ISLAMIC REPUBLIC OF PAKISTAN

MINERAL RESOURCES DEVELOPMENT IN WEST PAKISTAN

SURVEY REPORT

July 1971

Prepared for
Overseas Technical Cooperation Agency
Government of Japan
by Japanese Survey Team for
Development of Mineral Resources
in West Pakistan

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PREFACE

The Government of Japan, in response to a request of the Government of Pakistan, agreed to study the possibilities of the development of mineral resources in West Pakistan. For this purpose, a geological reconnaissance survey and data gathering were planned. The Government of Japan entrusted the Overseas Technical Cooperation Agency (OTCA) to Conduct the said study.

OTCA organized a survey team headed by Mr. Hideo Takeda, Chief Geologist, Overseas Department, Metallic Minerals Exploration Agency of Japan. The team was dispatched to Pakistan for a period of forty five (45) days from February 10 to March 26, 1971.

The team discussed with the staff of West Pakistan Industrial Development Corporation, Ministry of Industries and Natural Resources, Atomic Energy Commission, and Geological Survey of Pakistan. The major part of the survey was carried out in Chagai, Khuzdar, Fort Sandeman districts of Baluchistan State and Dera Ghazi Nhan district of Punjab State. Also the deposits in Hindubagh, Ziarat, Koh-i-Maran districts were surveyed.

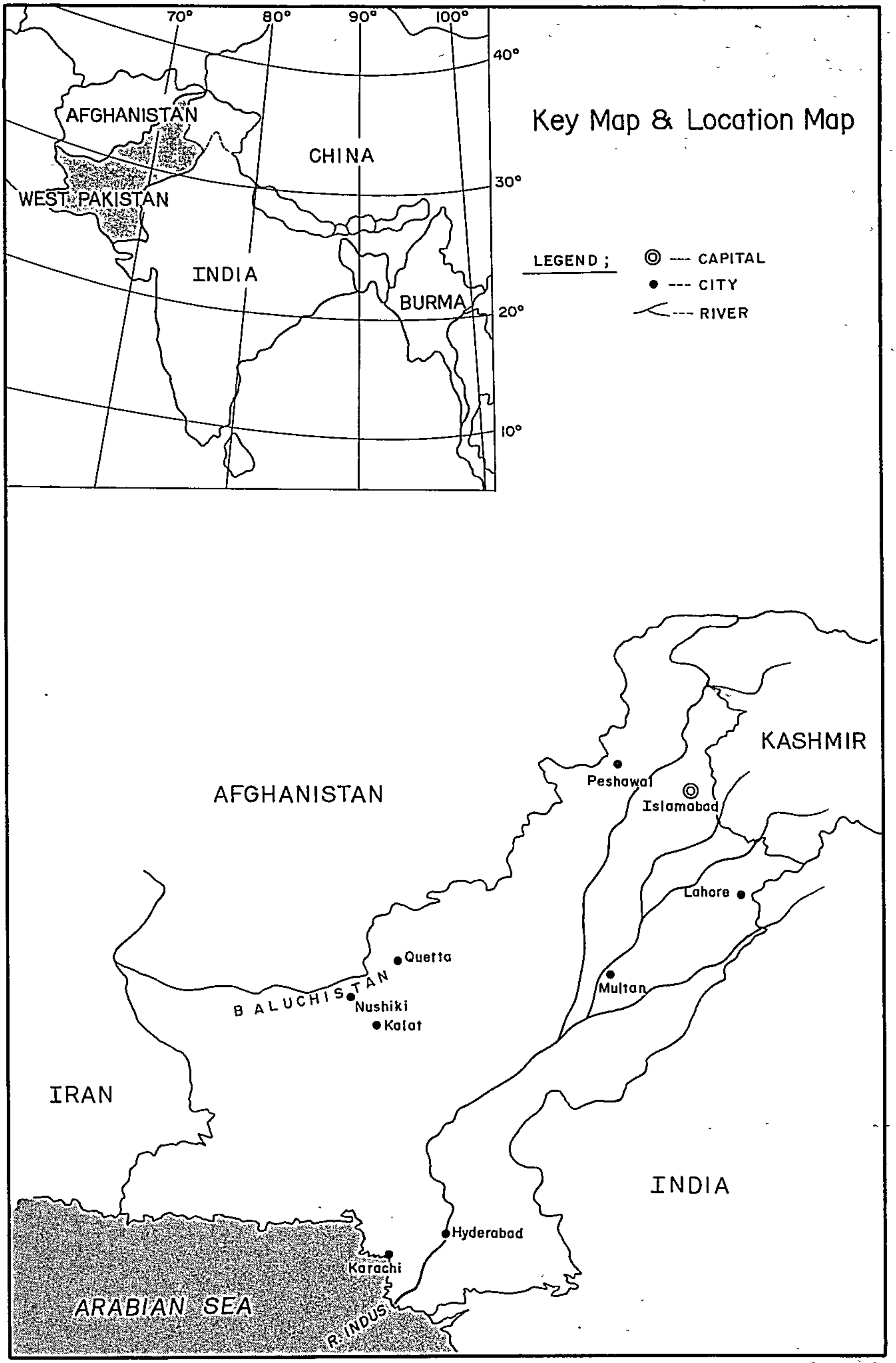
This report contains the results of the survey and information obtained by the team. It is recommended here to (1) carry out car-borne radiometric survey of the Tertiary formations distributed in West Pakistan, and (2) carry out survey for nickel and chromium resources in the ultrabasic rocks distributed south of Khuzdar district.

We sincerely hope that this report will contribute to the development of mineral resources and eventually lead to economic progress of Pakistan, and also wish that it will contribute to the mutual goodwill and friendship between Pakistan and Japan.

On behalf of OTCA, I would like to take this opportunity to extend my appreciation to the members of the survey team for their efforts and express my deep gratitude to the authorities of various agencies of the Government of Pakistan.

July 1971

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency


Key Map & Location Map
70°
80°
90°
100°
40°
30°
20°
10°
AFGHANISTAN
WEST PAKISTAN
CHINA
INDIA
BURMA
LEGEND ;
--- CAPITAL
--- CITY
--- RIVER
KASHMIR
AFGHANISTAN
Peshawar
Islamabad
Lahore
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BALUCHISTAN
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Multan
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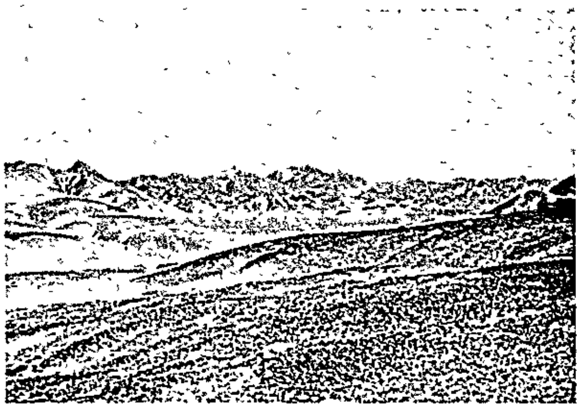
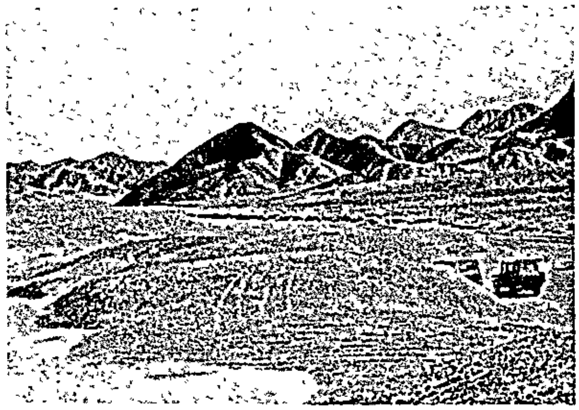
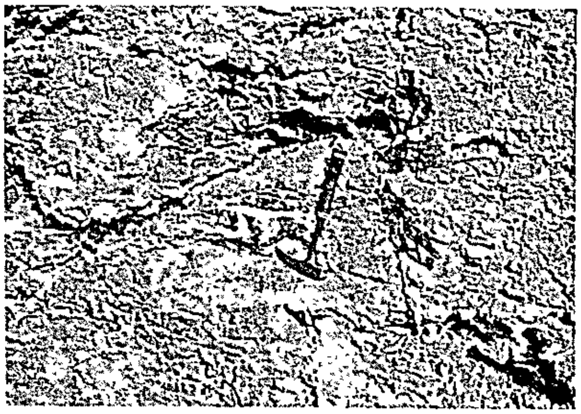


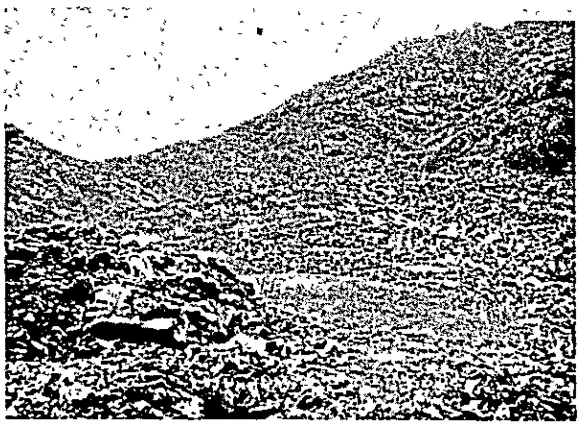
Saindak copper deposit. Mineralized area show low hills.



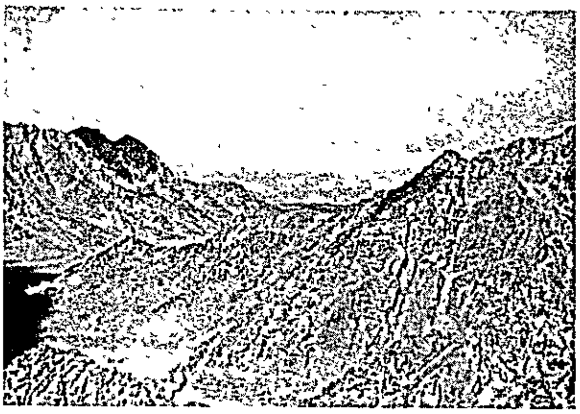
Saindak copper deposit.



Saindak copper deposits, Cu-oxide mineral-calcite network

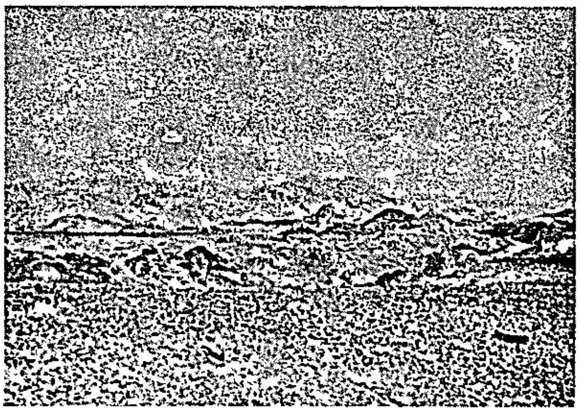


Chilghazi Iron ore deposit

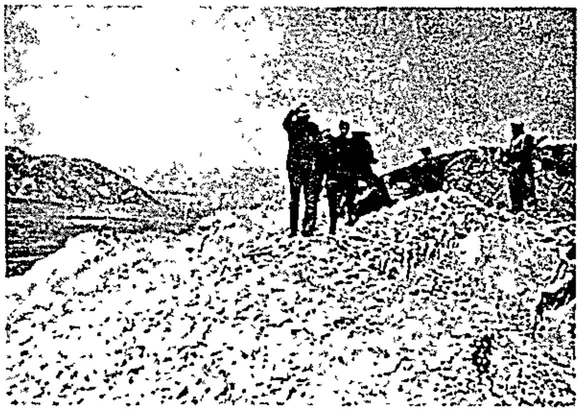


Ras Koh Intrusions (quartz diorite, monzonite, syenite etc.) along the Bandagan River

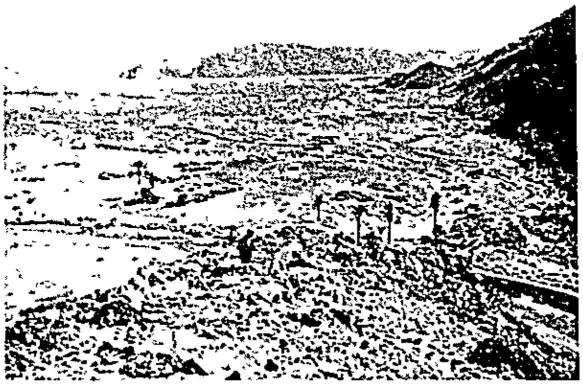
Bandagan Iron & Copper deposit.



Ultrabasic rocks, west of Khuzdar

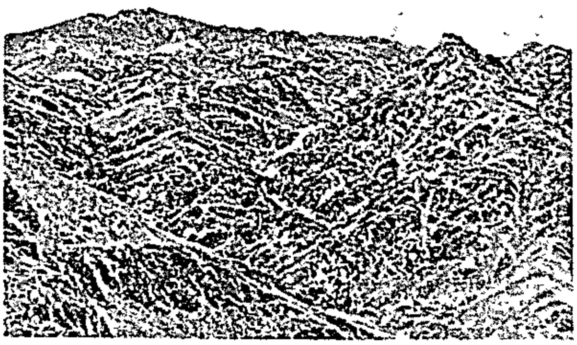


Monar Talar Barite deposits.

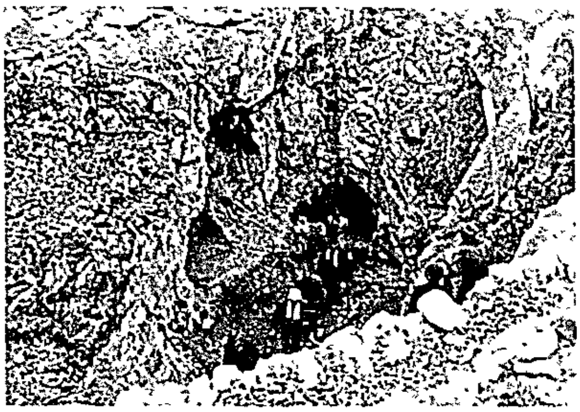


Shekran Iron ore deposits (Eastern parts).

Shekran Iron ore deposits (Central Parts).



Hindubagh Intrusion. Lighter colored-Dunite & Peridotite, darker colored-Harzburgite



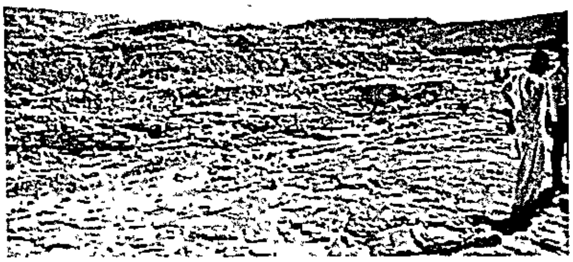
Open pit in Hindubagh mining areas.

Pakhrai Copper deposit, Fort Sandeman district

Torghundi Copper deposit, Fort Sandeman district.

Torghundi Copper deposit, Fort Sandeman district.

Rohak Copper deposit, Fort Sandeman district

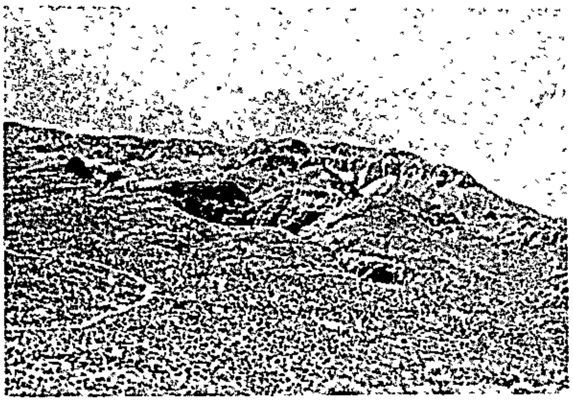


Siwalik sandstone, near the Uranium deposits of Dera Ghazi Khan

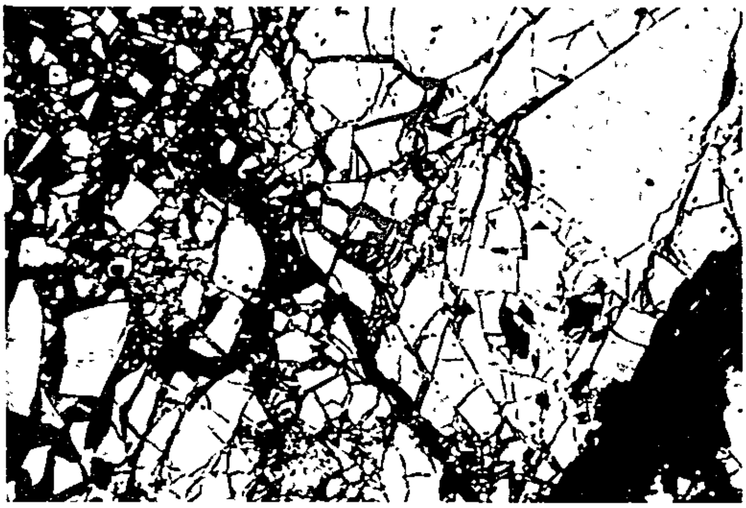
Uranium deposit of Dera Ghazi Khan

Koh-i-Maran Fluorite deposits, Fluorite-calcite vein under development

Koh-i-Maran Fluorite deposits, outcrop of fluorite vein.



Koh-i-Maran Mountains, Jurassic
Koh-i-Maran limestone.

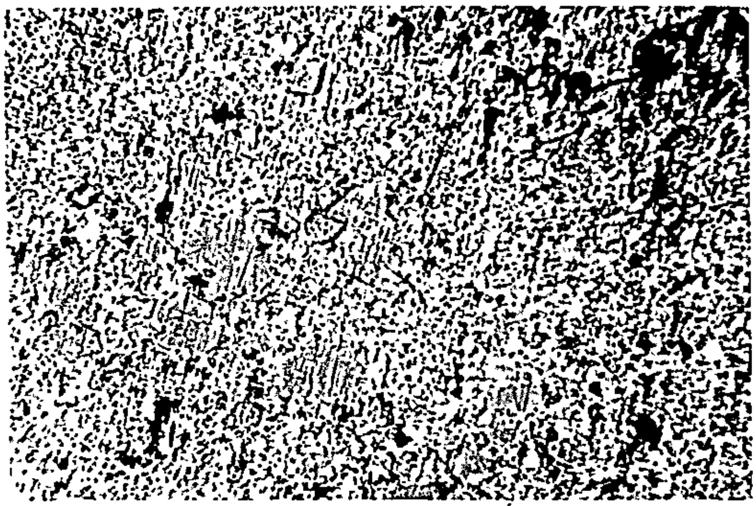


Chromite ore, Hindubagh.

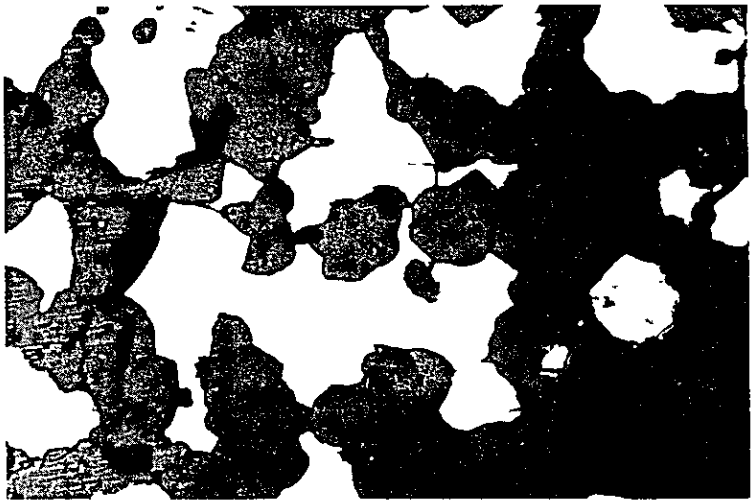
Chalcopyrite-Sphalerite, Pakhrai copper deposit, Fort Sandeman district. // Nicol

Diabasic rock, near Pakhrai copper deposit, Fort Sandeman district

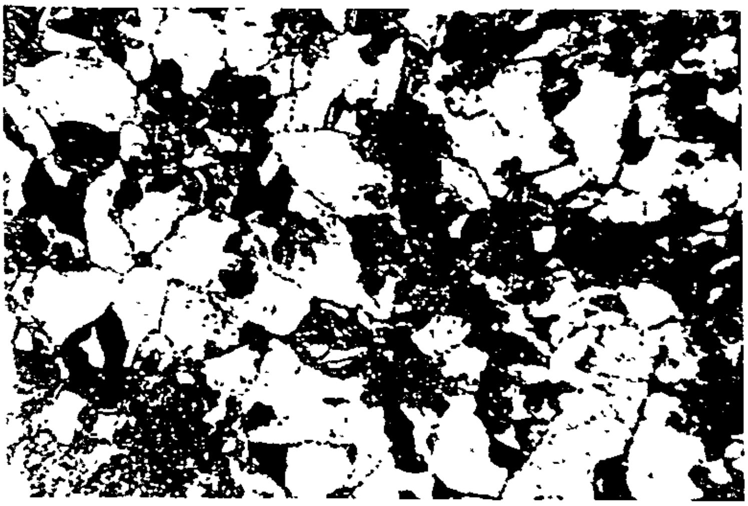
Porphyrite dike, Pakhrai copper deposit, Fort Sandeman district // Nicol



Magnetite ore, Chilghazi Iron deposit.

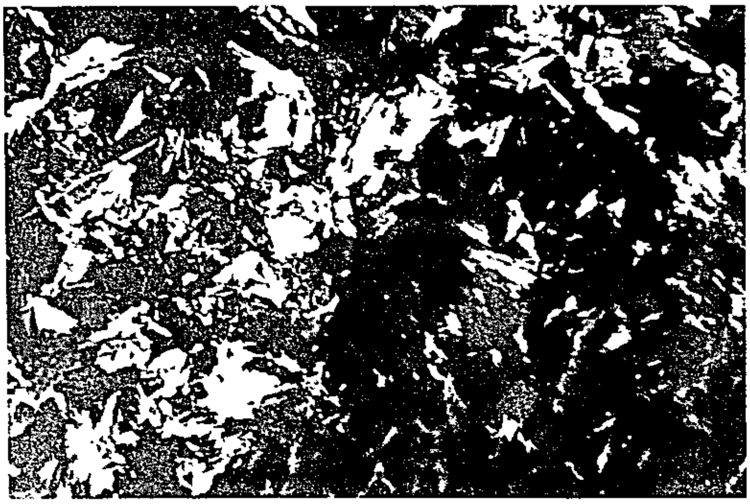


Chalcopyrite (white)-Sphalerite (gray), Bandagan Iron deposit.

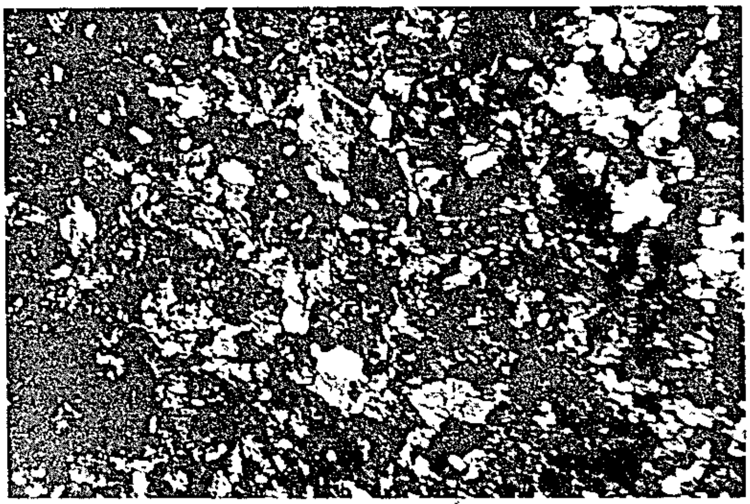


Magnetite ore, Bandagan Iron deposit

Andesite (Sinjrani formation), Saindak district.
// Nicol



Biotite-hornfels, Saindak district + Nicol



Hornfels (sinjrani formation), Chilghazi Iron deposit. + Nicol

Diorite near Bandagan Iron-Copper deposit
// Nicol

CONTENTS

Figures

1. INTRODUCTION

1-1 History of the Survey

Concerning the mineral resources of West Pakistan, basic survey has been carried out by the United States Geological Survey, Canadian Team and other groups mostly under the Colombo Plan. Exploration survey is being undertaken by the Geological Survey of Pakistan and Pakistan Industrial Development Corporation.

The Government of Pakistan, on the basis of various information concerning mineralization in West Pakistan, requested the Government of Japan to undertake a survey of these resources as a cooperative project.

The Government of Japan, upon receipt of the above request, entrusted the Overseas Technical Cooperation Agency with the execution of the survey and the team was organized.

As information available in Japan concerning mineral resources of West Pakistan is very fragmentary, and consequently the knowledge being very limited, the survey team worked on the mineral deposits mainly in Baluchistan State with the purpose of gathering basic data of mineral resources and also of finding projects which will be fitting for cooperative survey project.

1-2 Members of the survey team

Chief of the team:

Hideo Takeda,	Chief Geologist, Overseas Department, Metallic Minerals Exploration Agency of Japan.
Keiichi Yamada,	Senior Research Officer, Geological Survey of Japan.
Masaaki Suginohara,	Senior Geologist, Overseas Section, Power Reactor and Nuclear Fuel Development Corporation.

1-3 Itinerary of the survey team

number of days	month	day	
1	February	10	Lv. Tokyo - Ar. Karachi
2		11	Visit West Pakistan Industrial Development Corporation (WPIDC), Japanese Consulate General.
3		12	Visit WPIDC
4		13	Lv. Karachi - Ar. Islamabad Visit Japanese Embassy, Visit Ministry of Industries and Natural Resources (Meet Mr. R. Rahman) Dr. S.H.A. Shah accompanies the team throughout the survey.
5		14	Study of gathered material
6		15	Visit Ministry of Industries and Natural Resources, discussion with A.K. Soofi.
7		16	Lv. Islamabad - Ar. Lahore
8		17	Visit Mineral Resources Division, Atomic Energy Commission (AEC)
9		18	Lv. Lahore - Ar. Quetta Visit the State Government of Baluchistan, Visit Governor Riaz Hussain. Mr. Javed Ahmed accompanies the team.
10		19	Visit Geological Survey of Pakistan (GSP), meet Director A.M. Khan and others
11		20	Consultation on survey arrangements at G.S.P.
12		21	Preparation of survey, study of materials
13		22	Lv. Quetta - Ar. Dalbandin Survey of ore deposits at Chagai District
14		23	Lv. Dalbandin - Ar. Saindak
15		24	Survey of Saindak Copper deposits, Lv. Saindak - Ar. Nok Kundi

number of days	month	day	
16	February	25	Lv. Nok Kundi - Ar. Dalbandin. Survey of Chilghazi iron ore deposit
17		26	Survey of Bandagan copper iron deposits
18		27	Lv. Dalbandin - Ar. Quetta
19		28	Study of material
20	March	1	Lv. Quetta - Ar. Khuzdar
21		2	Survey of ultrabasic rocks and barite deposits
22		3	Survey of Shekran iron deposits
23		4	Lv. Khuzda - Ar. Quetta
24		5	Visit G.S.P.
25		6	Lv. Quetta - Ar. Ziarat Survey of laterite deposits
26		7	Lv. Quetta - Ar. Hindubagh
27		8	Survey of chromite deposits
28		9	Survey of same as above Lv. Hindubagh - Ar. Fort Sandeman
29		10	Survey of Fort Sandeman copper deposits
30		11	" " "
31		12	Lv. Fort Sandeman - Ar. Quetta
32		13	Visit G.S.P.
33		14	Survey of Koh-i-Maran fluorite deposits
34		15	Study of material and documents
35	March	16	Aerial survey of ultrabasic rocks in Khuzdar - Las Bela area

number of days	month	day	
36	March	17	Meet Governor Hussain of Baluchistan, report the outline of surveyed results. Lv. Quetta - Nultan - Ar. Sakhi Sarwar
37		18	Lv. Sakhi Sarwar - survey of uranium deposits - Ar. Multan
38		19	Lv. Multan - Ar. Islamabad. Report the results of the survey at Japanese Embassy.
39		20	Visit Ministry of Industries and Natural Resources, report the results of the survey.
40		21	Organize gathered data
41		22	Lv. Islamabad - Ar. Karachi Report the results of the survey at Japanese consulate.
42		23	Preparation for return
43		24	Lv. Karachi - Ar. Bangkok Visit ECAFE, Gather material
44		25	Visit ECAFE, Exchange of information.
45		26	Lv. Bangkok - Ar. Tokyo

1-4 Acknowledgements

During the course of the survey, the Government of Pakistan has extended various facilities and generously offered cooperation through the Geological Survey of Pakistan. Also the Government of the State of Baluchistan offered assistance for the work of the survey team. It was only through the assistance of the Pakistan Government and the people of Pakistan that the survey team was able to effectively survey large areas in a limited period of time in a foreign land. Thus the members of the team wish to express their deep appreciation.

Especially in the field, the Geological Survey of Pakistan and the State Government dispatched two geologists to guide the team and also made jeeps at the disposal of the team. This was indeed most helpful.

The survey and gathering of material were greatly facilitated by the kind cooperation of the Japanese Embassy in Pakistan and the Japanese Consulate General at Karachi. The members of the team wish to record their gratitude.

The team is greatly indebted to the cooperation and assistance of the following Pakistanian personnel.

Central Government (Ministry of Industries and Natural Resources)

Mr. A.K. Soofi	Deputy Secretary
Mr. Rezaur Rahman	Section Officer

(Geological Survey of Pakistan)

Dr. Abdul Manan Khan	Director General
Mr. J. M. Master	Deputy Director General
Dr. M.W.A. Igbal	"
Dr. S. Tayyab Ali	"
Dr. S.H.A. Shah	Director, (accompanied the team)

(West Pakistan Industrial Development Corporation)

Mr. W.U. Siddigui	General Manager
Mr. Aftab Ahamad Khan	Deputy Chief Geologist
Mr. Abdus Sattar Memon	Assistant Geologist

(Atomic Energy Commission)

Mr. K.M. Aslam	Director, Directrate of Nuclear Minerals
Mr. M. Younas Moghal	Senior Geologist

Government of Baluchistan

Mr. Qazi Igbal Saeed	Chief Economist
Mr. Amir Yusuf Ali Khan	Secretary, Industries and Mineral Division
Mr. Javed Ahmed	Geologist (accompanied the team)
Mr. Lt-Gen. Riaz Hussain	Governor

2. GEOLOGY AND MINERAL DEPOSITS IN SURVEYED AREA

The following ore deposits mainly in the Baluchistan State were selected for survey as a result of consultation with the Pakistan Government and in consideration of the weather conditions as well as the length of the survey.

1. Copper deposits in Chagai district
2. Barite and iron deposits in Khuzdar district
3. Chromite deposits in Hindubagh district
4. Copper deposits in Fort Sandeman district
5. Uranium deposits in Dera Ghazi Khan district
6. Laterite deposits in Ziarat district
7. Koh-i-Maran fluorite deposits

The details of the geology and ore deposits will be mentioned on the following pages.

2-1 Chagai District

2-1-1 General

The Chagai district has been noted as the area with the highest probability of new mineral deposits, and it is reported that the U.S.S.R. will cooperate with the Geological Survey of Pakistan in prospecting and development of mineral resources in this area with a loan for five years beginning in 1971.

There are a large number of various metallic mineral deposits or showings in the Chagai district. Of these mineralizations, the chromite deposits in the ultrabasic rocks of the Ras Koh Range are considered to have been formed in the oldest time. These ultrabasic rocks tend to occur along the tectonic line at the contact between the upper Cretaceous system and the lower Tertiary system. The chromite deposits in this area are mostly small, the thickness of the mineralized zone being 15 - 50 m and the strike length in some cases are as long as several hundred meters.

Also in this area, volcanic rocks of late Cretaceous period called

Sinjrani volcanic group are developed. In this volcanic group iron - copper mineralization concordant with the bedding are observed, and these are represented by the Chilghazi deposit. Many of these deposits are magnetite deposits associated with epidotization and they are generally in the order of 3 - 4 m in thickness and 0.5 - 2 km long.

There are skarn type deposits formed by the intrusion of acidic to intermediate igneous rocks into upper Cretaceous to lower Paleogene sedimentary rocks associated with volcanic activities. Bandagan and Kundi deposits are examples of this type.

Porphyry copper deposits, i.e. copper-molybdenum mineralization in acidic rocks at Saindak is warrants special attention. Quartz-tourmaline veins with pyrite-scheelite dissemination are known in the vicinity of this acidic body. Also small lead-zinc deposits are known in this area.

The most recent mineralization of this area is the native sulphur deposits associated with Quaternary volcanic activity, they are seen to the north of Koh-Kundi.

2-1-2 Saindak Copper Deposit

A Location and Access

Saindak deposit is located at the western end of Chagai district and is approximately five (5) miles from the Iranian border. The locality is 450 road miles (724 km) from Quetta, and is approximately 19 miles north of Juzzak on the main highway between Nok-Kundi and Mirjawa. Thus the deposit site is easily accessible by a jeep.

B Topography

The altitude of the Saindak district is 1,800 ft. above sea level at the desert plain to the north, 3,983 ft. at the Mt. Saindak Koh to the west, and 4,006 ft. at the Mt. Amalaf at the eastern part. The drainage pattern is well defined in the areas near Sinjrani volcanic group and diorite mass, but in areas near quartz monzonite and quartz diorite bodies, it is not clearly observed because of the low relief due to the progress of erosion. In general, the drainage is controlled by the strike and dip of the host rocks and southeast-northwest direction is predominant, but the valleys are dry because of the arid climate. It is preferable to carry out field work during the winter as the temperature rises to 115°F in the summer.

C Geology (Fig. 1)

Saindak district constitutes a part of the Baluchistan geosyncline and the geology is characterized by the Cretaceous volcanic activities and Tertiary acidic to intermediate igneous activities. The majority of the sedimentary formations are Cretaceous to Eocene in age, and they are overlain by Oligocene to Pliocene strata and Quaternary sedimentary rocks lie over these rocks.

The Cretaceous and Paleogene formations which constitute the basement of this area consist mostly of shale, sandstone, siltstone, and volcanic conglomerate with smaller amount of fossiliferous limestone and calcareous shale. Two periods of unconformity are confirmed in this area. Folds with northwest direction of axes and faults are observed.

The instrusive rocks are diorite, quartz diorite, porphyrite stocks, and the sedimentary rocks in the vicinity are thermally metamorphosed. Intermediates to basic dikes are found sporadically.

(1) Sedimentary Formations and Volcanic Rocks

i) Cretaceous System

The Cretaceous Sinjrani volcanic group is distributed in this area forming the geologic basement. The group consists of shale, tuffaceous sandstone, flysch sedimentary rocks such as marl, shale, sandstone and limestone with intercalated shallow marine volcanic rocks, and red shale, sandstone, conglomerate and others. The thickness of these formations are at least 5,000 ft., most probably several times the figure.

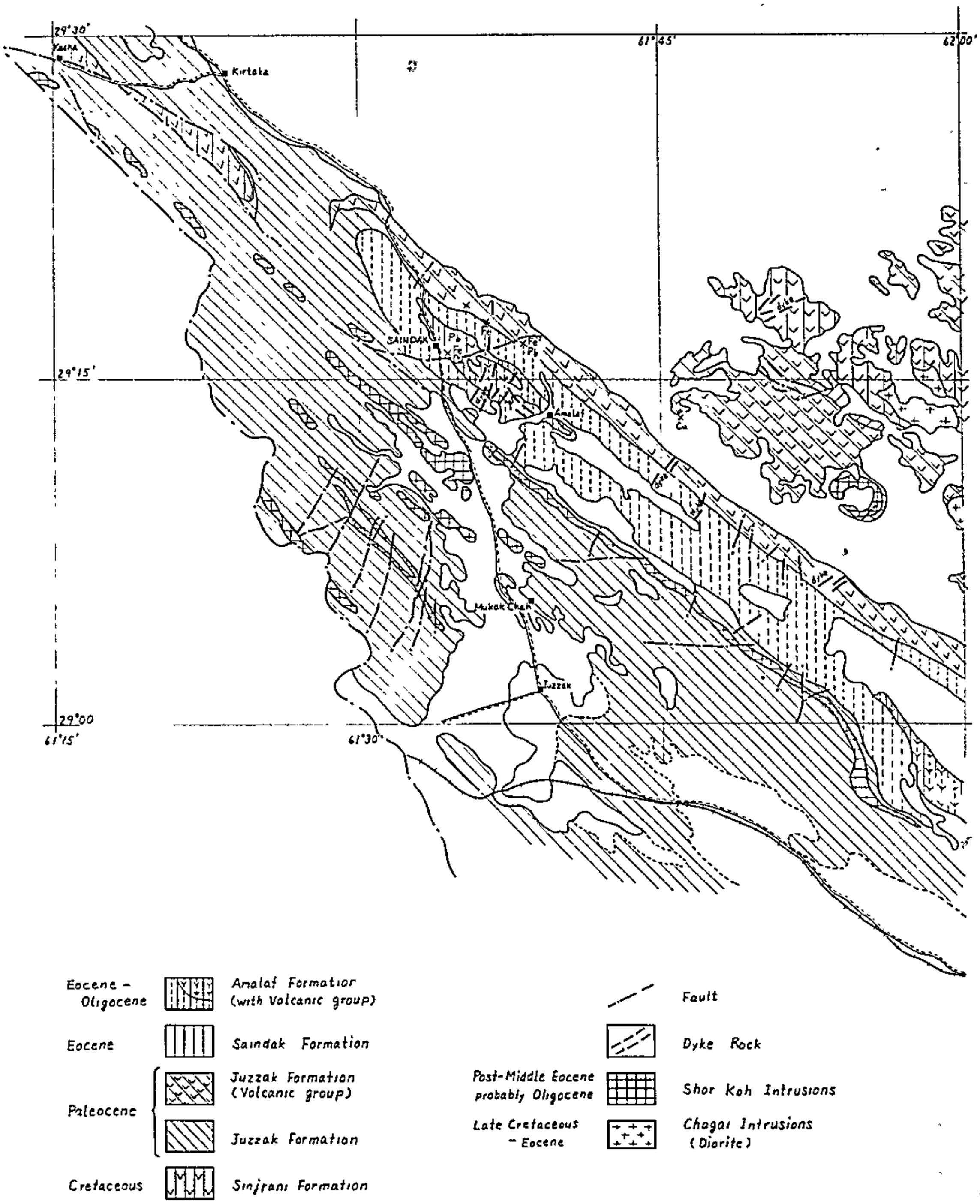
ii) Tertiary System

The Tertiary system of the Saindak district is divided from lower upward into three formations of Juzzak, Saindak, and Amalaf.

a) Juzzak Formation

Sinjrani volcanic group is overlain uncomformably by marine sedimentary rocks consisting of shale, siltstone, sandstone and marl

Fig. 1 Geologic Map of Saindak Area



accompanied by agglomerate and massive limestone. This marine sedimentary formation is called Juzzak formation and most of the units are Paleocene but the uppermost part is middle Eocene. The thickness of this formation varies considerably with 100 ft. in the east to 4,000 ft. in the western part.

b) Saindak Formation

This formation is divided into upper and lower members, the lower member consists of volcanic conglomerate, agglomerate and sandstone and is accompanied by small amount of lava. The upper member consists mainly of shale, siltstone, sandstone and marl. Juzzak and Saindak formations are conformable, and the age of this formation is believed to be Eocene. The thickness of this formation is 3,500 to 4,000 ft..

c) Amalaf Formation

Amalaf formation overlies the Saindak formation comformably. It generally consists of reddish brown shale, silstone, and sandstone. The age is determined to be Oligocene from fossils. The thickness of this formation in the Saindak district is 1,500 - 2,000 ft., but the general thickness is not known.

iii) Quaternary System

Quaternary system is developed in this area unconformably over the Tertiary formations. It consists mainly of gently folded volcanic conglomerate, accompanied by conglomerate with rounded pebbles, sandstone, and acidic tuff. The age is diluvial and is correlated to Kamerod formation. Alluvial deposits and sand dunes are also developed in this area.

(2) Intrusive Rocks

The igneous activities of this area are divided into four types. The most prominent intrusive bodies are porphyrite bodies distributed in southwest Saindak which was intruded before Paleocene epoch. Also there are some diorite stocks which intruded into the Tertiary system. Quarts diorite stocks which were active after the Oligocene epoch and which are closely related to mineralization are observed.

There are dykes which were active in various times after Cretaceous and whose composition ranges from basic to acidic. These dykes are found to be more abundant in the vicinity of the quartz diorite bodies.

(3) Thermal Metamorphic Rocks

In the Saindak district, thermally metamorphosed zones tend to be elongated in northwest direction from the quartz diorite stocks. These zones generally form high topographic relief as they are hardened by heat compared to the nonmetamorphosed parts. The grade of metamorphism is low on the whole, the metamorphic minerals are epidote and biotite, with amphibole in some cases.

(4) Geologic Structure

In this area, three stages of folding can be observed, namely, (1) late Cretaceous, (2) middle Paleocene and (3) Diluvium.

The late Cretaceous movement is represented by intense folding of N60°W of Cretaceous strata and Eocene formations were deposited over it. The Tertiary system also was folded in northwest direction, but the folding axis is N60°W in the southern parts and N20°W in the northwestern part. The folding in the diluvium deposits are generally weaker and the direction of the axes coincide with that of the Tertiary folds, but the drag folding observed near the axes is characteristic.

The fault movement can be divided into earlier and later stages. There are two fault systems in the earlier stage those normal to the folding axes of the Cretaceous formations at N20°E, and those parallel to the axes at N60°W. Strike faults are predominant in those of the later stage in the Tertiary system, accompanied by some cross faults normal to the former.

D Mineral deposits

Chalcopyrite and galena veinlets with oxidized zones, and also iron deposits were known in the Saindak district. In late 1960's porphyry copper deposits formed by copper-molybdenum mineralization were discovered and the Geological Survey of Pakistan carried out exploratory drilling.

The porphyry copper deposits consist of low grade dissemination of copper minerals in quartz diorite stock. Dissemination of chalcopyrite is observed in fresh parts, but in the weathered parts oxidized copper minerals occur. The existence of secondarily enriched zone is expected in some parts. Sampled typical specimen contain 2.65 % Cu and 0.0009 % Mo, but this does not necessarily represent the grade of the deposit as there are possibilities of leaching near the surface. The results of drilling by the Geological Survey of Pakistan show grade of Cu 0.23 % and Mo less than 0.1 %. But systematic geochemical and geophysical prospecting are insufficient and it is difficult to evaluate the deposit from these data alone.

There are malachite containing high grade hematite veins replacing limestone in the western part of the Saindak district, but they are small in scale. Also there are pyrrhotite veins in limestone. Irregular pyrite dissemination occurs in volcanic conglomerates, agglomerates and tuffs in this area. There are many hydrothermal veins containing galena, pyrite, malachite, cuprite, cerussite and other oxide minerals in the Saindak-Koh region.

E Recommendations

There are porphyry copper, and replacement and hydrothermal deposits in the Saindak district. Of these mineralizations, porphyry copper deposit is the most noteworthy. The survey carried out up to the present, however, is not sufficiently systematic to evaluate these deposits. It is desired that detailed geological survey, geochemical prospecting, and geophysical prospecting (especially I.P.) be carried out on the basis of accurate topographic maps, and select the drilling sites for Grid drilling from the results of these exploratory work.

Also from the geologic conditions, the possibilities of the existence of porphyry copper deposits are not limited to Saindak district, but also found in other areas of Chagai. Thus, re-examination of the analysis of aerial photographs and aeromagnetic and aero-electromagnetic survey will be very useful.

It is also necessary to investigate the water problem which will be indispensable during the development of these resources.

2-1-3 Chilghazi Iron Deposit

A Location and Access

The Chilghazi iron deposit is located near the Afgan border on the northern side of the Chagai district. It is 214 miles west of Quetta and 32 miles northwest of Dalbandin. The area is accessible by advancing a mile from Dalbandin on the main highway to Nok-Kundi, and then proceeding 34 miles northward on the road built by the Geological Survey of Pakistan by jeeps.

B Topography

The Chilghazi deposit is located in the Chagai Range. The range generally extends in east - west direction with the altitude of 3, 500 - 4, 500 ft., and it generally has steep topography on the northern side while it is more or less gentle on the southern side. Drainage near Chilghazi is southward, but as in the case of Saindak district, the valleys are dry because of the low precipitation of 5 - 15 mm per year. The maximum temperature is 60°F in the winter months of December and January, but it rises to 117°F in June and July. Thus field work should be carried out during the winter.

C Geology (Fig. 2)

As the Chilghazi area is in the Baluchistan geosyncline, there are many similarities between the geology of Chilghazi and Saindak areas. This area, however, had undergone uplift during the late Paleogene period and thus the Tertiary sedimentary rocks are very scarce compared to the Saindak district. The occurrence of acidic to intermediate rocks are similar to the case of Saindak area.

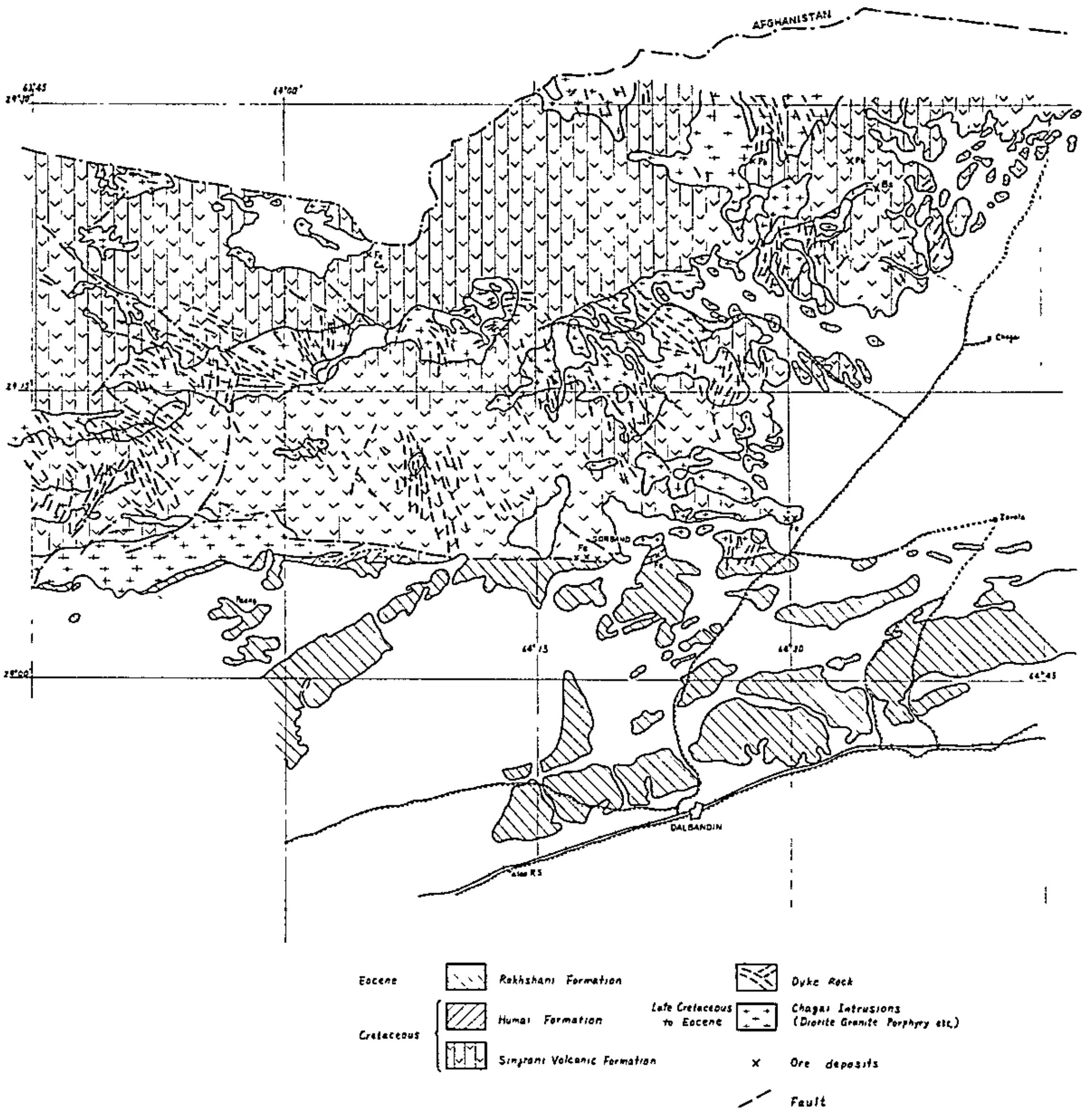
(1) Sedimentary formations and volcanic rocks

i) Cretaceous System

a) Sinjrani formation

Sinjrani formation again comprises the geological basement of the area, but the lithology is somewhat different from the Saindak district. It consists mainly of agglomerates, tuffs, volcanic

Fig. 2 Geologic Map of Chilghazi Area



conglomerates, and lava accompanied by shale, sandstone, and limestone. The total thickness ranges from 3,000 to 4,000 ft..

b) Humai formation

This formation is also of upper Cretaceous in age and consists mainly of limestone, shale, sandstone, and conglomerate associated with volcanic conglomerate, tuff, and lava. It is believed that Humai formation is in higher stratigraphic horizon than the Sinjrani formation, but pebbles of granite, granodiorite, and chert are included in the basal conglomerate of this formation. The thickness of this formation is from 300 to 1,000 ft..

ii) Tertiary System

Rakshani formation deposited during the period from late Cretaceous to early Tertiary era. This formation consists mainly of shale and sandstone, accompanied by conglomerate and limestone, the maximum thickness is approximately 5,000 ft..

iii) Quaternary System

The Quaternary system of the area is mostly diluvial deposits consisting of gravel and sand. They are generally volcanic in origin. There are also some alluvial deposits.

(2) Intrusive Rocks

In this area, there are plutonic rocks which intruded during the latter part of folding. They are granodiorite, quartz monzonite, and diorite. Also there are dykes which intruded after the folding.

i) Plutonic Rocks

a) Granodiorite

Granodiorite is distributed to the west and northwest of the Chilghazi deposit. The mineral composition of this rock is plagioclase 55 % (An 28 - 45), Quartz 20 %, hornblend 10 - 20 % biotite 8 - 10 %, and potash feldspar 12 - 14 %, accessory minerals are titanite, apatite, zircon and others. The time of intrusion is believed to be early Tertiary.

b) Quartz Monzonite

This rock occurs at three miles north of the Chilghazi deposit, and the mineral composition is plagioclase 35 % (An 20 ± 3), potash feldspar 35 %, quartz 20 %, hornblend 5 %, and biotite 5%, with association of titanite and apatite.

c) Diorite

Diorite is distributed to the north of Chilghazi. The mineralogy consists of plagioclase 44 - 55 % (27 - 32), hornblend 20 - 25 %, augite 10 - 12 %, quartz 10 %, and magnetite 5 %. Parts of the intrusive body is hydrothermally altered.

ii) Dyke Rocks

Most of the dykes are generally small in scale with width of about 4 - 10 ft.. The texture of the rocks is generally porphyritic with some aplitic parts. These intrusive rocks are post-kinematic, but are believed to be before diluvium.

(3) Geologic Structure

Great Chapper fault extends through about 6 miles south of the deposite of Chilghazi. Sinjrani and Humai-Rakshani formations are separated by this fault. The geology in the vicinity of the deposit consists of Sinjrani formation with anticlinal structure dipping 2° - 10° south on the southern wing and 5° - 20° north on the northern wing. This anticline is cut by two faults with WNW trend.

D Mineral Deposits

The Chilghazi deposit was discovered recently, and the Geological Survey of Pakistan conducted geological survey of the deposit in 1966, drilled 14 holes (total of 5, 443 ft.), carried out magnetic survey, and again drilled 6 holes (total of 1, 536 ft.). Detailed survey is now being done by WPIDC.

The deposit occurs in Sinjrani formation and the country rock is andesitic with quartz andesite in some parts. There are three mineralized layers, the lowermost is a low grade magnetic dissemination, the intermediate horizon is too small in scale to work. The most intensely mineralized horizon is the uppermost epicote-magnetite-andesite zone. The ore bodies consist generally of compact massive magnetite, are lens shaped, and conformable with the host rocks.

The thickness of the bodies is 3 - 5 ft. and the length is 0, 0.5 - 2 km. The ore minerals are generally fine-grained and consist mostly of magnetite, pyrite, and chalcopyrite with epidote, quartz, and soricite as gangue minerals. Oxidized copper minerals occur near the surface.

The grade is Fe 32 - 55 %, with average of 45 %, the Ti content is less than 0.5 %, and the result of drilling showed 2.46 million tons of probable ore reserves and 3.36 million tons of possible reserves. The grade of representative specimens collected during this survey was Cu 1.10 - 2.14 %, Fe 39.3 - 60.2 %.

E Recommendations

The possibility of developing the Chilghazi deposit is being investigated by the WPIDC. The conditions of the ore bodies show that open pit mining is difficult, the reserves are rather small, and the grade of Fe 45 % is not very high. Also the location is such that transportation costs will be considerable, and water is another problem, thus it does not seem feasible to develop the Chilghazi iron deposit independently. It would be worth considering, however, the possibility of establishing iron-steel works in a suitable location of West Pakistan and develop iron deposits in various parts of the country in order to supply ores to the iron works.

On the other hand, these copper containing iron mineralization of Chilghazi and Bandagan which will be mentioned later, indicate the possibility of the occurrence of contact metasomatic deposits in the Chagai area. Thus it is recommended to conduct an air-borne magnetic survey of the area for the purpose of prospecting for large scale contact metasomatic deposits.

2-1-4 Bandagan Iron Deposit

A Location and Access

Bandagan iron deposit is located in the Ras-Koh Range of Chagai area. The deposit is accessible by driving 6 miles southward on the road constructed by the Geological Survey of Pakistan from Jadone Landis by jeep and then walking 2 miles. Jadine Landis is about 47 miles east of Dalbandin on the main highway between Quetta and Zahedan.

B Topography

Ras-Koh Range is located in the southeastern part of Chagai area, it arcs from northeast to southwest direction, in the southern part the range is 3,200 - 6,600 ft. above sea-level and in the central parts it is 4,000 - 10,000 ft.. The slope is somewhat gentle in the northern parts of the range. This topography reflects the geology which is formed of Paleogene sedimentary rocks in the southern part of intrusive rocks in the central part, and of volcanic rocks in the northern part. The high peaks of Ras-Koh and Kambran is formed by diorite and monzonite. This range is also very arid, the drainage forms deep valleys with little water in the higher areas.

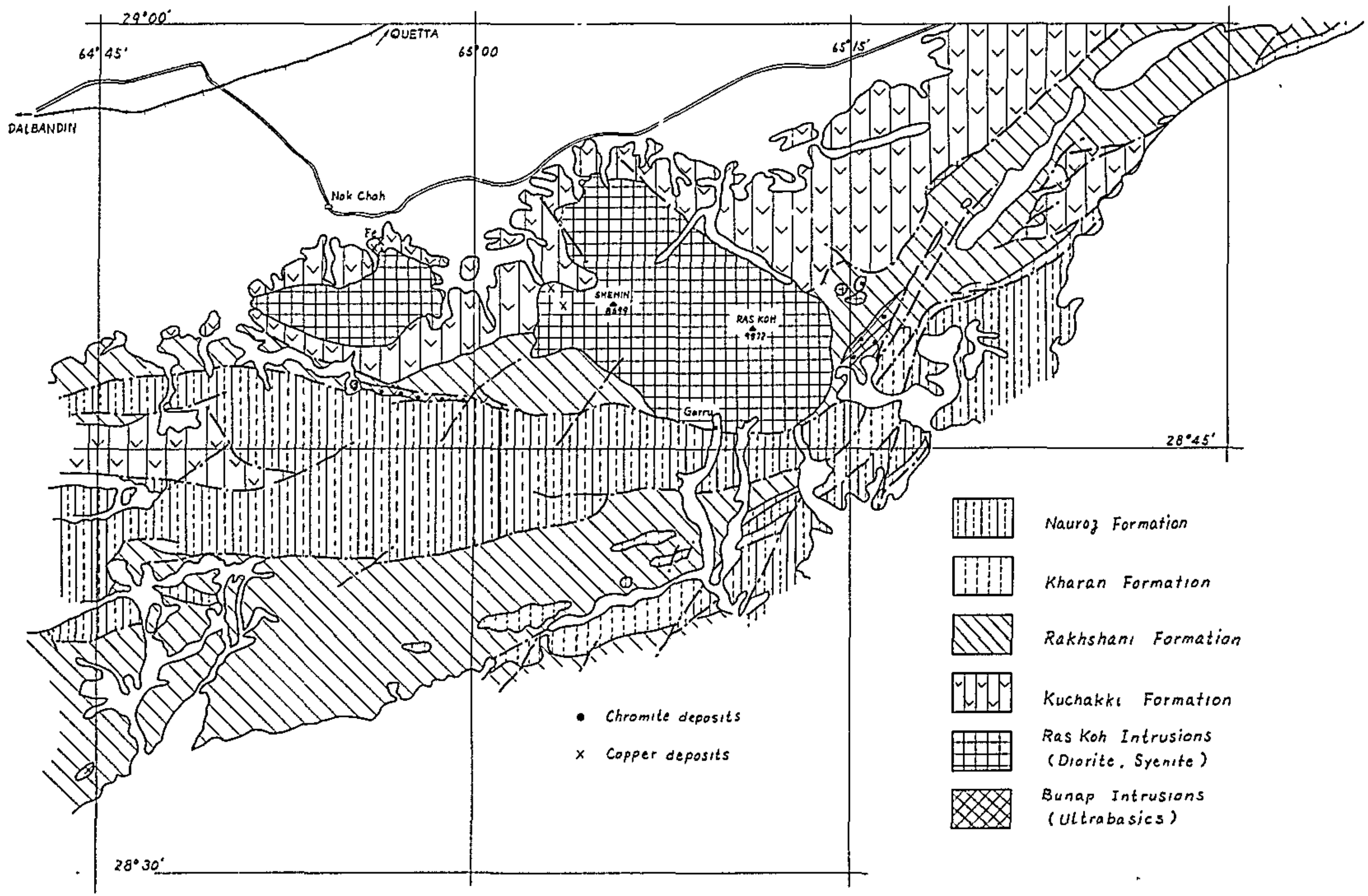
C Geology (Fig. 3)

Bandagan deposit is located in the eastern part of the Ras-Koh Range. The geology of the area consists of Sinjrani formation which is composed mainly of upper Cretaceous volcanic rocks, and sedimentary rocks containing lower to middle Eocene volcanic rocks. Ultrabasic and intermediate to acidic bodies have intruded into these formations. Quaternary system is developed overlying these formations. The stratigraphic relationship is shown in the following table.

The stratigraphy of the formations near Bandagan Alluvial and

terrace deposits		Quaternary
Sorag system		middle Eocene
Kullan shale		middle Eocene
Aplite	Dykes	lower-middle Eocene
Porphyrite	Dykes	lower-middle Eocene
Dolerite	Dykes	lower-middle Eocene
Syenite		lower-middle Eocene
Diorite		lower-middle Eocene
Ultrabasic rocks		lower-middle Eocene
Erikalag limestone		" "
Bunap shale		" "
Sinjrani system		late Cretaceous

Fig. 3 Geologic Map of Bandagan Area



These sedimentary formations are intensely folded with the exception of the Quaternary system. The axes of the folds are more or less parallel to the direction of the Ras-Koh Range, northwest. Also thermal metamorphism is observed near the instrusive bodies.

D Mineral Deposits

Bandagan deposit has been known from fairly olden times. The Geological Survey of Pakistan had conducted geological survey of the vicinity during the period from 1955 to 1957, carried out magnetic survey in 1961, drilled 9 holes (total length of 1,563 ft.) in 1962, and also made 5 shallow drillings.

The deposit is a magnetite deposit which replaced tuff in the Sinjrani formation and occurs at the contact of old volcanic rocks and syenite-monzonite intrusive rocks. Mineralization is observed along the Bandagan Valley for length of 400 ft. and width of 60 ft.. The thickness of the mineralized zone is about 15 ft. including the disseminated zone.

The major ore mineral is magnetite accompanied by veinlets of pyrite and chalcopyrite, oxidized copper minerals occur at the surface. The gangue minerals include garnet, quartz, and epidote.

The grade of these ores is Fe 35 - 60 %, Cu mostly 0.5 % with parts as high as 2.17 %. The reserves of 7,500 tons are confirmed by drilling, and possible reserves are 32,000 tons (Fe 40 - 50 %, Cu 0.5 - 1 %). The grade of the representative sampled specimens is Cu 0.03 - 4.56 %, Fe 12.4 - 57.8 %.

E Recommendations

Bandagan deposit is too small in scale to be of economic value. Also the location is not very favorable. As mentioned, in the section of Chilghazi deposit, however, these types of mineralization suggests the possibility of the occurrence of large scale contact metasomatic deposits in the vicinity, and the possibility of discovery of new deposits by regional exploratory work based on regional geological survey of the area should be noted.

2-2 Khuzdar district

2-2-1 General

A Location and Access

The Khuzdar district is located approximately 205 miles (about 330 km) south of Quetta. It can be reached by about five hour drive from Quetta (95 miles between Quetta and Kalat is paved, 110 miles between Kalat and Khuzdar is being paved). Khuzdar (lat. 27°47'N. and log. 66°35'E.) is a newly constructed town with a population of about 6,000, and is the administrative center of Kalat area. There is a road which leads to Karachi via Bela from Khuzdar.

B Topography

Khuzdar is located in the uppermost basin of Gaj River. Surrounded by Kirthar and Pab Ranges, there are mountains of 7,000 to 8,000 ft. altitude in the vicinity. The area is formed by steep mountains composed of sedimentary formations, hills where ultrabasic rocks are distributed, and wide dissected valleys and basins.

C Geology (Fig. 4)

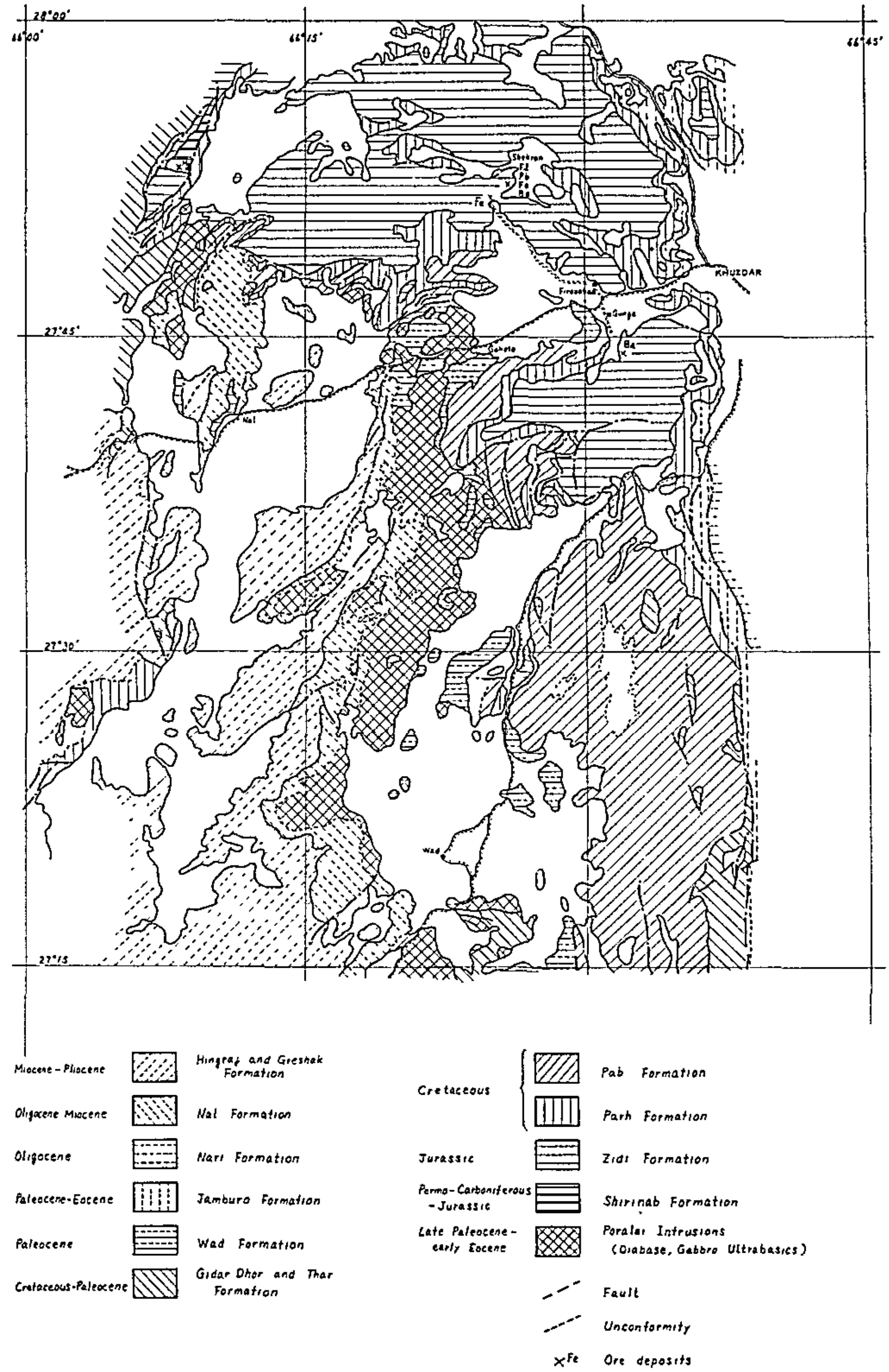
The geology of this area consists of Permo-Carboniferous, Jurassic, Cretaceous, and Paleocene-Pliocene formations, and Poralai intrusive rocks of late Cretaceous to early Tertiary age.

Shrinab group (Permian - early Jurassic). This group is distributed in a small area at the northwestern part of the district. It consists mainly of alternation of limestone and shale, oolitic and pisolitic textures are observed in the limestone. Chiltan limestone overlies this group in gradational relationship.

Zidi group, Chiltan limestone (Jurassic). Zidi group is widely distributed to the west of Khuzdar. It is composed of alternation of limestone and shale, and has complex folded structure. Chiltan group is distributed in small scale in the northwestern part of this district. It consists mainly of limestone accompanied by small amount of shale.

Parh group (Cretaceous). This group overlies the Zidi group, it is composed of shale in the lower horizons and limestone in the upper parts. This group is distributed widely in the area from the north of

Fig. 4 Geologic Map of Khuzdar Area



Karachi City to Fort Sandeman. To the south of this district, it includes basaltic lavas, tuff, agglomerate, breccia and other volcanic material and is called Bela volcanic group.

Pab group (late Cretaceous). This group overlies the Parh group and consists of sandstone. It is distributed in north - south direction in the eastern part of the district.

Thar group (late Cretaceous - Paleocene). The formations of this group are distributed southward from Wad which is located at west-southwest of Khuzdar. The group is composed of shale, sandstone, marl with a minor amount of limestone and volcanic conglomerate.

Bad Kachu group (late Cretaceous - Paleocene). It is distributed to the south of Khuzdar along the Pab Mountains. It consists of sandstone, shale, conglomerate, marl, and limestone. Ferruginous and calcareous marl, and shale are predominant in the basal parts. It overlies the Pab group conformably in general, but unconformable parts are also observed. The relationship with the Thar group is not clear.

Gidar Dhor group (late Cretaceous - early Eocene). This group barely crops out in the northwestern corner of this district. The major components are shale, sandstone, conglomerate, limestone, and pyroclastic rocks and lithological changes are conspicuous. It changes gradationally into the underlying Parh group.

Wad group (late Paleocene). This group is distributed to the south of Firozahad and to the south of Wad. It consists mainly of limestone with a minor content of brecciated chert. It overlies the Thar group with gradational relation.

Jamburo formation (Paleocene - early Oligocene). This formation occurs along the Pab Mountains. The major consitutents are shale, limestone, and marl. It overlies Parh group in gradational relation.

Nari group (Oligocene - early Miocene). This group is distributed widely along the Pab Mountains. It is composed mainly of sandstone, and shale, accompanied by limestone and conglomerate in the basal parts.

Nal limestone (late Oligocene - early Miocene). It is distributed in the western part of the area in north - south direction. The major units are limestone, shale, and sandstone, accompanied by conglomerate. Various fossils occur in this formation. Pebbles of serpentine, diorite, chert, limestone, and sandstone are found in the conglomerate.

Hinglaj group (Miocene - Pliocene). The formations of this group are widely distributed parallel to the Nal limestone in the western parts of the area. It is composed mainly of sandstone with minor content of conglomerate, shale, and limestone.

Poralai intrusive rocks (late Paleocene - early Eocene). These rocks are distributed widely from the west of Khuzdar to Bela. The lithology ranges from intermediate to ultrabasic, but very little granitic rocks occur in this period.

Pyroxenite, periodotite, and serpentine are the ultrabasic rocks of this area. They occur concordantly as small lenses.

Diorite and gabbro are the intermediate - basic rocks in this area. Diorite is especially widely distributed and partly accompanies pegmatite. It forms large intrusive bodies and complex masses by intruding into Thar, Wad, Parh and Pab groups.

D Mineral Deposits

Deposits and showings of asbestos, barite, iron, and lead are known in this area. The following includes the known occurrences of ores including specimen scale showings.

Antimony: The existence of antimony is reported in the Shekran Hill.

Asbestos: Occurrence of chrysotile is known from several localities near Wad.

Barite: Barite occurs associated with iron, lead, and fluorite at Shekran Hill. Monay Talar deposit will be mentioned later.

Copper: Copper showings consisting mainly of malachite is known to occur in Poralai intrusives and Bela group in Las Bela district which lies to the south of the present area.

Iron: Irregular massive - vein type deposits are known to occur in the Zidi group (hematite network veins occur near the barite deposits at Shekran Hill and Monar Talar. This network is 1. 5 - 3 m thick, about 800 m long, and the dip-side length along the slope of the mountain is 100 m, but it is said to be of small economic value.

Occurrences of hematite - limonite - malachite or siderite are known to the north and east of Las Bela.

Lead: Occurrence of galena is known in the barite deposits of Monar Talar and in the river beds near the deposit. Those at Shekran Hill are said to have been mined during the early 19 th century. This deposit is 0. 9 m wide and 20 m long and the lead minerals are associated with barite along the fault.

Magnesite: Magnesite veins are known to occur in this district and Nal, Wad, Khabri, Dhora, Uthal nearby.

Manganese: Bela area which lies to the south of this district is the major manganese-bearing area.

Nickel: Geological work has not been carried out for nickel. There are many ultrabasic bodies in the area extending from Khuzdar to the north of Karachi through Bela district. The surface of these areas are covered by laterites of various color, and forms hilly topography. Laterization in arid conditions is not very well known, but these areas of ultrabasic intrusive rocks are believed to be promising for exploratory work on nickel deposits.
(Sampled specimens show grade of Ni 0. 001 - 0. 182 %, Fe 4. 40 - 36. 9 %).

2-2-2 Monar Talar Barite Deposit

A Location and Access

The deposits are located approximately 6 miles (about 10 km) southwest of Khuzdar. Gunga Village is reached from Khuzdar by driving 7 miles (15 minutes) on a gravel road, and the deposits are reached by driving on the river bed for 2. 5 miles (15 minutes) from Gunga.

B Topography

There is a hilly zone called Mona Talar near the deposit.

C Geology

The geology in the vicinity of the deposits consists of Jurassic limestone formation of the Zidi group. The strike of the limestone is N 5°W dipping 35° west. The structure is monoclinic. The Zidi group is divided into the lower massive limestone and shale, and the upper limestone formation with fine bedding in this area.

D Mineral Deposits (Fig. 5)

The barite deposits occur at the foot of the Monar Talar Hills. They occur in bedded form in the lower strata of the Zidi group. The individual bodies are irregular lenses and the length of the distribution of the bodies is about 1.4 km in north-south direction. The thickness of the deposit is 6 m at the southern end and 15 m at the northern end. The deposits are divided into three groups of south deposit, main deposit and north deposit. Silicification and oxidation are observed to a maximum width of 30 m in the foot wall. There are parts in the lower horizons of the deposits with veinlets and heavy stains of hematite.

These deposits are reported to be of hydrothermal origin which replaced Jurassic limestone (Klinger and Ahmad 1967).

The south deposit comprises two ore bodies with N - S strike, and 50° - 70° W dip, one has length of 140 m, and the thickness of 4 - 5 m, and the other length of 80 m and the thickness of 2 - 5 m. The reserves amount to approximately 70 thousand tons with 85 % barite. The main deposit strikes N - S and comprises east ore body dipping 60° west and west ore body which dips 20° - 30° west. The total length is 360 m and the thickness is 9 - 24 m. The reserves amount to 1.45 million tons with 75 % barite. The north deposit is dome shaped with thickness of 1.5 - 12 m, and the total reserves are 120 thousand tons with 75 % barite.

E Ores and Grade

The ore consists mainly of barite and is said to be accompanied by calcite, quartz, small amounts of hematite, goethite, galena, cerussite, jarosite, cinnabar, and rhodochrosite.

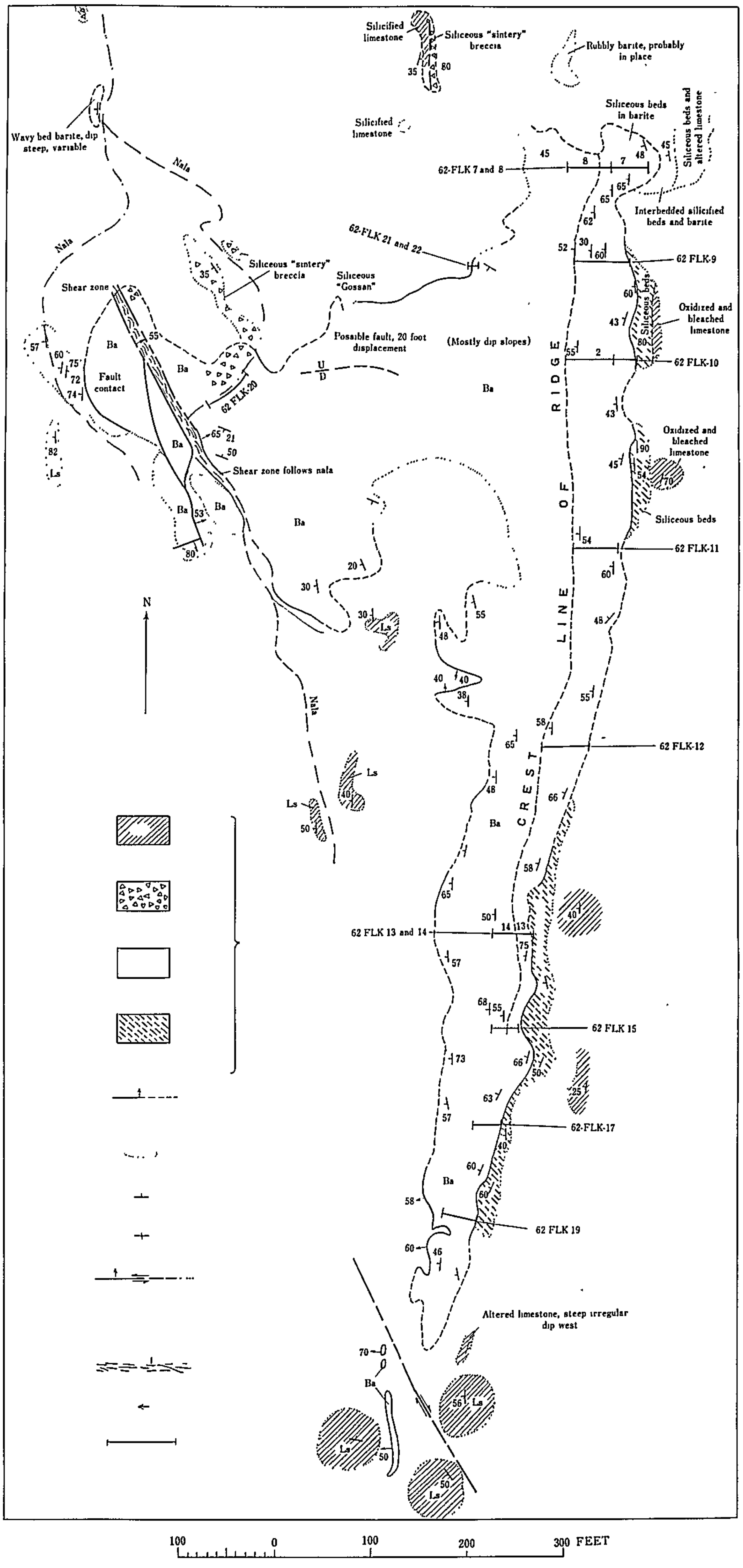


Fig. 5 — a Geologic map of barite-deposits

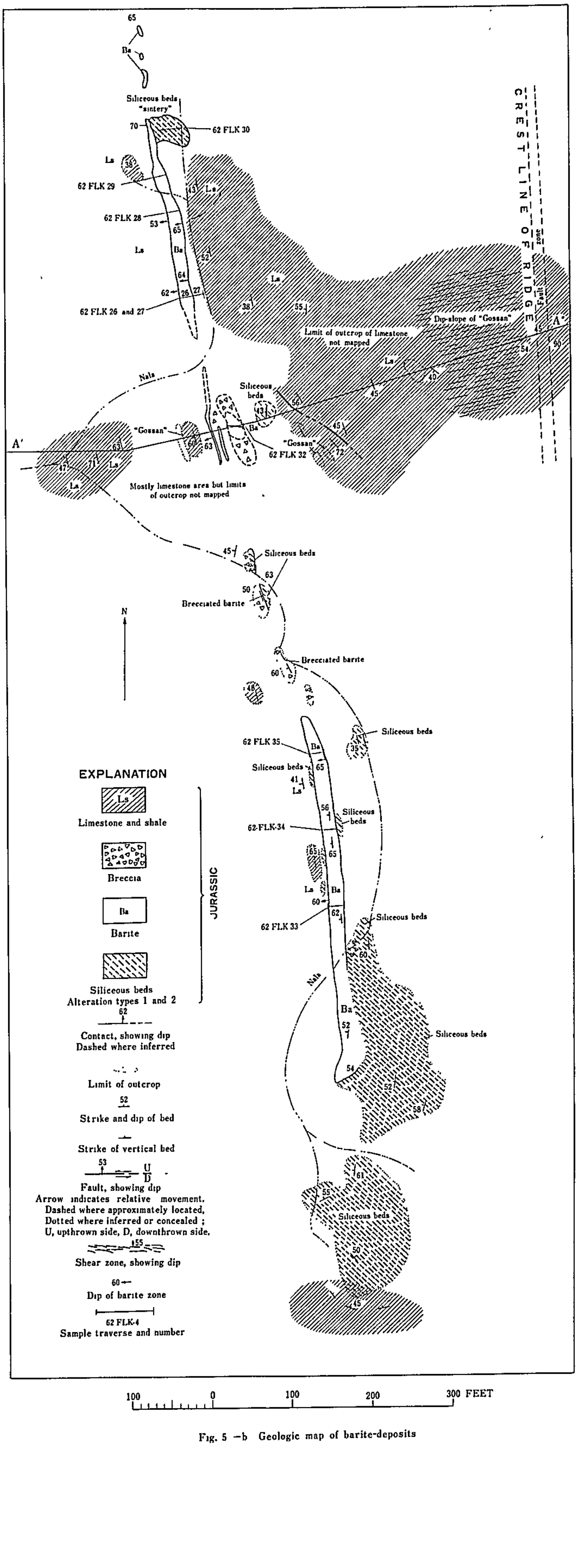


Fig. 5 —b Geologic map of barite-deposits

The chemical analyses of the ore from the main deposit show $BaSO_4$ 91.86 - 95.92 %, SiO_2 1.84 - 2.48 %, Al_2O_3 0.26 - 2.73 %. Fe_2O_3 0.02 - 0.0 %, CaO 0.49 - 0.98 %, MgO 0.76 - 1.91 % (Klinger and Ahmad, 1967).

The grade of the collected sample is $BaSO_4$ 95.6 %.

F Recommendation

There are many advantageous factors for exploration of these deposits such as relatively large scale, convenient location for transportation,and shallow ore bodies enabling open pit mining. Also the upgrading of the ores by hand-picking should be simple. Occurrence of barite is known in the surrounding areas, but sufficient exploratory work has not yet been carried out. It is highly possible that new deposits can be discovered by future surveys.

2-2-3 Shekran Iron Deposit

A Location and Access

This deposit is located 15 miles (about 24 km) west-northwest of Khuzdar, and is about 40 minutes drive from Khuzdar through Firozabad by jeep.

B Topography

The vicinity of the deposit is composed of intensely dissected wide valleys and fairly steep mountains consisting of Jurassic limestone.

C Geology

The geology of the area in the immediate vicinity of the deposit consists of limestone formation of the Jurassic Zidi group. The strike and dip of the limestone formation are N80 °W, 40°S in the southeastern part, N80 °E, 50°N at the foot wall of the deposit at the exposure, and varies westward to N55°E, 70°S; N45°N, and N20°E, 60°N. The structure is fairly complex with the development of irregular folds. A fault with NEE-EW trend is observed to the north of the deposit, and anticlinal axis with NW trend is found to the south of the fault. The occurrence of granite is reported from abandoned adits.

D Mineral Deposits

The deposit is a limonite-hematite-siderite-calcite vein which occurs in limestone of the Zidi group.

The vein crosses the bedding of the limestone, with strike of N85°W-EW, dip of 65°N, the length of about 70 m, and the width of 2-13 m. There are two or three branch veins (max. length 50 m) in the hanging wall. The vein contains hematite in a massive or network form, and many breccia of the host rock is included in the thick parts. The terminal parts of the vein grades into parallel calcite veinlets with limonite stains. The size of the mineralized zone including the barren parts is 300 m long and 20 m wide at maximum. Four such mineralized zones are found in the area of Shekran Hills and the mineralized zone attains 2. 5 km in length (Fig. 6). The vein in the central part of the mineralized zone is said to have been worked in the early 19th century and many old adits are found. It is seen in these abandoned adits that limonitized hematite is predominant to 6 m below the surface and siderite is the major component below that (Hunting Survey Corp., 1961). Near the southern end of the mineralized zone, limonite - siderite veins extend for 300 yards parallel to the major vein on the northern side.

There is a small similar deposit about 1. 0 km north of this deposit and fluorite, barite, and galena are said to be associated.

In these deposits, the ores are oxidized near the surface and massive ores consisting predominantly of limonite and hematite occur near the surface. But in the lower parts, the veins branch out into several veinlets consisting of calcite and siderite. The width of the veins is in the order of one meter.

Many calcite veinlets are developed in various directions and druses are formed within the veins. The calcite veinlets are more abundant towards the foot wall and the terminals of the veins.

E Ores and Grade

The ores are composed of limonitized hematite ores of pale brown, reddish brown, and dark brown color; and siderite ores of yellowish to pale brown.

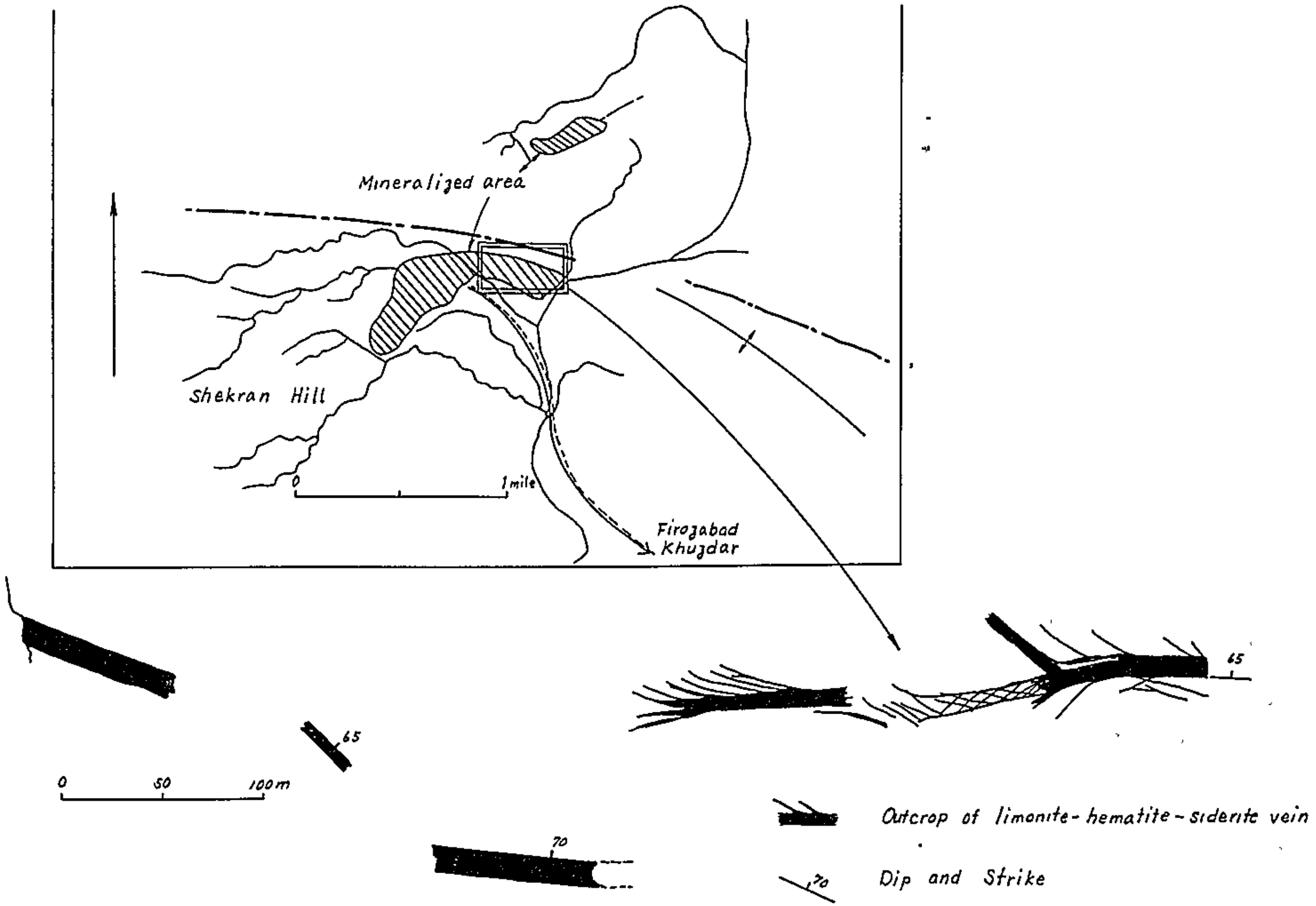


Fig. 6 Map showing distribution of Shekran iron deposits

The major ore minerals are limonite, hematite, and siderite, and is said to be accompanied by galena. Also antimony is detected from slag found near the abandoned adits.

The grade of the ores is said to be Fe 30 % ±. The analysis of the sampled specimen showed Fe 35.0 %.

F Recommendations

The total reserves of this deposit are calculated to be 9×10^6 t (Fe 40 %) and those of the deposit in the northern mineralized area are calculated to be 1.3×10^6 t (to 15 m below the surface) by Hunting Survey Corp. (1961)

The present survey showed 50 - 60 % of the total length of the veins to be barren, the depth of the oxidation to be for several meters at the most, the grade to be low, the transition of the veins into relatively thin veinlets of siderite below the exidized zone, and thus it is concluded that these deposits cannot be the object of development at the present state.

2-3 Hindubagh District

2-3-1 General

A Location and Access

Hindubagh is located approximately 80 miles (130 km) northeast of Quetta lat. 31°10' N and long. 67°44'E. There is a narrow gauge railway from Quetta to Fort Sandeman, and Hindubagh, Nasai and other stations are in the district (this railway runs once a week on Mondays). There is also a paved road from Quetta and the district is reached by two and a half hour drive.

B Topography

The district is located in the upper basin of the Zhob River, and alluvial plains of 5 - 10 km in width are developed along the river. The back mountains show fairly steep topography dissected by the branches of Zhob River in north-south direction, and ranges of 2,500 - 3,000 m altitude continues in east-west direction.

C Geology (Fig. 7)

The major geological units of this district are Permo-Carboniferous, Jurassic, Cretaceous, Paleocene-Miocene Tertiary formations and the Hindubagh intrusive rocks.

Structures of east-west trend is prevalent in the area south of the Zhob River and the formations are distributed in approximately the same direction, but north-south trending structures are also observed near the Hindubagh intrusive rocks. Northeast to east-west structures are developed in the area north of the Zhob River.

Alozai formation (Permo-Carboniferous - early Jurassic). This formation is widely distributed in east-west direction in the axial part of an anticlinal structure and is continuous in an echelon form to the north of Fort Sandeman. It consists mainly of limestone and shale and ferruginous limestone is found in the lower parts.

Loralai limestone formation (Jurassic). This formation conformably surrounds the Alozai formation. The major component is limestone with small amount of shale. Development of fine regular bedding is characteristic of this limestone.

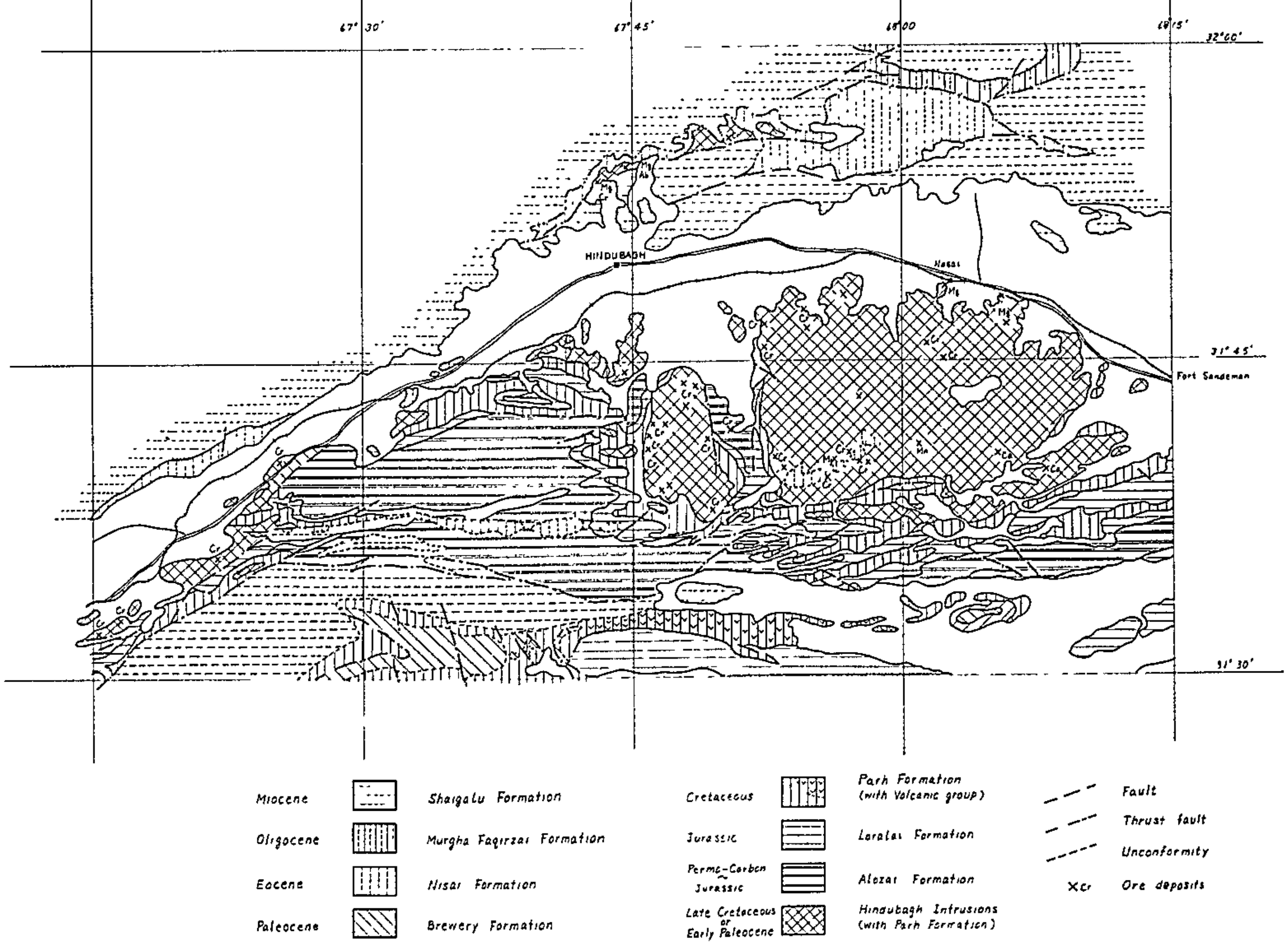
Parh group (Cretaceous). The Parh group of this area is correlated to lower and middle Cretaceous age. It consists mainly of shale, limestone and volcanic rocks (andesitic-basaltic lava, tuff, agglomerate). Conglomerate is intercalated in some parts.

Brewery limestone (late Cretaceous - Paleocene). This formation is distributed in east-west direction in the southern part of the district. The lowermost horizon is laterized in the Ziarat area.

Nisai group (Eocene - early Oligocene). Nisai group is distributed widely forming the mountains to the north of Zhob River. The component lithology is limestone, marl, and shale, with association of sandstone and conglomerate in some areas.

Murgha Faqirzai shale (Oligocene). This is distributed in small amount in the mountains to the north of Zhob River. Shale is the major component and sandstone and limestone are associated.

Fig 7 Geologic Map of Hindubagh Area



Shaigalu sandstone (late Oligocene - Pliocene ?). This sandstone is distributed widely constituting mountains at the northern side of Zhob River. It consists of sandstone and shale, and large amount of conglomerate and limestone are associated.

Urak formation (Oligocene - Pliocene). This formation is in approximately the same stratigraphic horizon as Shaigalu sandstone. It is distributed widely to the south of Zhob River. It consists mainly of conglomerate, sandstone, shale, and a small amount of limestone is observed in some cases.

Hindubagh intrusive rocks (late Cretaceous - early Paleocene). They are distributed mainly in the estuary of Zhob River and is composed of various lithologic units. They are most concentrated to the south of Hindubagh. Harzburgite, dunite, periodite, serpentine are the major rocks of this group and they grade into each other. Dolerite, gabbro and diorite also occur in these bodies. These intrusive rocks often take the form of sills, irregular stocks, and dykes. Ultrabasic rocks occur intercalated with volcanic and sedimentary rocks. The irregular stocks are distributed to the southwest of Hindubagh. Completely serpentinized stocks are distributed to the north of the River. Small sills and dykes were formed at the last stage of the igneous activity and dolerite is the major component. These dykes are arranged parallel in the area southeast of Hindubagh.

The dolerite dykes in this area have intruded into the Parh formation and is covered by Nisai formation. The ultrabasic rocks are intruded by these dykes and thus the activity of the Hindubagh intrusive bodies are placed at late Cretaceous - early Paleocene Tertiary.

D Mineral Deposits

Many chromite deposits related to the Hindubagh intrusive rocks are known in this district. Asbestos and magnesite deposits also occur in this area. The occurrence of coal is known from Urak formation.

Asbestos: There are fibrous amphibole asbestos veins in the serpentinized altrabasic rocks 8 miles north of Hindubagh.

Chromium: Occurrences of many chromite deposits associated with Hindubagh intrusive rocks are known. The ore deposits are mainly found in serpentinized dunite and peridotites. They occur as dissemination, veins, lenses, pod like bodies, and their sizes vary. The grade of the ores gradually decrease eastward. The deposits of this district are grouped into four areas from west eastward, Khanozai area, Jangtorghar area, Salplaitorphar area, and Nasai area.

Khanozai area: The ultrabasic rocks of this area is distributed in a zone 12 miles long and one mile wide. Serpentinized dunite occupies the major portion, and many basalt and dolerite dykes are observed. Parts of the area have been drilled by the Geological Survey of Pakistan. The range of the composition of the high grade ores is Cr_2O_3 49.3 - 52.9 %, and the Cr : Fe ratio ranges between 3.4 : 1 to 3.6 : 1.

Jongtorghar area: Chromite ores with the highest grade are produced from this area. The deposits are distributed around Mt. Jongtorghar (approximately 3,000 m). The deposits are dykes and lenses in serpentinized harzburgite.

Saplaitorghar area: The deposits are distributed in the mountainous area west of Jongtorghar. Cr_2O_3 44 - 52.5 %, Cr : Fe is constant at 3 : 1.

Nasai area: The area is located 20 miles east of Hindubagh and serpentinized dunite is the predominant igneous rock. The deposit is lens-shaped to tabular form. The grade of the low grade ores is 40.0 - 46.0 % with Cr : Fe of 2.5 - 2.8 : 1.

Pakistan Chrome Mines Ltd., is working the deposits of this area with the annual production of 30,000 tons.

2-3-2 Mine No. 7 ML Chromite Deposit

The mine is located about 30 km southeast of Hindubagh. The deposit consists of lenses which occur in serpentinized periodotite. It is elongated in N45° E direction with dip of 70° - 75°S. A branch of the deposit trending N30°W has been discovered. The deposit is 4 m wide and 25 m long in the strike direction. The ore consists of massive ores, banded ores, disseminated ores and other types. The grade of ores is said to be Cr_2O_3 47 % ±. Ni 0.2 to 0.3 % is detected from the weathered parts of the dunite of this area. High and low grade ores are being separated by hand picking. The present operation is conducted in the lower extension of the ore shoot of the body which was mined previously under the same name.

2-3-3 Mine No. 71 Chromite Deposit

This mine is located in the central part of the presently worked Salpaitorghar area. The deposit consists of veins in the intensely serpentinized dunite. Mining was started in 1925. The total past production of high grade ores amount to 75,000 tons. The present production is 300 tons monthly of Cr_2O_3 55 - 56 %, Cr : Fe = 3 : 1 ores.

2-3-4 Mine No. 153 Chromite Deposit

This mine is located approximately 32 km east of Hindubagh. The ore forms veins, network, and irregular pod-like bodies which occur in peridotite. Epidote - magnesite network zone is developed in and near the deposit. The main ore body is flattened and pod shaped with N50°E strike and 65°S dip and the dimensions are 6 m wide and approximately 60 m long in dip direction. Dissemination zones are observed in the footwall side. There is also a vein-network deposits with E-W trend and 60°N dip, they were worked by open cut and underground methods. The grade of the massive ores is Cr_2O_3 48 %.

2-3-5 Nasai Magnesite Deposit

The deposit is located approximately 40 km east of Hindubagh. It consists of magnesite veins with N80°W strike and 90° dip which occur in serpentinized dunite. The vein is 1.5 - 5 m wide and 200 m long, and approximately 30 m deep, it extends further eastward. The ore is white, fine-grained, massive and consists of almost pure cryptocrystalline magnesite. It is being worked by Pakistan Chrome Mines Ltd., and the reserves near the exposure are said to be 60,000 tons. The grade of sampled specimens is NgO 21.0 %.

2-3-6 Recommendations

The chromite deposits of this area were discovered in 1901 and mining operations began in 1903. The total production up to 1969 was approximately 910 thousand tons. At present Pakistan Chrome Mine Ltd., is mining these deposits and the reserves are said to be 1.5×10^6 tons of high grade ores (Cr_2O_3 higher than 48 %). The analysis of the sampled high grade massive ore was Cr_2O_3 47.1 %, FeO 22.4 %. The maximum dimensions of the deposits are in the order of 0.3 x 3 x 30 m.

The ultrabasic rocks are widely distributed in the area, for example two bodies south of Hindubagh occupy an area of 40 km long and 20 km wide. There are various difficulties in prospecting and developing these chromite bodies because of the intense lithological changes of the host peridotite, the small size of individual ore bodies, the lack of regularities of ore distribution or structural control, and other factors. The development of low grade disseminated ores near the massive high grade part is another problem which must be solved.

Concerning exploration, it will be necessary to clarify the regularities of the distribution of the chromite deposits or the structural control of the ore bodies by detailed surface work on the lithological changes, together with the study of the known deposits. Topographic map of detailed scale should be prepared for the area.

2-4 Fort Sandeman District

2-4-1 General

A Location and Access

Fort Sandeman is located at lat. 31° 22'N, long. 69°27'E. It is 226 miles east-northeast of Quetta.

There is a narrow gauge railway of West Pakistan Railways between Quetta and Fort Sandeman. It is in service once every week. It is 7 hour drive from Quetta.

B Geology (Fig. 8)

Fort Sandeman is located in the northern part of the central axis of Baluchistan Geosyncline, and the major geological units of the area are early Jurassic - Miocene formations and Hindubagh intrusive rocks of late Cretaceous - Paleocene age.

Anticline and synclinal structures trending NE - SW are developed in these formations and faults are also observed.

There is a NNE - SSW trending fault 14 miles west of Fort Sandeman and it separates the Eocene - Miocene formations on the west side and Jurassic - Cretaceous formations on the eastern side.

Alozai formation (Permo-Carboniferous - late Jurassic). This formation is distributed mainly to the north of Fort Sandeman which is the central part of the district and consists mainly of shale and limestone.

Loralai limestone (Jurassic). This is distributed on the east and west side of Alozai formation.

Parh formation (Cretaceous). There are two distributions of this formation, one occurs in a belt to the east of Fort Sandeman, and the other in the basal part of the geosynclinal structure where Loralai formation occurs. Hindubagh intrusive rocks have intruded into the latter type of this formation and it forms one of the major mineralized areas.

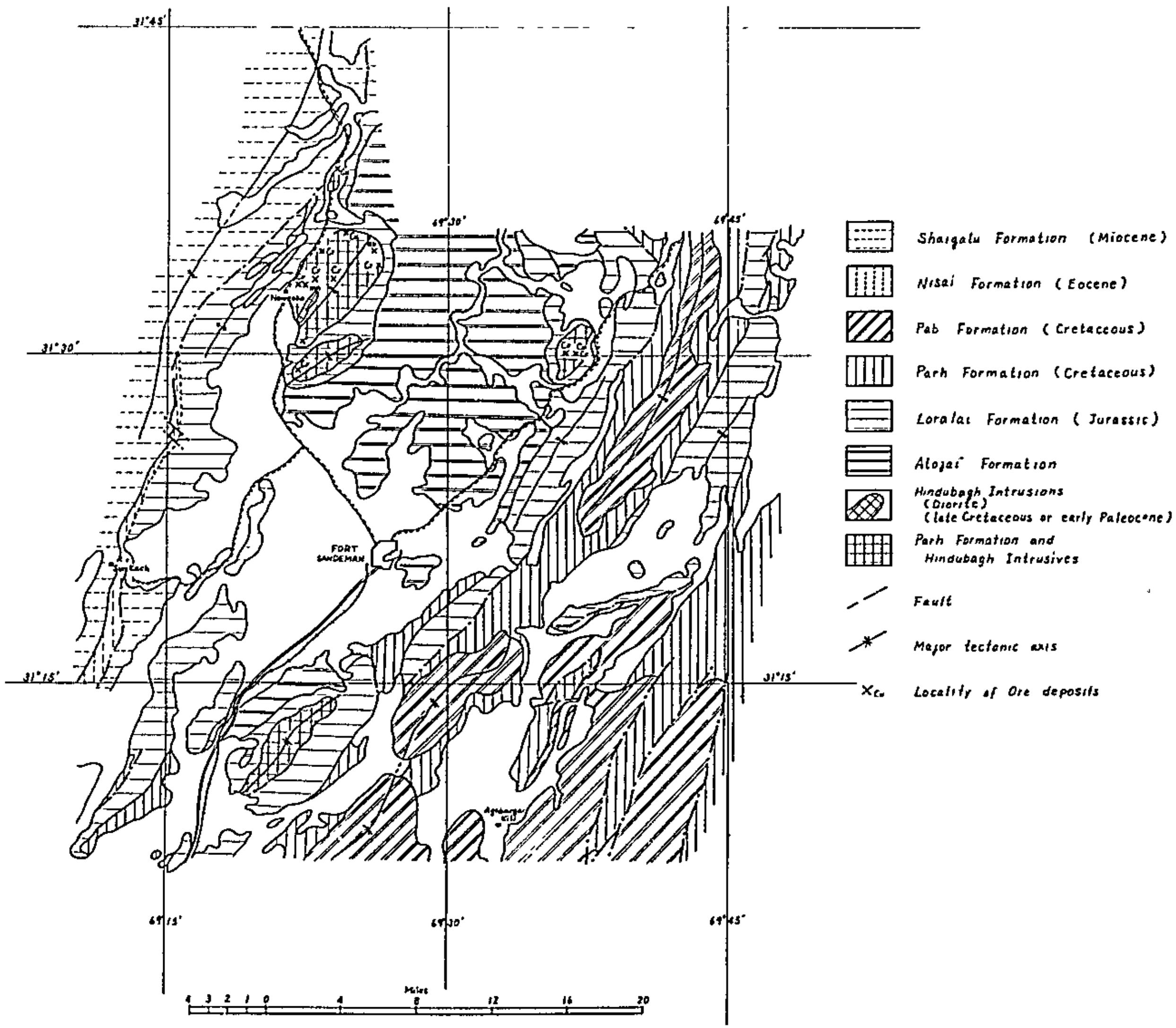
Pab sandstone (upper Cretaceous). This sandstone is distributed in the eastern part of the area with synclinal structure. The main components are sandstone, shale and marl.

Nisai Formation (Eocene - Oligocene). This is distributed in a narrow belt to the west of Fort Sandeman. It is composed of limestone and shale.

Nurgha Faqirzai shale (Oligocene). This formation is distributed in the western part of this area.

Multana formation (middle Oligocene - early Quaternary). This formation is widely distributed to the north and south from Naweboa. The major component is conglomerate associated with shale and

Fig. 8 Geological Map of Fort Sandeman Area



sandstone. Shale and sandstone are predominent in the north.

Hindubagh intrusive rocks (late Cretaceous - Paleocene). These rocks are distributed near Naweoba southwest of Fort Sandeman, and Mt. Zhizha. These were intruded into the Parh formation with basinal structure and the rocks are peridotite, gabbro, diabase, and porphyrite. These occur as small sheets, dykes, and stocks. Igneous activity after late Cretaceous had been active in this area similar to Waziristan district to the north. There were various mineralizing activities related to these igneous bodies and is especially strong in the Parh formation.

C Mineral Deposits

Many exposures of ore deposits are known in this area. These deposits were formed in relation to the activities of the Hindubagh intrusive rocks and commodities include copper, chromite, asbestos and others.

Asbestos: Small chrysotile veins are known to occur east of Naweoba and Mt. Zhizha.

Calcite: Calcite veins are known at Tor Ghundi which is northeast of Naweoba and at localities southeast of Naweoba. The Tor Ghundi veins are said to be 0.3 - 1.8 m wide and 60 - 120 m long and transparent material had been mined for ornamental use for the ceilings of the mosques in the area.

Chromite: Deposits are known at Naweoba and Zhizha. The deposit at Naweoba occurs in serpentinized peridotite and comprises eight bodies. There are two peridotite bodies which are 1 - 1.5 miles long and 500 - 1,000 ft. wide at Zhizha, and chromite bodies are known to occur in them. This deposit consists of small lenses of 0.6 - 1.0 m in width. The total length of the deposit is 15 m.

Fluorite: Fluorite occurs at Khojakzai Kalai which is northeast of Fort Sandeman.

Manganese: Showings of manganese are reported from limestone which is intercalated with Hindubagh intrusive rocks to the east of Naweoba.

Copper: Showings have been reported from Sange Gar, Zhizha, Shin Ghar, Otman, Sulaiman Dawal, Ollaskar and other localities.

Geological and exploratory work have not yet been carried out on the deposits of this area because the mineralized area is in the tribal areas. Thus the ores are in the stage of exposure discoveries. For example, geological conditions similar to those in the vicinity of known chromite deposits near Naweoba are found to the southwest of Fort Sandeman and other areas, but detailed geological and exploratory work have not yet been carried out. It is, however, considered that the possibility of finding large metallic deposits in this area is relatively small from the nature of igneous activities, the distribution of igneous rocks and other factors. But it is necessary to clarify the occurrences, size, grade and other factors of the known deposits.

2-4-2 Pakhrai Copper Deposit

A Location and Access

The deposit is located at lat. 31°33'N, long. 69°22'E, which is 24 km in N18°W direction from Fort Sandeman.

The deposit is reached from Fort Sandeman by driving 21.3 miles (34.1 km) north along the road leading to Wana, and by walking approximately 500 m eastward. The total time is about 50 minutes from Fort Sandeman.

B Topography

This area consists of foot hills with fairly steep mountainous region to the east.

C Geology

The geological units of this area consists of lower Cretaceous Parh formation consisting of limestone, sandstone, mudstone and diabase which intruded into the above formation with a width of approximately 200 m. The Parh formation in this area shows synclinal structure with NE - SW axis and the deposit occurs in the western wing.

D Mineral Deposits

The mineralized zones are observed near the diabase and porphyrite dykes intruding into the diabase with N 60°E, 60°SE direction and width of 1 m.

Ores occurring in film form along the hanging wall and foot wall of porphyrite for 1.5 - 2 m are exposed. They are limonitized.

Secondary copper minerals are observed along the fine cracks in the diabase near the porphyrite. They are accompanied partly by quartz veins. The diabase is generally intensely epidotized and chloritized.

E Ores and Grade

The major ore minerals are secondary copper minerals such as malachite and chrysocolla, but chalcopyrite is observed in some parts. Galena also occurs in small amount.

The gangue minerals are chlorite, epidote, quartz, and calcite. The grade of the representative smaples is Cu 2.59, Fe 11.2 %.

2-4-3 Torghundi Copper Deposit

A Location and Access

The deposit is located at long. 31°38'N, lat. 69°24'E and is 34 km in N8°W direction from Fort Sandeman.

The deposit is 300 m north of Torghundi village. The village is reached from Fort Sandeman by proceeding northward for 27 miles (43 km) on the road leading to Wana, and then advancing 500 m along the river bed in northeast direction.

The time necessary from Fort Sandeman is about an hour and a half.

B Topography

This area is topographically a hilly region near the river bed of the branch of Sri Toi River.

C Geology

The geology of this area consists of lower Cretaceous lapilli tuff and tuff, it is generally reddish brown.

D Mineral Deposits

The deposit consists of copper-bearing calcite veins in tuff. The vein is about 1 m wide and the strike is N65°W and dip is 80°N.

The vein consists almost solely of calcite and secondary copper minerals such as malachite and azurite are observed.

Several parallel veins of similar composition are observed in the vicinity, but they are all small in scale and are not worth exploration.

E Ores and Grade

The ore minerals are malachite and azurite. Sphalerite and galena also occur. The gangue mineral is calcite.

The grade of the representative samples collected was Cu 17.6, Fe 4.58 % and Cu 0.36, Fe 0.74 %.

2-4-4 Rohak Copper Deposit

A Location and Access

The deposit is located at 27 km N8°W of Fort Sandeman and is lat. 31°35'N and long. 69°25'E.

It is accessible by proceeding approximately 23 miles (37 km) northward from Fort Sandeman on the road leading to Wana, and then advancing 7.2 miles (11.5 km) northeastward along a river. The outcrop at the mountainside can be reached by climbing a mountain path for a height difference of 100 m. The time necessary for the trip is one and a half hour drive and a half hour climb.

B Topography

The topography of the area is mountainous and steep, it was formed by the erosion of ultrabasic rocks. The copper outcrop is at the mountainside.

C Geology

The ultrabasic rocks of the Hindubagh intrusives which is considered to have had been active during late Cretaceous to early Eocene are widely distributed in this area. The lithology is mostly peridotite or serpentine.

D Mineral Deposits

Malachite and azurite occur along parallel cracks formed at 30 cm interval in north-south direction with dip of 30°E in the serpentinized peridotite. The length is about 3 m. And the continuity of the outcrop is very poor.

E Ores and Grade

The major ore minerals are malachite and azurite. The grade of the representative samples collected was Cu 3.48, Fe 10.0 %.

2-4-5 Shingar Hill Station Copper Deposit

A Location and Access

The deposit is located 48 km N30°E of Fort Sandeman.

It is about 1 mile climb from Shingar Hill Station, which is reached from Fort Sandeman by driving about 32 miles (52 km) northeast on the road leading to Mughat.

B Topography

The deposit is at an altitude of 2,140 m above sea level. The area generally consists of gently sloping mountains and the exposure is at the mountain side.

C Geology

The geology of this area consists of lower Cretaceous shale and tuffaceous shale. The tuffaceous shale is reddish color because of iron oxide contents.

D Mineral Deposits

The exposure consists of secondary copper minerals occurring as small lenses or films in cracks of N45° E direction in the shale and tuffaceous shale. The width of the cracks is 0.2 m and the length confirmed 1 m. The conditions of the exposure are very poor.

E Ores and Grade

The ore minerals are malachite.

The grade of representative sample collected is Cu 0.69, Fe 2.10 %.

F Recommendations

Only the exposures were observed of the four deposits reported above and data are insufficient for evaluation. Although the analyses of the samples collected show contents of Cu 0.36 - 17.6 %, these were only sampled only locally from the rich parts and the present conditions indicate little economic values. It is, however, necessary to survey these deposits and confirm the dimensions, grade, and distribution of the ores.

2-5 Dera Ghazi Khan District

2-5-1 Uranium Deposits

A Location and Access

The deposit is located at lat. 30°00'N, long. 70°20'E. It is 37 miles (60 km) west of Sakhi Sarwar which is 26 miles (42 km) west of Dera Chazi Khan.

There is a "metal road" (a simple paved road) to Sakhi Sarwar. The road from Sakhi Sarwar to the uranium outcrop is very narrow and rough, jeeps are barely passable, and it can be made in 2 hours and 40 minutes.

A railroad leading north to Lahore via Multan and south to Karachi, passes through the vicinity of Muzaffargarh which is about 30 miles east of Dera Ghazi Khan.

B Topography

The deposit is at an altitude of 1960 m, and the area consists of gently sloping hills.

C Geology

Formations of Siwalik group which consists of thick non-marine post-orogenic sedimentary formations are widely distributed in this area. These were deposited in relation to the Himalayan uplift after Miocene.

At Potwar Plateau, the type locality of this group, the lower horizons are composed of middle Miocene pseudo-conglo-merate, sandstone, and shale with the thickness of 1,500 m, the middle horizons of late Miocene - early Pliocene sandstone and conglomerate with thickness of 1, 800 m. These thick sediments were deposited with the subsidance of the frontal plains of Himalaya related to the uplift of the Range.

The distribution of this formation is roughly divided into three zones of northern, central, and southwestern zones. In the northern zone, the formation is distributed in east-west direction along the northern foot of the Salt Range from northern Sialkot to Bannu through Rawalpindi. In the central part, it extends from Bannu to the vicinity of Quetta through Dera Ghazi and arcs along Sulaiman Range. And in the southern belt, it is distributed along the Nakran Coast Range which is developed along the Arabian Sea from Khuzdar.

The Siwalik group is generally strongly affected by the crustal movement during the period from late pliocene to Diluvium, and intense folding is observed.

The geology of the area near the deposits consists of Siwalik group developed over Eocene limestone. The Eocene series and the Siwalik group constitute the eastern wing of the anticline.

The constituents of the Siwalik group are mainly medium-grained arkose sandstone, and it is generally pale yellow to pale gray, and compact, and contains many fragments of biotite and muscovite. Also lenses of conglomerate 10 to 100 cm thick consisting of granules and pebbles are intercalated in the sandstones. Clay beds are also intercalated in some parts. The strike and dip of the foramtion near the exposure are N20°E and 20°E.

D Mineral Deposits

Radioactive anomaly was discovered in May 1959 by J.A. Reinemund and Nuhammad Abu Bahr at Rakhimunh Village, Dera Ghazi Khan at the central part of West Pakistan. The anomaly was found in the Siwalik group. The anomaly was surveyed by A. Asad (Geological Survey of Pakistan) in May 1960, by the French Team in January 1961, and by S.A. Asad and R.G. Schmidt (United States Geological Survey) in September 1961. Since 1968, detailed survey including trenching and drilling have been carried out by the Atomic Energy Commission of Pakistan, and the occurrence of many anomalies along a belt extending for approximately 120 miles (200 km) in north-south direction from Dera Ghazi Khan to Dera Ismail Khan in the north were confirmed. Survey by UNDP funds from October 1971 for two years is being planned.

Radioactive anomalies are confirmed from six localities of this area, and the Atomic Energy Commission has carried out drilling and trenching in one of these localities.

About 300 shallow drillings (depth, 50 - 100 ft.) have been made in grids of 50 ft. intervals near the outcrops, and trenches have been cut at several to 10 m intervals.

The ore bodies have been followed in the strike direction, but the extent in the dip direction is not well known and future work will be necessary on this point.

The host of the deposit is medium to fine-grained Pliocene sandstone of Siwalik group. It consists mainly of quartz, feldspars, biotite, muscovite, and a few percent of limestone. It is loosely consolidated.

The dimensions of the ore bodies are generally oblong with 200 - 300 ft. in long axis and 100 - 200 ft. in short axis, and the thickness is 2 - 5 ft.. The largest body found to date is 1,200 ft. long and 3 ft. thick.

The ore bodies occur concordantly along the bedding of the medium-grained sandstone. Also there are occurrences which suggest some relationship between the precipitation of uranium and limonite. Lenses of clay stone intercalated in the sandstone are observed in some outcrops. This shows the close relationship between the permeability of the host rock and the precipitation of uranium. Concentration of uranium is also found associated with fragments of plants in some places. Carbonaceous matter is not found in the outcrops, but they have been found in other parts of the Siwalik group. This is another important feature of the host rock.

As S.A. Asad and R.G. Schmidt (1962) pointed out, the lithology of the Siwalik group in the vicinity of the deposits is very similar to that of the Morrison formation at Colorado, U.S.A, and these deposits are considered to be worth detailed exploration.

E Ores and Grade

The grade of the ores is in the order of 0.1 - 0.5 % U_3O_8 and those over 2 % are found very locally. The average is said to be 0.14 %.

The results of the analyses of samples from three localities showed 0.47, 0.86, and 1.09 % U_3O_8.

The major ore mineral is the secondary mineral tuyamunite ($Ca(UO_2)_2(UO_4) \cdot nH_2O$) (S. Hirono, 1971). Marie Lindberg reported (USGS, Report No. WX-2898) that the uranium minerals of the area was probably metatuyamunite. Also L. Warning confirmed the existence of uranium and vanadium (USGS, Report Mp. WS-3897).

F Recommendations

Only a small part of the mineralized area has been surveyed in detail yet. Although individual ore bodies of this deposit are small, several ore bearing horizons have been discovered by detailed survey in the upper Siwalik group. Uranium showings have been found in a vast area northward to Dera Ismail Khan. The average grade of the ore is around 0.14 % U_3O_8 and there are parts containing up to more than 1 %. Thus this area is considered to be quite promising for uranium.

Concerning exploration, although there may be technical difficulties with drilling, the distribution of the ore bodies in the dip direction should be investigated.

The distribution of the Siwalik group occupies, an extremely large area. It is considered that in view of the depositional environment of the group, the entire area of Siwalik group should be surveyed for uranium. Car-borne radioactive survey would be the first step of such surveys.

2-6 Ziarat and Koh-I-Maran Districts

2-6-1 Ziarat Laterite Deposit

A Location and Access

Ziarat is located at lat. 30°20'N, long. 67°43'30"E. The deposit can be reached from Quetta by driving the first 56 km on a paved road and the following 74.5 km on a gravel road. The time necessary is about two and a half hours. The laterite deposits are scattered along the road from Kach (42 km northwest of Ziarat) to Sang Sanjawi (60 km east of Ziarat).

B Topography

The topography of the Ziarat area represents the geologic structure of the area and is characterized by the narrow mountains and valleys extending in east-west direction. But, zig zag pattern of valleys is developed in areas of Cretaceous sedimentary rocks and the features differ.

C Geology (Fig. 9)

The geology of this area consists of Jurassic Loralai (or Chiltan) limestone, Cretaceous Belemnite shale and Parh limestone, late Cretaceous to early Eocene Dunghan limestone, and Eocene Ghazij shale.

Loralai limestone is gray to dark gray and in places brown. It is fine-grained, crystalline with coarse bedding or massive.

Belemnite shale overlies Loralai limestone unconformably and limestone is intercalated in the upper horizons.

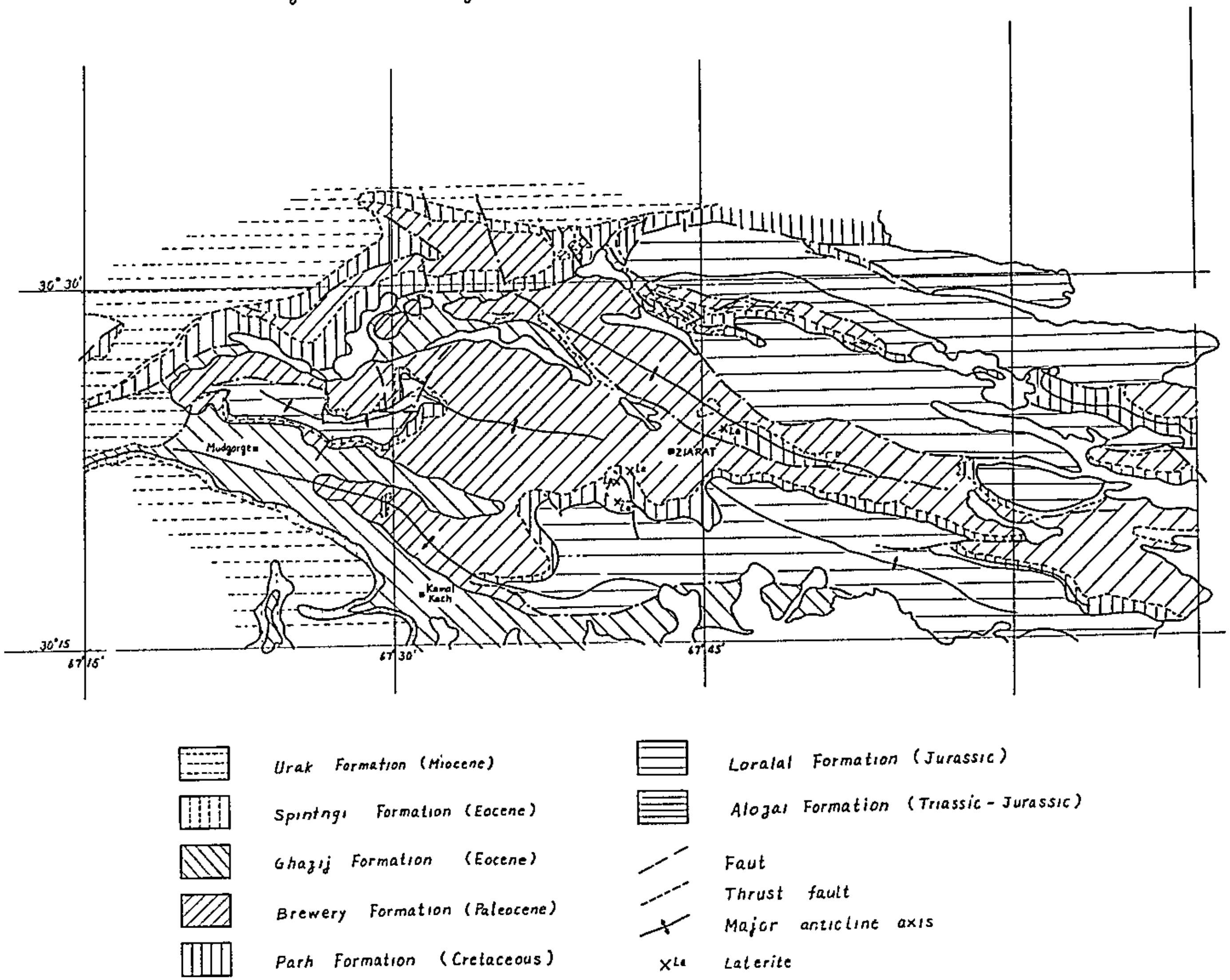
Parh limestone is pastel colored with brown banding. Bedding is developed and small amounts of shale and marl are intercalated.

Dunghan limestone overlies the Parh limestone unconformably, is dark brown to gray, contains many fossils, has coarse bedding, and nodular structure is observed. Laterite is distributed in basal part of this formation.

Ghazij shale is gray, yellowish gray, or brown. It is calcareous and small amounts of limestone and sandstone are intercalated.

Folded structure with E - W to NWW - SEE axes is developed in

Fig. 9 Geological Map of Ziarat Area



this area. Also faults and thrusts parallel to the folding axes are also observed.

D Minerals deposits

The deposits of this area have been studied by Kazmi (1954), Shah (1960), Hunting Survey Corporation (1960) and others. Hunting Survey Corporation reported that the laterite deposits of this area was formed by the weathering of the Parh limestone in the lower horizons. Kazmi and Shah places the original material to the volcanic formation which is distributed in the laterite bearing horizon. J. J. Matzuko and S. A. Stanin of USGS have reported on the stratigraphy and ore mineralogy of the deposit.

The laterite bodies occur in the unconformity between the Parh and Dunghan limestone formations. The thickness of the deposits is 0 - 15 m with an average of 4 m $\pm$. The deposits are traced along the unconformity for a total length of 100 km. Shah (1960) calculated the total reserves to be 15×10^6 tons.

E Ores and Grade

The color of the ores ranges from brown, red, yellow, dark gray to gray, and is pebbly. Clayey nodules are included and pisolitic, oolitic, and nodular structures are common. Limonite is accompanied in places.

Matzk and Stanin reported that the major constituent minerals were boehmite, hematite, limonite, and diaspore associated with kaolin, calcite, gypsum, gibbsite, quartz, feldspars and others. And the grade was Al_2O_3 22.6 - 42.0, Fe_2O_3 31.0 - 37.0 %.

The grade of representative samples collected was Fe 24.5, Ni 0.001 %.

F Recommendations

The members of this team have reached the conclusion that these deposits were formed by the alteration of pyroclastic material which occur in the basal part of the Dunghan limestone. The total length of the ore distribution is more than 100 km and the ores occur along the road between Quetta and Loralai. The average thickness, however, is only about 4 m and the grade is low, also the deposits dip steeply. Thus there are technical difficulties in mining and their economic values are not high.

2-6-2 Koh-i-Maran Fluorite Deposit

A Location and Access

This deposit is located 65 miles (105 km) south of Quetta at lat. 29°31'N and long. 66°54'E.

The closest railway station is Kalpur. There is a paved road between Quetta and Kalpur (28 miles, 45 km), and the 37 miles (60 Km) from the Kalpur to the deposit is a road passable by cars. The necessary driving time is about 3 hours by jeep from Quetta and 2 hours from Kalpur. Tang and Isplinji are the villages in the vicinity.

B Topography

Mt. Koh-i-Maran is the representative peak of the Koh-i-Maran area and the topography is rather steep. The deposit is situated near the summit of the mountains and the vicinity is rather flat with gentle slope. The valleys are steep and extend in east-west or north-south directions. The average altitude of the area near the deposit ranges between 2, 200 and 2, 500 m.

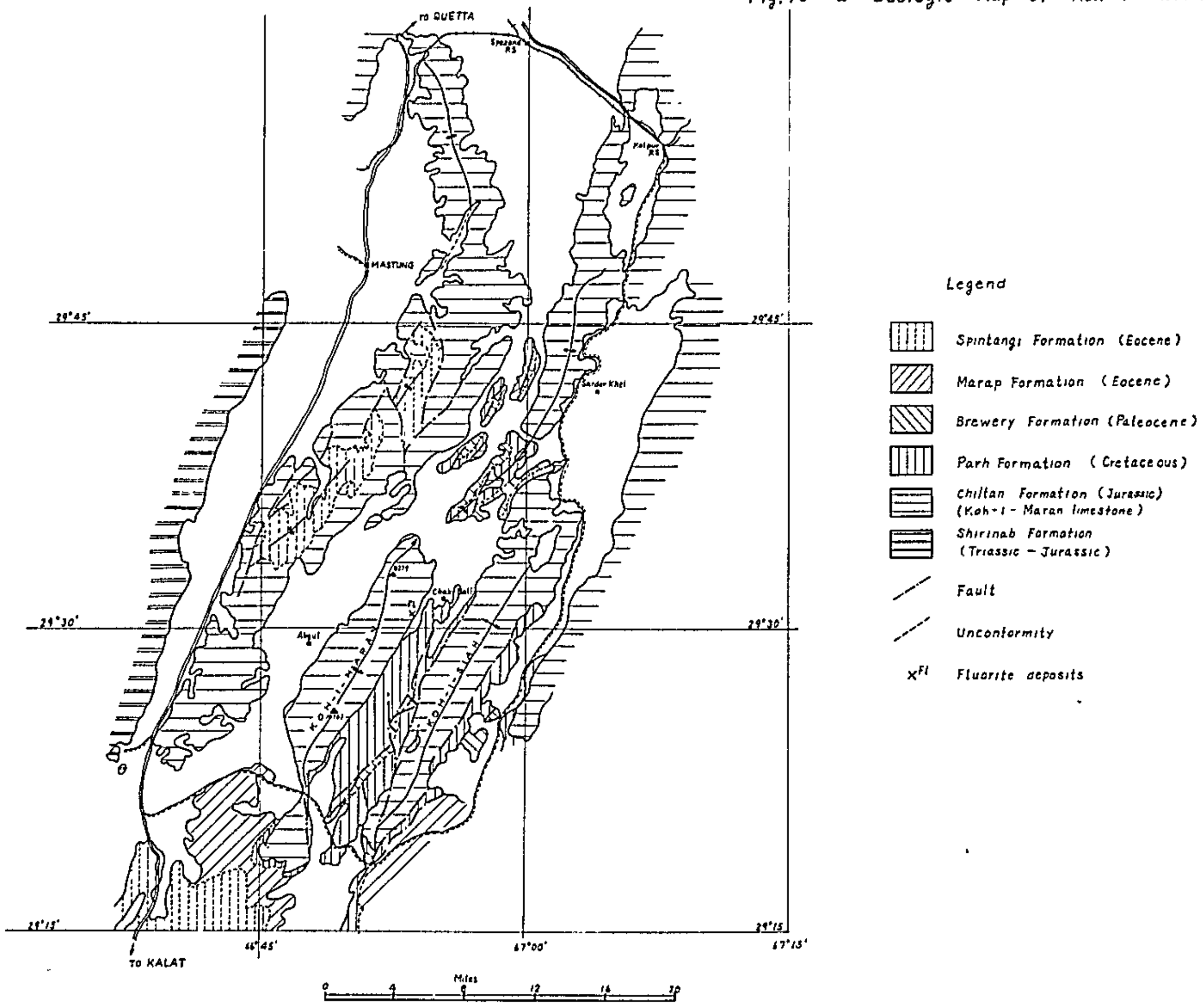
C Geology (Fig. 10)

The geology of the Koh-i-Maran Mountains consists of Jurassic and Cretaceous limestone formations. They tend to extend in NNE direction and parallel anticlines and synclines are observed in the same direction.

The Jurassic limestone formations are called Chiltan group (named Koh-i-Maran limestone in this area). It is gray to grayish black and shows brecciated, nodular, oolitic or small cavernous structures. This formation has anticlinal structure in NNE direction and has joints parallel and normal to the anticlinal axis. In the eastern wing of the anticline, several faults including Hapurshi fault are known.

The Cretaceous formations are divided into the lower Belemnite shale and the upper Parh limestone. They are distributed parallel to

Fig. 10 - a Geologic Map of Koh-i-Maran Area



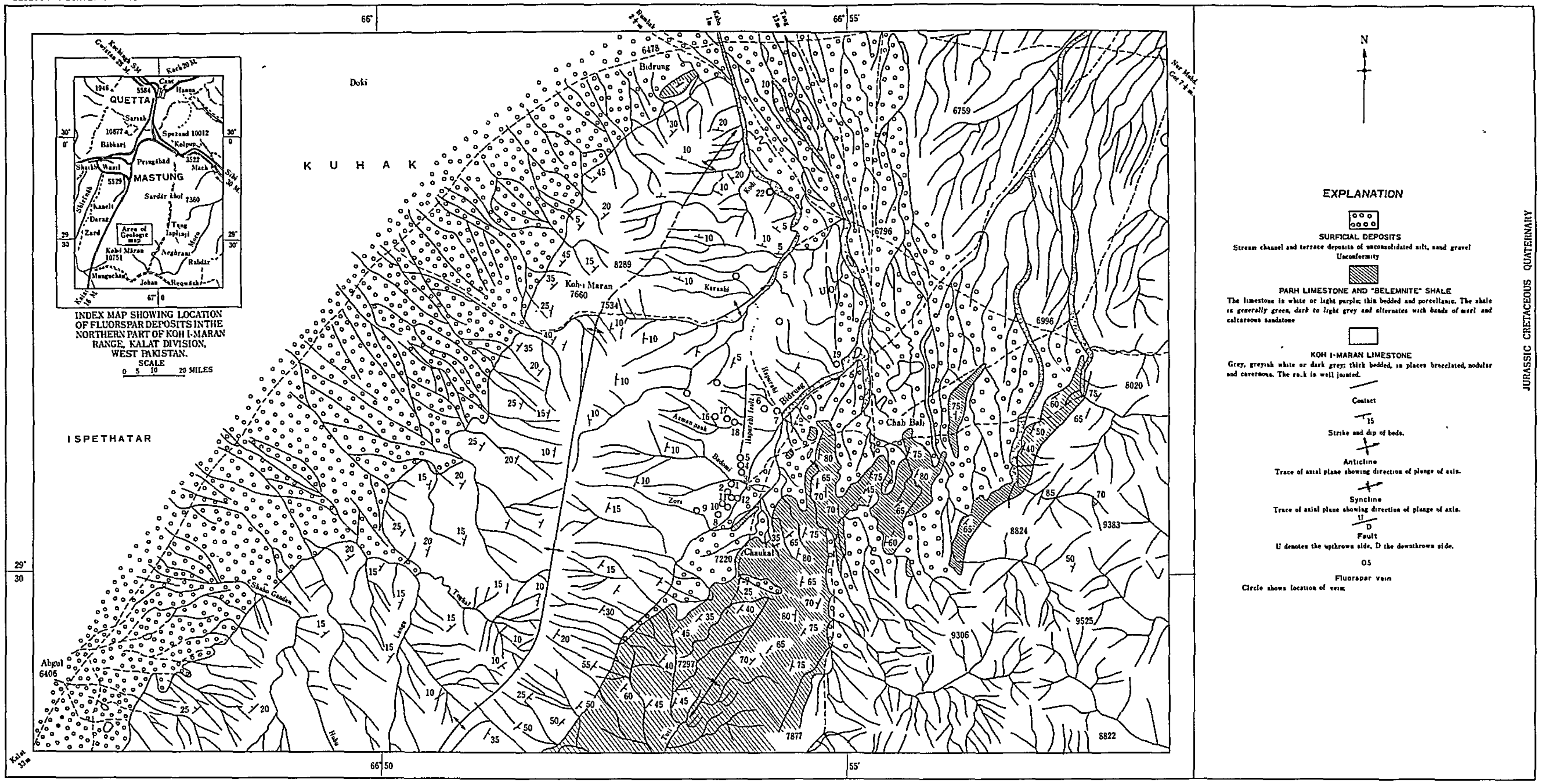


Fig. 10—b Geologic map of Koh-i-Maran Area

0 1 2 3 MILES.

the Jurassic formation to the east of the Jurassic limestone and have synclinal structure. The Belemnite shale is green, dark gray-pale gray with intercalation of marl and calcareous shale. The Parh limestone is red-pale purple and the bedding is well developed, with thin intercalation of shale and chert.

D Mineral Deposit

This deposit was discovered in 1954, survey and exploratory work was carried out by GSP and WPIDC in 1957. It is presently being worked on a small scale.

The fluorite deposit of this area occurs in Jurassic Koh-i-Maran limestone (Chiltan group). There are 25 calcite-fluorite veins. These veins are distributed in an area of about 4 square miles at the eastern wing of the anticline of the Koh-i-Maran Mountains. There are three systems of the veins namely, N-S, N-E, and E-W systems. The width of the veins ranges from several centimeters to a maximum of 2 m, and the length varies from several meters to 300 m. The average of the major 14 veins is 1 m in width, 300 m in strike length, and 30 m in dip length.

Calcite veinlets and network veins several millimeters to several centimeters wide occur in the limestone of the area. These veins widen to 1 m locally and in some parts contain fluorite.

E Ores and Grade

The ores consist of calcite and fluorite, and the color ranges from white, pale yellow to pale violet. The fluorite content of the ores is said to be 10 - 80 % and fluorite larger than 1/4 inch are being hand picked. They were tested at the electric furnace plant of the Pakistan Western Railway in Lahore and was concluded to be suitable for steel making in electric furnaces.

F Recommendations

The fluorite deposit of this area is being worked on a small scale. Detailed survey of the area in the vicinity of the veins has not yet been carried out, and the relationship of the veins is not clear. The mining is being done by trenching from the surface and many factors such as the size of the veins, the extension in dip direction, the position, size, and shape of the bonanzas are yet unknown.

It is believed that structural characteristics of the ore in which the veins occur, the nature of the mineralization will be clarified, and also discovery of new veins would be possible by detailed surface geological survey. There is also a possibility that the results of these surveys would warrant large scale systematic development of the deposit.

3. CONCLUSION AND RECOMMENDATIONS

3-1 Conclusion

The type, size, country rocks, and the grade of the mineral deposits surveyed by this team are shown in Table 1

The conclusion and recommendations concerning the deposits visited were mentioned in the chapters concerned. The following items, however, will be applicable to all of these deposits for further survey and exploration.

(1) Preparation of topographic maps and utilization of aerial photographs.

(2) Basic geological survey of the areas in the vicinity of the deposits.

At present, both of the above basic works have not been carried out to a sufficient degree. For future exploration, it will be necessary to clarify the lithological distribution, geological structure, the overall distribution of outcrops, the stratigraphic relation of the outcrops, the dimensions of alteration zones near the deposits where they occur as well as to prepare topographic maps. These data can be obtained without much difficulty judging from the conditions of the exposure of the rocks and they will be instrumental in promoting further exploration and development.

(3) Application of geophysical and geochemical prospecting methods.

At present, drilling or mining operations are being carried out immediately after the discovery of outcrops. And the results are not always satisfactory. It will be desirable to apply geophysical or geochemical prospecting methods together with basic surveys. In this case the methods to be applied should be selected with the type and conditions of the deposits. This will enable you to clarify the concentration and dispersion of elements associated with mineralization, the subsurface geologic structure, the distribution of the mineralized zones and other important factors together with the geological conditions at the surface.

Table 1 Surveyed Deposits

District, Name of Deposits	Type of Deposits	Size of Deposits	Major Ore Minerals	Country Rock	Grade
Chagai district					
Saindak copper deposit	Dissemination (porphyry copper)	Mineralized area 1 sq. mile	Malachite, azurite pyrite	Granite & diorite intruded into Saindak group	
Chilghazi iron deposit	Platy replacement	Outcrop length 15 - 200 m 61 ore bodies Fe 55% 2,500,000 t	Magnetite	Sinjrani (Cretaceous)	
Bandagan copper, iron deposits	Contact (Vein form)		Chalcopyrite, pyrite, magnetite, hematite	Fractured zone at the contact of Pish formation and syenite, monzonite and diorite.	Fe 35.5% Cu 0.5%
Khuzdar district					
Barite deposit	Bedded, lens	Individual bodies are 80m x 2-5m, 140m x 4-5m, 360m x 9-15m Strike N-S, dip 20-30°W, 50-80°W reserves 1,640,000 t	Barite	Jurassic limestone (Zidi group)	75-85% barite
Shekran iron	Veins	Strike E-W 70-300m x 2-20m, 4 veins, total length 2,500m	Limonite, hematite, siderite		Fe 30% ±
Hindubagh district					
Chromite deposit	Veins, lens, dissemination		Chromite	Serpentinized peridotite in Hindubagh intrusive rocks	Cr_2O_3 47-55%
Magnesite deposit	Veins	Strike N80°W, dip 90° ± 200m x 30 ± x 1.5-5m	Magnesite		
Fort Sandeman district					
Pakhrai copper deposit	Veins	Strike N60°E, dip 60°SE length 1.5-2.0m	Malachite, azurite, sphalerite, galena	Diabase dyke intruded into lower Cretaceous	
Torghundi copper deposit	Veins	Strike N65°W, dip 80°N, width 1.0m, parallel veins	Nalacite, azurite	Lower Cretaceous tuff	
Rohak copper deposit	Veins	Strike N-S, dip 30°E, length 30m, parallel veins	Malacite azurite	Serpentinized peridotite in Hindubagh intrusive rocks	
Shingar copper deposit	Veins	Strike N45°E, width 0.2m ± length 1.0m ±	Malacite	Lower Cretaceous shale	
Dera Ghazi Khan district					
Uranium deposits	Bedded	Strike N20°E, dip 20°SE, 60-100m x 30-60m x 0.5-1.5m max. 360m x 1.0m, several ore bodies	Tuyamunite	Middle Miocene upper Siwalik	0.1-0.5% U_3O_8, av. 0.14% U_3O_8 repres. ore 0.47 1.09% U_3O_8
Others					
Ziarat laterite deposits	Bedded	Thickness 0-15m (av. 4m ±) total length 100km +	Hematite, limonite, boehmite, diaspare	Unconformity between Cretaceous Parh limestone and Cretaceous-Eocene Dunghan limestone	Al_2O_3 22.0-42.0% Fe_2O_3 31.0-37.0%
Koh-i-Maran fluorite deposit	Veins	300m x 30m x 1.0m (av. of 14 veins), total of 25 veins	Fluorite, calcite	Jurassic Koh-i-Maran limestone	10-80% fluorite Caf2

(4) Transportation and water

The occurrences of major ore minerals with few exceptions, in West Pakistan are in the northern and northwestern highlands and Baluchistan State. The railways and roads of these areas are yet to be developed, and this is a distinct disadvantage for exploration and development of ore deposits. Also water will be a large problem for these operations. Therefore, except in cases of extremely large deposits and especially high-grade ores, it will probably be economically difficult to develop the individual deposits independently. As mentioned in the section on the deposits of Chagai district, it would be more feasible to plan overall regional economic development and incorporate the development of these smaller deposits within the large projects.

3-2 Future Projects

The present survey team considers the following to be suitable for realization by future technical co-operation projects between Japan and Pakistan.

(1) Survey of uranium resources

Car-borne radiometric survey of Siwalik formation and corresponding formations.

(2) Survey of nickel and chromium resources

Surface geological and geochemical survey of ultrabasic bodies distributed in the Khuzdar-Bela region.

(3) Aeromagnetic survey

Technical co-operation concerning the implementation of a part or the total aeromagnetic survey project planned by the Pakistan Government.

3-2-1 Survey of Uranium Resources

(1) Geological environment

The uranium deposits west of Dera Ghazi Khan occur in the Miocene formation of the upper horizon of the Siwalik group. The Siwalik group consists of non-marine sedimentary formations which consist mostly of medium-grained arkose sandstone, associated partly with conglomerate lens (several tons of centimeters to 1 m thick) and shale. When the members of this group deposited the division of the Baluchistan geosyncline had progressed and the Central and Las Bela geoanticlines were completed in the central part of the geosyncline. And it was the period when the uplifting movement of the Himalaya Range was most intense. It is believed to be the period when the frontal sedimentary basin changed to form a narrow trough by the effect of the movement, the fluviatile sediments originating from the Himalayas formed the Siwalik group.

(2) The distribution of the Siwalik group and corresponding formations

The Siwalik group extends in west-northwest direction from north of Sialkot to the vicinity of Rawalpindi, and then in east-west direction along the northern edge of the Salt Range, and is further distributed in north-south direction from the vicinity of Bannu to the west of Dera Ghazi Khan. Sibi formation occupies the same stratigraphic horizon as the Siwalik group. It is distributed from south of Sibi along a large synclinal axis through east of Quetta and further in a belt to the south. The extension of this formation lies at the eastern foot of the Kirthar Mountains, and continues to the vicinity of Karachi where it is called the Gaj group and Manchar group. Gaj and Manchar groups are known to occur along the Makaran coast of the Arabian Sea.

Gaj and Manchar groups deposited in a different sedimentary basin from the Siwalik and Sibi groups. The members of the groups deposited as delta or flaviatile sediments in the southern Makaran sedimentary basin and the original material is believed to have been derived from the Chagai Mountains and the central parts of the geosyncline.

(3) The possibility of the exsistence of workable deposits

As mentioned carlier, uranium deposits were discovered to the west of Dera Ghazi Khan in the upper formation of the Siwalik group. And several showings have been found in the area extending to Dera Ismil Khan in the north. Thus the possibility of finding new deposits in areas where Sibi and Siwalik groups are distributed is very high. The radioactive anomalies in the Gaj and Manchar groups have not yet been surveyed. The occurrence of uranium concentration in these groups must be investigated.

(4) The methods of survey

Car-borne radiometric survey is most suitable for the first phase of the survey covering large areas. Radioactive anomalies found by this first phase should be followed by detailed geological survey and exploration. The Siwalik group in the area between the neighborhood of Rawalpindi to Bannu, the Sibi formation southward from the vicinity of Sibi, and the Marakan Coast would be the areas for starting the survey.

Also together with the survey of the Tertiary formations, investigation of older formations with similar sedimentary environment is also desirable.

3-2-2 Mineral Survey of Khuzdar - Bela Area

(1) Geology and mineral deposits

The Khuzdar-Bela area is located in the central part of the geosyncline and extensive basic and ultrabasic igneous activities took place in Pliocene - Eocene age. Occurrence of granite is known very locally. These igneous rocks are distributed in an area of more than 100 miles in north-south direction. Also these ultrabasic rocks have been laterized to various degrees.

The known deposits of this area are iron, barite, manganese, and also occurrences of asbestos, copper, fluorite, celestite, and chromite are known. These deposits were formed in relation to the activities of Bela igneous rocks and Loralai intrusive rocks. These minerals are known to occur, but neither geological nor mineral surveys have been carried out with a few exceptions. Also the laterite deposits which occur near the surface of the ultrabasic bodies have not been studied geologically.

(2) The objectives of the survey

Mineral survey for nickel in the area of ultrabasic rocks would be most desirable. The grade of the ore sampled at west of Khuzdar was Ni 0.001 - 0.182 % and Fe 4.4 - 36.9 %, but the distribution of Ni must be clarified by regional survey so that evaluation of the deposits will be possible.

The occurrences of other minerals will naturally become clear by this survey and the results will serve as a basis for future exploratory work. From the geological conditions observed from the surface, it probably will not be possible to find large resources such as porphyry copper deposits, contact metasomatic deposits and others. But, if the dimensions, forms and other factors of acidic igneous bodies in the deeper parts can be confirmed by geophysical methods, exploration for blind deposits will be greatly facilitated.

(3) Methods of survey

Surface geological and geochemical surveys will yield the best results for the exploration of nickel. Various rocks are well exposed in this area and pitting and trenching in grids for systematic sampling from the surface to the original rocks should be done in areas of ultrabasic rocks. The analysis of these minerals will enable economic evaluation of the deposits and the results will serve as the basis for selecting sites for further detailed work. The nickel mineral is garnierite in the laterites.

3-2-3 Air-borne Magnetic Survey

Upon the recommendation of the Geological Survey of Pakistan, the Government of Pakistan is planning an air-borne magnetic survey of seven areas of the country including East Pakistan.

The areas were selected on the basis of information concerning mineralization, and the major objective is the direct exploration of the mineralized areas and also to understand the geologic structure of areas related to mineralization.

Of these seven areas, the present team was able to visit the two areas of No. 2 Chagai and Kharan area, and No. 5 Khuzdar - Bela area. As we were not able to visit other areas, we will discuss here on the air-borne magnetic survey plans of the above two areas.

(1) No. 2 Chagai and Kharan areas

During our discussions of the Saindak, Chilghazi, and Bandagan deposits, we mentioned the necessity of aerial survey because of the high possibility of the occurrence of porphyry copper and contact metasomatic deposits in this area.

Acidic to intermediate igneous activities were especially intense in this area and also iron, copper, lead, zinc, and other mineralization is known, and chromite deposits associated with ultrabasic rocks have been found.

The general outline of the geology of this area is known from the Hunting Report submitted by Canada, and various surveys carried out by the Geological Survey of Pakistan on individual deposits. There are, however, many areas which have not yet been surveyed.

Aerial photographs were analysed and geological maps were made from the interpretation in the Hunting Report. The correlation of magnetic anomalies obtained from aerial magnetic survey with these geological maps will be most useful for exploratory work. Especially in the Chagai area, the rocks are very well exposed, but the surface of these rocks are uniformly black due to oxidation, and the possibility of not recognizing ore outcrops cannot be denied, therefore it is necessary to check the results of the geological interpretation of the aerial photographs by air-borne magnetic survey.

(2) No. 5 Khuzdar-Bela area

The air-borne magnetic survey project of this area is somewhat different from that of the Chagai district and it probably will not be directly useful for mineral exploration. The reason is that most of the deposits in this area are of epithermal origin, and contact metasomatic deposits cannot be expected to exist near the surface in this area. Also as the rocks are again very well exposed, bodies related to ores such as ultrabasic rocks is distinguished on aerial photographs and the magnetic anomalies and new deposits may not be related.

But shallow hydrothermal deposits occur in this area and as these deposits are related to acidic to intermediate igneous activities, this indicates that there are hidden igneous bodies in this area. Thus the magnetic survey may be useful in confirming the existence of such bodies and it will be instrumental for future mineral exploration for blind deposits.

(3) In other areas planned for the air-borne magnetic survey, geological interpretation of the aerial photographs has not been made and it should be carried out simultaneously with the magnetometer survey. After the completion of the air-borne work, surface geological, geophysical, and geochemical work must be carried out and then proceed to drilling operations. This will be the normal procedure for mineral exploration.

References

Hunting Surv. Corp. Ltd. (1961) ; Reconnaisance Geology of Part of West Pakistan

Kazi S. Ahmad (1969) ; A Geography of Pakistan

Zaki Ahmad (1969) ; Directory of Mineral Deposits of Pakistan. Records of the Geological Survey of Pakistan (Rec. G S P), Vol. 15, Part 3

Ministry of Finance (1970) ; Pakistan Economic Survey 1969-1970

Rafe Uz Zaman (1970) ; Pakistan Year Book 1970

E.R. Gee (?) ; The Mineral Resources of North Western India. Rec. G S P, Vol. 1, Part 1

M. L. Ahamad (1951) ; Volcanos and Sulphur of Western Baluchistan. Rec. G S P, Vol. 4, Part 3.

M. Abu Bakr (1957) ; Preliminary Report on Vermiculite near Doki River in Western Ras Koh Range, Kalat Division, West Pakistan. Information Relase (I. F.), No. 5, G S P

A. H. Kidwai & S. A. Immam (1958) ; Magnetite Deposits of Dammer Nissar, Chitral State, West Pakistan. I. F. No. 7, G S P

R. A. Khan Tahirkheli (1959) ; Report on Lead-Zinc Deposits near Ushu, Swat State, West Pakistan. I. F. No. 9, G S P

W. Danilchik & R. A. Khan Tahirkheli (1959) ; An Investigation of Alluvial Sands for Uranium and Minerals of Economic Importance : The Indus, Gilgit, Nagar and Hunza Rivers, Gilgit Agency, West Pakistan. I. F. No. 11, G S P

Jan M. Master (1960) ; Manganese Showings of Las Bela District, West Pakistan. I. F. No. 13, G S P

Waheeduddin Ahmed (1960) ; Iron Deposits of the Baluchap and Kundi Areas, Dalbandin, Chagai District, West Pakistan. I. F. No. 16, G S P

R. G. Bogue (1961) ; Cost Estimate for Concentrating Low-Grade Chromite Ore, Hindubagh Mining District, West Pakistan. Mineral Information Circular (M. I. C.) No. 1, G S P.

Waheeduddin Ahmed (1962) ; Copper Showing near Barwa-Kambat, Dir State, West Pakistan, M. I. C. No. 7, G S P

Muhammad Abu Bakr (1962) ; Vermiculite Deposits in the Doki River Area, Ras Koh Range, West Pakistan. Rec. G S P, Vol. 9, Part 1.

Muhammad Abu Bakr (1962) ; Fluorspar Deposits in the Northern Part of Koh-i-Maran Range, Kalat Division, West Pakistan. Rec. G S P, Vol. 9, Part 2.

Richard G. Bogue (1963) ; Manganese Deposits at Sanjro near Bela, Kalat Division, West Pakistan. M. I. C. No. 9, G S P.

M. Abu Bakr (1963) ; Geology of the Western Ras Koh Range, Chagai and Kharan Districts, Quetta and Kalat Divisions, West Pakistan. Rec. G S P, Vol. 10, Part 2-A.

S. A. Bilgrami (1964) ; Mineralogy and Petrology of the Central Part of the Hindubagh Igneous Complex, Hindubagh Mining District, Zhob Valley, West Pakistan. Rec. G S P, Vol. 10, Part 2-C

Curt Teichert (1964) ; Recent German Work on the Cambrian and Saline Series of the Salt Range, West Pakistan. Rec. G S P., Vol. 11, Part 1

M. Abu Bakr (1965) ; Geology of Parts of Trans-Himalayan Region in Gilgit and Baltistan, West Pakistan. Rec. G S P., Vol. 11, Part 3.

W. Ahamed (1965) ; Onyx Marble of Chagai District, Quetta Division, West Pakistan. Rec. G S P., Vol. 12, Part 2.

S. Tayyab Ali, J. A. Calkins & T. W. Offield (1964) ; Mineral Deposits of the Southern Hazara District, West Pakistan. Rec. G S P., Vol. 13, Part 1.

M. A. Rashid & et al (1965) ; Mineral Deposits of the Eastern Kohat Region, West Pakistan. Rec. G S P., Vol. 13, Part 2

S. H. A. Shah (1965) ; The Structure of the Area between Ziarat and Wani, Sibi and Loralai District, West Pakistan. Rec. G S P., Vol. 14, Part 2.

Abul Farah & Arif Raza Jafree (1965) ; Regional Gravity Survey of Tatta District, Hyderabad Division, West Pakistan. Rec. GSP., Vol. 15, Part 2

M. Abu Bakr (1965) ; Vermiculite Deposits of Pakistan. Rec. GSP., Vol. 16, Part 1.

M. Abu Bakr (1965) ; Fluorspar Deposits of Pakistan. Rec. GSP., Vol. 16, Part 2.

M. Ahmed (1965) ; Marble in Pakistan. Rec. G S P., Vol. 17, Part 1.

F. L. Klinger, J. J. Matzko & S. H. Abbas (1966) ; Antimony Deposits of the Quetta-Pishin District, Quetta Division, West Pakistan. USGS Techinical Letter Pakistan Investigation Pk-2

W. Ahmed, S. N. Khan & R. G. Schmidt (1966) ; Geology of the Saindak Quadrangle, Chagai District, Pakistan. Pakistan Investigation Pk-9

J. J. Matzko & S. A. Stanin (?) ; Stratigraphy and Mineralogy of Laterite beds near Ziarat, Quetta Division, West Pakistan. USGS Technical Letter Pakistan Investigation Pk-23

R. H. Nagell (1967) ; Reconnaisance of the Geology and Ore Mineralization in Part of the Chagai District, West Pakistan. USGS Project Report Pakistan Investigations (IR)-Pk-27

Roger von Vloten (1967) ; Interim Results of Geological Investigations of Chromite Deposits in the Nasai Area, Hindubagh Mining District, West Pakistan. USGS Project Report Pakistan Investigation (IR)- Pk - 41

R. G. Schmidt (1967) ; Exploration Possibilities in the Western Chagai District, West Pakistan. USGS Technical Letter Pakistan Investigation Pk-42

S. Anisuddin Ahmed (1966) ; Report on Limestone Resources of Loralai and Harnai Area, West Pakistan. Pre-Publication Issue No. 60, GSP.

S. A. Bilgrami (1968) ; Geology and Chemical Mineralogy of the Zhob Valley Chromite Deposits, West Pakistan. Am. Mineral Vol. 54, P. 134-148.

Ali Asad (1962) ; Uranium Mineralization near Rakhimunh Village, Dera Ghazi Khan District, West Pakistan. M. I. C. No. 5, G S P.

R. G. Bogue (1962) ; Introductory Mineralogic Studies of Chromite, Hindubagh and Fort Sandeman Mining District, West Pakistan. Interim Geological Report No. 1, G S P.

F. L. Klinger (1967) ; Barite Deposits near Khuzdar, Kalat Division, West Pakistan. USGS Technical Letter Pakistan Investigation Pk-21.

R. A. Khan Tahirkheli (1967) ; Reconnaisances for Radioactive Minerals in Dardistan, Baltistan and Harmosh in Gilgit Agency, West Pakistan. I. R. No. 33, G S P.

A. D. Shcheglov (1969) ; Main Features of Endogenous Metallogeny of the Southern Part of West Pakistan. Memoirs of the Geological Survey of Pakistan, Vol. 7

S. Hasan Gauhar (1969) ; Economic Minerals of Pakistan (A brief review). Pre-Publication Issue No. 88., G S P.