THE ISLAMIC REPUBLIC OF PAKISTAN
REPORT ON THE COOPERATIVE MINERAL EXPLORATION
IN KHUZDAR AREA OF BALUCHISTAN
PHASE 1
JUNE

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PREFACE

In response to the request of the Government of the Islamic Republic of Pakistan, the Japanese Government decided to conduct a mineral exploration in Khuzdar Area and entrusted the survey to the Japan International Cooperation Agency. Considering the technical aspects, the Agency sought collaboration with the Metal Mining Agency of Japan to accomplish the task. The Government of the Islamic Republic of Pakistan appointed the Geological Survey of Pakistan to excute the survey as a counterpart to the Japanese team. The survey is being carried out jointly by experts of both Governments. For the 1986 work, the first phase, the Metal Mining Agency of Japan dispatched a survey team consisting of four geologists and three geophysicists, to Pakistan during a period from December 8, 1986 to April 21, 1987. This report summarizes the results of the first phase. We wish to express our heartful gratitude to all sides concerned in the execution of the survey.

June, 1987

Keisuke Arita President,
Japan International Cooperation Agency

Junichiro Sato President,
Metal Mining Agency of Japan

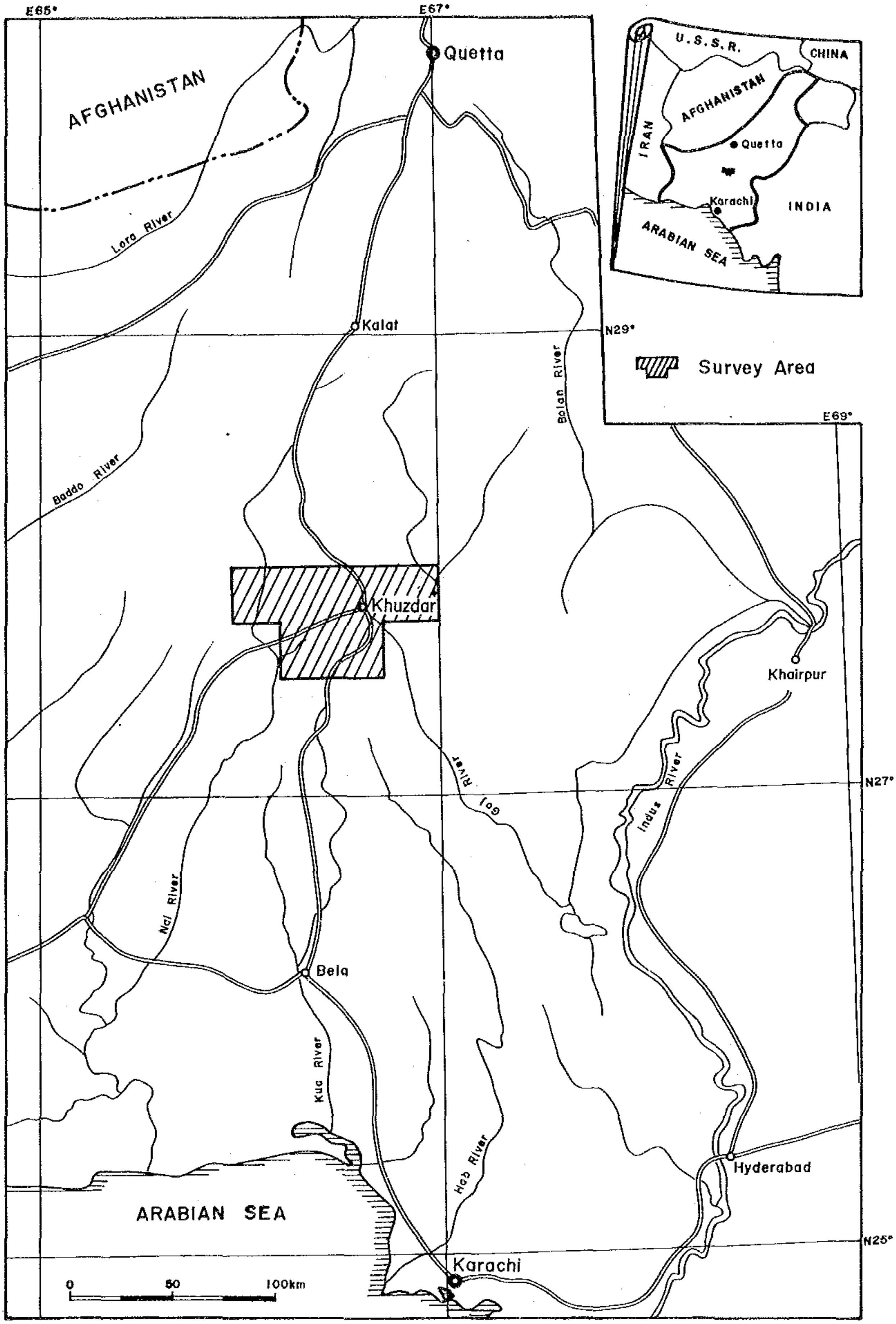

Fig. 1 Index Map of the Survey Area

SUMMARY

The first phase survey of The Coorperative Mineral Exploration of Khuzdar district in the Islamic Republic of Pakistan was conducted with the aim of unravelling promising areas of emplacement of the Mississippi Valley-type lead and zinc mineral deposits. The first phase consisted of geological and geochemical surveys on an area of 1,350 km² distributed in Jurassic carbonate rocks in the Khuzdar district, and detailed gelogical, geochemical and geophysical surveys on the Surmai Area, a part of the Khuzdar district, in which a few mineral indications had been found.

1. Khuzdar district

The survey area is underlain by highly folded carbonate rocks of Cretaceous ~Jurassic age in the folds-faults zone of the northwestern edge of the Indo-Pakistani Plate. The only Jurassic rocks exposed in the area are those of the lower Jurassic Shirinab Formation. The formation is divided, in ascending order,into three members : the dominantly sandstone Spingwar, the mainly limestone Loralai, and the Anjira which is limestone intercalated with shale.

The regional trend of the geological structure is N-S~ NNW-SSE in the southern and eastern parts. It progressively changes to E-W in the northern part, and then to NE-SW in the western part of the survey district. The Jurassic stratified rocks are complexly folded with synclines and anticlines extending parallel to the trend of the regional geological structure.

Several occurrences of Mississippi Valley-type lead and zinc mineralizations, such as the Gunga mineral deposits currently producing barite ore, Surmai, Malkhor, Ranj Laki, East Sekran and Sekran mineral indications, have been identified in the carbonate sediments of lower Jurassic age. These 6 occurrences of Pb-Zn mineral indications each show about a 1 km in length which are arranged discontinuously in a narrow zone extending approximately 25 km in length parallel to the trend of the geological structure. The mineralizations are divided into two types : strata-bound deposits mainly in the Loralai Member and vein type deposits along faults and fractures in the Shirinab Formation. Almost complete oxidation of ores on and near groundsurface have resulted in gossans. The ore consists of limonite, calcite, quartz, siderite, and hemimorphite on the surface. Zinc content in gossans is likely to depend on hemimorphite, and assay result on gossans present an average of 0.5% Pb and 5.0% Zn. The ore below the groundwater table that is expected to lie

more than 100m in depth from the surface, is presumed to be comprised of sulphide minerals. Although parts of the Malkhor, Ranj Laki, East Sekran and Sekran show a fairly strong mineralization standing in comparison with the Surmai, details still remain unclear due to complicated geological structure.

A rock geochemical survey has been conducted on Pb,Zn,Ba,Mg,Hg,and S in the Jurassic carbonate rocks. The survey has revealed that Pb, Hg, and Zn had mutualy high correlations and formed anomalies on and near the gossans. Barium formed anomalies on non-mineralized rocks near the gossans. The A rank anomalies defined by the combination of the Pb, Zn and Hg anomalies near the Surmai and Malkhor～Sekran mineralized areas suggest that they will be usuful in selecting potential mineralized areas.

2. Surmai Area

The Surmai Area is underlain by three Members of the Shirinab Formation. They are in ascending order, Spingwar, Loralai and Anjira. The Loralai and Anjira are divided, respectively, into 4 Unit(Ⅰ～Ⅳ) and 3 Unit(Ⅰ～Ⅲ). These Jurassic beds generally strike N-S throughout most of the survey area and form the elevated anticlinal hill in half the eastern area and the synclinal valley in half the western area. The mineral indications, Surmai Ⅰ, Ⅱ and Ⅲ, extend discontinuously from north to south, show approximately 1 km of length each along a N-S strike and occur in an elevated zone. The occurrences of Surmai Ⅰ and Ⅲ mineral indications are confined mainly to Units Ⅱ and Ⅲ of the Loralai Member and partly show a high content of zinc.

On the other hand, mineral indications of Surmai Ⅱ lie sporadically and discontinuously in the fault zone. Thus, it might be stated that further exploration on Surmai Ⅱ is of no value. Therefore, Surmai Ⅰ and Ⅲ mineral indications appear to be the most promising target areas for future prospecting, especially at depth.

The result of the rock geochemical survey shows the clear anomalies of Pb,Zn,and Hg on the gossans and surrounding area. The geophysical survey revealed that promising I.P.and S.I.P.anomalies that are likely due to sulphide ore, have been obtained 100～200 m below the surface gossans. Thus, diamond drilling explorations are recomended in the second phase survey to determine the extention of the mineral indications and to investigate the variation of oxidized ore to sulphide ore in the deep sections of Surmai Ⅰ and Ⅲ. Drilling stations have been proposed for both Surmai Ⅰ and Ⅲ.

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"DISTRICT" will be use instead of "AREA" for describing on Khuzdar's in order to avoid confusion with area of Surmai area

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PART I INTRODUCTION

PART I INTRODUCTION

Chapter 1 Outline of the Survey

1 − 1 Survey Purpose

The first phase survey (1986) has been conducted in accordance with the Scope of Works signed on October 2, 1986 between the Japanese and the Pakistani Governments. In this phase, geological and geochemical surveys were conducted in the Khuzdar District and the Surmai Area, and in Surmai, geophysical surveys were also conducted for the purpose of exploring and assessing the mineral potential.

1 − 2 Survey Area

The survey area covers approximately 10 km^2 of the Surmai Area for geological and geophysical surveys, an area of approximately 1,350 km^2 of the Khuzdar District, including the above 10 km^2, for geochemical survey, and a central portion(about 0.3 km^2) of the Gunga mineral deposit for geophysical survey as shown in Fig. I -1-1.

1 − 3 Survey Methods and Quantity

Summary of Survey and Laboratory works undertaken are as follows

(1) Geological survey

Khuzdar District: Area covered ··············· 1,350 km^2

Surmai Area: Area covered ··············· 10 km^2

(2) Geochemical survey

Khuzdar district: Number of rock samples obtained ······ 2,700

Surmaii area: Number of rock samples obtained ········ 205

(3) Geophysical survey

Surmai area

I P: Line length 7.8 km, Count of data measured ········ 420

SIP: Line length 8.2 km, Count of data measured ········ 410

Gunga mine area

SIP: Line length 1.2 km, Count of data measured ········· 80

(3) Laboratory works

Number of: Thin sections observed ··············· 20

Polished sections observed ··············· 20

X-ray diffraction examinations ··············· 100

Total rock chemical analyses (13 elements) ······ 5

Ore assays	20
Geochemical analyses of rocks (6 elements)	2,905
SIP laboratory tests on rocks and ores	40

1 − 4 Survey Period and Organization of Survey Team

1-4-1 Survey Period in Pakistan

Geological and Geochemical survey : Dec.15,1986~Mar.22,1987
Geophysical survey : Feb. 5,1987~Apr.19,1987

1-4-2 Organization of the Survey Team

Japanese Members		Pakistani Members	
Planning and Coordinating			
Ken-ichi Orita	(MITI)	Waheeduddin Ahmed	(GSP)
Takashi Kamiki	(JICA)	A. H. Kazmi	(GSP)
Makoto Ishida	(MMAJ)		
Yasuo Endo	(MMAJ)		
Yoshiyuki Kita	(MMAJ)		
Yoshitaka Hosoi	(MMAJ)		
Survey Team			
Team leader			
Kazuo Shuto	(NED)	M.Ishaque Durrazai	(GSP)
Geological and geochemical surveys			
Tsutomu Ichinose	(NED)	A. Mahmood Subhani	(GSP)
Hideo Suzuki	(NED)	Asad Jalil	(GSP)
Kenji Sato	(NED)	Chouhdary Ferozuddin	(GSP)
		Syed Mukhtar Zaidi	(GSP)
		Mohammad Ashfaq	(PMDC)
Geophysical survey			
Masao Yoshizawa	(NED)	Akbar Khurshid	(GSP)
Toshio Fujimoto	(NED)	S.W. Hyder Nagvi	(GSP)
Norikiyo Sugiura	(NED)	Hyder Zaman Khan	(GSP)

GSP	Geological Survey of Pakistan
PMDC	Pakistan Mineral Development Corporation
MITI	Ministry of International Trade and Industry of Japan
JICA	Japan International Cooperation Agency
MMAJ	Metal Mining Agency of Japan
NED	Nikko Exploration and Development Co.,Ltd.

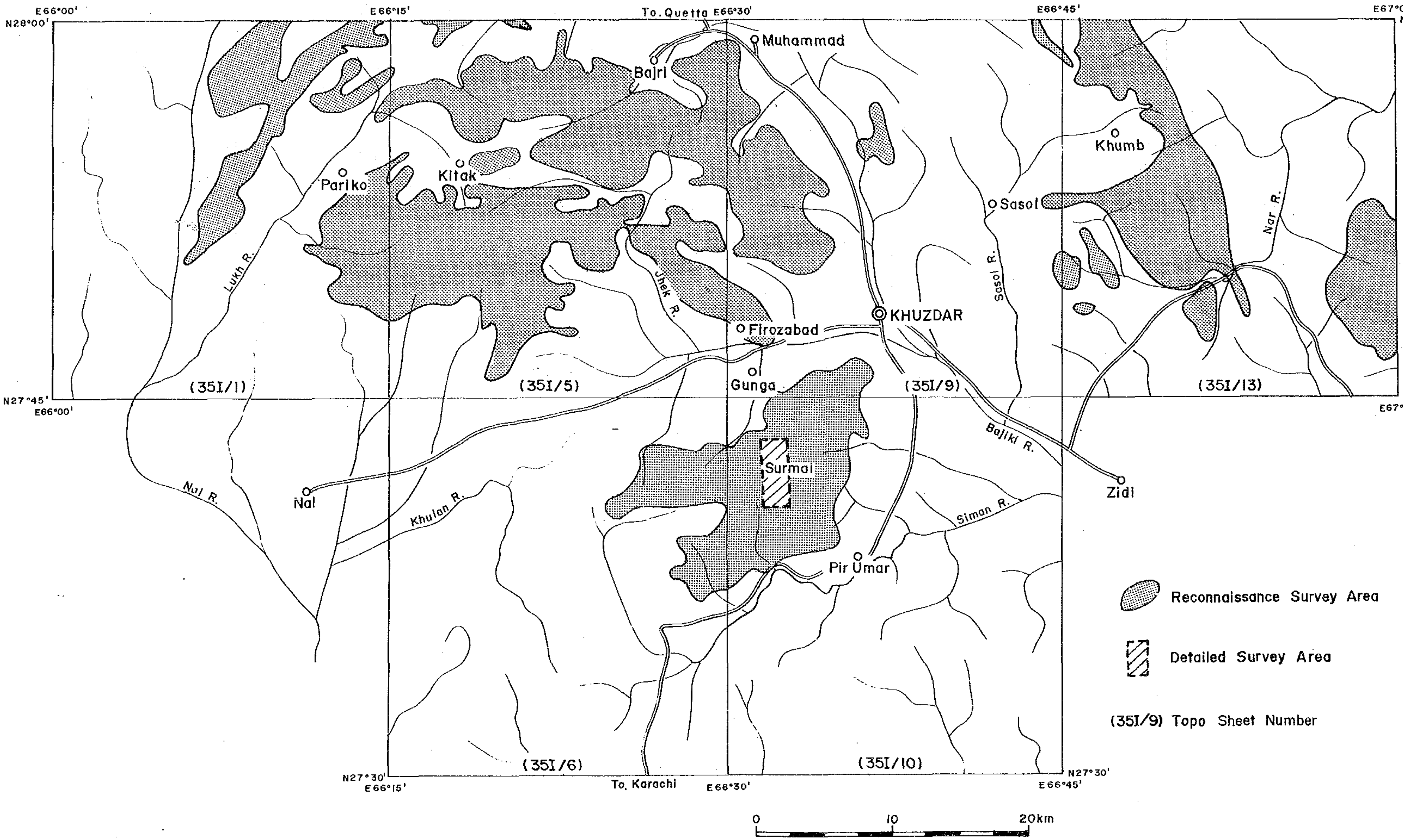

Fig. I-1-1 Location Map of the Survey Area

Chapter 2 Outline of The Survey Area

2 − 1 Geography

The survey area is situated in the southeast portion of the Central Brahui Range. It extends more than 300 km southwest-northeast, occupys central Baluchistan and included in 6 toposheets at a scale of 1:50,000 : 35 -I/1, I/5, I/9, I/13, I/6 and I/10.

The area, underlain by Cretaceous and Jurassic rocks, shows a rather rugged topography due to tight folds and faults, and ranges in elevation from 1,200 m at the town of Khuzdar, to 2,100 m at Siah peak on toposheet No.35-I/13. A town of Khuzdar,having a population of about 20,000, is located nearly at the center of the surveyed area and can provide commodities for daily life. The distances from Khuzdar to Karachi, the former capital city of this country, and to Quetta, provincial capital, are approximately 350 km and 270 km respectively, as the crow flies. Paved roads lead to both cities from Khuzdar.

Outcrop is very common along cliffs except at debris-covered areas. Natural vegetation is largely confined to xerophytic grasses and small semi-dessert shrubs such as sagebush and camel-thorn. Tall grasses and scrub trees such as dwarf palm and oleander, grow along many of the stream courses.

Extremes of diurnal and annual temperature, low humidity, and low precipitation are the main features of the climate. Mean annual temperature are 15-20°C and mean annual rainfall is 150mm at Khuzdar. A winter low temperature of about -15°C and a summer high temperature of over 49°C has been recorded in the survey area.

2 − 2 Geological Outline of the Survey Area.

The strata-bound,low temperature hydrothermal Pb-Zn-Ba-F mineralization emplaced in the Jurassic interbedded limestone and shale along the west margin of the Indo-Pakistan Plate is distributed in a narrow metallogenic zone from Lasbela in the south to Khuzdar and Dera Ghaz khan in the north. This zone is more than 600km long,and represents a regional metallogenic unit of Western Asia, in which several metallogenic zones containing strata-bound low-temperature Pb-Zn-Ba-F in carbonate sequences occur.

In contrast to other carbonate-hosted Pb-Zn-Ba-F deposits in western Asia, these deposits were formed in an environment lacking contemporaneus volcanic activity. The Pb-Zn-Ba-F mineralization so far found is confined to a monotonous succession of Jurassic limestone intercalated with partly calcareous shale, and, locally, sandstone.

Sediments which were deposited along the northwestern margin of the Indo-Pakistan Plate in the early Mesozoic to the early Oligocene are typical of the platform enviroment of an epicontinental sea. They are mostly chemical and biochemical carbonate with a subordinate but large proportion of shale. The concurrent growth of a rudimentary geanticline ridge within the basin and its intermittent emergence produced a chain of islands leading to a discontinuous and localized development of shoals, tidal spits and reefs along the geanticlinal axis. (Fig. I -2-1, I-2-2)

2 – 3 Previous Geological Work.

The oldest reference pertaining to the Jurassic geology of this area and of *Baluchistan in general is that of Vredenburg (1909) who divided* the Jurassic of Baluchistan into 3 Units, in ascending order, Lower Jurassic dark gray limestone interbedded with shale, Middle Jurassic massive limestone, and Middle Jurassic "Polyphemus Beds" (alternations of thinly bedded limestone and shale) and also suggested that a disconformity was observable between the Polyphemus Beds and the Belemnite Shale of Cretaceous age.

In the Khuzdar District, Units 2 and 3 of Vredenburg are not developed where Hunting Survey Corporation (1960) introduced "Zidi formation" for the Jurassic rocks and "Parh series" for the Cretaceous sequence. The stratigraphic succession established in the Khuzdar District by HSC (1960) is shown on Fig. II -1-2.

At about the same time Dean Williams (1959) divided the thin to well bedded sequence of Jurassic into three formations, namely Spingwar (oldest), Loralai and Anjira. His type locality of Anjira lies south of Kalat in between Khuzdar and Karat which he dated as Early Jurassic to Bajocian (Middle Jurassic).

In 1977, considering the data accumulated as to the stratigraphy on the Khuzdar District, the Geological survey of Pakistan concluded it as follows.

The Shirinab Formation correlative to lower～middle Jurassic in age are devided into 3 Members, in ascening order, Spingwar, Loralai, and Anjira and is uncomformably overlain by the Sember Formation of mainly shale correlative to lower Cretacious in age.

Concerning to mineral prospects, the first survey (1974～1979) has been conducted by United Nation as United Nation Development Programme which abstracted Lasbela~Khuzdar area as a promising area for Pb-Zn mineralization. Geological Survey of Pakistan in late 1978 (Waheeduddin Ahmed *et al*, *1978), first identified zinc-lead sulphide mineralization at* Gunga, Malkhor and Sekran in the vicinity of Khuzdar. Exploration and preliminary geological evaluation for zinc-lead and barium was carried out at Gunga from February 1981 through end of December 1983. This survey proved the Gunga deposit to contain 11.0 million tons of ore, over 6% zinc and lead combined.

The encouraging results at the Gunga deposit obtained by the Geological Survey of Pakistan gave a new impetus to their exploration programme for lead and zinc. During 1983-84 field season, Nayyer identified development of gossan at Surmai Garri while doing regional mapping on 1:50,000 scale in toposheet No.35 I/10. During 1984-85 field season, chip sampling for chemical assay to determine the extent and type of mineralization at Surmai Garri was done. The results were encouraging and indicated three bodies at Surmai Garri, which could become a deposit of economic significance (Asad,J.& Subhani,A.M., et al. 1986).

Tectonic Movement and
Principal Stractural Line around Himalaya Region

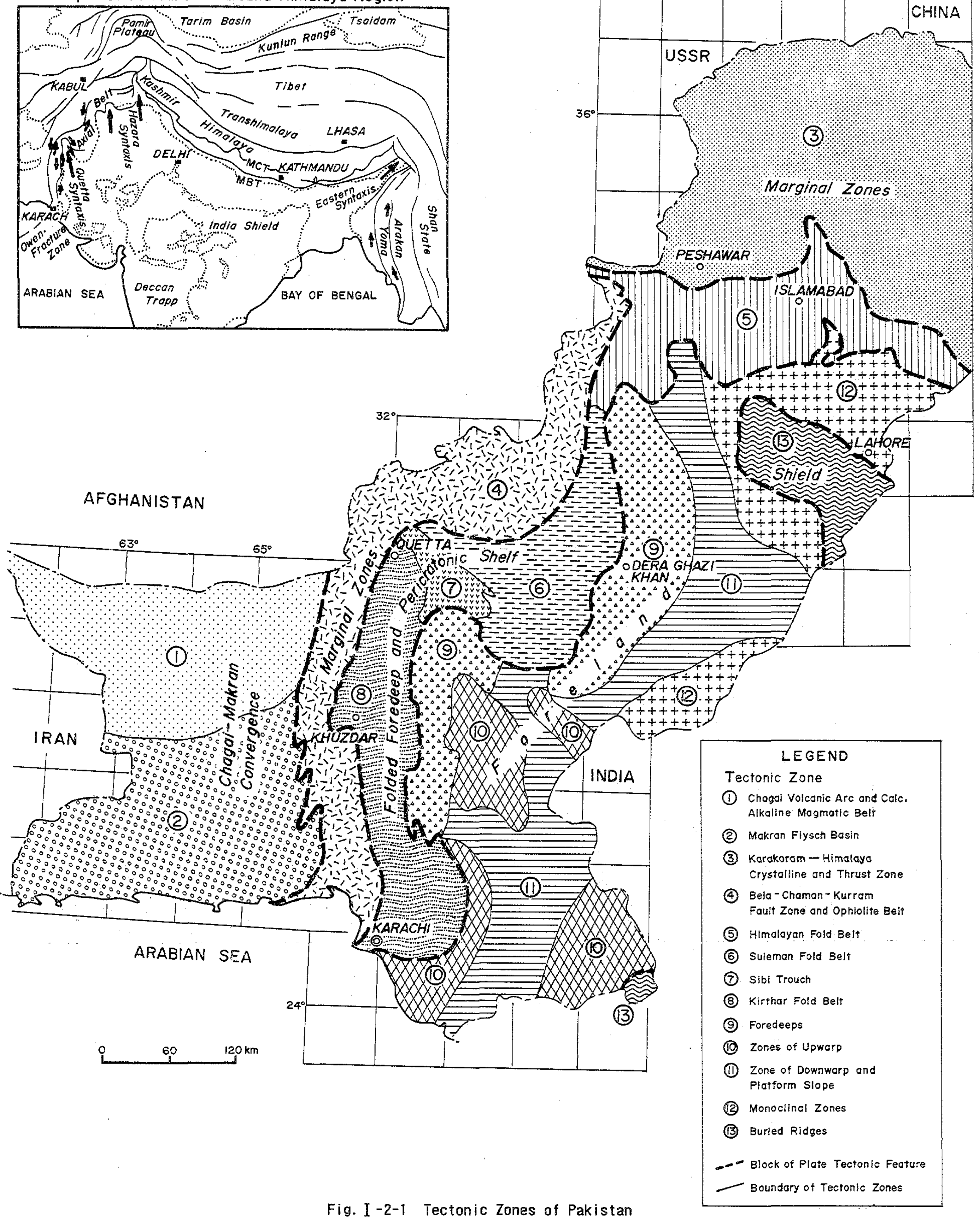

Fig. I -2-1 Tectonic Zones of Pakistan

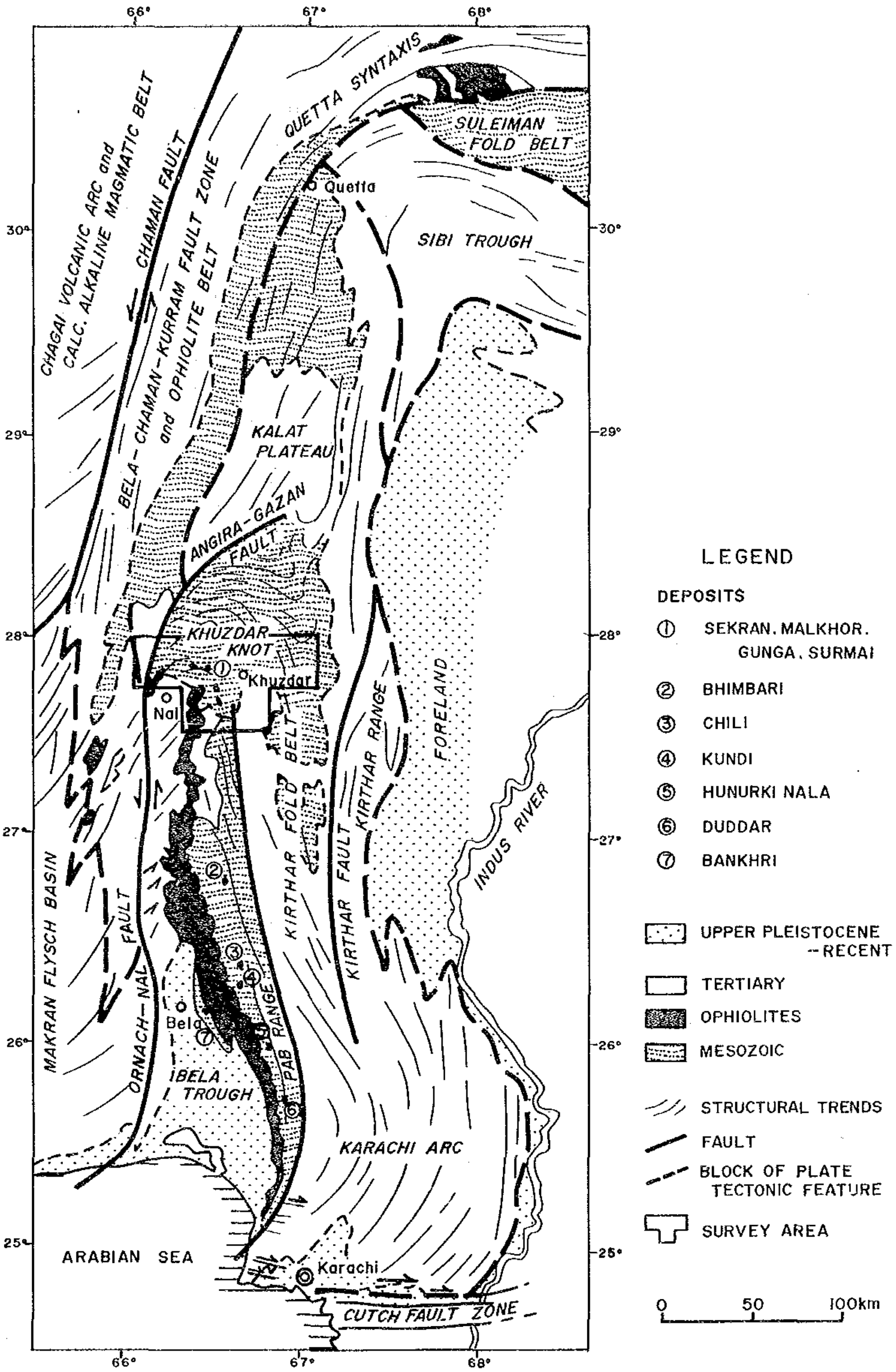

Fig. I-2-2 Geology, Structural Features and Distribution of Mississippiy Valley Type Pb・Zn・Ba Deposits Around the Survey Area

PART II KHUZDAR DISTRICT

(RECONNAISSANCE SURVEY)

PART II KHUZDAR DISTRICT (Recnnaissance Survey)

Chapter 1 Geological Survey

Geological mapping was carried out on the distribution area of Jurassic carbonate rocks at a scale of 1:25,000 by checking the existing 1:253,440 geological map. Known mineral indications in the area have been mapped on a scale of 1:2,000.

Representative rocks and ore samples have been taken and provided for laboratory works as previously mentioned on chapter 1. Table II-1-2～II-1-6 show the summaries of laboratory works.

1－1 Outline

The survey area is underlain mainly by Jurassic carbonate rocks,shale and a minor amount of sandstone, Cretaceous carbonate rocks, shale and sandstone, Tertiary carbonate rocks, and alluvium. The survey was focussed on an area of Jurassic rocks because emplacements of the strata-bound, low temperature hydrothermal Pb-Zn mineralization have ,according to previous works,been confined to Jurassic interbedded limestone and shale. The Geological map of the survey area(Fig.II-1-1) shows the distribution areas having an area of approximatly 1,350 km^2 of Jurassic rocks. Geological maps and their profiles on the distribution area of Jurassic carbonate rocks are shown as PL.II-1-1～II-1-7, and Table II-1-1 summarizes the classification of limestone in the survey district following Folk(1959)(Table II-1-1).

Table II-1-1 Classified List of Limestone

Orthochem	Allochem	Name of Limestone
Micrite > Sparite	(1) poor in allochems	Micrite
	(2) abound in intraclast	Intramicrite
	(3) abound in ooids	Oomicrite
	(4) abound in pellets	Pelmicrite
	(5) abound in fossils	Biomicrite
Sparite > Micrite	(1) abound in intraclast	Intrasparite
	(2) abound in ooids	Oosparite
	(3) abound in pellets	Pelsparite
	(4) abound in fossils	Biosparite

1 − 2 Stratigraphy

The Jurassic rocks exposed in the district are only lower Jurassic in age. A generalized stratigraphic column of the district is shown in Fig. II-1-2. These lower Jurassic sediments are represented by the Shirinab Formation. The Shirinab Formation is widely exposed in the ridges northwest, south, and east-northeast of Khuzdar and can be devided into three members which, in ascending order, are the Spingwar, Loralai and Angira.

1-2-1 Spingwar Member

This member is exposed broadly in the southern and northwestern area of Pariko and Kitak as well as in a limited area along a fault zone in Surmai. No exposures of it have been recognized in the ridges east-northeast of Khuzdar. It consists of calcareous sandstone(Table II-1-4), quartzose sandstone with poorly preserved molluscan shells, intercalated shale and limestone as minor interbeds. The upper part consists of calcareous sandstone, sandy limestone and shale interbeds which become less sandy in the upper part. The Spingwar has a mixed carbonate and clastic lithology which is overlain transitionally by the Loralai Member and is poor in fossils except for some poorly preserved mollusca in the calcareous sandy unit.

1-2-2 Loralai Member

This member is a thick to massive mottled gray brown, resistant limestone unit which crops out in topography forming steep slopes or cliffs. The limestone shows various texture, such as pelletal, oolitiic, coquinoid, and micritic with frequent bioturbated beds(Photo.-1). It has sub-ordinate marl or marly limestone intercalations and is gradational with the over and underlying members. The Loralai has abundant fragmentary gastropods, bivalves, crinoids, brachiopods, and corals at different levels.

1-2-3 Anjira Member

The Loralai gradually passes into the Anjira with an increase of soft nodual marly limestone and hard splintery marl interbeds. The lower thick to medium bedded part of the Anjira is frequently mottled but is generally

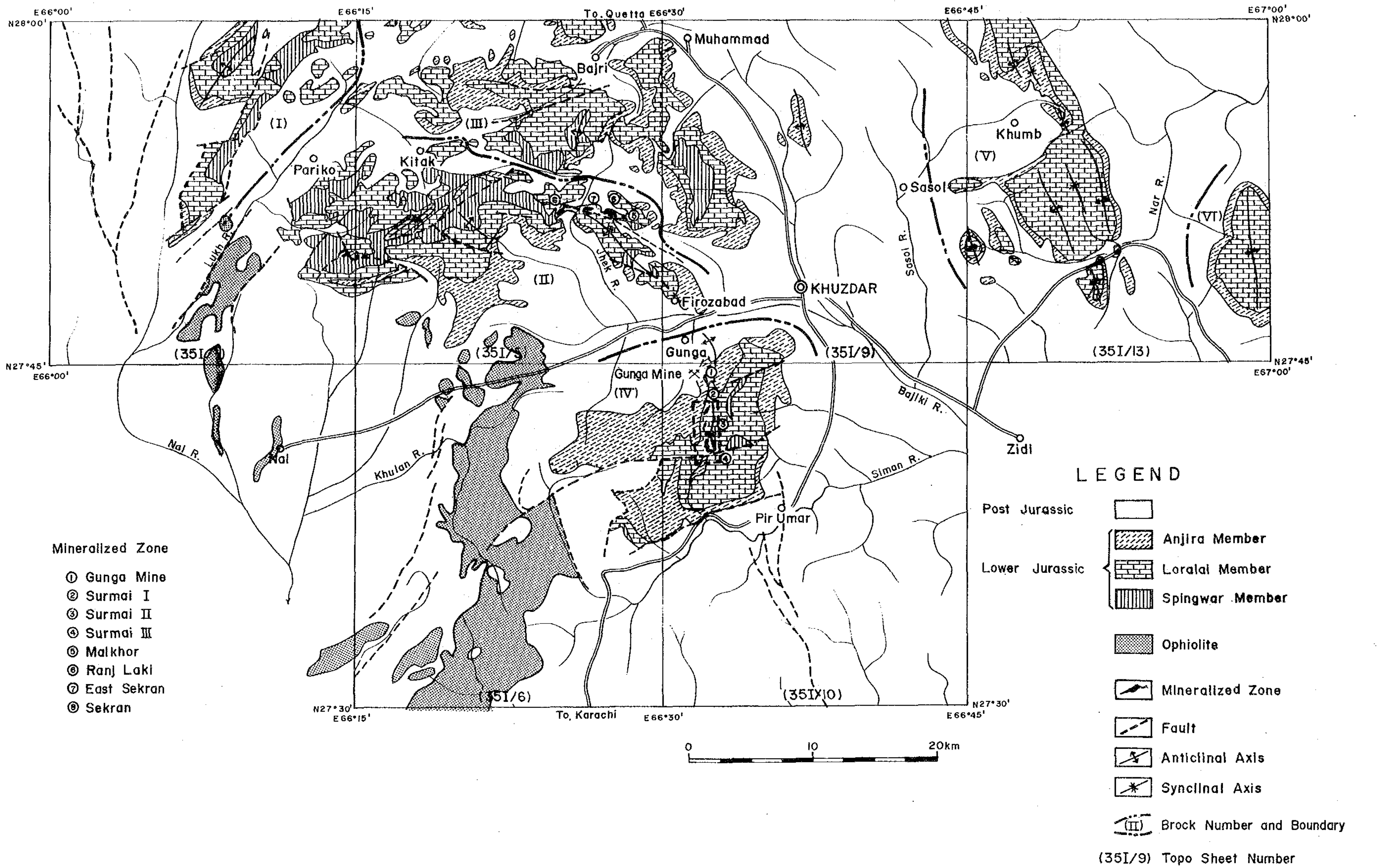

Fig. II-1-1 Geological Map of Khuzdar District

Geologic age		Hunting Survey Corp. (1961)		Cooperative Exproration (1987)		Lithology	Thickness	Columnar Section	Mineralization
Tertiary		Jamburo group		Jamburo group		Ls., Shale, Ss	+100		
Cretaceous	Late	Parh series	Pab Ss.	Pab Sandstone		Sandstone	+490		
			Parh group	Parh Limestone		Ls., Chert	+270		
	Early			Goru formation & Sembar formation		Marl, Ls.	+540		
Jurassic	Late	Zidi formation		Unconformity					
	Mid								Gu
	Early			Shirinab formation	Anjira member	Ls., Shale	+290		Sm
					Loralai member	Ls., Shale	+380		Ms
					Spingwar member	Ss., Shale, Ls	+240		

Abbreviation Gu: Gunga, Sm: Surmai, Ms: Malkhor～Sekran
Ls: Limestone Ss: Sandstone

Fig. II-1-2 Geological Stratigraphy of Khuzdar District fine grained, micritic, and contains soft marly interbeds with brachiopods, corals, radiolarias and other mollusca including Lower Toarcian ammonoids and nautiloids(Table II -1-4). The upper part of the Anjira becomes more regularly interbedded with marl or marly limestone, and the bedding becomes more regular. It is generally medium to thickly bedded, varying from 10cm to about one meter. The result of total rock chemical analisis presents that SiO_2 contents of limestone and marl in the survey area are high than that of average limesyone and marl of the world(Table II -1-6).

1 − 3 Geological Structure

Geotectonically, the survey area lies on the so-called"Khuzdar Knot" or northern part of the Khuzdar-Karachi Block.

The Khuzdar Knot is formed mainly of Mesozoic rocks, by two successive changes in the fold trend. The Ornach-Nal fault lies along the western edge of the Khuzdar Knot and the Bela Ophiolite Complex occupies a narrow north-south belt to the southwest. There is another feature called "the Karachi Arc" which lies southeast of the Khuzdar Knot and consists mainly of eastward convex axial traces of folds of Tertiary rocks. The tectonic term for the combined knot-arc feature is "the Khuzdar-Karachi Block".

The Khuzdar-Karachi block is located right on the western margin of the Indo-Pakistan subcontinent and is delineated by the Ornach-Nal-Gazan fault system to the west and north, and by the Cutch fault zone to the south. To the east it is bounded by the Kirther fault and Indus River between Manchar Lake and the Cutch fault zone(Fig. I -2-2).
The regional strike of the Jurassic carbonate rocks intercalated with shale and sandstone is NNW-SSE or N-S throughout most of the eastern part of the surveyed area(Toposheet I/13,I/09), but it progressively changes to E-W, then NE-SW in the western part of the surveyed area (Toposheet I/05,I/01). The regional dip ranges from 0° to 90° in most of the survey district because the Jurassic stratified rocks are highly folded and faulted into anticlinoriums and dome structures. Most faults in the district are small to medium, normal and reverse faults which are traceable for as much as 5 to 10 km horizontally. Displacements commonlly range from 10 m to several hundred meters at maximum.

1－4 Mineralization;

Mineral indications of iron, lead, zinc and/or barite have been found in the Loralai and Angira Members. The iron-lead-zinc outcrops of the Malkhor, Ranj Laki, East Sekran and Sekran mineral indications are located in the vicinity of Malkhor Tribe, and they extend discontinuously on an almost east-west line for approximately 6 km. Surmai mineral indications of iron, lead and zinc, which will be described in a later chapter, is 12 km to the south-west of Khuzdar. The Only mineral deposit producing barite ore in the surveyed area is the Gunga mine which is 1 km north of the Surmai outcrops. The detailed geological sketches on a scale of 1: 2,000 were conducted with a tape measure on the Malkhor, Ranj Laki, East Sekran and Sekran outcrops as shown in Fig.Ⅱ-1-3～Ⅱ-1-5. Almost complete oxidation on and near the surface of mineral deposits resulted in gossans. Mineralization is in the form of veins along cross cutting fractures and bedding planes. Partial replacement mineralization in solution collapsed breccia and limestone strata are generally confined to the Loralai limestone except in the north-western part of Sekran where vein type mineralization along a fault in brecciated sandstone of the *Spingwar member occurs*.

The mode of emplacement of mineralization is divided into the following 4 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.

D type : veinlets associated with A, B, and C types.

The gossans are composed visibly of yellowish to reddish brown limonite, dark gray siderite, silicified limestone with limonitic stains and small amounts of massive galena grains. Minerals detected by x-ray diffraction studies on these gossans are as follows: calcite, quartz, dolomite, kaolinite, sericite, chlorite, iron oxides(limonite, goethite, hematite), hemimorphite, and sphalerite(Ⅱ-1-5).

1-4-1 Malkhor~Sekran Mineral Indication Zones.

(1) Malkhor and Ranj Laki Mineral Indication Zones

These two mineral indication zones are regarded as a continuous mineralized zone from a geological view, and they are confined to the limestone of the Loralai Member(Fig Ⅱ-1-3).

The main mineral indication of the Malkhor is embedded along the south limb of the syncline which extends ENE-WSW, dips vertically at the footwall side and 50°S at the hangingwall side and forms a wedge-shape. The scale of mineralization at surface is 300m long and 90m wide. The mineral indication shows a gradual lateral change in type of mineralization from thick-bedded massive ore(A-type) in the northern part to open-space filling in breccia(B-type) in the southern part.

The Ranj Laki mineral indication zone is the largest and most indispersed of the Malkhor~Sekran mineral indication zones. It shows 700m long with a maximum width of 250m and strikes E-W. The deposit consists of 7~8 sheets of bedded ore bodies(A-type) each showing 2~5m thick, and several brecciated and bedded ore bodies(B-type) showing 5~10m thick interbedded with the former. These bedded ore bodies are conformable with host rocks.

(2) East Sekran Mineral Indication Zone

This mineral indication zone is located between Ranj Laki and Sekran, and shows 400m long and 200m wide in scale(Fig II-1-4). The mineral indication is confined to the limestone of the Loralai Member. The deposit consists of several bedded ore bodies(A,B type) each showing 3~10m thick, which are accompanied by veins(A type) in the lower portion of the same horizon. These bedded ore bodies are conformable with host rocks. The veins occur along almost vertical cross-cutting fractures, show 1~2m thick and pinch out toward the deeper part.

(3) Sekran Mineral Indication Zone

This mineral indication zone is located in the westernmost part of the Malkhor~Sekran zone and is 1.5km long from east to west. This zone appears to be divided into two parts, the eastern and the western deposit, due to covering by the fluvial bed between the two mineral indications (Fig II-1-4).

The gossans of the eastern deposit are distributed on a little hill and are 350m long from east to west. The gossans consist of several bedded ore bodies(A type) which show 1~5m thick each and are acommpanied by 0.5~1m thick veins(A type) at a lower portion of the same horizon. The bedded ore bodies are conformable with the limestone of the Loralai Member.

The area around the western deposit is dominated by the sandstone of the Spingwar Member in the western part and by the limestone of the Loralai Member in the eastern part. The gossans are 1.3km long, 100～200m wide,and mineral indications occur as vein type mineralizations along fault planes(C type) which run on the Spingwar and Loralai Members, and as bedded deposits which are conformable with the limestone of the *Loralai Member(A type). The former type of mineralization usually* contains calcite and siderite in big crystals. The largest vein in the fault is 600m long and 20～50m thick and has N-S strike and vertical dip. The latter consists of 4～5 sheets of parallel ore beds each 1～10m thick, and are accompanied by veinlets in network(D type).

1-4-2 Gunga Deposit

The Gunga is a low temperature stratabound-hydrothermal deposit in the Jurassic interbedded limestone and shale sequence(Fig.II-1-6). Two main minera-lized zones are recognized:

1. The lower mineralized zone consists of lenses, irregular veins formed along a brecciated zone, and patches. These mineralized bodies mostly contain over 6 percent zinc and 1 percent lead, and locally even exceed 10 percent combined lead and zinc. Sphalerite and galena are the main minerals, and they are transformed in the zone of oxidation to smithonite and cerrussite. Mixed oxide-sulphide mineralization is confined to a transition zone, predominantly 50-120 m beneath the surface along the dip.

2. The upper mineralized zone is mainly composed of barite, but significant concentrations of sphlersite and galena are found in the lower part of the barite bed. Unlike the lower zone, the ore mineralization in the barite bed is evenly distributed and confined to a narrow zone.

The mineralized tabular bodies or elongated lenses are commonly more than 20-30 m thick. Eleven million tons of ore, over 6 percent zinc and lead combined, has been blocked out based on information obtained from 14 drill holes and assay data on the outcrops.

Table II-1-2 Chemical Analyses of Ore

Sample No.	Formation	Locality	Pb (%)	Zn (%)	Ba (%)	Ag (g/T)
A - 6	Loralai - II	Surmai III	0.18	0.42	0.02	3.3
A - 10	Loralai - II	Surmai III	0.48	4.92	<0.01	6.5
A - 11	Loralai - II	Surmai III	0.34	1.22	0.01	3.9
A - 33	Loralai - II	Surmai III	0.09	2.77	0.01	1.9
B - 13	Loralai - II	Surmai III	0.19	2.32	<0.01	2.3
C - 10	Loralai - IV	Surmai II	2.90	2.66	<0.01	24.0
C - 15	Loralai - IV	Surmai II	0.57	4.60	<0.01	12.0
C - 20	Anjira - I	Surmai II	1.63	1.92	0.02	8.0
D - 29	Loralai - II	Surmai III	0.93	1.30	<0.01	33.0
D - 41	Loralai - II	Surmai III	0.63	3.05	0.02	8.5
D - 55	Loralai - II	Surmai III	tr	tr	<0.01	5.5
D - 68	Loralai - II	Surmai III	1.34	0.35	0.02	21.5
E - 5	Loralai - III	Surmai I	0.57	1.59	<0.01	6.5
E - 8	Loralai - II	Surmai I	0.23	5.64	0.01	4.1
E - 29	Loralai - III	Surmai I	0.26	0.13	<0.01	3.3
E - 35	Loralai - I	Surmai I	0.13	<0.01	<0.01	2.3
E - 42	Loralai - I	Surmai I	<0.01	0.43	<0.01	1.7
K - 12	Loralai	Sekran	0.02	3.15	<0.01	1.7
M - 1	Loralai	Malkhor	0.02	0.59	<0.01	2.3
M - 14	Loralai	Ranj Laki	0.30	2.61	<0.01	7.0

Ditection Limit : Pb 0.01%, Zn 0.01%, Ba 0.01%, Ag 0.1g/t

Analytical method : Atomic Absorption and Common Assey

Table II-1-3 Description of Microscopic Observation of Ore Polished Specimens

Sample No.	Localty	Mineral											Note
		Ge	Ma	Py	He			Q	Ca	Do	Hf		
A - 6	Surmai-III	◎	●					◎	◎				Lo-II
A - 10	Surmai-III	○						◎					Lo-II
A - 11	Surmai-III	◎	△					○	○				Lo-II
A - 33	Surmai-III	○	△					●	●	○			Lo-II
B - 13	Surmai-III	○		△				○	△	○			Lo-II
C - 10	Surmai-II	◎						○	△				Lo-IV
C - 15	Surmai-II	○	△		△			○	●		△		Lo-IV
C - 20	Surmai-II	◎						○	●				Anj-I
D - 29	Surmai-II	◎						○	●		△		Lo-II
D - 41	Surmai-II	○			●			○	●				Lo-II
D - 46	Surmai-II	◎						○			●		Lo-I
D - 53	Surmai-II	◎						○	●				Lo-I
D - 55	Surmai-II	○						◎	○				Lo-II
D - 68	Surmai-II	◎		△				◎	○				Lo-II
E - 5	Surmai-I	◎			●			○	●				Lo-III
E - 8	Surmai-I	○						◎	△				Lo-II
E - 26	Surmai-I	◎						◎	○				Lo-I
E - 29	Surmai-I	◎	△					○	●				Lo-III
E - 35	Surmai-I	◎		△				△	○				Lo-I
E - 42	Surmai-I	◎		△				○	○				Lo-I

Abbreviation
- ◎ : Abundant
- ○ : Common
- ● : A Few
- △ : Rare

Shirinab Formation
- Anj : Anjira Member
- Lo-IV : Loralai Member IV
- Lo-III : Loralai Member III
- Lo-II : Loralai Member II
- Lo-I : Loralai Member I

Ge : Goethite   Ma : Marcasite   Py : Pyrite   He : Hematite
Q : Quartz   Ca : Calcite   Do : Dolomite   Hf : Hemimorphite

Table II-1-4 Description of Microscopic Observation of Thin Sections

Sample No.	Locality	Rock Name	Rock Facies	Allochems /Grain	Orthochems /Matrix	Unit
A-2	Sur-I	Ls.	biomicrite	bioclasts. gastropd. d:1mm.	micrite.	An-I
A-20	Sur-II	Ls.	oomicrite.	ooids, bioclasts. limo, d:0.2mm.	micrite>sparite	Lo-II
A-23	Sur-II	Ls.	biomicrite	bioclasts. bivalve. d:+1mm.	micrite.	Lo-III
A-37	Sur-I	S. s.	limy sandstone	qz, d:0.1mm.	fine cal, clay, opaque min.	Sp
A-38	Sur-I	Sh.	limy shale (siltstone)	fine qz, cal.	clay, dolc.	Lo-I
B-3	Sur-II	Ls.	biomicrite	bioclasts. d:1mm. sparry cal.	micrite.	Lo-IV
B-5	Sur-II	Ls.	biomicrite	bioclasts. d:1mm. sparry cal.	micrite.	Lo-III
B-10	Sur-III	Ls.	cherty biomicrite	radioraria. d:0.1mm. qz, cal.	micrite. limo, dolc.	An-I
B-21	Sur II～III	Ls.	cherty biomicrite	radioraria. d:0.1mm. qz, cal.	micrite. limo, dolc.	An-II
B-22	Sur II～III	Sh.	cherty biomicrite	radioraria. d:0.1mm. qz, cal.	micrite. limo, clay, dolc.	An-II
B-35	Sur-I	Ls.	oosparite	ooids. d:0.4mm.	sparite.	An-III
C-7	Sur-II	Ls.	biomicrite	bioclasts. d:1mm. sparry cal.	micrite.	Lo-IV
D-1	Sur II～III	Ls.	biomicrite	bioclasts. d:0.5mm. sparry cal.	micrite. dolc. opaque min.	Lo-III
D-22	Sur-III	Ls.	oomicrite	ooids, bioclasts. d:0.3mm. micrite.	micrite, clay.	Lo-II
D-60	Sur-III	Ls.	oosparite	ooids. d:0.3mm.	sparite.	Lo-II
E-9	Sur-I	Ls.	oomicrite	ooids d:0.2mm. sparry cal.	micrite,. dolc.	Lo-III
E-12	Sur-I	Ls.	biomicrite	bioclasts. d:1mm. sparry cal.	micrite.	Lo-IV
E-22	Sur-I	Ls.	oosparite	ooids d:0.2mm	sparite.	Lo-II
E-23	Sur-I	Ls.	micrite	(sparry cal vein wd:0.3mm)	micrite.	Lo-I
E-48	Sur-I	Ls.	biomicrite	bioclasts. d:0.5mm. gastropod.	micrite.	Lo-IV

Sur:Surmai　d:diameter　min:mineral　An:Anjira
Ls.:Limestone　limo:limonite　dolc:dolomitic　Lo:Loralai
Sh.:Shale　qz:quartz　Sp:Spingwar
S. s.:Sandstone　cal:calcite

Table Ⅱ-1-5 X-Ray Diffraction Analysis (1)

Sample No.	Locality	Minerals																			Note
		Ca	Q	Do	Ka	Se	E	Ch	Fe	Ge	Fl	Sp	Hf	He	Es	Gy	Cr	Ce	Sm	Mg	
A - 2	Surmai-Ⅱ	◎	●																		Ls.,Anj-Ⅰ
A - 6	Surmai-Ⅱ	△	●						◎	●											Ore,(Lo-Ⅲ)
A - 10	Surmai-Ⅲ		◎						◎	o											Ore,(Lo-Ⅱ)
A - 11	Surmai-Ⅲ	○	○						◎	o											Ore,(Lo-Ⅲ)
A - 20	Surmai-Ⅱ	◎	●		?					△											Ls.,Lo-Ⅲ
A - 23	Surmai-Ⅲ	◎	●	?																	Ls.,Lo-Ⅱ
A - 26	Surmai-Ⅲ~Ⅱ	o	◎	?	△				◎	●											Ore,(Lo-Ⅲ)
A - 33	Surmai-Ⅱ	●	●	o					◎	●											Ore,(Lo-Ⅲ)
A - 35	Surmai-Ⅰ	◎	●																		Ls.,Lo-Ⅲ
A - 37	Surmai-Ⅰ	○	◎		o																S.s.Spi
A - 38	Surmai-Ⅰ	◎	○	△	△	△															Ls.Lo-Ⅰ
A - 40	Surmai-Ⅰ	◎	●	?																	Ls.,Lo-Ⅲ
B - 3	Surmai-Ⅲ	◎		●	●																Ls.,Lo-Ⅳ
B - 5	Surmai-Ⅲ	◎	●		△																Ls.,Lo-Ⅱ
B - 10	Surmai-Ⅲ	◎	●	△																	Ls.,Anj-Ⅱ
B - 13	Surmai-Ⅱ	△	○	o					○	●											Ore(Lo-Ⅲ)
B - 21	SurmaiⅢ~Ⅱ	◎	○	△	△		?														Ls.,Anj-Ⅲ
B - 22	SurmaiⅢ~Ⅲ	◎	◎	△	●	●	?														Sh.Anj-Ⅲ
B - 35	Surmai-Ⅰ	◎	●																		Ls.,Anj-Ⅲ
C - 5	Surmai-Ⅲ	△	○						◎	●											Ore(Anj-Ⅲ)
C - 7	Surmai-Ⅲ	◎	●																		Ls.,Lo-Ⅳ
C - 10	Surmai-Ⅱ	△	◎						○	●											Ore(Lo-Ⅳ)
C - 15	Surmai-Ⅲ	●	◎						○				△								Ore(Lo-Ⅳ)
C - 17	Surmai-Ⅲ	△	○						◎				●								Ore(Anj-Ⅰ)
C - 20	Surmai-Ⅲ	●	○						◎	○											Ore(Anj-Ⅰ)
D - 1	SurmaiⅢ~Ⅱ	◎	●	△																	Ls.,Lo-Ⅲ
D - 22	Surmai-Ⅲ	◎	●		△																Ls.,Lo-Ⅱ
D - 27	Surmai-Ⅲ								◎	△			●		○						Ore(Lo-Ⅲ)
D - 29	Surmai-Ⅲ	●	○						◎	●			△	o							Ore(Lo-Ⅲ)
D - 38	Surmai-Ⅲ	o	◎						○	o			●								Ore(Lo-Ⅱ)
D - 41	Surmai-Ⅲ	△	o						◎	o											Ore(Lo-Ⅲ)
D - 46	Surmai-Ⅱ	?	◎						○	o			●								Ore(Lo-Ⅰ)
D - 53	Surmai-Ⅲ	●	○						◎	●											Ore(Lo-Ⅰ)
D - 55	Surmai-Ⅲ	△	○						◎	○											Ore(Lo-Ⅲ)
D - 60	Surmai-Ⅱ	◎	●	△																	Ls.,Lo-Ⅲ
D - 68	Surmai-Ⅱ	●	◎						○	●											Ore(Lo-Ⅲ)
E - 5	Surmai-Ⅰ	●	○						◎	o				●							Ore(Lo-Ⅱ)
E - 8	Surmai-Ⅰ	?	o						◎	o											Ore(Lo-Ⅱ)
E - 9	Surmai-Ⅰ	◎	○	●																	Ls.,Lo-Ⅱ
E - 12	Surmai-Ⅰ	◎	●																		Ls.,Lo-Ⅳ
E - 19	Surmai-Ⅰ		○						◎	●			△								Ore(Lo-Ⅱ)

Abbreviation
- ◎ : very Abundant
- ○ : Abundant
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- ● : A Few
- △ : Rare
- ? : Unclear

Shirinab Formation
- Anj : Anjira Member
- Lo-Ⅳ : Loralai Member Ⅳ
- Lo-Ⅲ : Loralai Member Ⅲ
- Lo-Ⅱ : Loralai Member Ⅱ
- Lo-Ⅰ : Loralai Member Ⅰ

Ca : Calcite
Q : Quartz
Do : Dolomite
Ka : Kaolinite
Se : Sericite
E : Eurite
Ch : Chlorite
Fe : Oxide Iron
Ge : Goethite
Fl : Fluorite
Sp : Sphalerite
Hf : Hemimorphite
He : Hematite
Es : Esperite
Gy : Gypsum
Cr : Cristobalite
Ce : Cerussite
Sm : Smithsonite
Mg : Magnesite
Ls : Limestone
Sh : Shale
Ss : Sandstone

Table Ⅱ-1-5 X-Ray Diffraction Analysis (2)

Sample No.	Locality	Ca	Q	Do	Ka	Se	E	Ch	Fe	Ge	Fl	Sp	Hf	He	Es	Gy	Cr	Ce	Sm	Mg	Note
E - 22	Surmai-Ⅰ	◎	△																		Ls.,Lo-Ⅲ
E - 23	Surmai-Ⅰ	◎	●	●																	Ls.,Lo-Ⅰ
E - 26	Surmai-Ⅰ	●	◎						◎	●											Ore,(Lo-Ⅰ)
E - 29	Surmai-Ⅰ	●	○	△					◎	●											Ore,(Lo-Ⅲ)
E - 35	Surmai-Ⅰ	●	●						◎	●				△							Ore,(Lo-Ⅱ)
E - 42	Surmai-Ⅰ	●	●						◎	●											Ore,(Lo-Ⅰ)
E - 43	Surmai-Ⅰ	●	◎	△					○	●											Ore,(Lo-Ⅱ)
E - 48	Surmai-Ⅰ	◎	●																		Ls.,Lo-Ⅳ
E - 51	Surmai-Ⅰ	◎	●	●	△																Ls.,Lo-Ⅱ
K - 3	Sekran	◎	△																		Ls.,Lo
k - 4	Sekran	○							◎	●											Ore,(Lo)
K - 6	Sekran	◎	●																		Ls.,Lo
K - 12	Sekran	○	○					●	◎	●											Ore,(Lo)
K - 15	Sokran		◎						○	●		●									Ore,(Lo)
K - 16	Sekran	◎	△																		Ls.,Lo
K - 23	Sekran	◎	○																		S.s.,Spi
K - 24	Sekran	○	●		?				◎	●											Ore,(Lo)
K - 25	Sekran	◎	●																		Ls.,Lo
k - 26	Sekran	◎	●	△																	Ls.,Lo
M - 1	Malkhor	●	◎		△				○					●							Ore,(Lo)
M - 2	Malkhor	△	○						◎	●				●							Ore,(Lo)
M - 3	Malkhor	◎	●																		Ls.,Lo
M - 4	Malkhor	◎	●																		Ls.,Lo
M - 6	Malkhor	●	◎		△				●	△				△							Ore,(Lo)
M - 7	Malkhor	◎	●	△		△															Ls.,Lo
M - 8	Malkhor	◎	●																		Ls.,Lo
M - 9	Ranj Laki	●	○						◎	●	●			●							Ore,(Lo)
M - 10	Ranj Laki	◎	●																		Ls.,Lo
M - 11	Ranj Laki	△	○		?				◎	●				●							Ore,(Lo)
M - 12	Ranj Laki	◎	△																		Ls.,Lo
M - 13	Ranj laki	△	○					?	◎	△				●							Ore(Lo)
M - 14	Ranj Laki		○						◎	●											Ore,(Lo)
M - 15	Ranj Laki	●	○					?	◎	o			●								Ore,(Lo)
M - 17	Ranj Laki	◎	●																		Ls.,Lo
M - 18	Ranj Laki	○	○					?	◎				●								Ore,(Lo)
M - 20	Ranj Laki	◎	●																		Ls.,Lo
M - 21	Ranj Laki	△	◎						●	●			○							?	Ore,(Lo)
M - 22	Ranj Laki	◎	◎		●																S.s.,Sp
M - 23	Ranj Laki	◎	●																		Ls.,Lo
M - 24	Ranj Laki	●	●						◎	●						?					Ore,(Lo)

Minerals: columns Ca through Mg.

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Ca : Calcite	E : Eurite	Sp : Sphalerite	Cr : Cristobalite	Ls : Limestone
Q : Quartz	Ch : Chlorite	Hf : Hemimorphite	Ce : Cerussite	Sh : Shale
Do : Dolomite	Fe : Oxide Iron	He : Hematite	Sm : Smithsonite	Ss : Sandstone
Ka : Kaolinite	Ge : Goethite	Es : Esperite	Mg : Magnesite	
Se : Sericite	Fl : Fluorite	Gy : Gypsum		

Table Ⅱ-1-5 X-Ray Diffraction Analysis (3)

Sample No.	Locality	Minerals																			Note
		Ca	Q	Do	Ka	Se	E	Ch	Fe	Ge	Fl	Sp	Hf	He	Es	Gy	Cr	Ce	Sm	Mg	
S - 1	C-D Section	○	◎		●																S.s.,Spi
S - 6	C-D Section	◎	○		△	△															Ls.,Spi
S - 14	C-D Section	◎	●																		Ls.,Lo-Ⅰ
S - 17	C-D Section	◎	●		?																Ls.,Lo-Ⅰ
S - 20	C-D Section	◎	●																		Ls.,Lo-Ⅰ
S - 40	C-D Section	◎	●	△	△																Ls.,Lo-Ⅱ
S - 48	C-D Section	◎	●		△																Ls.,Lo-Ⅲ
S - 54	E-F Section	◎	●																		Ls.,Lo-Ⅲ
S - 57	E-F Section	◎	●																		Ls.,Lo-Ⅳ
S - 58	E-F Section	◎	●																		Ls.,Lo-Ⅳ
S - 59	E-F Section	◎	●	●																	Ls.,Anj
S - 60	E-F Section	◎	●				?														Ls.,Anj
S - 64	A-B Section	◎	○		●																S.s.,Spi
S - 67	A-B Section	◎	●		●	△															Ls.,Spi
S - 70	A-B Section	◎	●	△	●																Ls.,Lo-Ⅰ
S - 72	A-B Section	◎	●	●																	Ls.,Lo-Ⅰ
S - 78	A-B Section	◎	●																		Ls.,Lo-Ⅱ
S - 90	A-B Section	◎	○		△																Ls.,Lo-Ⅱ
S - 99	A-B Section	◎	●																		Ls.,Lo-Ⅲ
S - 102	A-B Section	◎	●																		Ls.,Lo-Ⅲ
S - 104	A-B Section	◎	●																		Ls.,Lo-Ⅳ
S - 105	A-B Section	◎	●				?														Ls.,Lo-Ⅳ
S - 106	A-B Section	◎	●				?														Ls.,Anj
S - 107	A-B Section	●	●				?														Ls.,Anj

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Hf : Hemimorphite
He : Hematite
Es : Esperite
Gy : Gypsum
Cr : Cristobalite
Ce : Cerussite
Sm : Smithsonite
Mg : Magnesite
Ls : Limestone
Sh : Shale
Ss : Sandstone

Table II-1-6 Whole Rock Compositions of the Carbonate Rocks

Sample NO.	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	TiO_2 %	P_2O_5 %	MnO %	LOI %	FeO %	Ba ppm	Total %	Remark
A - 38	27.86	10.74	2.89	1.67	26.22	0.14	2.12	0.45	0.17	0.05	26.38	1.23	180	99.94	Lora-I, Shale
B - 21	24.76	3.94	1.17	1.30	34.57	0.38	0.81	0.22	0.10	0.11	29.96	1.81	190	99.13	Anji-II, Ls
D - 22	4.23	0.29	0.88	0.42	50.59	0.02	0.08	0.01	0.04	0.08	41.22	0.29	70	98.16	Lora-II, Ls
E - 12	6.83	1.14	0.99	0.53	47.51	0.04	0.21	0.05	0.06	0.08	39.39	0.60	60	97.44	Lora-IV, Ls
H - 148	1.66	0.51	0.14	0.35	52.72	0.02	0.14	0.01	0.05	0.01	42.66	0.14	40	98.44	Lora-II, Ls

Average Composition of Mainly Sedimentary Rocks in the World (Reference)

Rock Name	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	TiO_2 %	P_2O_5 %	MnO %	LOI %	FeO %	Ba ppm	Total %	Remark
Ls	5.2	0.8	0.5	0.05	42.6	0.05	0.3	0.07	0.09	0.05	42.4	**		99.96	*1
Ss	78.7	4.8	1.1	1.2	5.5	0.5	1.3	0.25	0.04	0.01	6.6	0.3		100.30	*2
Pel	58.9	16.7	2.8	2.6	2.2	1.6	3.6	0.77	0.16	0.1	6.3	3.7		99.43	*3

Abbreviation

Lora-I : Unit of Loralai Member
Ls : Limestone
Ss : Sandstone
Pel : Pelitic Rock

*1 :Average of 345 Samples, Clarke
*2 :Average of 253 Samples, Clarke
*3 :Average of 277 Samples, Wedepohl
** :Contained in Fe_2O_3

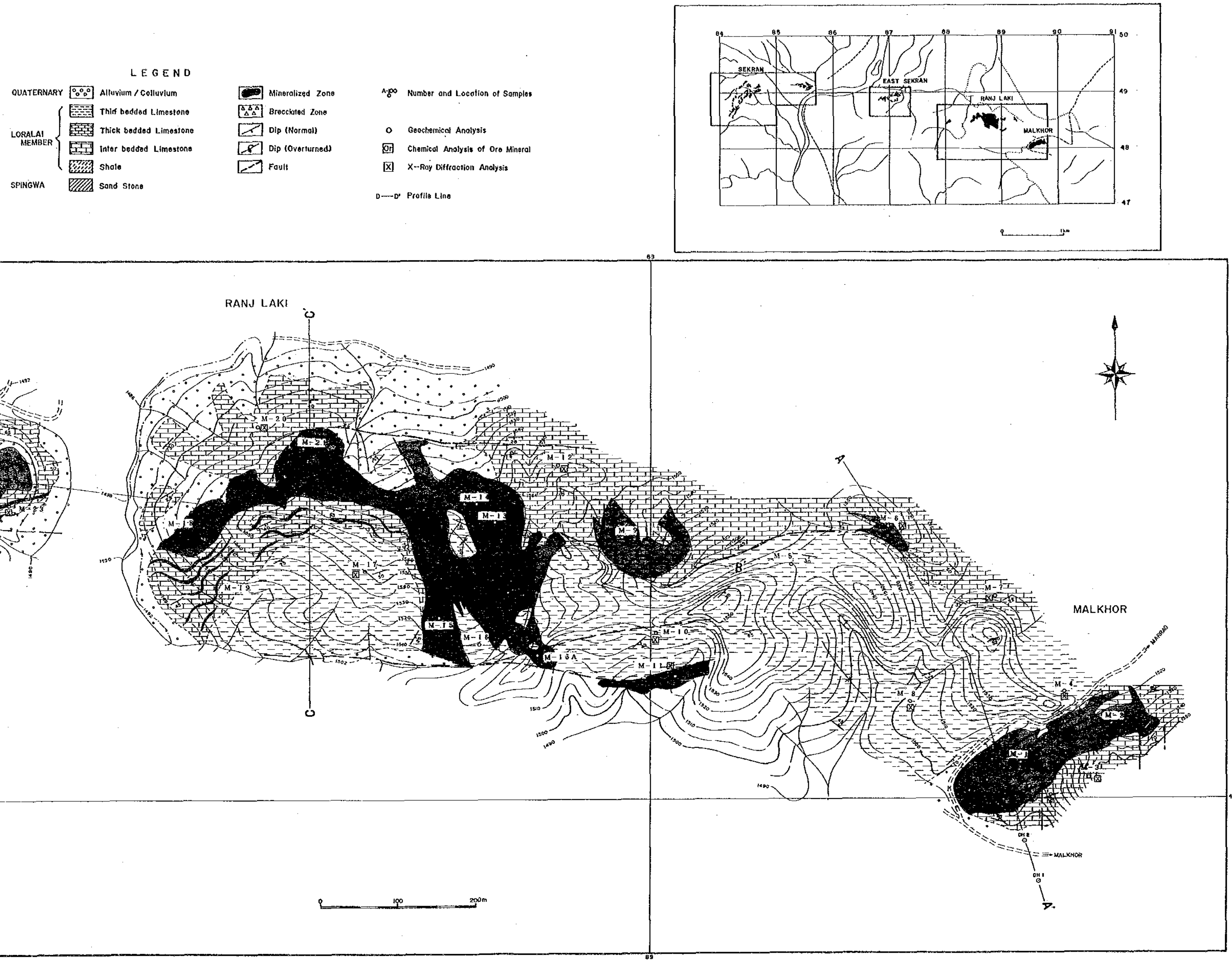


Fig. II-1-3 Geological Map of Malkhor and Lanj Laki

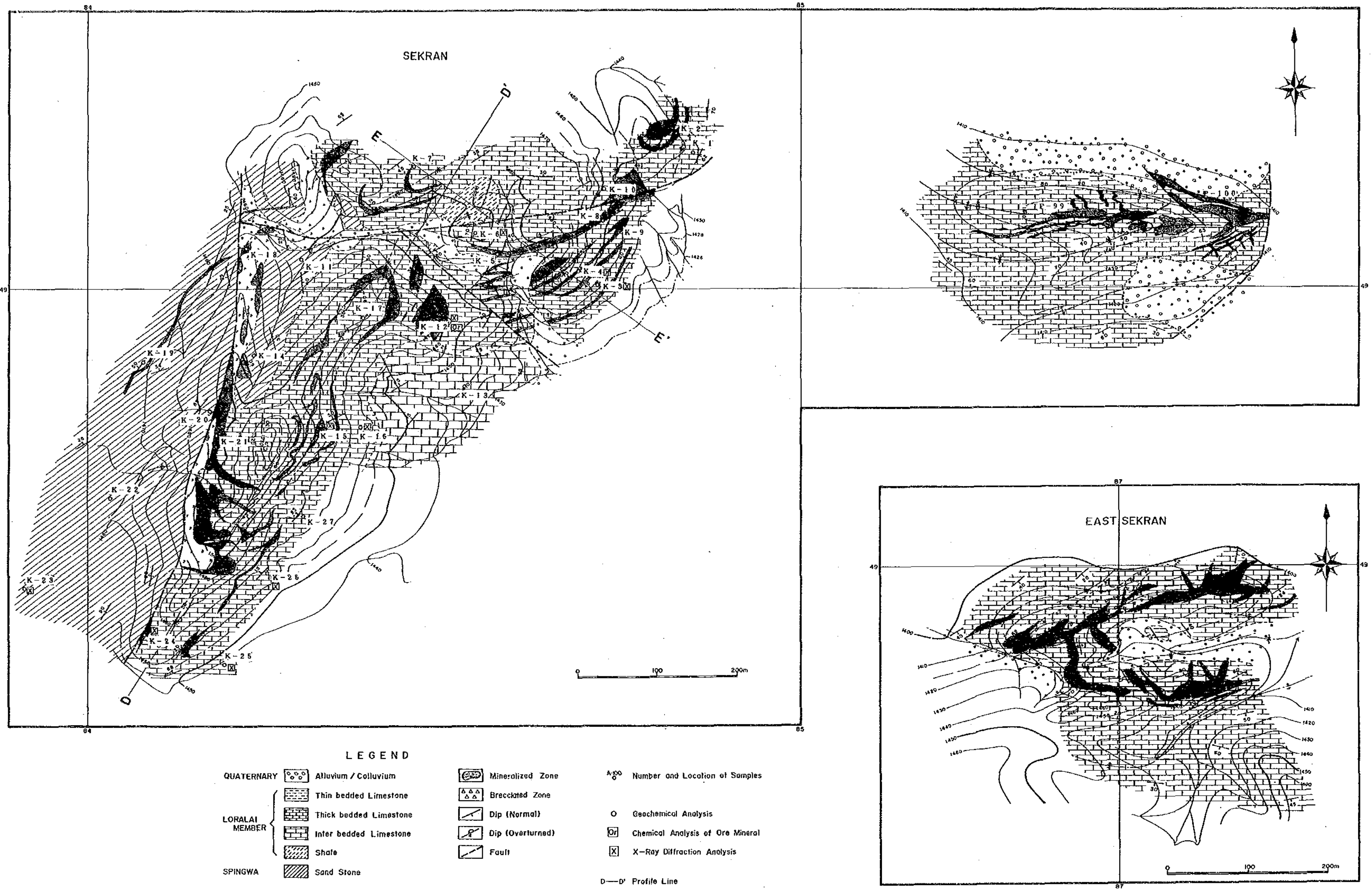


Fig. II-1-4 Geological Map of the East Sekran and Sekran

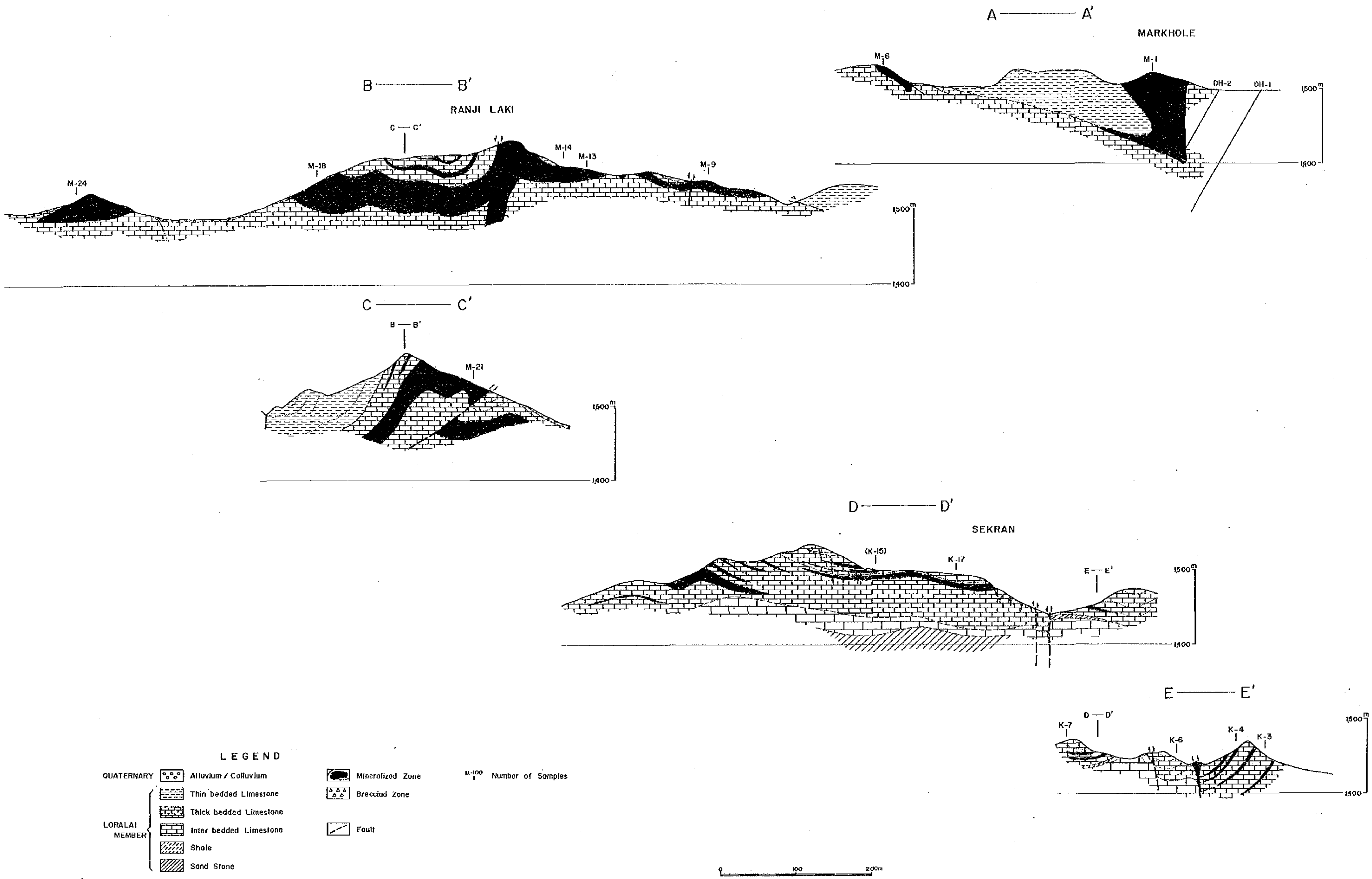


Fig. II-1-5 Geological Profile of Malkhor, Lanj Laki and Sekran

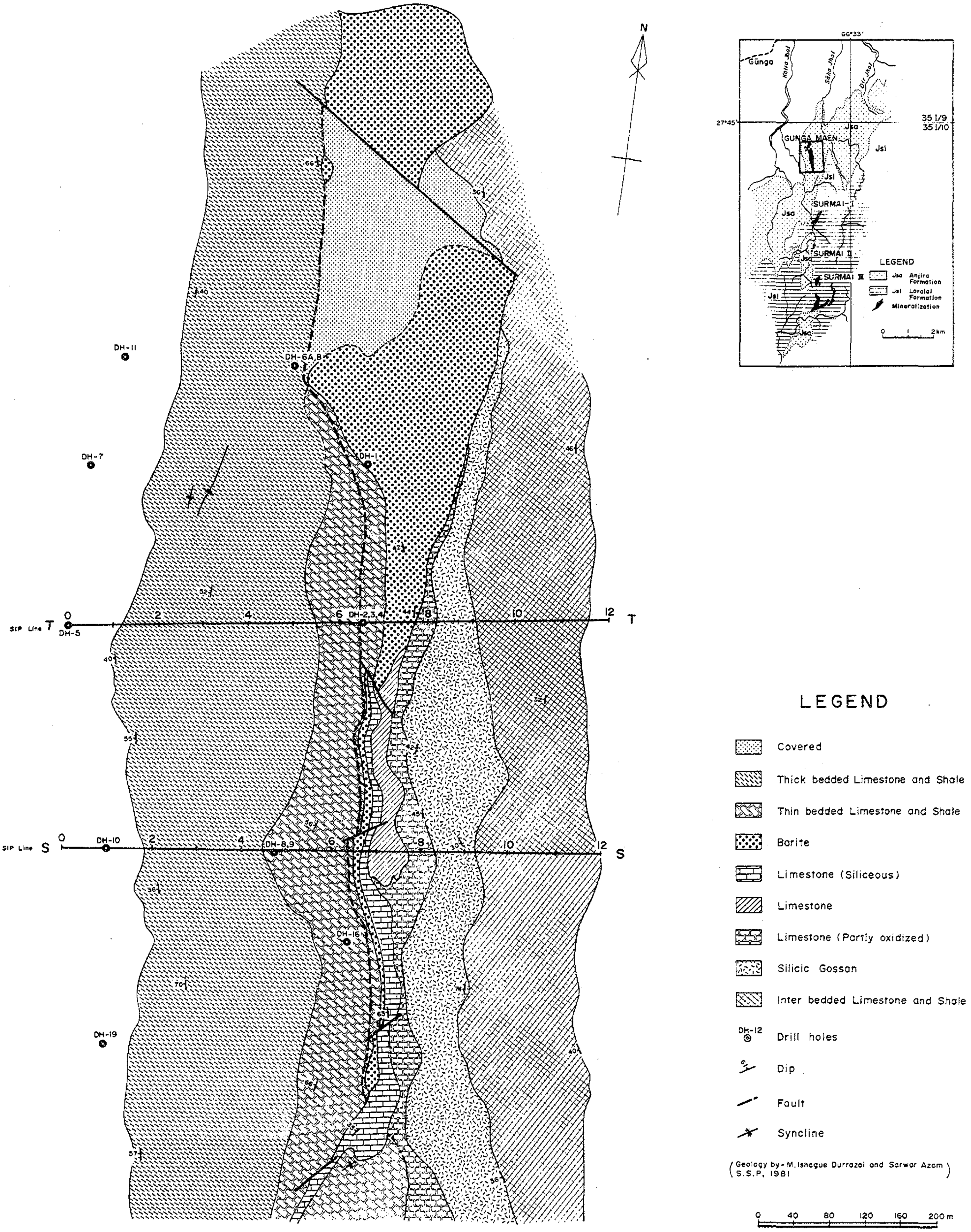


Fig. II-1-6 Geological Map of Gunga mine

Chapter 2 GEOCHEMICAL SURVEY

2－1 Outline

A rock geochemical survey was conducted in conjunction with the geological survey to unravel geochemical characteristics of mineralization, and to find new prospectable mineralized areas in the Khuzdar District. In total, 2,700 rock samples were collected from the survey area of 1,350km^2 with the average ratio of 2 samples per 1 km^2, taking into consideration even distribution and sampling of geologically representative rocks around a sample point(PL-II -2-1～PL-II -2-6).

A total 2,750 samples, conbining the above mentioned 2,700 samples and 50 samples selected from samples of the Surmai area, were used for the investigation on the whole survey area. The data were statistically processed for the respective groups of the Member and the Block. In addition, 107 rock samples (included in the 2,700 samples) which were collected along a line cross-cutting the strike of the strata in the eastern end of Block-II were also statistically processed for each Unit of the Block as was the case for the Surmai Area.

After crushing, each sample was reduced to about 50 grams through quarter dividing method, pulverized to under 80 mesh in size, and a sample of 10 grams was chemically analyzed.

Six elements, namely Pb, Zn, Hg, Ba, Mg and S, were analyzed for their concentration using atomic absorption spectrophotometry(AAS) analysis. Detectable limits of these elements are as follows :

Pb …………	1ppm	Ba …………	10ppm
Zn …………	1ppm	Mg …………	50ppm
Hg …………	10ppb	S …………	0.001%

The result of the analysis are shown in Table 2 of the Appendices.

2－2 Statistic Analysis Procedure of the Geochemical Data

Mean value(M), standard deviation(σ), and so on of the 6 elements are shown in Table II -2-2 correlative distribution between each two elements in Fig.II -2-5, histogram of the 6 elements in Fig.II -2-1, and cumulative frequency distribution of the 6 elements in Fig.II -2-2.

Value contour lines of these elements were delineated by running the average method of 500m grid.

Threshold values of these elements were determined using the methods of Lepeltier (1967) or A.J.Sinclair(1974). Cumulative frequency curves of these elements shown in Fig.Ⅱ-2-2 indicates that the five elements of Pb,Zn, Hg, Ba and Ba are clearly grouped into 2 populations of anomalous value and back-ground value, while S consists of a population showing a straight line.

The obtained threshold values of the elements in the Khuzdar District are shown in Table Ⅱ-2-1.

TableⅡ-2-1 Threshold Value of Geochemical Statistical Analyses in Khuzdar District

	Pb ppm	Zn ppm	Hg ppb	Ba ppm	Mg ppm	S %
Threshold value	29	225	340	350	11,000	0.074

2－3 Statistic Analysis Results

2-3-1 Distribution of Elements in the Shirinab Formation

(1) Distribution tendency of the assay values in the Member

Lead : Pb values have a tendency to be remarkably concentrated in the Sipngwar Member (n = 402, M = 2.60ppm, σ = 0.475), but standard deviation is larger in the Loralai Member, 0.650.

Zinc : Zn is not concentrated in any particular member since their mean values are in a narrow range from 14.11 to 16.64 ppm, and their standard deviation values are also not distinctly different among these members(0.329 to 0.575).

Mercury : The concentration of Hg tends to be higher and standard deviation is also larger as shown by 0.501 in the Loralai Member.

Barium : Comparing the mean value of all samples(210.39ppm), Ba (M :189.73ppm) in the Loralai Member is slightly less concentrated than in other members. Their standard deviation values are generally low, ranging from 0.213 to 0.300.

Magnesium : As in the case of Ba, Mg has a tendency to be less concentrated in the Loralai Member(3,365 ppm), in comparison with the mean value of 3,657ppm in the whole area. Standard deviation of the Spingwar Member is slightly larger, as shown by its value of 0.450.

Sulpher : The Anjira Member has a tendency to have concentrated S, in comparison with the S content in other Members. Its standard deviations are large in general, ranging from 0.586 to 0.678.

(2) Distribution tendency of assay values in Blocks

Jurassic limestone occurs separately as 6 blocks in the Khuzdar District, as mentioned previously. The assay values were statistically processed, dividing the populations of the 6 blocks.

Lead, Zinc, Barite and Mercury : Mean values of Pb, Zn , Ba and Hg contents are higher, and their standard deviation values are larger in Block-II and Block-IV . Hg is also high in content in Block-III . Above all, the Hg content in Block-III is the highest among those in all the blocks. The standard deviation values in Block-II and Block-IV which are twice those of other blocks may be due to the presence of mineral indications, such as the Malkhor and Surmai, in these two blocks.

Magnesium : Although Mg contents in these blocks are similar in mean values and standard deviation values, the mean values become higher from Block-I to Block-VI , Block-I to Block-IV via Block-V and Block-IV in order. The standard deviation values are slightly larger in Block-I and Block-II .

Sulpher : S contents are mostly low in the blocks in spite of them increasing in mean values in the order of Block-I ,Block-V , Block-IV and Block-VI .

Standard deviations of S are not variant in these Blocks, ranging from 0.5 to 0.6.

(3) Distribution tendency of assay values along cross-cut lines on stratigraphic units.

Two sampling lines cross-cutting stratigraphic units are located between the Sulmai and Sekran mineralized zones, as shown in Fig. II -2-3. Three members of the Shirinab Formation, namely the Anjira, Loralai and Spingwar Members, occur on the sampling lines. The Loralai Member is divided into four units, namely I , II , III and IV , and the Spingwar and Anjira Members are each regarded as a Unit.

Assay results are plotted in the cross-sections of Fig. II -2-3 and Fig. II -2-4. Statistic values of the assay results are shown in Table II -2-3.

Lead : Pb concentrates are comparative in the Spingwar Member, Loralai II Unit and Anjira Member, ranging 39.01 to 35.46 ppm in mean value. The largest standard deviation of 0.769 is in the Loralai II Unit.

Zinc : Zn concentrates are comparative in the Loralai II Unit and Anjira Member, ranging 33.81 to 26.32 ppm in mean value. Standard deviation is largest in the Loralai II Unit at 0.753.

Mercury : Hg concentrates are comparative in Loralai II and Loralai III, containing 33.81 and 26.32 ppb in mean value. Both units have large standard deviations as shown by 0.409 and 0.474 respectively.

Barium : Ba is richest in the Spingwar Member as shown by 332.7 ppm mean value, while the lowest grade is in the Loralai II Unit.

Magnesium : Loralai I has the highest mean value of Mg with 7,256ppm while Loralai II has the lowest grade. Standard deviation is generally small in all blocks.

Sulpher : The highest concentration of S is a mean value grade of 0.013%. However, the element is generally distributed with large standard deviation ranging from 0.81 to 0.68 in the Loralai I Unit, Spingwar Member, and Loralai II Unit.

The statistic analysis reveals that Loralai II and Loralai III contain high values of Pb, Zn, Hg, while the Spingwar Member and Loralai I are high in Ba and Mg. The Spingwar Member contains slightly high Pb, and the Anjira Member is also slightly high in Pb and Zn contents.

2-3-2 Correlation between the Elements

Correlative coefficients among 6 elements in the Khuzdar District are shown in Table II-2-4, and the correlations plot in Figure II-2-5. Pb vs Zn, Pb vs Hg and Zn vs Hg show very good positive-correlation with correlative coefficients greater than 0.5. Ba vs S has a poor correlation.

Table II-2-4 Coefficiency of Correlation of Geochemical Analyses in Khuzdar District

	Pb				
Zn	0.686	Zn			
Hg	0.506	0.520	Hg		
Ba	0.015	0.098	0.011	Ba	
Mg	-0.066	0.024	-0.137	0.130	Mg
S	0.179	0.238	0.170	0.316	0.166

Correlative coefficients among these elements on the cross-cut lines on stratigraphic units are shown in Table II-2-5. Since the samples were collected from the Surmai and Malkhor areas including the horizon of mineral indication, these elements show characteristic correlation in each unit. That is, in the Loralai II Unit area which has high mean values of grade and large standard deviation , Pb, Zn and Hg show very good correlation with each other, and S vs Pb shows a poor correlation, while Ba vs Pb and Zn show inverse correlations. In the case of Loralai I and Loralai III , Pb, Zn and Hg show some correlation.

In the upper Units such as the Anjira Member and Loralai IV , Pb, Zn, Hg and Mg show very good correlations with each other. To the contrary,Ba and Mg show poor correlations with Pb, Zn and Hg.

2-3-3 Selection and Evaluation of Anomalies

(1) Selection of Anomalous Areas

Value contour maps of assay results delineated by running average method with 500 m grid are shown in PL-II-2-7～PLII-2-12. Anomalous areas were selected from the value contour maps on the basis that an anomalous value is determined as such by being of higher content than the threshold value defined by the statistic procedures previously outlined.

These anomalous areas are characterized by the following tendencies in their distribution : ① Most anomalous areas are distributed in Block II and Block IV. ② Anomalous areas of Pb, Zn and Hg occur in the central part of mineral indication areas, with good correlations to each other. ③ Anomalous areas of Ba are in the outer part, apart from anomalous areas of Pb, Zn and Hg.

These anomalous areas for each element are summarized as follows ;

Lead : The anomalous areas occur not only in and around mineral indication areas but also in the area of the Spingwar Member .

Zinc : The anomalous areas are mainly distributed in and around mineral indication areas.

Mercury : The anomalous areas occur with or without Ba, in Pb and Zn anomalous areas, and also in the Spingwar Member area or along a fault.

Barite : The Ba forms a comparatively high grade anomalous area in the Spingwar Member area. In the Loralai and Anjira Member areas, the Ba anomalous areas occur in surrounding parts of the Pb and Zn anomalous areas.

Magnesium : Mg anomalous areas occur extensively in the Loralai Member area, and also in surrounding areas of the Pb, Zn and Hg anomalous areas.

Sulpher : S anomalous areas co-exist with Ba anomalous areas in the Anjira Member area, and low grade anomalous areas are also found around scattered and small-scale anomalies of Pb, Zn, Hg, Mg and Ba.

(2) Evaluation of Complex Anomalous Areas

Anomalous areas of several elements usually occur overlapping one upon another, and these anomalous areas can be classified into two groups, namely one which consists mainly of Pb and Zn and another which consists mainly of Ba. Thus in order to evaluate the geochemically anomalous area, they are grouped into Pb-Zn anomalous areas and Ba anomalous areas, and are evaluated as poli-element complex anomalous areas. These "complex anomalous areas" are classified into 4 ranks of A, B, C, and D , on the basis of evaluation standards shown in Table II -2-6.

TableⅡ-2-6 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.

The list of complex anomalous areas obtained is shown in Table II -2-7, and their distribution is shown in Fig. II -2-6.

Remarkable complex anomalous area ares selected as follows ;

(1) Rank A

No.10 (Pb-Zn anomalous area)

This complex anomalous area extends in and around the area from the Markhor to Sekran mineral indication areas. Anomalous areas of Pb, Zn and Hg are distributed in the same place as the mineral indication areas, and those of Ba occur at the east and west extentions from these mineral indication areas. Mg anomalous areas are emplaced in a section south and southeast of the No.10 area.

Weak anomalous values of S are scattered sporadically in other element anomalous areas.

No.16 (Pb-Zn anomalous area)

This complex anomalous area overlies mostly the Surmai mineralized area. Distribution of the Pb-Zn-Hg anomalous area trends along a southeast direction, associated with mineral indication zones. Ba-anomalous areas are distributed at the northwest and southwest parts of this area. These Ba anomalous areas are surrounded by a wide low Ba-anomalous margin ranging from ($M+\sigma$) value to threshold value.

No. 15(Ba anomalous area)

This complex anomalous area occurs on the Gunga ore deposit and extends northeast. This complex anomalous area consists of Ba and Hg anomalous areas accompanied in part by Zn anomalous values.

(2) Rank B

No.6 (Pb-Zn anomalous area)

This complex anomalous area is situated in the western extention of the Markhor and Sekran zone. An anomalous area of Pb covers the entire No.6 area, and a Zn anomalous area occupies the centalr part of the Pb anomalous area. Although an A-rank Ba anomalous area is found in the southern part, this area is generally regarded as a B-rank Pb-Zn complex anomalous zone.

No. 11 (Pb-Zn anomalous area)

This complex anomalous area is situated between the Gunga ore deposit and Malkhor mineralized zone of the Surmai ~ Sekran zone. Ba and S anomalous areas occur on the Spingwar Member exposed on part of the anticlinal structure in the central part, and Pb and Zn anomalous areas on the Loralai Member exist on both sides of the anticline.

No. 12 (Pb-Zn anomalous area)

This complex anomalous area is present 5 km east of the Malkhor-Sekran zone. Zn and Hg anomalous areas are extensively distributed overlapping each other in the Loralai Member which is exposed in the central part of this area, while Zn anomalous areas occur in the Spingwar Member in western part.

No.19 (Pb-Zn area)

In this complex anomalous area occurring in the southern extention of the Surmai Area, low-value Zn and Pb anomalous areas are emplaced in the central to eastern part, the Mg anomalous area in the western outer part, and the Ba anomalous area in the southern part.

TableⅡ-2-2 List of Statistic Parameters of Khuzdar District

		Total	by Member of Shirinab F.			by Block Number*						Line Sampling
			Anjira	Loralai	Spingwar	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	
Number of Samples		2,750	869	1,479	402	204	731	834	505	334	142	107
Pb (ppm)	min	1	1	1	1	1	1	1	1	1	1	1
	max	10,000	10,000	10,000	950	33	10,000	4,600	10,000	27	13	2,700
	σ	0.563	0.400	0.650	0.479	0.303	0.736	0.336	0.722	0.303	0.194	0.558
	平均(M)	1.90	1.53	1.97	2.60	1.44	3.13	1.42	2.21	1.47	1.20	3.55
	M+σ	6.9	3.8	8.8	7.8	2.9	17.0	3.0	11.6	2.9	1.8	12.8
	M+2σ	25.3	9.6	39.3	23.5	5.8	93.1	6.6	61.5	5.9	2.9	46.2
	M+3σ	92.5	24.2	175.8	70.8	11.7	507.4	14.4	324.3	11.9	4.5	167.1
Zn (ppm)	min	1	3	1	1	4	1	1	1	3	5	6
	max	10....	10,000	10,000	5,500	215	10,000	3,340	10,000	90	54	6,560
	σ	4.489	0.329	0.575	0.422	0.320	0.640	0.347	0.574	0.310	0.266	0.581
	平均(M)	16.02	16.64	16.21	14.11	10.96	20.74	13.10	20.09	14.75	12.88	25.94
	M+σ	49	35	60	37	22	90	29	75	30	23	98
	M+2σ	152	75	229	98	47	394	64	282	61	43	377
	M+3σ	468	161	861	261	99	1,700	143	1,059	125	80	1,439
Hg (ppb)	min	10	10	10	10	10	10	10	10	10	10	10
	max	55,000	1,500	55,000	960	210	55,000	2,000	29,000	170	90	770
	σ	0.440	0.346	0.501	0.379	0.310	0.507	0.449	0.559	0.264	0.222	0.388
	平均(M)	23.11	22.95	23.33	22.67	18.33	23.90	27.32	25.68	16.91	14.57	25.00
	M+σ	63	50	73	54	37,	76	76	73	31	24	61
	M+2σ	175	112	234	129	76	246	216	212	57	40	149
	M+3σ	482	249	741	309	156	793	609	612	104	67	363
Ba (ppm)	min	20	40	30	20	80	30	20	50	80	100	40
	max	6,800	4,200	6,800	6,400	1,720	5,800	2,700	6,400	6,800	2,800	4,300
	σ	0.249	0.265	0.213	0.300	0.173	0.287	0.201	0.271	0.257	0.244	0.266
	平均(M)	210.39	241.94	189.73	227.43	178.18	226.36	194.84	231.65	207.04	211.95	190.86
	M+σ	373	445	310	452	268	437	309	432	373	371	352
	M+2σ	663	819	506	905	394	847	492	807	675	651	649
	M+3σ	1,177	1,508	828	1,806	586	1,639	783	1,508	1,220	1,143	1,197
Mg (ppm)	min	300	450	320	300	1,200	320	300	350	800	1,900	320
	max	90,000	48,500	90,000	85,000	55,000	70,000	90,000	80,000	52,000	21,000	17,500
	σ	0.314	0.216	0.312	0.450	0.358	0.343	0.309	0.272	0.250	0.209	0.328
	平均(M)	3,657	3,931	3,365	4,252	5,081	3,266	3,128	4,114	4,521	4,094	2,966
	M+σ	7,532	6,462	6,906	11,980	11,576	7,200	6,375	7,687	8,040	6,629	6,318
	M+2σ	15,511	10,622	14,174	33,755	26,373	15,877	12,992	14,365	14,298	10,734	13,458
	M+3σ	31,944	17,460	29,087	95,104	60,083	35,008	26,478	26,841	25,426	17,382	28,664
S (%)	min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001
	max	1.21	1.21	0.862	0.638	0.167	0.862	0.123	1.21	0.221	0.301	0.136
	σ	0.640	0.586	0.631	0.678	0.619	0.661	0.605	0.675	0.605	0.512	0.672
	平均(M)	0.004	0.006	0.003	0.004	0.003	0.004	0.003	0.005	0.005	0.007	0.029
	M+σ	0.017	0.024	0.013	0.017	0.014	0.017	0.012	0.024	0.025	0.022	0.014
	M+2σ	0.075	0.093	0.056	0.082	0.059	0.079	0.048	0.112	0.086	0.079	0.065
	M+3σ	0.327	0.359	0.239	0.393	0.243	0.361	0.191	0.530	0.348	0.237	0.306

*Block No.: Block of Distributed Jurassic Limestone
σ : log.

Table II-2-3 Statistic Parameters of Stratigraphic Cross-section in Khuzdar District

Elements	Unit of Member	Anjira	Lora-IV	Lora-III	Lora-II	Lora-I	Spingwar	Total
	N	4	4	20	44	15	20	107
Pb (ppm)	min	2	1	1	1	1	2	1
	max	7	2	7	2,700	23	8	2,700
	σ	0.236	0.130	0.361	0.769	0.343	0.220	0.558
	平均(M)	4.14	1.19	2.63	4.16	3.36	4.25	3.55
	M+σ	7.1	1.6	6.0	24.4	7.4	7.0	12.8
	M+2σ	12.1	2.1	13.8	143.8	16.3	11.7	46.2
Zn (ppm)	min	21	7	8	6	9	6	6
	max	163	13	448	6,560	60	63	6,650
	σ	0.383	0.096	0.489	0.753	0.241	0.245	0.581
	平均(M)	35.46	9.27	28.01	39.01	16.87	15.58	25.94
	M+σ	85	11	86	220	29	27	98
	M+2σ	206	14	266	1,248	51	48	377
Ba (ppm)	min	160	130	90	40	100	100	40
	max	360	180	320	200	4,300	1,760	4,300
	σ	0.153	0.054	0.117	0.119	0.408	0.285	0.266
	平均(M)	195.96	151.31	174.58	139.00	274.00	332.72	190.86
	M+σ	278	171	228	182	701	641	352
	M+2σ	395	194	299	240	1,795	1,236	649
Mg (ppm)	min	2,500	2,700	320	850	3,700	800	320
	max	4,450	3,3050	7,000	15,000	17,500	13,500	17,500
	σ	0.104	0.022	0.285	0.288	0.177	0.348	0.328
	平均(M)	3,426	2,859	2,672	2,130	7,256	3,417	2,966
	M+σ	4,358	3,005	5,135	4,136	10,918	7,620	6,318
	M+2σ	5,544	3,159	9,940	9,031	16,429	16,996	13,458
Hg (ppb)	min	10	10	10	10	10	10	10
	max	30	20	500	770	40	70	770
	σ	0.172	0.130	0.474	0.409	0.229	0.269	0.388
	平均	18.61	11.89	26.32	33.81	18.03	19.24	25.00
	M+σ	27	16	78	86	30	35	61
	M+2σ	41	21	233	222	51	66	149
S (%)	min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	max	0.025	0.003	0.017	0.071	0.136	0.030	0.136
	σ	0.286	0.389	0.444	0.682	0.809	0.704	0.672
	平均(M)	0.013	0.001	0.005	0.002	0.003	0.003	0.029
	M+σ	0.025	0.003	0.013	0.012	0.016	0.014	0.014
	M+2σ	0.049	0.007	0.035	0.057	0.104	0.073	0.065

σ : log.

Table II-2-5 Coefficiency of Correlation in Geochemical Analyses of Stratigraphic Cross-section in Khuzdar District

Total (N:107)

	Pb	Zn	Ba	Mg	Hg
Zn	0.647				
Ba	-0.125	-0.188			
Mg	-0.154	-0.258	0.247		
Hg	0.562	0.591	-0.171	-0.272	
S	0.313	0.156	0.301	0.015	0.131

Loralai M. - II

	Pb	Zn	Ba	Mg	Hg
Zn	0.709				
Ba	-0.531	-0.551			
Mg	-0.197	-0.311	0.088		
Hg	0.764	0.640	-0.379	-0.231	
S	0.425	0.157	-0.208	0.039	0.334

Anjira M.

	Pb	Zn	Ba	Mg	Hg
Zn	0.553				
Ba	0.557	0.999			
Mg	0.996	0.624	0.627		
Hg	0.435	0.122	0.105	0.415	
S	-0.341	0.571	0.572		-0.482

Lorlai M. - I

	Pb	Zn	Ba	Mg	Hg
Zn	0.578				
Ba	0.076	0.306			
Mg	-0.308	-0.117	-0.323		
Hg	0.575	0.186	0.316	-0.418	
S	0.189	0.283	0.904	-0.250	0.321

Loralai M. - IV

	Ba	Zn	Ba	Mg	Hg
Zn	0.886				
Ba	0.803	0.756			
Mg	0.749	0.361	0.462		
Hg	-0.333	-0.076	-0.702	-0.450	
S	-0.577	-0.132	-0.384	-0.963	0.577

Spingwar M.

	Pb	Zn	Ba	Mg	Hg
Zn	0.324				
Ba	-0.071	0.251			
Mg	-0.443	0.004	0.142		
Hg	0.382	0.230	-0.080	-0.52	
S	0.250	0.055	0.325	0.041	-0.161

Loralai M. - III

	Pb	Zn	Ba	Mg	Hg
Zn	0.567				
Ba	0.108	0.380			
Mg	0.035	0.039	0.103		
Hg	0.133	0.571	0.167	0.081	
S	0.380	0.215	0.335	0.125	-0.172

Table Ⅱ-2-7 Complex Anomalous Areas in Khuzdar District (1)

No.	Locality	Amount of Anomalous Points (Maximmum Values : ppm)												Geological Benviroments	Rank of Evaluation	
		Pb		Zn		Ba		Mg		Hg (ppb)		S (%)				
		Th	M+σ	Th	M+σ	Th	M+σ	Th	M+σ	TH	M+σ	TH	M+σ		Pb,Zn	Ba
1	Central part of Block Ⅰ	1	3	1	2	5	1				1		5	Spingwar, loralai	C	B
		(33)		(215)		(1,720)		(13,500)		(80)		(0.04)				
2	Southen part of block Ⅰ		1		1	1	1	2	2		10		1	Loralai、Spingwar、Anjira	D	C
		(5)		(47)		(520)		(21,500)		(210)		(0.08)				
3	Western part of Block Ⅱ	2	12	1	1	14	3	13	8		1	6	12	Spingwar, Loralai	C	B
		(52)		(212)		(5,800)		(62,000)		(70)		(0.64)				
4	Western part of Block Ⅱ		7	1	2	12	3	3	5			1	10	Spingwar、Loralai、Anjira	C	B
		(20)		(224)		(2,400)		(27,000)		(40)		(0.31)				
5	Central part of Block Ⅱ	11	18	1	6	15	6	8	4				10	Spingwar、Loralai、	C	B
		(62)		(180)		(2,800)		(25,000)		(68)		(0.05)				
6	Central part of Block Ⅱ	10	15	5	3	12	6	5	4			1	9	Loralai、Spingawr	B	A
		(197)		(1,250)		(5,000)		(30,000)		(170)		(0.11)				
7	Western part of Block Ⅲ					12	2	3	1				5	Loralai	–	A
		(3)		(35)		(2,100)		(52,500)		(60)		(0.05)				
8	Central part of Block Ⅲ		2	1	7	7	1						4	Loralai、Anjila	C	B
		(14)		(280)		(2,300)		(8,000)		(150)		(0.01)				
9	Central part of Block Ⅲ			2	2								1	Loralai Anjira	D	–
		(12)		(630)		(740)		(4,860)		(90)		(0.06)				
10	Eastern part of Block Ⅱ	21	8	19	6	19	5	4	5	14	27		25	Loralai、Spingwar、Anjira [Malkhor～Sekran]	A	B
		(10,000)		(10,000)		(3,300)		(46,500)		(22,000)		(0.14)				
11	Eastern part of Block Ⅱ	8	6	7	5	13	4	3	1		5		7	Spingwar, Loralai, Anjira	B	C
		(2,700)		(6,560)		(4,300)		(42,500)		(770)		(0.14)				
12	Southern part of Block Ⅲ	9	10	1	3	6	3	26	13	18	62		12	Loralai、Spingwar, Anjira	B	C
		(4,600)		(940)		(2,700)		(62,000)		(2,000)		(0.07)				
13	Eastern part of Block Ⅲ	3			1	5	4		2	1	5			Anjira	C	C
		(14)		(81)		(1,500)		(10,500)		(360)		(0.04)				
14	Eastern part of Block Ⅳ	8	7	3	2	18	10				21	1	29	Loralai, Anjira	C	A
		(385)		(1,580)		(3,600)		(14,000)		(300)		(0.20)				
15	Central part of Block Ⅳ			2	5	13	2		1				9	Anjira [Gunga Mine]	B	A
		(18)		(590)		(2,800)		(9,600)		(60)		(0.04)				

Table II-2-7 Complex Anomalous Areas in Khuzdar District (2)

No.	Locality	Amount of Anomalous Points (Maximmm Values :ppm)												Geological Renviroments	Rank of Evaluation	
		Pb		Zn		Ba		Mg		Hg (ppb)		S (%)			Pb,Zn	Ba
		Th	M+σ	Th	M+σ	Th	M+σ	Th	M+σ	Th	M+σ	Th	M+σ			
16	Central part of Block IV	40	4	39	8	20	11	2	12	26	17	12	18	Loralai、Anjira、Spingwar	A	C
		(10,000)		(10,000)		(1,620)		(61,000)		(40,000)		(1.21)		(Surumai)		
17	Western part of Block IV					19	5				1	1	10	Anjira	–	B
		(7)		(51)		(1,760)		(10,500)		(70)		(0.20)				
18	Southern part of Block IV	2	6		2	8	3	2	9		3		14	Anjira	C	B
		(92)		(91)		(1,180)		(20,000)		(90)		(2.18)				
19	Southern part of Block IV		4	2	1	3	4	4	4	1	1		6	Loralai、Anjira	B	C
		(13)		(6,550)		(340)		(47,000)				(0.05)				
20	Eastern part of Block IV	3	5		1	2	2	7	2	1	2		1	Loralai、Spingwar	C	C
		(210)		(67)		(360)		(80,000)		(170)		(0.03)				
21	Northern part of Block V					6	2	2	2		1	2	8	Loralai、Anjira	–	C
		(3)		(28)		(3,600)		(6,000)		(170)		(0.08)				
22	Northern part of Block V					6							1	Anjira	–	C
		(2)		(14)		(2,100)		(5,500)		(40)		(0.03)				
23	Central part of Block V		3		2	12	1	1	1		1		10	Loralai、Anjira、Spingwar	–	C
		(10)		(73)		(4,200)		(13,500)		(80)		(0.08)				
24	Central part of Block V		11			3	1	8	3			2	12	Loralai、Anjira	–	C
		(27)		(55)		(6,800)		(52,000)		(60)		(0.16)				
25	southern part of Block V					3	2				1	1	3	Anjira、Loralai	–	D
		(6)		(78)		(900)		(8,000)		(100)		(0.21)				
26	Northern part of Block VI					7	2					1	6	Anjira、Loralai	–	C
		(4)		(54)		(2,800)		(5,500)		(50)		(0.30)				
27	Western part of Block VI		2			15	2		1				6	Anjira	–	D
		(13)		(47)		(2,300)		(8,500)		(40)		(0.04)				

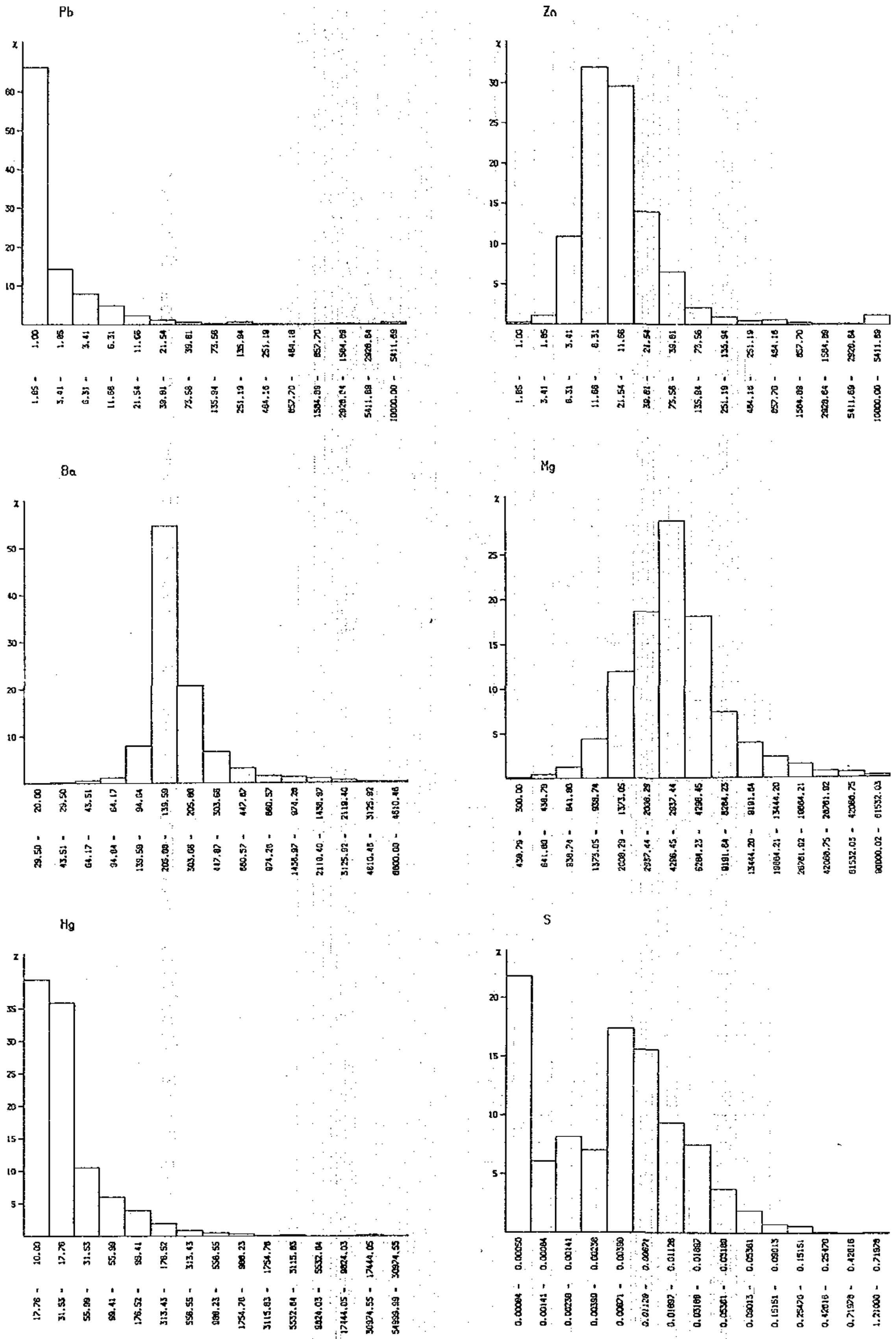


Fig. II-2-1 Histogram of 6 Elements in Khuzdar District

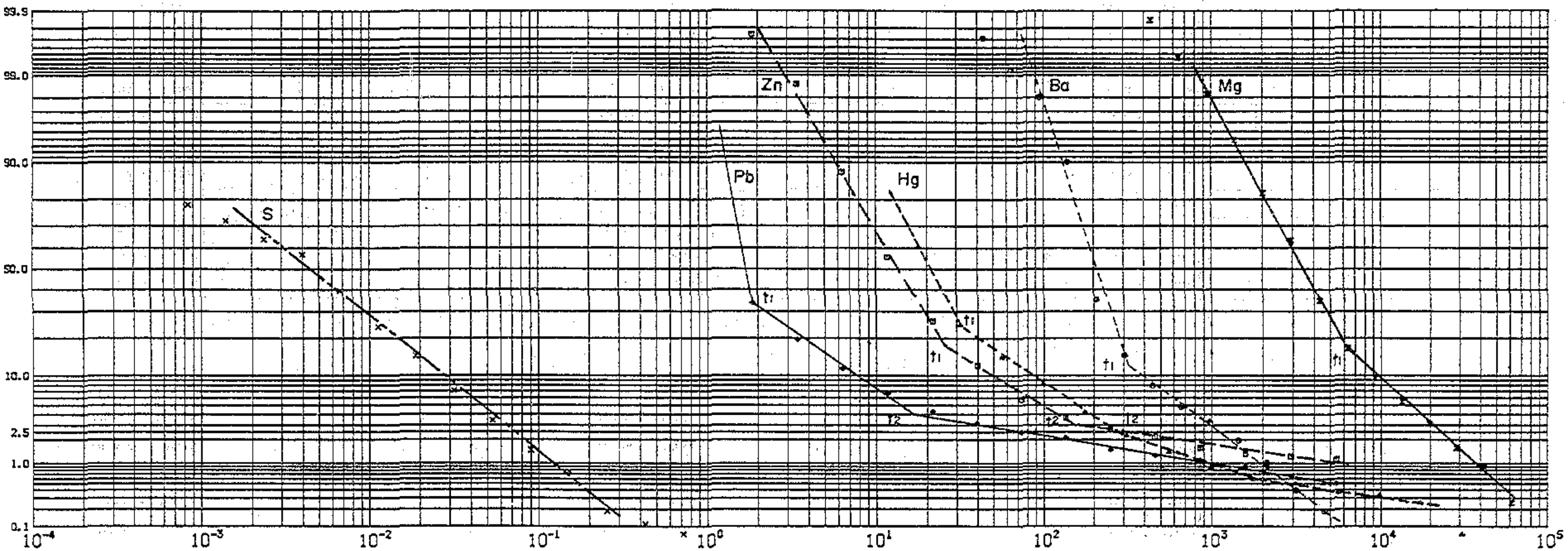
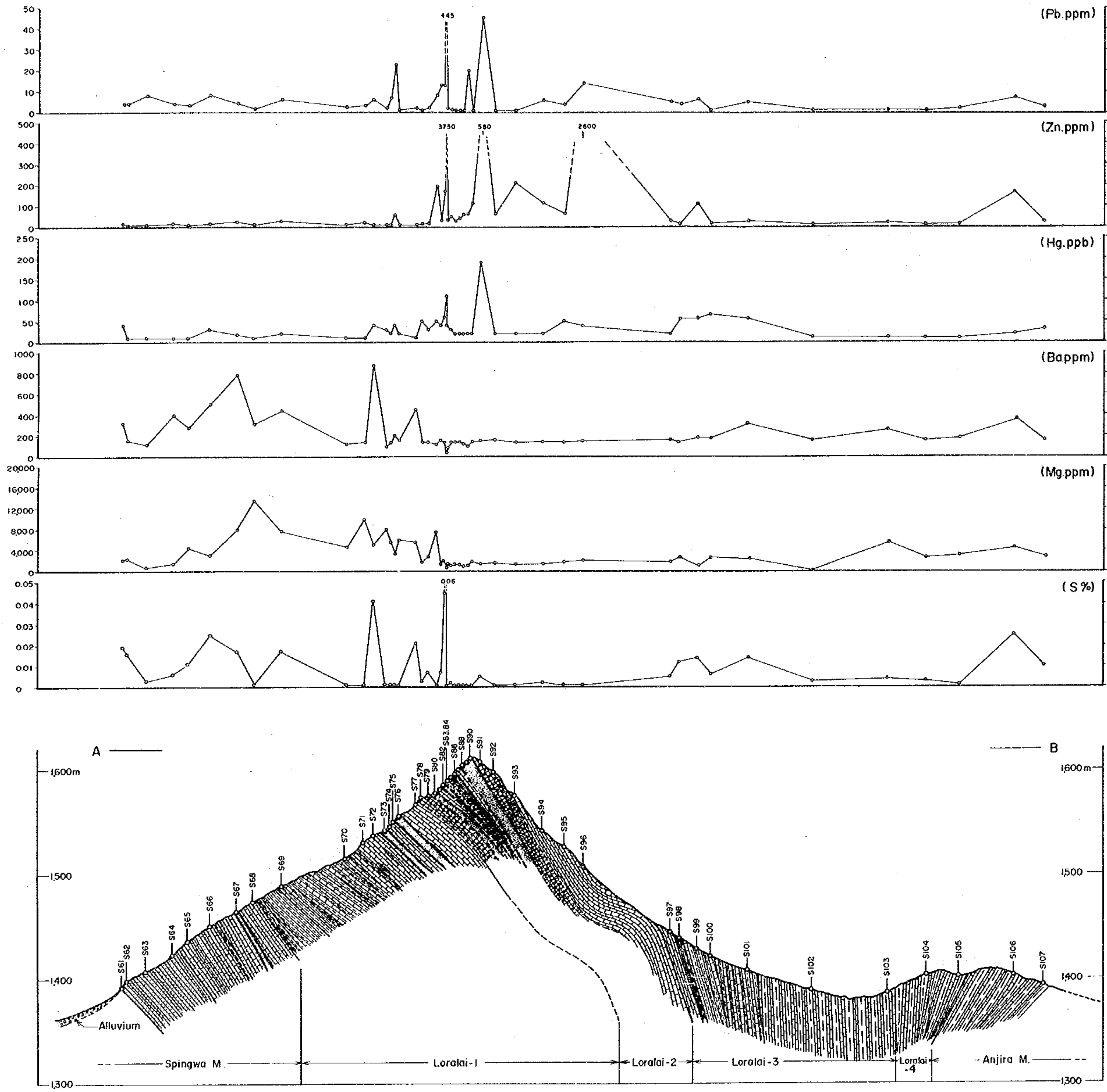


Fig. II-2-2 Cumulative Frequency Distribution Curve of 6 Elements in Khuzdar District



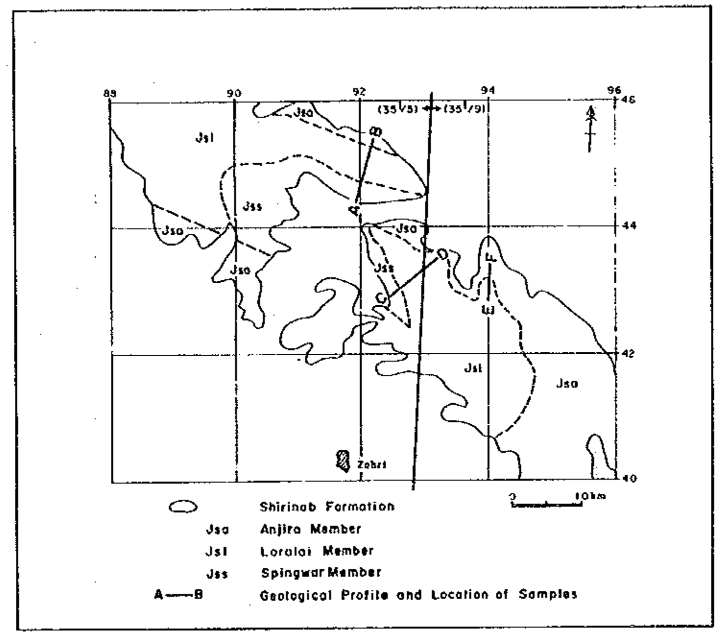


Fig. II-2-3 Geochemical Assay Map of Stratigraphic Cross-section(1)

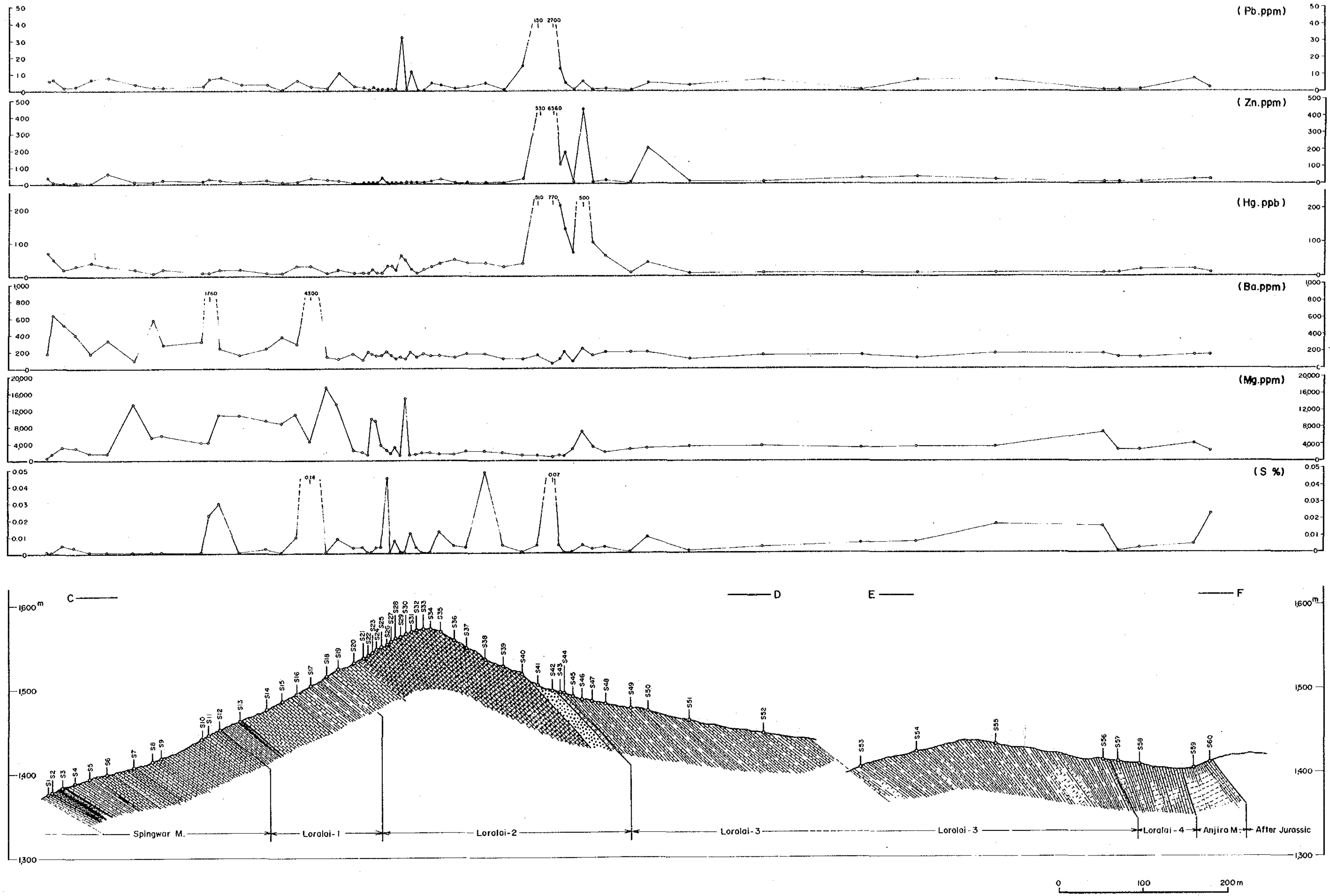


Fig. II-2-4 Geochemical Assay Map of Stratigraphic Cross-section(2)

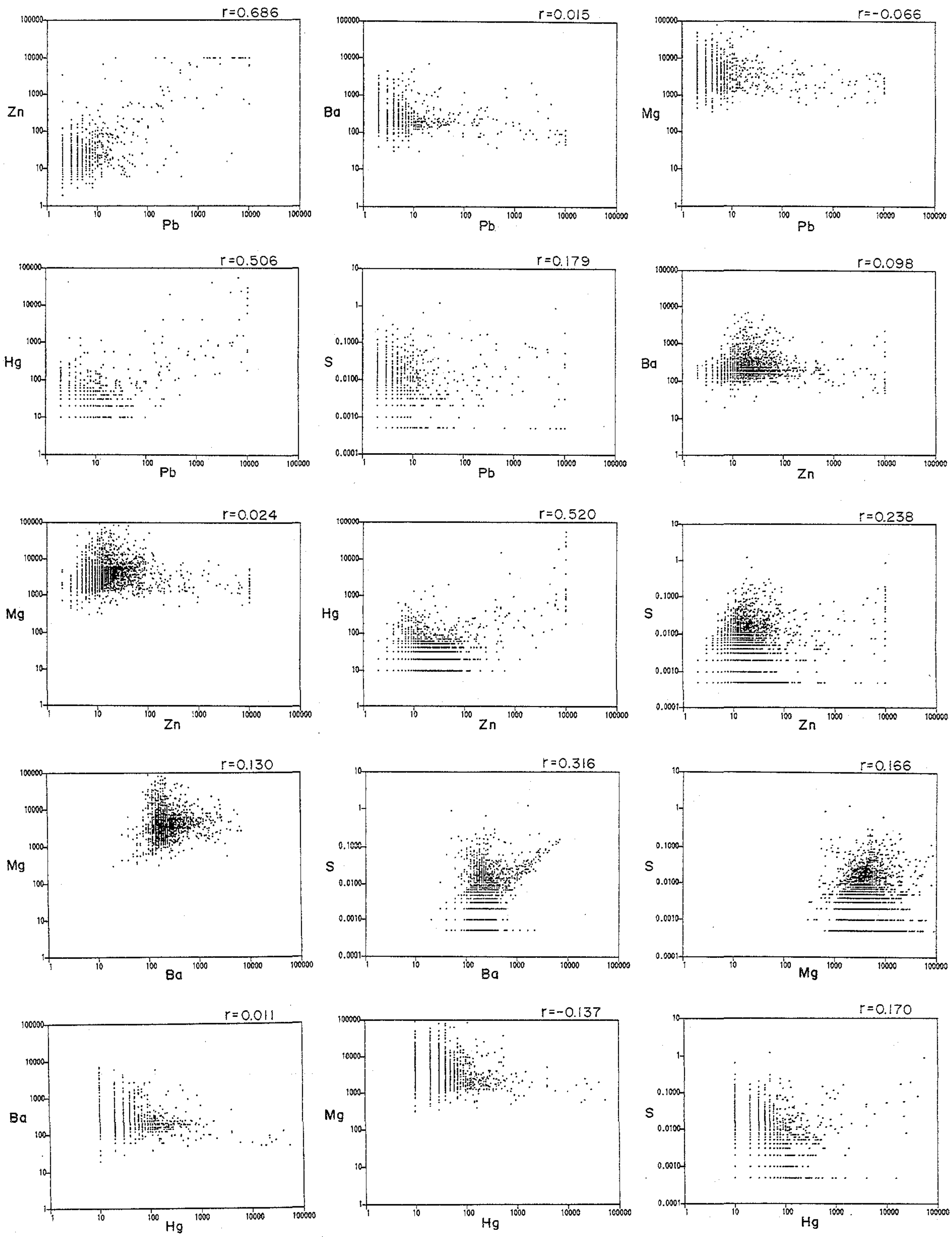


Fig. II-2-5 Correlation Diagram of Geochemical Assay in Khuzdar District

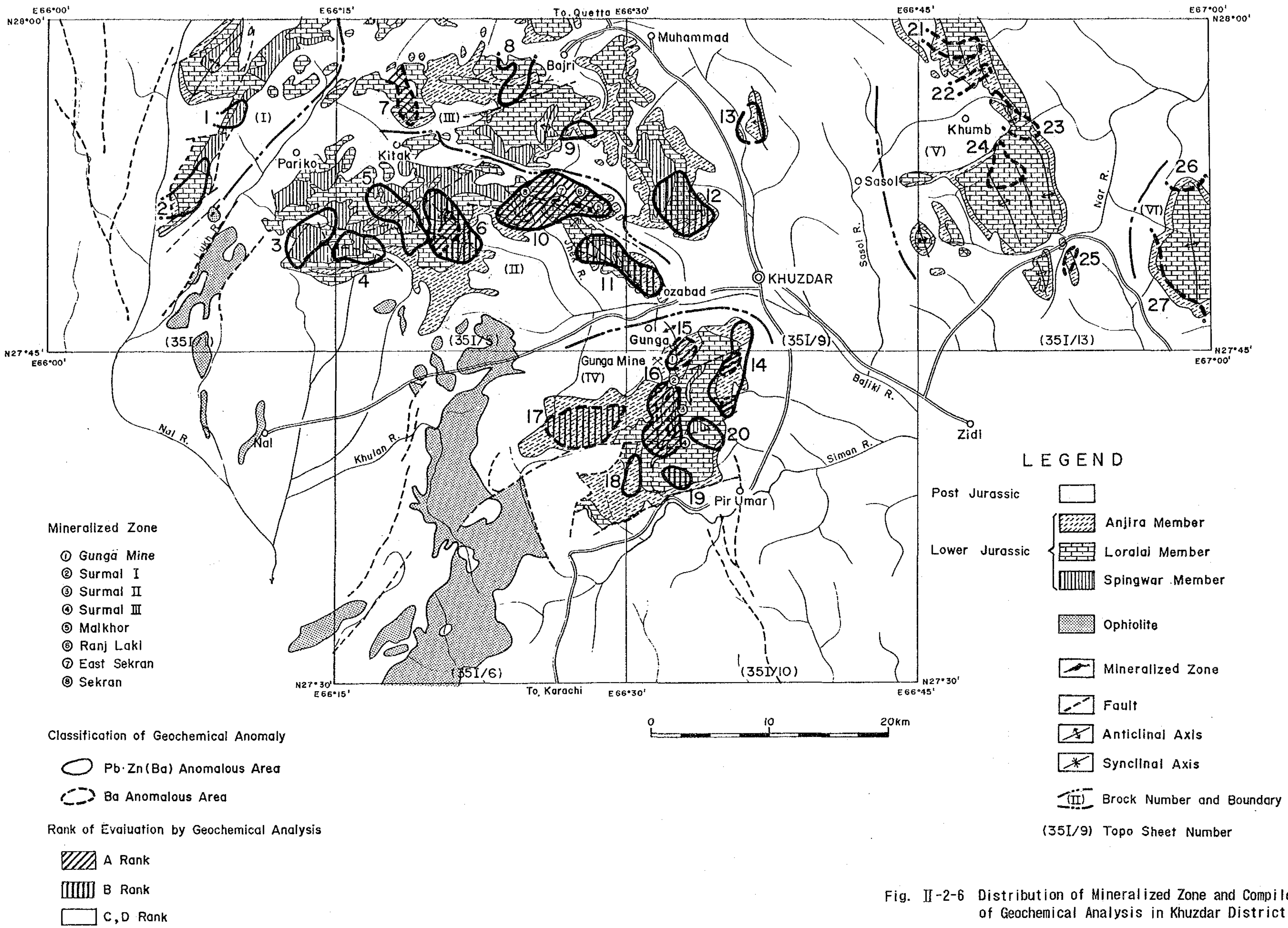


Fig. II-2-6 Distribution of Mineralized Zone and Compile Map of Geochemical Analysis in Khuzdar District

Chapter 3. Integrated Consideration

3 − 1 Relationship between Mineralized Zone and Geological Structure

In addition to the mineral indications in Malkhor and Sekran, and to the Gunga deposits, there exists, in this area, the mineral indications in Surmai which will be described later (Fig.II-1-1). These were situated within a narrow zone, called the Surmai-Sekran zone, about 2km wide, extending some 25 km from Block-IV to II in the middle of the area. The zone is located in the bend where the structure of the Khuzdar Knot changes its trend from a N-S to an E-W direction, surrounding a submerged basin filled with the Anjira Member and the Cretaceous system. This zone may be correlative with the zone of upheaval in the peripheries of the ancient basin. The Surmai-Sekran zone is located on the northern extension of the fault zone, which divides the Kirthar orogenic zone from the ophiolite zone, and a large concealed tectonic zone is assumed beneath the Surmai-Sekran zone. In the submerged zone, the northern end of the ophiolite zone stretches out to the east, extending from the west of Karachi over a distance of some 200 km, which may have participated in genesis of the mineralized zone.

3 − 2 Relationship between Mineralization and Geochemical Anomalies

The geochemical survey has revealed that Pb, Zn and Hg have a common behavior and that they form anomalous areas around gossans of lead and zinc mineral indications, whereas these areas are surrounded by anomalies of barite. If the distribution of anomalies in the area can be expressed by Pb-Zn and Ba, which are objective components of the present investigation, then anomalies are concentrated in the Surmai-Sekran zone and in its vicinity.

Anomalies of rank A on Pb and Zn at Nos.16 and 10 have been located over the area of mineral indications in Surmai and the zone in Malkhor-Sekran, and anomalies of rank B have been delineated on their extensions and peripheries. The anomalies are centered with respect to occurrences of the Loralai Member and are spread over areas of surrounding Anjira and Spingwar Members. An expanse of anomalies depends on the distribution of the ore horizon of the Loralai Member and of the tectonic lines.

The anomalies of rank A of barite have a wider distribution on the extensions of the Pb-Zn anomalies and their peripheries, and occur predominantly in the Anjira Member of Block-IV and in the Spingwar Member at the east of Block-II .

PART III SURMAI AREA

(DETAIL SURVEY)

PART Ⅲ SURMAI AREA (Detail Survey)

Chapter 1 Geological Survey

Geological mapping was carried out at a scale of 1: 2,000 through checking with the existing geological map.

1－1 Outline

Zinc-lead prospects are located at several places on the west margin of the Indian Plate all along the transform boundary zone. The mineral indications are confined to the lower Jurassic rock sequence i.e the middle and upper member of the Shirinab Formation.

The Surmai area is located in the survey of the Pakistan Toposheet No.35 I/10. The coordinates are latitude 27° 40′ to 27° 43′ N and longitude 66° 32′ to 66° 33′ E. It is approximatly 13 km southwest of Khuzdar.

The area shows quite a rugged topography especially along anticlinal axes and ranges in altitude from 1,450m in a northern creek to 1,850m at Big Munatallar Peak in the southern portion. The survey area is mostly underlain by shallow water marine calcareous and clastic sediments, i.e. limestone,shale and sandstone which belong to the Shirinab Formation of lower Jurassic age. It has three easily recognizable and well exposed members viz Spingwar,Loralai and Anjira.It is exposed as high rounded hills which mark the center of anticlines, and domes that dominate the area. The formation is tightly folded, and rolling of beds is a common feature.

1 − 2 Stratigraphy

The stratigraphic sequence of the Surmai is as follows.

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, motteled with a zone of thin interbedded limestine and shale.	80~100		
			III	Limestone and shale interbedded. Limestone dark grey,thin to med bedded,motteled,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,motteled and ooloitic occaisionally.Shale of black colour.	100~150		
		Spingwar		Interbedded sandostone 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. III-1-1 Geological Stratigraphy of Surmai Area

1-2-1 Spingwar Member

The Spingwar Member is mostly comprised of sandstone with shale and limestone as minor interbeds. The sandstone is grey, white and pinkish medium to fine grained orthoquartzitic and calcareous, and weathers to brownish grey. Quartz as a predominant constituent is present as rounded to subrounded grains which are moderately to poorly sorted. Feldspar is present as minor amounts(less than 5%) in the form of tiny subhedral twinned crystals. The matrix which is a fine, mainly argillaceous aggregate is less than 10%. The cement (25-30%) is a coarse, clear spary calcite. Minute zircon crystals are present in traces. Subhedral to euhedral grains of magnetite partially altered to limonite are common as disseminations.

Shale is grey to light brown, fine grained and arenaceous and weathers to brownish grey. Calcite is mainly in the form of fine grained microcrystalline aggregates of brown colour. The colour may be due to partial oxidation.

Terrigenous minerals, dominantly quartz with minor feldspar and illite, are the minor constituents. Quartz is rounded to subrounded, and corroded where in contact with calcite and loosely packed (grain size 0.74). Feldspar is present as tiny subhedral twinned crystals, while illite is in small lath shaped and fibrous forms. Euhedral to subhedral grains of magnetite partially to completely altered to yellowish brown limonite are common as disseminations.

1-2-2 Loralai Member

The Loralai Member is dominantly composed of limestone with shale as the minor constituent present in various proportions as interbeds in different units. It is characterised by thin, medium to thick bedded, mottled limestone. It is olive grey to brownish black and weathers to brownish grey, reddish brown and orange.

The limestone is allochemical mainly sparse biomicritic(or bioclastic). Allochems are rounded, oval, elongate and string shaped shell fragments. Less commonly, well preserved shells of gastsropods, brachiopods, bivalues and corals filled with clear sparry clacite are in Unit-Ⅲ. Some oomicritic and intramicritic limestone are present in Units-Ⅱ and Ⅰ. Detrital, rounded to subrounded quartz grains (grain size 0.0317mm) are minor constituents (less than 5% very dusky red carbonaceous material is