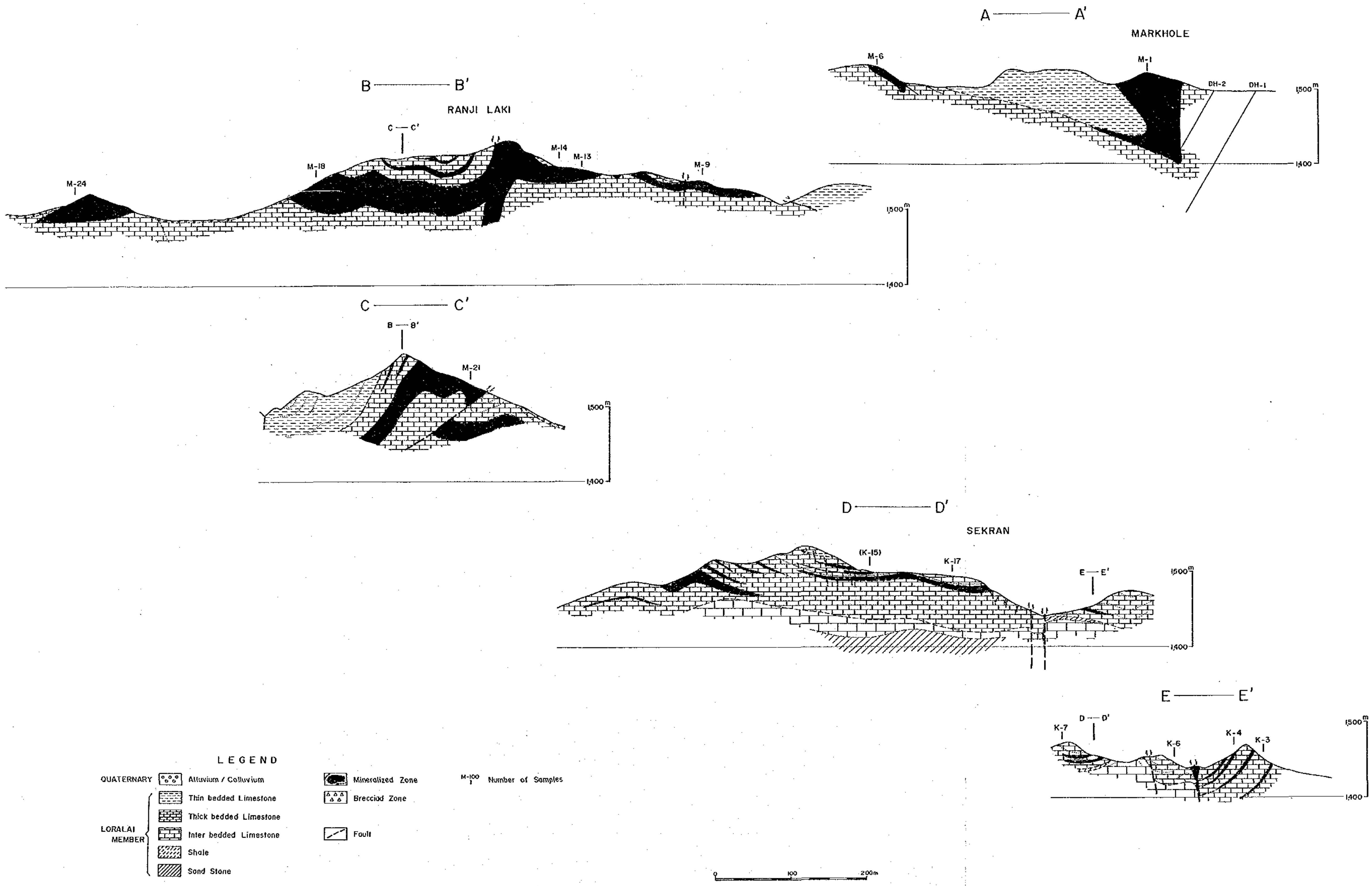


Fig. II-1-3 Geological Profiles of Malkhor, Lanj Laki and Sekran

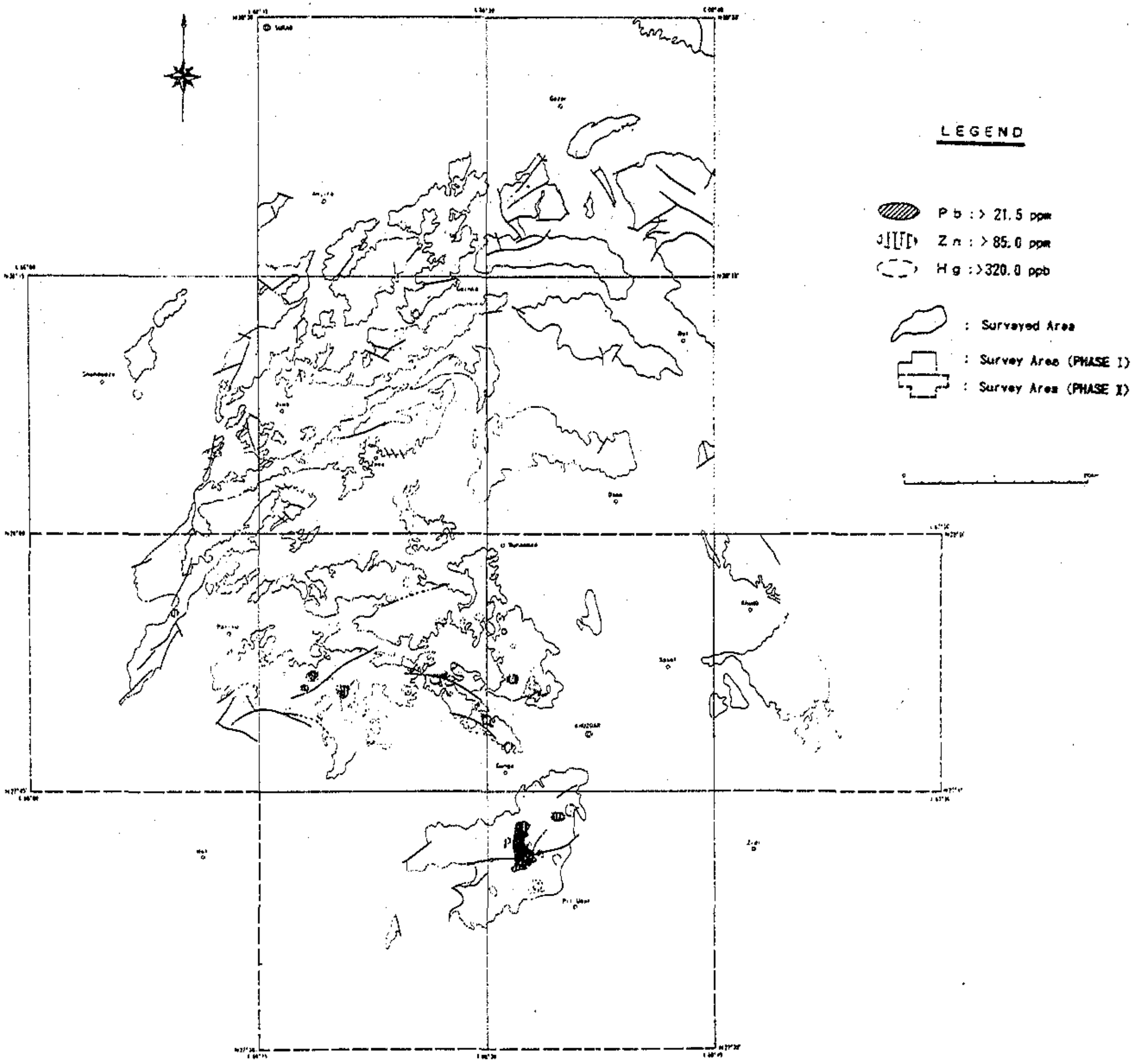


Fig. II-1-4 Geochemical Anomalous Areas in Khuzdar District (Pb, Zn, Hg)

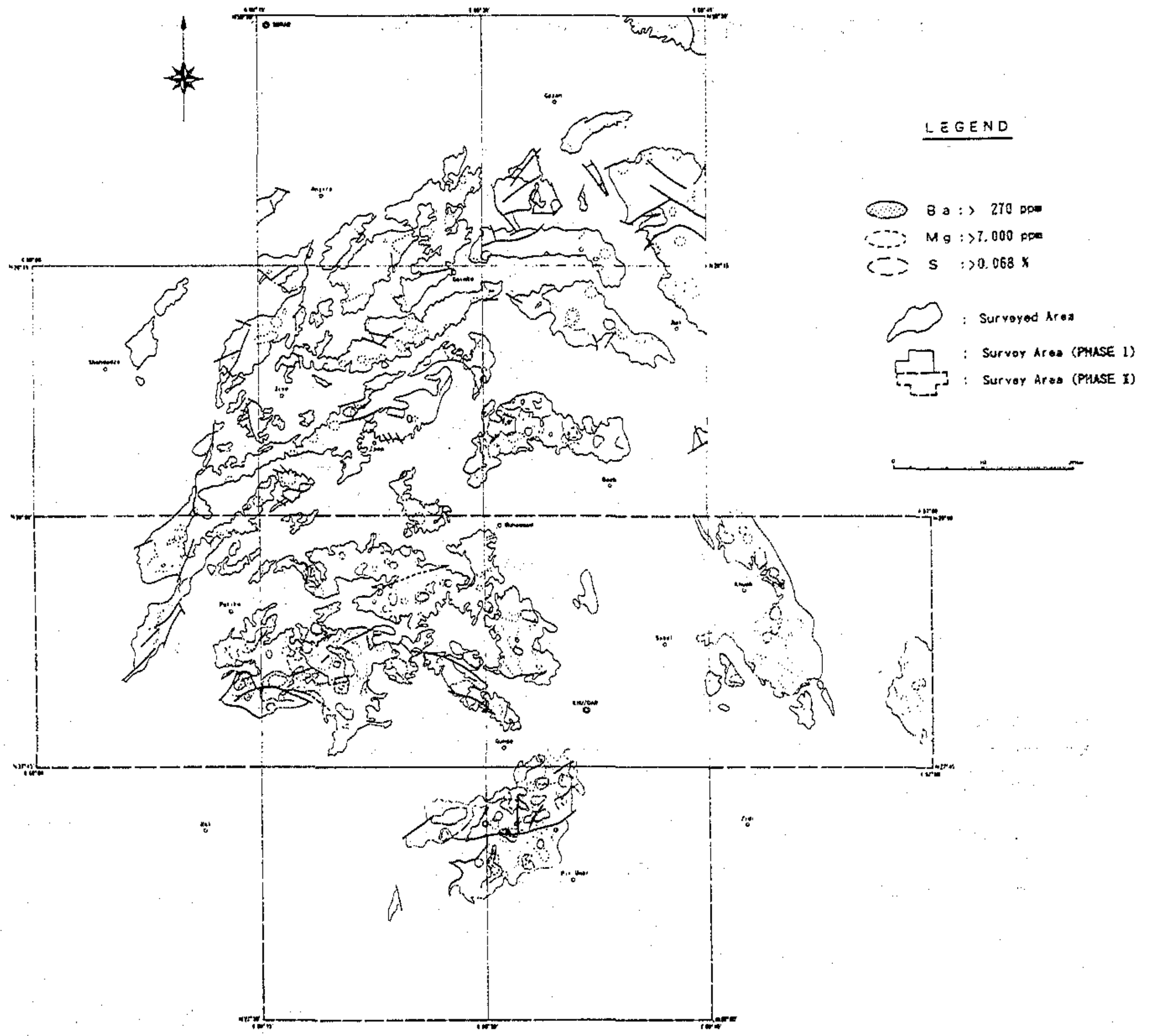


Fig. II-1-5 Geochemical Anomalous Areas in Khuzdar District (Ba, Mg, S)

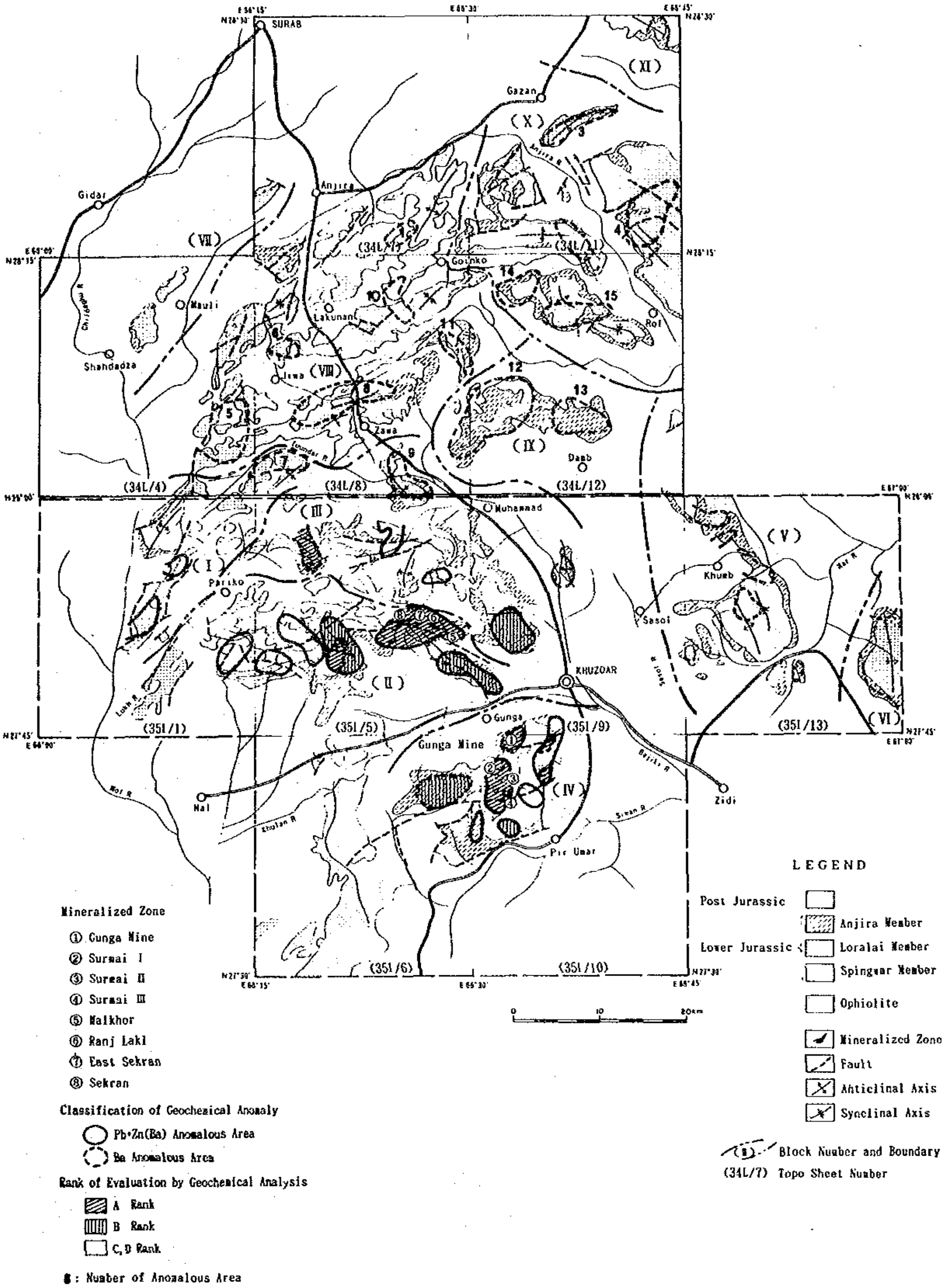
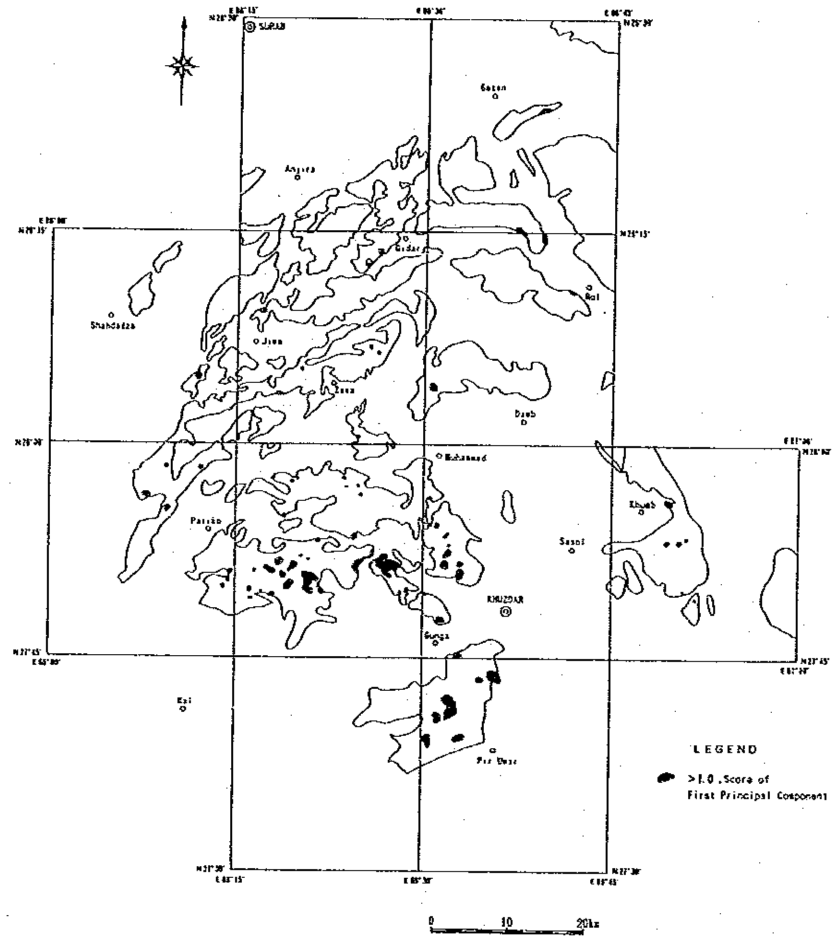
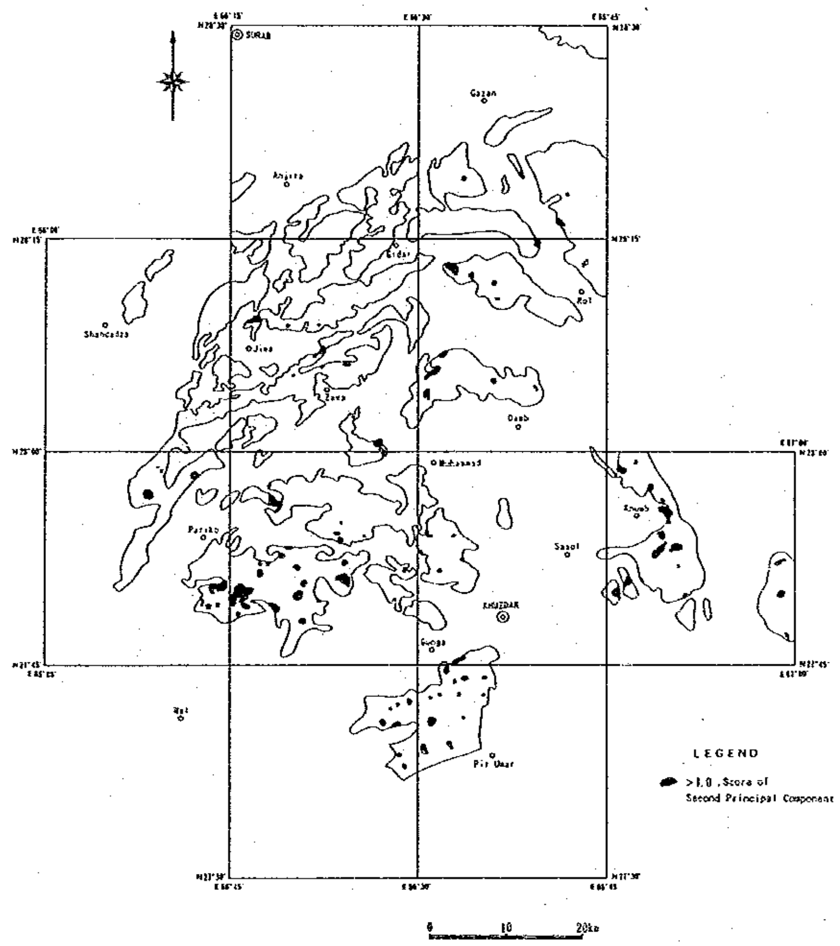


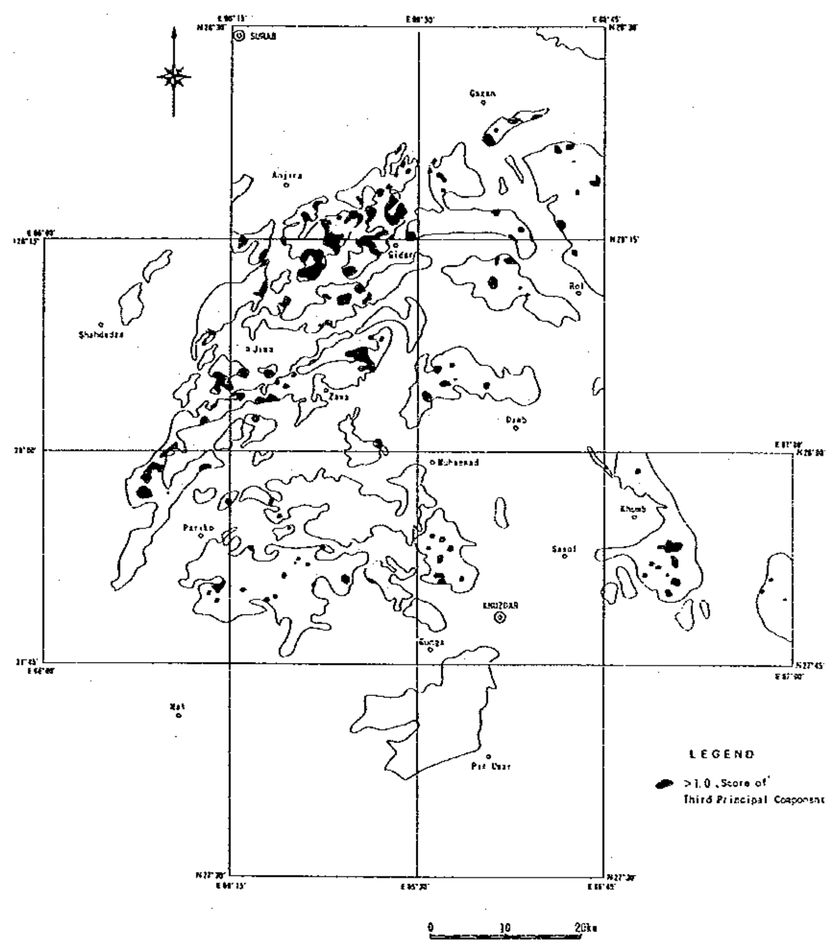
Fig. II-1-6 Compiled Map of Geochemical Analysis in Khuzdar District



First Principal Component



Second Principal Component



Third Principal Component

Fig. II-1-7 Distribution Map of Principal Component in Khuzdar District

CHAPTER 2 SURMAI AREA

2－1 Geological Survey

2－1－1 Geology

Three members of Shirinab Formation are distributed in the Surmai Area. The Spingwar is distributed in a limited area in the northeastern part, Anjira in three separate occurrences in north-south arrangement in the western half and Loralai in the remainder of the 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-3-5 and the geological map and cross sections including the drilling site are laid out
in Figures Ⅰ-3-6～8.

2－1－2 Geologic Structure

This area form the western limb of the anticline with north-south trending axis and has a largely westward dipping strata. There are however, intense folding locally. The strata of Surmai-Ⅲ has a particularly complex structure with two anticlines extending north-south.

2－1－3 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. These gossans are believed to have formed by the 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 showing 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 1.5km 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. The result of microscopic study for the samples of the gossans is shown in App.10.

2－2 Geochemical Prospecting

Geochemical prospecting was carried out parallel with geological survey during the first phase. A total number of 205 rock samples cotainning 36 samples from gossan were collected. The investigation (basic statistical analysis) was done by the same methods as in the case of investigation of the Southern and Northern Khuzdar District. The statistical values of the area are listed in App.11.

The investigation revealed 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 interpretation is the same as in the case of the Southern and Northern Khuzdar District (Fig.II -2-1～2).

2－3 Geophysical Prospecting

The field survey of the geophysical prospecting (IP,SIP) was carried out in two areas, the Surmai Area and the Gunga Mine Area where the shapes of the deposits had been cleared, in the first phase. Also SIP laboratory studies on 40 rocks and ore samples from the survey area were done in order to understand their SIP characteristics.

2－3－1 Methods and Contents

Field work specifications were set as follows :

a. Length of Survey Line　　17.2 km in twenty lines

SIP	9.4 km in eleven lines	490 points
I P	7.8 km in nine lines	420 points

b. Survey Line Separation : Surmai I , II　150 m
Surmai III　300 m
Gunga Mine　240 m

c. Electrode Configuration : dipole-dipole array

d. Electrode Separation : Surmai I , II and Gunga Mine　a= 50 m
Surmai III　a=100 m

e. Electrode Separation Coefficient : n = 1 ～ 5

f. Measurement Method : Frequency domain

g. Frequencies : SIP　0.125 ～ 88 Hz (18 frequencies)
I P　0.3 / 3.0 Hz

2 − 3 − 2 Results of the Prospecting

The results are shown in the interpretation maps (Fig. II -3～5: Interpretation Maps, Fig. II -2-6～7: Interpretation Profiles). Representative apparent resistivity distribution and PFE distribution are plotted on these maps. The localities of the anomaly sources deduced from simulation are plotted on the planar maps. The following is the summaryof the results of SIP•IP survey of each zone.

(1) Surmai-I

a. PFE anomalies were detected below the gossan of the Main Orebody of Traverses B, C, D. The location of these anomalies coincides with the lead-zinc mineralized zones confirmed by the second and third phase drilling.

b. Negative PFE anomalies were detected near the eastern end of Traverses B and C. These are considered to reflect the small mineralization along the bedding and samll faults in Unit-I of Loralai Member in the southeastern part.

c. High PFE value at the western end of Traverse C is considered to be caused by faults.

(2) Surmai-II

a. There is a weak N-S trending anomaly in this area, but this is interpreted to reflect small mineralized zones accompanying faults.

(3) Surmai-III

a. PFE anomalies were detected in Traverses J, R in the northwestern part and in Traverse L in the central part.

b. The location of the anomaly of Traverses J, R coincides with the deeper extension of the Northern Orebody of the West Deposit. Mineralized zones continuous to the above anomaly was confirmed by the second and third phase drilling. The reason for not detecting the anomaly above the mineralized zone is believed to be the excessive electrode interval.

c. In Traverse L, anomalies were detected at two points, namely stations 6~7 and 9~12. The former is located in the eastern part of the Southern Orebody of the West Deposit and is believed to occur along faults. The latter anomaly coincides with the location of the Eastern Orebody.

d. Mineralized zone was confirmed between the West and East Deposits by the third phase drilling (MJP-14, 15). Negative anomaly over a wide area at the above mineralized zone was detected by geophysical prospecting (Traverse K). This is believed to be caused by the traverse being parallel to the fault plane.

(4) Vicinity of Gunga mine

SIP anomaly which coincides very well with the Gunga Deposit was detected (Fig.II-2-8: Traverse Map, Fig.II-2-7). This deposit is composed of barite zone in the hanging-wall side and the thick silicified zone containing lead-zinc sulfide ores in the foot-wall side. It was shown by laboratory work that the physical properties of the barite sample are similar to those of the host rock. Thus it is difficult to detect barite deposit by IP•SIP method and this anomaly is believed to reflect the silicifide zone accompanied by lead-zinc ores.

2-4 Drilling

2-4-1 Location, Direction and Length of the Holes

The Main Orebody area of Surmai-I, Northern Orebody area of West Deposit, Intermediate area between West and East Deposits of Surmai-III are the three areas targeted for drilling. Fifteen holes were drilled from six sites. The locality, direction and length of each hole are shown in Table II-2-1. The locality of the holes is plotted in Fig.I-3-6~7. The core section (column) was prepared in 1:200 scale and the whole core was photographed in colour.

Table II-2-1 Locality, Direction and Length of Drill Holes

Drill No.	Area, Coordinates(X, Y), Altitude(H)				Direction from T.N.	Angle	Length
	Area	X	Y	H			
				m			m
MJP- 1	Surmai- I	2,008,151	1,125,382	1,461	–	-90°	401.0
MJP- 2	ditto	ditto	ditto	ditto	108°	-70°	351.0
MJP- 3	ditto	ditto	ditto	ditto	108°	-45°	300.8
MJP- 4	ditto	ditto	ditto	ditto	118°	-70°	401.0
MJP- 5	Surmai-III	2,007,983	1,123,076	1,550	135°	-60°	401.0
MJP- 6	ditto	ditto	ditto	ditto	135°	-30°	401.0
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							5,012.8

2 – 4 – 2 Objective of the Drilling

(1) Surmai-I

The geological 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 third 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 geological 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 lead-zinc sulfide 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 third 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 deposits, characteristics, their extent and the subsurface geological structure of the zone in question.

2 - 4 - 3 Methods, Equipment and Working System

(1) Methods

For soil containing gravel, operation was as follows; drilled by HX single bit, reamed by HX casing metal bit, inserted HX casing. For the bedrock consisting mainly of limestone and shale, wireline method was used with NQ and BQ oversized bit. Fractures were 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.

(2) Equipment

The rig used was Longyear L-38 and the specifications of the major equipment are shown in App.12.

(3) Working system and others

a. 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. The summary of the drilling operation time is shown in App.13～14.

b. 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 8 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.

c. Water for drilling : The water necessary for drilling was transported by trucks from near Gunga for 6～10 km to the drilling site.

d. Withdrawal : After the completion of the operation, usable equipment except expendable items was shipped to Japan. The cores were stored by the GSP at Quetta and Karachi.

2-4-4 Results of the Survey

2-4-4-1 Geology

The horizons confirmed by the drilling are from Loralai Member Unit-I to Anjira Member Unit-II. The rocks of these units are basically limestone and shale. Marly shale forms alternations with the above two rocks and these are divided lithologically into two types of alternation.

Sketches of core of the above four lithologic units are shown in Fig. II-2-9. The results of the microscopic studies on ten rock samples of the core do not differ significantly from those of previous work in Surmai Area (App.15).

2 - 4 - 4 - 2 Stratigraphy

The stratigraphic correlation chart of the drill holes is shown in Figure II-2-10. The stratigraphic correlation of the surface and of the drill holes was carried out and geologic cross sections were prepared (Fig.II-2-11~17). Also the geologic cross sections of the zone between Northern Orebody of Surmai-III West Deposit and East Deposit is laid out in Figure II-2-18~19. The beds of each formations can be correlated between drill holes and also between Surmai-I and III rather clearly, even if they are cut by faults at several parts.

2 - 4 - 4 - 3 Geologic Structure and Position of the Mineralization

(1) Surmai-I

a. Vicinity of Main Orebody : In this zone, Units II-IV of Loralai Member are distributed and they strike N30°E, and dip 70°W. There is a normal fault which strikes N5°E and dips 80°W with displacement of 300~400 m in the western part. This fault intersects the above units. The lead-zinc mineralized zone is 400 m long in strike direction and 30~35 m thick. It is emplaced more or less parallel to the bedding in the lower part of Unit III and the upper part of Unit II. This mineralized zone is intersected at the depth of 150 m in MJP-1~3 section and at 200 m depth in MJP-7,13 by the above fault. The mineralized zone was not located above the fault. The transition from the surface oxidized zone to the deeper sulfide zone is believed to be near 50 m below the surface.

(2) Surmai-III

a. Vicinity of Northern Orebody : Unit-I of Loralai Member to Unit-II of Anjira Member is distributed in this area. There is a normal fault at the western part with N-S strike, 8°W dip and 300~400 m displacement and it intersects the above beds. The beds above Unit-IV of Loralai Member occur in the hanging wall side of the fault with N5~10°E strike and 45°~70°W dip. Units I~III of Loralai Member occur in the foot wall side of the fault with N45°~70°E strike and 55°W dip which decreases to 30°W in the north. Lead-zinc mineralized zone occur in the lower part of Unit-III to lower part of Unit-II of Loralai Member along the bedding. The zone is 350 m long in strike direction, 50 m thick in central part and 25~30 m in the north. It wedges out in the northern margin and is cut by the fault in the south. This zone is cut by the fault at 400 m below the surface near the MJP-8,9,10 section and at 200 m depth near the MJP-5,6 section. Near the MJP-11,12 section, however, the extension below 80 m is not clear. The mineralized zone could not be located above the fault. The transition between the oxidized and the deeper sulfide zones is inferred to occur near 50 m below the surface.

b. Intermediate zone between the West and East Deposit : The general structure of this zone is a northward plunging syncline with N-S trending axis. This syncline lies within a series of anticlines which opens northward in a horse-shoe manner. The deposits of Surmai-III which is originally of a continuous nature, crops out on the surface along this anticlinal structure. The lead-zinc mineralized zone occurs along the bedding in the lower part of Unit-III to the upper part of Unit-II of Loralai Member. The mineralization at 288.6~347.3 m of MJP-14 and 200.8~300.2 m of MJP-15 is although dissected by three E-W faults, continuous to the surface exposure of the Southern Orebody of the West Deposit shown at the southern end of the section. The three mineralized zone confirmed at 126.2~151.5 m of MJP-14 all consist of mineralized and fractured boulders of limestone and intensely fractured and argillized shale occur in the vicinity. Thus they are considered to be boulders of the fault zone. The ground water table depth is inferred to be approximately 100 m from the distribution of hematitized zone. The transition from oxidized zone to the deeper sulphide zone is considered to have occured near 50 m depth.

It is seen that the beds of the Shirinab Formation form, from west eastward, anticline ~ syncline ~ anticline structure with intense local folding. The mineralized zone of the West Deposit~East Deposit is originally continuous and is distributed concordantly with the above structure in the lowermost part of Unit-Ⅲ to middle of Unit-Ⅱ of Loralai Member. The occurrence of the mineralized zone continuing from 288.6~347.3 m of MJP-14 to 200.8~300.2 m of MJP-15 is limited in E-W direction by faults.

2 - 4 - 4 - 4 Mineralized Horizon

The surface survey and drilling revealed that the major part of the mineralization is controlled stratigraphically and occurs in Loralai Member. The mineralized parts caught by the drilling investigation are summarized and correlated in Figure Ⅱ-2-10. It is seen that the lead-zinc mineralized horizons are in Unit Ⅱ-Ⅲ of Loralai Member and they have been named A, B and C horizons from the upper horizon downward. The mineralized parts of the drill holes were numbered in accordance with the holes such as A-3, B-2, C-2. The A-Horizon is situated at the lowest part of Unit-Ⅲ to middle of Unit-Ⅱ of Loralai Member, B-Horizon is at middle to the lower part of Unit-Ⅱ and C-Horizon in the lower part. The thickness of the horizons are 100 m for A, 6~7 m for B and 10~15 m for C. The mineralization is distributed in these zones with varying vertical locations. These three horizons are clearly correlated and it is established that they are distributed continuously from Surmai-Ⅰ to Surmai-Ⅲ.

Assay was done on 219 samples collected from the mineralized parts. A quarter of the core was sampled, crushed, quatered to 100g, ground to under 80 mesh and 20 g were used for the assay. The elements analysed are Pb, Zn, Ba and Ag. The prepared samples were sent to Chemex Labs Ltd. and AAS was used. The results are laid out in App.16~17. The characteristics of the mineralized zone are; although locally high, the Pb+Zn grade is generally low and there are not many promising zones, Ba content is generally very low, Ag content on the other hand is relatively higher than most Mississippi Valley type lead-zinc deposits.

The depth, average and maximum grade,and the promising zone for mining of each hole drilled during the third phase are shown in Table II -2-2～3. The criteria for defining the promising zone are; over 2.5 m wide and over 5 % Pb+Zn content.

2 － 4 － 4 － 5 Mineralization

Mineralization consists mainly of disseminated powdery to granular sphalerite and galena replacing limestone with siderite and calcite veins and veinlets intersecting the above mineralized zone. Also small amount of pyrite, chalcopyrite and weak silicification are associated with the activity. Sphalerite and galena often occur separately. The veins mentioned above sometimes contain medium to large crystals of sphalerite and galena which were probably formed at a late stage. Lead-zinc mineralization in shale is rare. Siderite and calcite often occur in the same vein and the calcite is in the central part while siderite occur in the marginal (near the host rock) part of the veins. Siderite, therefore, crystallized before calcite. A sketch of a typical mineralized part of the core is laid out in Figure II -2-9. Limonite and lead and zinc sulphides occur together in the mineralized zone encountered in MJP-7, 11 and 12, they are believed to be the transitional zones between the upper oxidized and lower sulfide zones.

Polished sections of 45 samples from the mineralized zone of the drill cores were studied microscopically. The results of microscopic observation are shown in App.18～19. Also 10 samples from the above were studied by X-ray powder diffraction. The results of microscopic observation are shown in App.20.

Sphalerite is usually subrounded with 0.05～2 mm diameter and occurs in mainly limestone matrix as scattered spots or in concentrated parts. Galena is euhedral with diameter in the order of 1 mm. It is rare to find sphalerite and galena occuring together or these minerals with inclusion of other minerals. In many samples the transition of these two sulphides to carbonates (smithonite and cerussite) was observed. Pyrite and chalcopyrite occur widely, but they are of minute grain size and of small amount and they occur mostly in veins. It is noteworthy that, although in small amount, electrum was identified in the samples. These are usually 2～20 μm (maximum 40 μm) in diameter and occur mainly with the gangue minerals. Also Ag-Pb-Bi minerals and Ag-Pb-Sb minerals were inferred to occur in some samples.

2－5 Reserve Calculation

Ore reserves were calculated for Main Orebody of Surmai-Ⅰ, Northern Orebody and the orebody between the West and East Deposits of Surmai-Ⅲ. The basic data for these orebodies were obtained by drilling. The existence ratio for the calculation was assumed to be 100 %. The orebodies were divided into large blocks which included the larger area for which the continuity of the mineralization was considered certain and small blocks which were established around the high-grade portion (PZM) within the large blocks. The large blocks were further divided into the sulphide zone and the oxide zone (shallower than 50 m depth) while the small blocks were all in the sulphide zone. The results of drilling were the sole source for the basis of calculation. These figures are in the possible reserve category.

2－5－1 Surmai-Ⅰ

(1) Main Orebody : The area and the block number is shown in Figure Ⅱ-2-20. The reserves are summarized and shown in Table Ⅱ-2-4.

2－5－2 Surmai-Ⅲ

(1) Northern Orebody : The areas and the block numbers are shown in Figure Ⅱ-2-21. The reserves are summarized and shown in Table Ⅱ-2-4.

(2) Intermediate Orebody between West and East Deposits : The areas and

the block numbers are shown in Figure II -2-22. The reserves are summarized and shown in Table II -2-4.

2 − 5 − 3 Summation of Reserve Calculation

The reserves of Surmai-I and Surmai-III are summarized and shown in Table II -2-4.

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 average grade of the crude ore is appraximately 10 % of combined Pb+Zn. 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 atotal 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 a larger area 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.

2 - 6 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 North 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. Therefore, 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 .

Table II-2-2 Condition of Mineralized Zones at Cores of Second Phase

Area	Drill No.	Position		Depth (m)	Width (m)	Pb (%)	Zn (%)	Ba (%)	Ag (g/t)
Surmai-I	MJP-3	A-3-1	Average	169.1~172.9	3.8	0.38	4.73	< 0.01	7.6
			Maximum	171.9~172.9	1.0	1.17	7.68	< 0.01	17.0
			P.Z.M.	169.1~172.9	3.8	0.38	4.73	< 0.01	7.6
		A-3-2	Average	176.3~191.7	15.4	0.25	0.80	< 0.01	4.9
			Maximum	176.3~177.1	0.8	0.20	8.86	< 0.01	15.2
		A-3-3	Av.& Max.	210.1~211.8	1.7	0.54	2.02	< 0.01	5.7
	MJP-2	B-2	Average	288.2~292.3	4.1	0.04	0.89	< 0.01	1.0
			Maximum	290.4~291.0	0.6	0.23	5.74	< 0.01	3.9
		C-2	Average	323.2~328.6	5.4	0.03	1.00	< 0.01	0.6
			Maximum	326.0~328.6	2.6	0.06	1.54	< 0.01	0.8
	MJP-4	B-4	Average	283.4~290.1	6.7	0.33	0.62	< 0.01	3.3
			Maximum	289.0~289.6	0.6	0.16	4.11	< 0.01	2.8
		C-4-1	Average	308.5~310.4	1.9	0.01	0.03	< 0.01	< 0.5
			Maximum	308.5~309.6	1.1	0.01	0.03	< 0.01	< 0.5
		C-4-2	Average	316.2~320.4	4.2	0.04	1.11	< 0.01	0.9
			Maximum	319.9~320.2	0.3	0.06	11.10	< 0.01	5.6
Surmai-III	MJP-6	A-6-1	Average	168.5~182.4	13.9	0.66	3.25	< 0.01	6.0
			Maximum	170.3~172.4	2.1	1.81	13.90	< 0.01	16.8
			P.Z.M.	170.3~172.8	2.5	1.68	11.77	< 0.01	15.3
			P.Z.M.	168.5~172.4	3.9	1.01	8.59	< 0.01	9.7
		A-6-2	Average	185.6~190.3	4.7	0.51	3.66	< 0.01	5.5
			Maximum	186.0~186.6	0.6	0.34	20.90	< 0.01	8.5
			P.Z.M.	185.6~188.1	2.5	0.23	6.64	< 0.01	3.6
		A-6-3	Average	191.8~197.9	6.1	0.24	0.64	< 0.01	0.7
			Maximum	191.8~193.8	2.0	0.10	1.59	< 0.01	0.8
		A-6-4	Av.& Max.	199.3~199.7	0.4	< 0.01	4.79	< 0.01	< 0.5
	MJP-5	B-5	Average	215.0~216.8	1.8	0.19	0.85	< 0.01	1.8
			Maximum	215.2~215.8	0.6	0.39	1.89	< 0.01	3.7

〔Abbreviation〕 P.Z.M. : Promising Zone for Mining

Av.& Max. : Average & Maximum

Table II-2-3 Condition of Mineralized Zones at Cores of Third Phase (1)

Area	Drill No.	Position		Depth (m)	Width (m)	Pb (%)	Zn (%)	Ba (%)	Ag (g/t)
Surmai-I	MJP-7	A-7-1	Average	44.2~ 54.0	9.8	0.52	3.40	< 0.01	6.8
			Maximum	45.8~ 46.8	1.0	0.83	18.00	< 0.01	6.5
			P.Z.M.	44.3~ 46.8	2.5	0.55	10.42	0.03	4.3
		A-7-2	Av.& Max	57.7~ 58.3	0.6	0.27	0.10	< 0.01	2.5
		A-7-3	Average	64.1~ 79.7	15.6	0.77	2.49	< 0.01	14.4
			Maximum	76.6~ 79.7	3.1	2.50	7.65	< 0.01	53.0
			P.Z.M.	76.6~ 79.7	3.1	2.50	7.65	< 0.01	53.0
	MJP-13	A-13	Average	131.3~181.8	50.5	0.54	1.10	< 0.01	7.3
			Maximum	155.9~157.4	1.5	6.85	0.21	< 0.01	96.0
			P.Z.M.	155.9~158.4	2.5	4.36	0.21	< 0.01	61.4
Surmai-III	MJP-9	A-9	Average	265.8~267.9	2.1	1.19	4.24	0.09	11.0
			Maximum	265.8~266.4	0.6	2.60	7.67	0.19	24.5
			P.Z.M.	265.8~268.3	2.5	0.94	3.56	0.08	9.4
	MJP-11	A-11-1	Av.& Max.	44.6~ 46.6	2.0	0.22	0.08	< 0.01	1.8
		A-11-2	Average	53.5~ 77.0	23.5	0.52	1.84	< 0.01	5.5
			Maximum	53.4~ 58.9	5.4	0.62	3.68	< 0.01	8.5
		A-11-3	Av.& Max.	88.0~ 88.9	0.9	3.70	9.64	< 0.02	62.0
			P.Z.M.	88.0~ 90.5	2.5	1.33	3.47	< 0.02	22.3
		A-11-4	Av.& Max.	98.0~100.0	2.0	1.18	3.51	< 0.01	12.5
		A-11-5	Av.& Max.	136.3~138.0	1.7	4.99	0.06	< 0.01	30.5
	MJP-12	A-12-1	Average	40.4~ 43.6	3.2	1.05	4.29	0.04	9.1
			Maximum	40.4~ 42.4	2.0	1.12	5.70	0.04	11.0
			P.Z.M.	40.4~ 42.9	2.5	1.08	4.95	0.04	10.0
		A-12-2	Average	46.6~ 71.3	24.7	0.61	3.52	0.02	7.9
			Maximum	54.4~ 56.3	1.9	3.22	9.22	< 0.01	35.5
			P.Z.M.	54.4~ 59.0	4.6	1.68	5.27	0.02	21.3
		A-12-3	Av.& Max.	78.7~ 80.4	1.7	0.19	3.06	< 0.01	3.0

Table II-2-3 Condition of Mineralized Zones at Cores of Third Phase (2)

Area	Drill No.	Position		Depth (m)	Width (m)	Pb (%)	Zn (%)	Ba (%)	Ag (g/t)
Surmai-III	MJP-14	A-14-1	Average	126.2~133.2	7.0	7.26	2.48	< 0.04	110.8
			Maximum	126.2~127.3	1.1	43.3	1.30	< 0.01	670
			P.Z.M.	126.2~133.2	7.0	7.26	2.48	< 0.04	110.8
		A-14-2	Av.& Max.	149.2~151.5	2.3	3.21	< 0.01	< 0.01	30.5
		A-14-3	Average	288.6~347.3	58.7	0.22	0.25	< 0.01	2.4
			Maximum	312.9~313.7	0.8	1.21	2.68	< 0.01	12.0
	MJP-15	A-15-1	Av.& Max.	200.8~201.5	0.7	0.20	0.04	< 0.01	2.5
		A-15-2	Average	211.5~214.5	3.0	0.57	0.79	< 0.01	6.7
			Maximum	212.1~212.6	0.5	0.15	4.42	< 0.01	7.5
		A-15-3	Average	216.4~221.9	5.5	0.20	0.16	< 0.01	2.1
			Maximum	221.2~221.9	0.7	0.79	0.87	< 0.01	8.0
		A-15-4	Average	238.8~258.7	19.9	1.04	2.15	< 0.01	10.9
			Maximum	245.9~246.7	0.8	0.66	15.90	< 0.01	7.2
			P.Z.M.	241.5~246.7	5.2	1.77	6.51	< 0.01	16.5
		A-15-5	Average	277.1~300.2	23.1	1.30	4.03	< 0.02	14.0
			Maximum	288.8~295.1	6.3	3.54	10.10	< 0.01	37.2
			P.Z.M.	288.8~298.1	9.3	3.01	9.03	< 0.01	32.1
	MJP-8	B-8	Average	331.2~337.4	6.2	1.60	2.03	0.01	16.2
			Maximum	335.1~336.5	1.4	5.79	7.35	< 0.01	58.0
			P.Z.M.	334.9~337.4	2.5	3.61	4.59	< 0.01	9.5
	MJP-9	B-9	Average	272.6~283.2	10.6	0.59	0.77	0.04	3.5
			Maximum	275.5~276.1	0.6	0.17	5.40	< 0.01	3.0

Fig. Ⅱ-2-4 Total Ammount of Ore Reserves

Area	Body	Block			Tonnage (1,000t)	Grade Pb(%)	Zn(%)	Ba(%)	Ag(g/t)
Surmai -Ⅰ	Main Ore Body	Large Block	ⅠML	Su	4,511	0.40	1.51	< 0.01	6.6
				Ox	2,020	0.40	1.51	< 0.01	6.6
			Total		6,531	0.40	1.51	< 0.01	6.6
		Small Block	ⅠMS-1～4 Total		212	2.08	5.93	< 0.01	34.4
Surmai -Ⅲ	Northern Ore Body	Large Block	ⅢNL	Su	5,362	0.65	3.03	0.02	6.6
				Ox	3,800	0.66	3.05	0.02	6.7
			Total		9,162	0.65	3.04	0.02	6.6
		Small Block	ⅢNS-1～6 Total		351	1.53	5.44	0.01	13.9
	E～W Deposit Ore Body	Large Block	ⅢEWL	Su	12,668	0.76	1.98	< 0.01	8.1
				Ox	1,993	0.76	1.98	< 0.01	8.1
			Total		14,661	0.76	1.98	< 0.01	8.1
		Small Block	ⅢEWS-1～2 Total		307	2.57	8.13	< 0.01	26.5
	Total	Large Block	Su		18,030	0.73	2.29	< 0.01	7.7
			Ox		5,793	0.69	2.68	0.01	7.2
			Total		23,823	0.72	2.38	< 0.01	7.6
		Small Block	ⅢEWS-1～2 Total		658	2.02	6.70	< 0.01	19.8
Grand Total		Large Block	Su		22,541	0.66	2.13	< 0.01	7.5
			Ox		7,813	0.62	2.38	< 0.01	7.0
			Total		30,354	0.65	2.19	< 0.01	7.4
		Small Block	Total		870	2.03	6.51	< 0.01	23.4

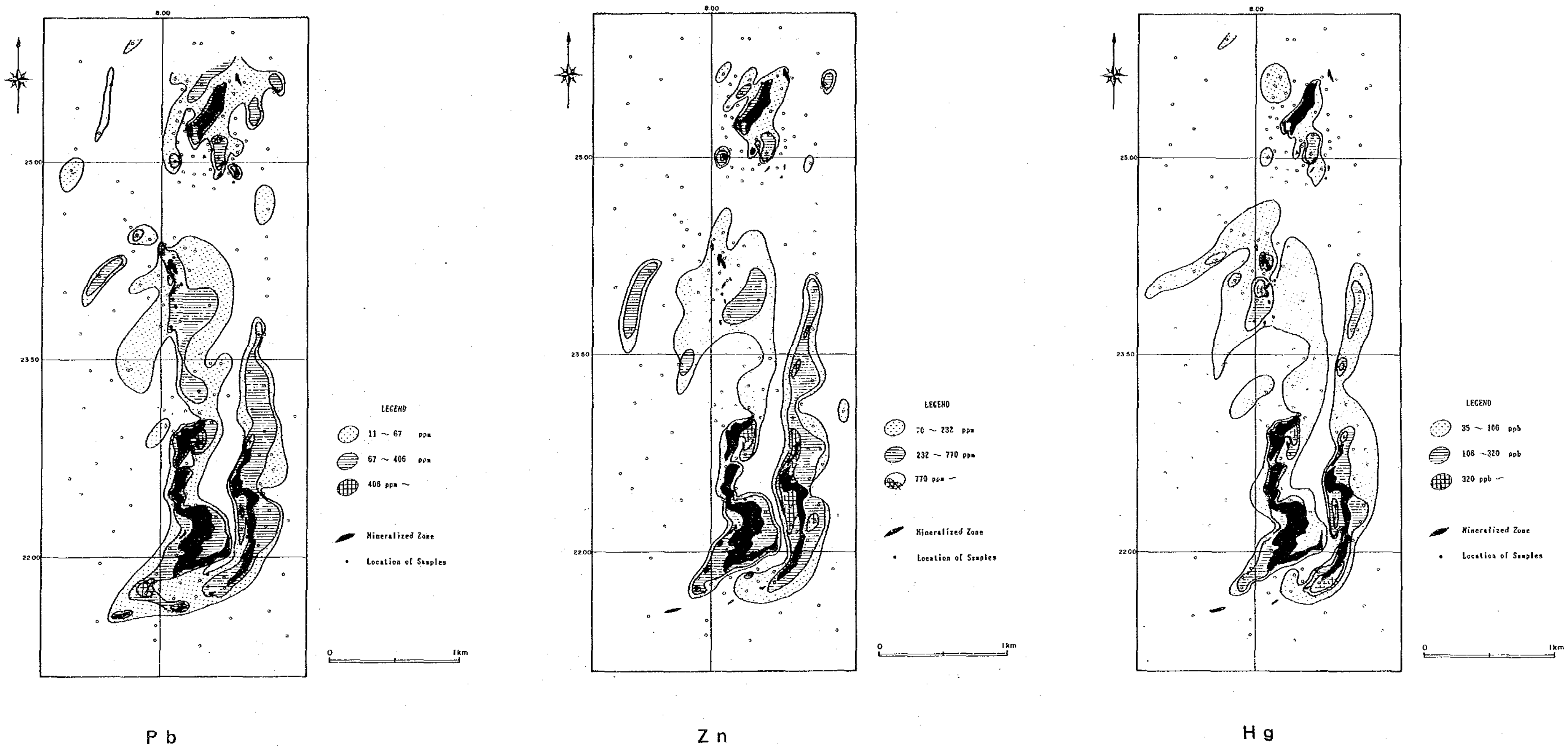


Fig. II-2-1 Distribution Map of Geochemical Elements in Surmai Area (Pb, Zn, Hg)