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ECONOMIC PROGRAMME

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January 29, 1976

CENTO UNCLASSIFIED
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ERTS

PI = MORRIS CRAWFORD

ADVISORY GROUP ON MINERALS DEVELOPMENT

REGIONAL INVESTIGATION OF TECTONIC AND IGNEOUS GEOLOGY IN CENTO REGION - FIRST QUARTERLY REPORT

(E76-10297) REGIONAL INVESTIGATION OF TECTONIC AND IGNEOUS GEOLOGY IN IRAN, PAKISTAN AND TURKEY Quarterly Report (Central Treaty Organization, Ankara (Turkey).) 28 p HC $4.00 CSCI 08G G3/43
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Reference EC/24/D7 (Para 10) dated December 17, 1975.

2. CENTO is participating in the Earth Resources Technology Satellite Programme of the National Aeronautics and Space Administration (NASA) of the USA and has entered into an agreement to conduct investigations of tectonic and igneous geology in six test sites of the Region for which images and data acquired by remote sensors are to be supplied by NASA.

3. Under the terms of the agreement CENTO Secretariat is required to submit quarterly progress reports to NASA on the basis of investigations and results reported by the National Geological Organizations of the Region i.e. Geological Survey of Iran (GSIR), Geological Survey of Pakistan (GSP) and Mineral Research and Exploration Institute of Turkey (MTA). Submission of first quarterly report to NASA is due in January 1976. Till now only GSP and MTA have furnished their reports on the basis of which Secretariat has compiled the First Quarterly Report on the project which is attached as Annex 'A' and is being transmitted to NASA.

ACTION REQUESTED

4. The Government of Iran is requested to advise the Geological Survey of Iran to expedite submission of their report on the project as early as possible.

DISTRIBUTION

Iran	12
Pakistan	10
Turkey	12
U.K.	16
U.S.A.	30
Files	3
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28410

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ANNEX 'A' TO
EC/24/M/D10

INVESTIGATION No. 28410

FIRST QUARTERLY REPORT ON REGIONAL INVESTIGATION OF TECTONIC AND IGNEOUS GEOLOGY IN IRAN, PAKISTAN AND TURKEY

BY

CENTRAL TREATY ORGANIZATION SECRETARIAT

JANUARY 29, 1976

28410 - REGIONAL INVESTIGATION OF TECTONIC AND IGNEOUS GEOLOGY IN IRAN, PAKISTAN AND TURKEY

I. INTRODUCTION

Central Treaty Organization (CENTO) is participating in the ERTS Follow-On Programme and has entered into an agreement with National Aeronautics and Space Administration (NASA) to conduct analysis of ERTS data, through the National Geological Organisations of its Regional Member Governments for investigation of tectonic and igneous geology in six test sites in the Region 2 in Iran, 2 in Pakistan and 2 in Turkey. Principal objectives of the project are as follows:

(i) To test the usefulness of ERTS multispectral imagery, within the geological and evironmental conditions of the CENTO region, in:

a) Identifying, tracing, and determining the extent of fault lines, offsets, landslides, slumping, drainage changes, and other phenomena associated with recent faulting.

b) Identifying and mapping intrusive and volcanic rocks, and their structural and contact relationships, with special attention to the mapping of ophiolites and centers of volcanism.

c) Identifying and delineating areas of mineralized and altered rocks, with special attention to base metal mineralization associated with granitic intrusives.

d) Identifying geological environments favorable for geothermal exploration.

(ii) To prepare geologic and tectonic maps of selected areas along major zones of faulting and igneous activity in each of the CENTO region countries in order to illustrate the applications of ERTS imagery and lay the base for geologic and tectonic maps of the entire region.

/ (iii) To obtain

(iii) To obtain more information about the relationship of metallogenesis to tectonic and igneous activity, and help identify guidelines for mineral exploration.

(iv) To evaluate the relation between tectonic and igneous activity in the areas of investigation for comparison with the relationships that exists along typical boundaries of crustal plates.

2. Deputy Secretary General (Economic) of CENTO is Principal Investigator of the Project while each National Geological Organization (Geological Survey of Iran, Geological Survey of Pakistan, Mineral Research and Exploration Institute of Turkey) has nominated one Co-investigator for data handling and conducting as well as coordination of research work within the country.

3. The Principal Investigator, under the terms of agreement, is required to submit quarterly progress reports to NASA one month after the end of each quarter. First consignment of adequate data to initiate the studies under this project was received by the Coinvestigators in August 1975 which made the first quarterly report due in January 1976. As the investigations under this project are to be conducted in parts by Coinvestigators, the reports for each part were awaited by the Principal Investigator for submission of this quarterly report to NASA. By 29th January 1976, the date of this report only Turkish and Pakistani parts were received which were also not essentially in the format as specified in Attachment 'D' to the "Provisions for Participation For ERTS Follow-On Program". This appears to be mainly due to the reason that Regional Geological Organizations have yet to straighten out the difficulties being faced in procurement of necessary equipment for photo-reproduction and photo - interpretation.

/ II. TECHNIQUES

II. TECHNIQUES

4. For tectonic study, Remote Sensing Cell of Geological Survey of Pakistan has reported to have used black and white prints on 1:1,000,000 of 3 frames falling between latitude 25°N to 26°N and longitude 64°E to 27°E taken on 18th February 1975, 19th February 1975 and 10th February 1975 in MSS bands 4,5,6 and 7. Structural delineation was possible by comparative study of black and white prints in band 5 and 7 of the same frames with the help of magnifying glass (5X) under ordinary tube light. Transperencies of the same frames in bands 4,5 and 7 on scale 1:369,000 taken during 3rd November 1972, 29th November 1972 and 15th January 1973 were also viewed separately and as colour composite on colour additive viewer model I^2S but the image quality was not found to be good. The Ornach-Nal fault system and mud volcane cones picked up on the imageries were compared with Geological map of Pakistan on 1:2,000,000 Scale and found to be accurate and showing added lateral extent of the fault not indicated on earlier maps.

5. For study of Intrusive and volcanic rocks of Bela igneous complex, Remote Sensing cell of GSP used 70 mm positive transperencies, 9 1/2 inch positive transperencies, and 9 1/2 inch black and white prints of one frame falling between latitude 25°to 26°30 N and longitude 66°to 67°E. The 70 mm. imagery was taken on 3rd November 1972 free of cloud cover but of poor image quality while 9 1/2 inch imagery was acquired on 18th February 1975. 70 mm. Transperencies in MSS band 4,5 and 7 were studied on color additive viewer Model I^2S. For separating sedimentary and extrusive rocks from ultramafics best results were achieved on 70 mm transperencies by adding small red colour tint in band 4, full green in band 5 and full blue in band 7. However, this technique obscured vegetation details and cultural features. 9 1/2 inch positive transperencies were utilized for preparation of colour composite by a diazo printer using yellow film for band 4, magenta for band 5 and cyon for band 7. All three prints when superimposed gave best results for plotting separately on overlays (i) physiographic and cultural features

/(ii) linear features

(ii) linear features (iii) ultramagic complex (iv) mafic complex including basalt, gabbro and aggromerate as its separate identification on imageries is difficult and ambiguous and (v) lava flows interbedded with sedimentary rocks. 9 1/2 inch black and white prints when studied under magnifying glass was found to be most useful in band 5 for separating ultramagic from mafic rocks (gabbro & basalt) while bands 6 and 7 did not provide much tonal contrast. The studies of Bela igneous complex were based on colour composites prepared from 9 1/2 inches positive transperencies and benefits were taken of comparison with 70 mm. transperencies and 9 1/2 in black and white prints. Field checks for one intrusive body (showing sharp discordant contact with surrounding rock and found to have dark colour due to higher percentage of dissemunated iron) and for few linear features were made while rest of it was compared with previous maps.

6. Mineral Exploration and Research Institute of Turkey (. MTA) has started the work on the project by preparation of a photo mosaic of Turkey in 1:1,000,000 scale in band 5 and its comparison with overlay of same scale containing available geological and tectonic information. It is reported that some igneous rocks correlate well with grey tone variations but this criteria to identify volcanic rocks has not been found always successful and needs further verifications by study of drainage systems. Tectonic features observed on the images show a good correlation with known tectonics and also indicate some new information.

III. ACCOMPLISHMENTS

(i) Pakistan

7. Ornach-Nal fault, a significant capable fault in the southern region of Pakistan earlier known to have lateral extent of 200 Km. was delineated for 330 Km. upto Arabian Sea and appearance of fault trace of about 8 Km. on Ormara Island suggest it to be in continuation. Fault traces through alluvium were not indicated on previous maps but

/came up nicely

came up nicely on imageries. Probable northward extension of this fault shall be studied later.

8. Bela igneous complex was found to be an assemlage of ultramafic complex, mafic complex and lava interlayered with sedimentary rocks which suggests that this complex represents part of ophiolitic sequence. The presence of concentric zoned body of basalt, detected on imageries and on examination being found rich in iron and calcium minerals may be indicative of consuming plate margin.

(ii) Turkey

9. MTA is busy in sythesing the existing geological and tectonic information for comparison with photo mosaic of 1:1,000,000 scale prepared from black and white prints and selection of areas for initiating detailed studies.

IV. SIGNIFICANT RESULTS

10. Although specific benefits from the investigations so far carried out cannot be spelled out but it is apparent that mapping of intrusive and volcanic rocks in the region shall be accelerated and similarly the project will yield improved tectonic maps of the region.

V. PUBLICATIONS

11. The following reports furnished by the regional geological organisations are appended.

a) Report on Remote Sensing Studies in Pakistan in the field of recent tectonics describing Ornach-Nal fault system by M.S. Hasan, Remote Sensing Cell Geological Survey of Pakistan November,1975.

b) Report on Remote Sensing Studies in the Field of Intrusive and Volcanic rocks covering parts of Bela area in Pakistan by M. S. Hasan and S. G. Abbas, Remote Sensing Cell, Geological Survey of Pakistan, November 1975.

c) First Progress Report on Regional Investigation of Tectonic and Igneous Geology, MTA, December 1975.

/ VI PROBLEMS

VI. PROBLEMS

12. Remote Sensing Cell of Geological Survey of Pakistan in its above reports have indicated the need for procurement of diazo printing machine to prepare colour composites, light tables with magnifying glasses and transparent overlay material for tracing details from imageries. At present GSP is using photo interpretation facilities of Pakistan Space and Upper Atmosphere Research Committee (SUPARCO).

13. Turkish report at Paragraph 11 indicates that they had difficulty with quality of photo reproduction which they have partially solved by experimentation with developing agents and exposure time and as a permanent soltuion are procuring high quality reproduction equipment.

14. Iranian delegation at the December 1975 Advisory Group Meeting have indicated that to meet requirements of the project they are procuring necessary viewers for photo interpretation.

VII. DATA QUALITY AND DELIVERY

Coinvestigators both from Pakistan and Turkey have expressed satisfaction over quality of data. Pace of delivery of data to investigators has been regular after first significant delivery in August 1975 which necessitates that period of investigation of 18 months may be reckoned from September 1, 1975.

VIII. RECOMMENDATIONS.

U.S. Remote Sensing Coordinator has been requested to take up a tour of the Region in February 1976 to help the regional scientists to identify areas for initiating detailed studies and formulating schedules and reporting procedures.

/ IX CONCLUSIONS

IX. CONCLUSIONS.

CENTO has an active programme in the Region to accelerate the mapping, exploration and utilization of mineral resources. It has constituted Working Groups on Recent Tectonics as well as on Intrusive and Volcanic Rocks having experienced geologists from all the Member Countries. It is firmly believed that ERTS data and investigations under this project will yield new maps of the region and useful information for directing future programme of these two Working Groups.

ORIGINAL PAGE IS
OF POOR QUALITY

REPORT ON REMOTE SENSING
STUDIES IN PAKISTAN IN THE FIELD OF RECENT TECTONICS
DESCRIBING ORNACH-NAL FAULT SYSTEM

BY

M. S. HASAN

REMOTE SENSING CELL, GEOLOGICAL SURVEY OF PAKISTAN

NOVEMBER, 1975.

10

C O N T E N T S

ABSTRACT

Remote sensing studies in connection with Recent Tectonics in Pakistan were conducted in three ERTS imagery frames between latitude 25°00 to 28°ooN and longitude 64°oo to 67°00E. The trace of Ornach-Nal fault has been delineated for 330 km and its behaviour along the strike studied. Ornach-Nal fault is "capable, active fault" having sinistral movement with west side moving up and possibly has a preeroganic history.

INTRODUCTION

Purpose and scope of the report:

The Geological Survey of Pakistan has set up a Remote Sensing Cell in the Headquarters. The broad functional objectives of this cell are (1) Cataloging, classification and storage of ERTS data (2) Initiation of research programmes on application of ERTS data in different field of geology (3) Dissimination and extention of geological information extracted from ERTS imagery for the of Development Agencies.

The CENTO Coordinator for Remote Sensing working Group approached the Incharge, Remote Sensing Cell through Director General, Geological Survey of Pakistan to conduct remote sensing studies in Pakistan for CENTO Working Group on Recent Tectonics. Since this project has basic significance for application in global geodynamic process, priority has been given to the study and use of ERTS imagery. The programme of work is being followed in close consultation and cooperation of Mr. A. Farah, Country Coordinator on CENTO Recent Tectonic working Group.

Acknowledgement:

The author is grateful to Dr. M. Shafi Ahmad, Dr. M. Ishaq Mirza and other staff of Pakistan Space and Upper Atmospheric Research Committee for their extension of Remote Sensing workshop facility.

STUDIES ON ORNACH-NAL FAULT SYSTEM OF PAKISTAN

Method of Investigation:

ERTS Imagery black and white prints on 1:1,000,000 of 3 frames falling between latitude 25°N to 28°N and longitude 64°E to 67°E taken on 18th February, 1975, 19th February, 1975 and 10th February, 1975 in MSS band 4,5,6 & 7 were studied.

Contd...p/3.

Transparencies of scale 1:369,000,000 of the same frames taken during 3rd November, 1972, 29th November, 1972 and 15th January, 1973 were viewed on Colour Additive Viwer Model I^2S available at SUPARCO Office Karachi. The transporencies of MSS bands 4,5 & 7 were studied separately and also as in the form of colour composite. The image quality of 1:369,000,000 available at SUPARCO was not good. The Black and white prints supplied by NASA through CENTO are of high quality and proved useful for structural delineation. The structural details thus delineated were plotted on overlay by comparative study of black and white prints in band 5 & 7 of the same frames with the help of magnifying glass (5X) under ordinary tube light. The cultural overlay was superimposed on standard 1:1,000,000 topomap and Latitude and Longitude were corrected. Finally the cultural map was used as base map and fault system was plotted on it form structural overlay and final map was prepared.

Sifnificant Results

Ornach-Nal fault is one of the most significant fault of southern region of Pakistan and it could be classed as capable fault. Gawad, 1971 has described this fault as Kirthar Wrench Zone. Auden 1974, Farah, 1975 described this fault to be 200 km long with vertical and sinistral movements and cuts recent alluvium. They believe it to be generated during Eocene. Abrupt terminations of strike on the two sides of fault at $27^{\circ}07'$N : $66^{\circ}07'$E was noted by Auden. It has been mentioned in Reconnaissance Geology of Part of West Pakistan, 1960 that Ornach-Nal fault is regional transcurrent fault, traceable for 180 miles and the stratigraphic separation is several thousand feet with west side moving up relative to east. The structure on either sides of the faults differ in both kind and scale, they are possibly younger than fault but evidently consequent to the same direction of principal stress. It is believed that Ornach-Nal fault has a pre-organic beginning. Contemporaneous strata on either side of fault are of great lithological contrast even though closely adjacent. Two recent movements mentioned by Kazmi, 1974 occurred at 25.5N, 66.7°E on 12th October, 1973 and 8th June 1974 which had a magnitude of 4 and epicenter at 33 km depth in Sonmiani Bay. These earthquakes are probably linked with this fault.

On ERTS imagery, the trace of Ornach-Nal fault was picked up and lateral extension was delineated. The trace was tracked in three frames between latitude 25°N to 28°N and longitude 64°E to 67°E for about 330 km, from south of north. The study for its extension further north is being continued and the results will be presented in the next report. For a distance of about 220 km, the strike of the fault between location, latitude 28°N longitude $66^{\circ}8'$E to latitude 26°N longitude $66^{\circ}12'$E has north-south direction. Within this length the trace is not straight. It is six times concave towards east and three times concave towards the west in the following order starting from the north (28°N, $66^{\circ}8'$E)

Concave east for 29 km at 33 km radious
Concave west for 32 km at 40 km radious
concave east for 28 km at 35 km radious
straight for 21 km
concave east for 10 km at 13 km radious
straight for 7 km
Concave east for 7.8 km at 13 km radious
concave west for 8 km at 13 km radious
concave east for 16 km at 65 km radious
concave east for 11.8 km at 10.5 km radious

Further south this fault swangs at S 25°w and maintains this strike direction to a location latitude 25°35'N longitude 66°2'E for a distance of about 45 km. In this part the fault trace is cut by two small faults running in NW-SE direction and having sinistral movement. Further south the fault trace is aligned at S 55°w for a distance of about 15 km and then it is E-W upto a point latitude 25°32'N, longitude 65°40'E for a distance of about 15 km. Beyond this point the fault swangs south-ward at S 58°w and can be traced for about 35 kms upto the coast and then it appears to enter into Arabian Sea. A trace of fault alemost 8 km long appearing on Ormara island may be a continuation of Ornach-Nal fault (Fig.I) through its probable trace in the sea. In the northern part, north of Hazargangi the fault shows branching towards north-east and north west at acute angles. Branching is also observed north west of Bela fecing south and making on angle or 35° toward the west.

Anoth-r fault system running parrellel to Ornach fault includes Hingol and Arra faults. The trace of these faults is not visible continously throughout their length as shown in Fig.I. Branching in Arra fault is facing south.

A fault with branching facing SW and aligned in NE-SW direction was mapped in Garr Hills. A major fault running NE-SW passing through Pasht Koh was also picked up. Branching in the northern part of Pasht Koh fault faces north. The traces of other smaller faults are aligned generally is N-S direction in the north of Latitude 26°N, whereas in the south they have east west trend.

Mud volcanos near Ornach fault zone were located. The conees picked up on imagery are marked in the map. The cones which do not show up on imagery have not been shown.

It may be pointed out that the map showing Ornach-Nal fault systems (Fig-I) has been compiled entirely with the help of imagery and no correction has been made on account of previous data. The faults shown on Fig.I were compared with 1:2,000,000 Geological map of Pakistan and the results were found to be exseptionally good. Most of the faults were found to be correct and accurately picked up. The trace of major faults passing through allavium was not shown in the previous map but it did come up nicely on imagery. From previous record the length of Ornach-Nal fault is stated to be about 209 km. During present compilation it is traced for 330 km and it might contiue further north.

PLANS FOR THE NEXT QUARTER:

(a) Study of the northern extension of Ornach-Nal fault and make field checks.

(b) Study of Kirthar fault zone and make field checks.

(c) Study of Chaman Fault System and make field checks.

COMMENTS AND RECOMMENDATIONS:

(1) A diazo printing machine is required to prepare colour composite to help in locating the fault traces enhanced by vegitation pattern on either sides of fault,

(2) Two magnifying glassese fitted with light tubes are also needed as these are not available in Pakistan.

(3) Overlay material available in Pakistan is translucent. Transparent quality overlay film is need for tracing the details from imagery.

(4) 70 mm transparency of Pakistan may also be supplied preferably of the same date and time as that of black and white print out. This could be studied at SUPARCO Office, Karachi on Colour Additive Viewer.

(5) Negative transparencies may also be supplied to help in preparation of black and white enlarged frames.

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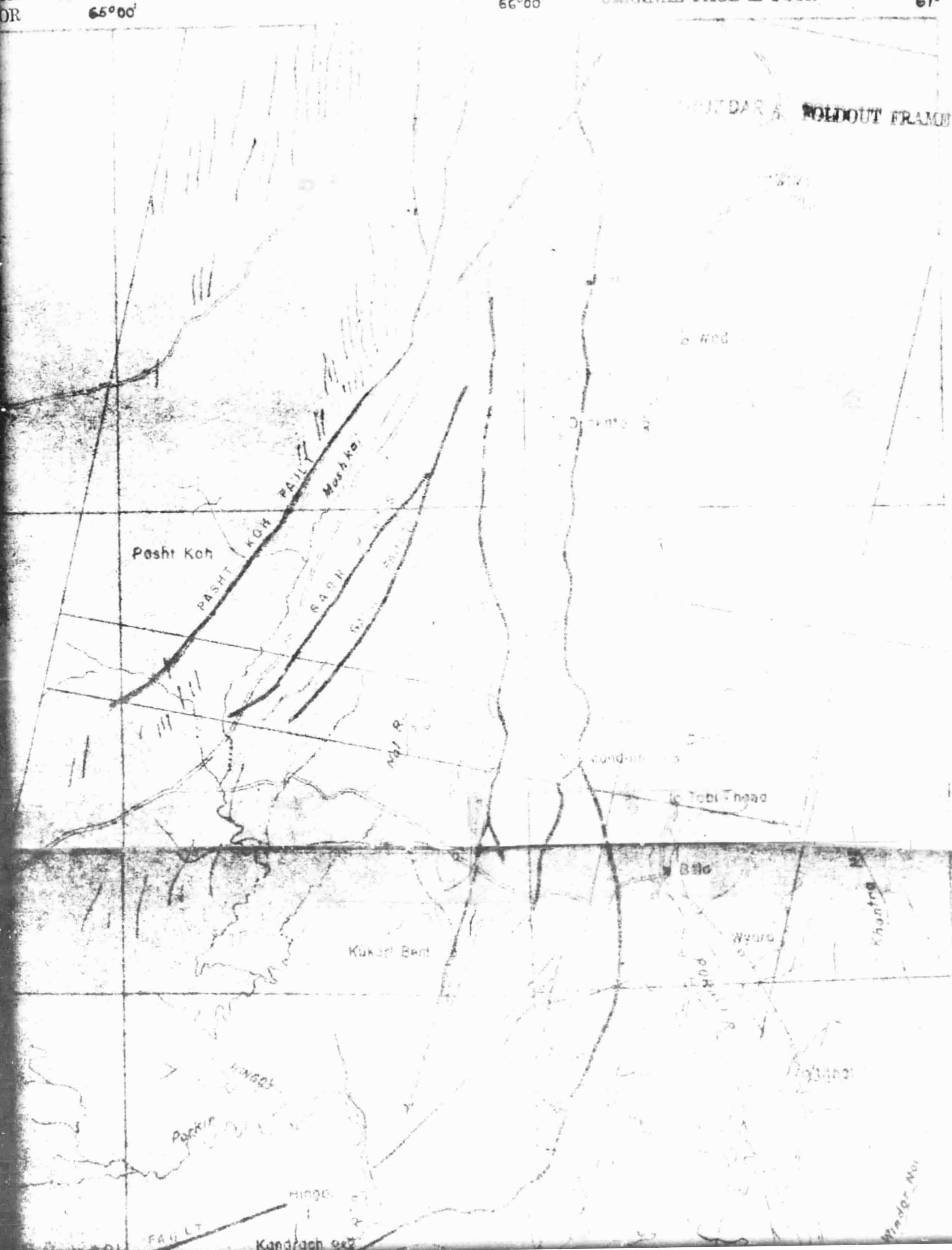
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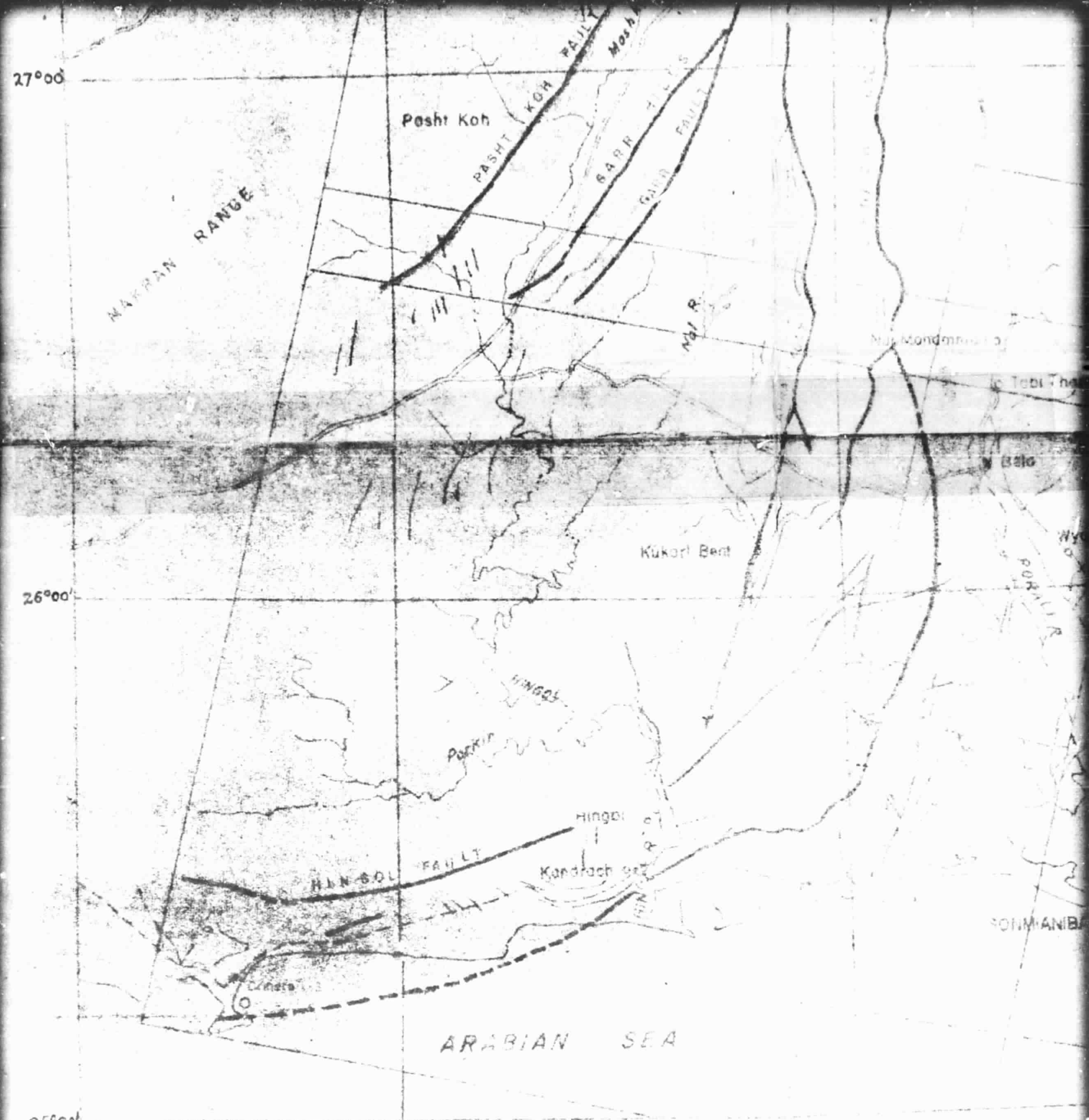
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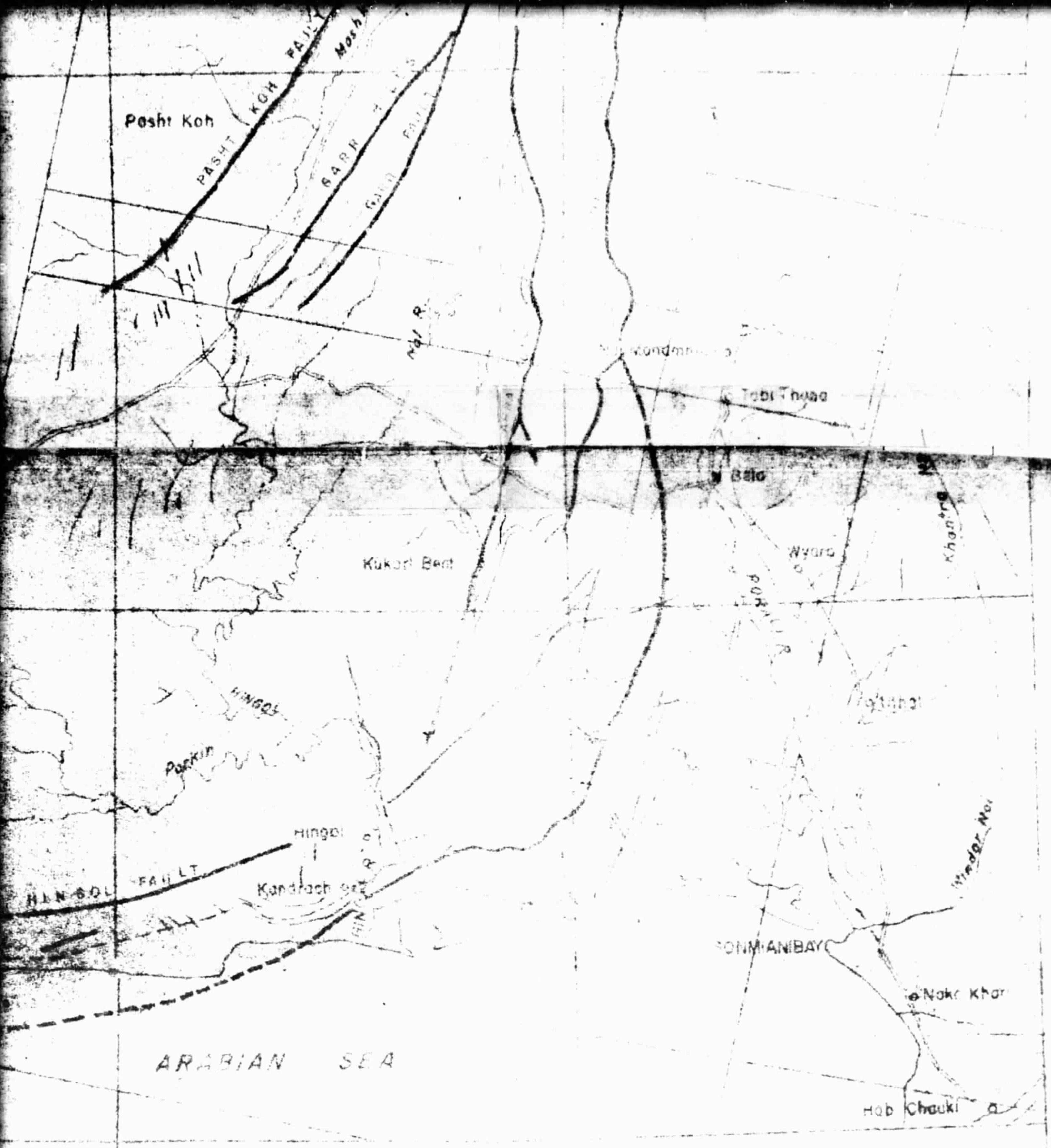
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SONMIANI BAY
Hob Chauki
Windar Nai

18 A+B

REPORT ON REMOTE SENSING STUDIES IN THE FIELD OF INTRUSIVE AND VOLCANIC ROCKS COVERING PARTS OF BELA AREA, PAKISTAN.

BY

M. S. HASAN

&

S. G. ABBAS

REMOTE SENSING CELL

GEOLOGICAL SURVEY OF PAKISTAN

NOVEMBER, 1975

C O N T E N T S

ILLUSTRATION

INTRODUCTION

Purpose and scope of the report

A Remote Sensing Cell has been set up recently in the Headquarters of the Geological Survey of Pakistan. The broad functional objectives of this cell are (1) cataloging, classification and storage of ERTS data (2) initiation of research programmes on application of ERTS data in different field of geology (3) dissimination and extension of geological information extracted from ERTS imagery for the use of development agencies.

The CENTO country coordinator for Remote Sensing Working Group approached the Incharge, Remote Sensing Cell through Director General, Geological Survey of Pakistan to conduct remote sensing studies in Pakistan for CENTO Working Group on Intrusive and Volcanic Rocks. Since these studies fall within the functional objectives of the cell and the results obtained would be of much help in geodynamic process responsible for present configuration along Axial Belt or Indian Plate boundary, the project was given priority. This is the first report on the project by the Cell. In the absence of adequate Remote Sensing Workshop facilities and short time notice the results achieved can not be reckoned as complete. Much more improvement is possible if proper equipment is made available,

The present report is the outcome of preliminary findings pertaining to the application of ERTS imagery for extracting in information on intrusive and volcanic rocks and associated features related with geodynamic processes.

ACKNOWLEDGEMENTS

The auther is grateful to Dr. M. Shafi Ahmed, Dr. M. Ishaque Mirza and other staff of Pakistan Space and Upper Atmospheric Research Committee for their cooperation in using their Remote Sensing working Workshop facilities. Acknowledgements are also due to Mr. A. Majid Khan, Director, Lasbela Khuzdar Project for providing office and transport facilities at Karachi and for arranging the field visit to the project area where possible.

STUDIES ON INTRUSIV AND VOLCANIC ROCKS

Method of investigation:

Three types of imagery frames which include 70 mm positive transparencies, 9½ inch positive transparencies and 9½ inch black and white prints were studied. MSS band 4, 5 and 7 of 70 mm transparency was studied on Mini Adisol Viewer Model I²S. For separating sedimentary and extrusive rocks with ultramafic, the best results were achieved by adding small red colour tint in band 4, full green colour in band 5 and full blue colour in band 7. Although this process is different from normal preparation of colour composite but it sharpend the boundary of ultramafic with surrounding rocks. This process obscured the vegitation details which acquired blue tint. Cultural features were also masked. The 70 mm imagery was taken on 3rd Nov'72, free of cloud cover, but the image quality was not good.

Black and white imagery prints of the same frame on 1:1,000,000 scale (9½" x 9½") taken on 18th February 1975 was studied under magnifying glass. These prints are excellent in quality. Band 5 was found to be most useful for separating ultramafic with mafic rocks (gabbro and basalt). The same band was found to be the best for studying sedimentary sequence and structural details. Band 6 and 7 did not provide much tonal contrast between ultramafic and mafic rocks. These prints were best under magnifying glass but as soon as overlay was laid most of the details were masked and it became impossible to trace the features The overlay film being used is translucent.

Positive transparencies of imagery on 1:1,000,000 (9½"x9½") scale taken on 19th May 1975 were utilised for the preparation of colour composite with the help of dia printer. Yellow film was used for band 4, Magenta for band 5 and [illegible] for band 7. All the three prints when superimposed provide the best results. The details could be transferred to overlay on tracing table with the help of magnifying glass. The results included in the report are based on the studies carried out on this colour compo[illegible]. 70 mm transparencies projected on viewer and 1:1,000,000 [illegible] k and white prints mentioned above were used for comparative studies. Five different types of features were plotted separately on overlays which include (1) physiographic and cultural features (2) linear features which could be fault (3) ultramafic complex (4) mafic complex (which includes Basalt, gabbro and agglomerate) (50 Lava flows interbedded with sedimentary rocks.

Significant Results:

Geological map of part of Bela igneous complex extending from Gadani in the south to 53 km north of Bela was prepared. Igneous complex was separated from sedimentary rocks. Brief description of geology is given in Fig. I. Igneous complex consists of ultermafic rocks; basaltic rocks; agglomerate; gabbro; and lava flows interlayered with sedimentary rocks.

The spectral reflectince characteristic of these rocks except ~~of~~ for ultramafic rock is quite similar. In band 4 all these rocks have lighter tone. In band 6 and 7 all of these are dark. On band 5 the reflectince registered has some difference in the signature of ultramafic with other rocks. Colour composite prepared from band 4, 5 and 7 was found to be most useful in separating the ultramafic complex.

Efforts were made to separate basaltic rocks, lava flows, agglomerate and gabbro. These rocks are ambigously distinguished and as such it is difficult to separate them on 1:1,000,000 scale. However, basalt, agglomerate and lava flows intruded by gabbro have been grouped as mafic complex. Lava flows interlayered with sedimentary rocks are shown separately.

One oblong features which appeared to be intrusive body having a sharp contact with surrounding rocks was picked up on the imagery. The drainage pattern within this body studied on imagery did not look different from rest of the area. Field checks indicated that it was discordant cont~~r~~act with surrounding sedimentary and extrusive rocks. It is porphyritic basalt plug, darker than surrounding rocks. The study of thin section of the rock shows that it contains 40% ground mass of small laths of altered feldspar, about 30% small grains of ferromagnesium mineral, altered to chlorite. Due to alteration ground mass has a yellowish tint. Carricitization was ~~ix~~ also found. About 20% opaque grains of dessiminated magnetite are also present.

Some of the magnetite grains are altered into heamatite. Pyroxene phenocrysts are altered along border into chlorite. Some phenocrysts which have been completely replaced by calcite resemble in outer boundary with feldspar crystals. The alteration is so complete that it is difficult to identify the nature of feldspar. The reasons that this igneous body attracts immediate attention is its sharp discordant circular contact with surrounding rocks, darker colour due to the presence of higher percentage of dessiminated iron, and having phenocrysts of ferromagnesum minerals.

Linear features aligned against the strike direction which show displacement were picked up and plotted. Few of them were checked in the field and found correct. Rest of them were compared with previous maps and found to be accurately mapped.

The assemblage of intrusive and volcanic rocks discussed above can be classified as ophiolite in view of the characteristics of ophiolite sequence agreed upon in Penrose Foeld Conference on Ophiolites in 1972. The three complex rock types found in the area are ultramafic complex, mafic complex which include basalts, sills like bodies of gabbro, agglomerate, and pillow lava interlayered with sediment-ary rocks. This assembledge is believed to be the remnant of oceanic crust which was abducted on the continental edge of Indian plate within the zone of convergence. The concentric zoned body of basalt, rich in iron and calcium minerals may be indicative of consuming plate margin as described by Moores 1973.

PLANS FOR THE COMING QUARTER

1. Complete the interpretation of Lasbela igneous complex with the help of ERTS imagery and make field checks to confirm the results where possible.

2. Start the interpretation of Muslimbagh igneous complex and make field checks to confirm the interpretation.

COMMENTS AND RECOMMENDATIONS

1. A diazo printing machine along-with sensitive printing films in yellow cyan and Magenta colour may be provided as it was found to be advantageous to work with colour composite transparensies.

2. Two magnifying glasses with flexible arm and fitted with tube lights may be imported as these are not available in Pakistan.

3. Overlay material available in Pakistan is translucent and masks the details of imagery when laid for tracing purpose. Transparent quality overlay film may be imported.

4. 70 mm transparencies of Pakistan may also be procured. These should be of the same date and time as that of black and white prints. The transparencies will be studied on Colour Additive Viewer in SUPARCO office at Karachi. The study on viewer will help in the extraction of information more accurately as certain features are enhanced by adding different colours of different intensities in different bands of same image.

5. Negative transparencies may also be procured to help in preparation of black and white enlarged frames.

REFERENCES

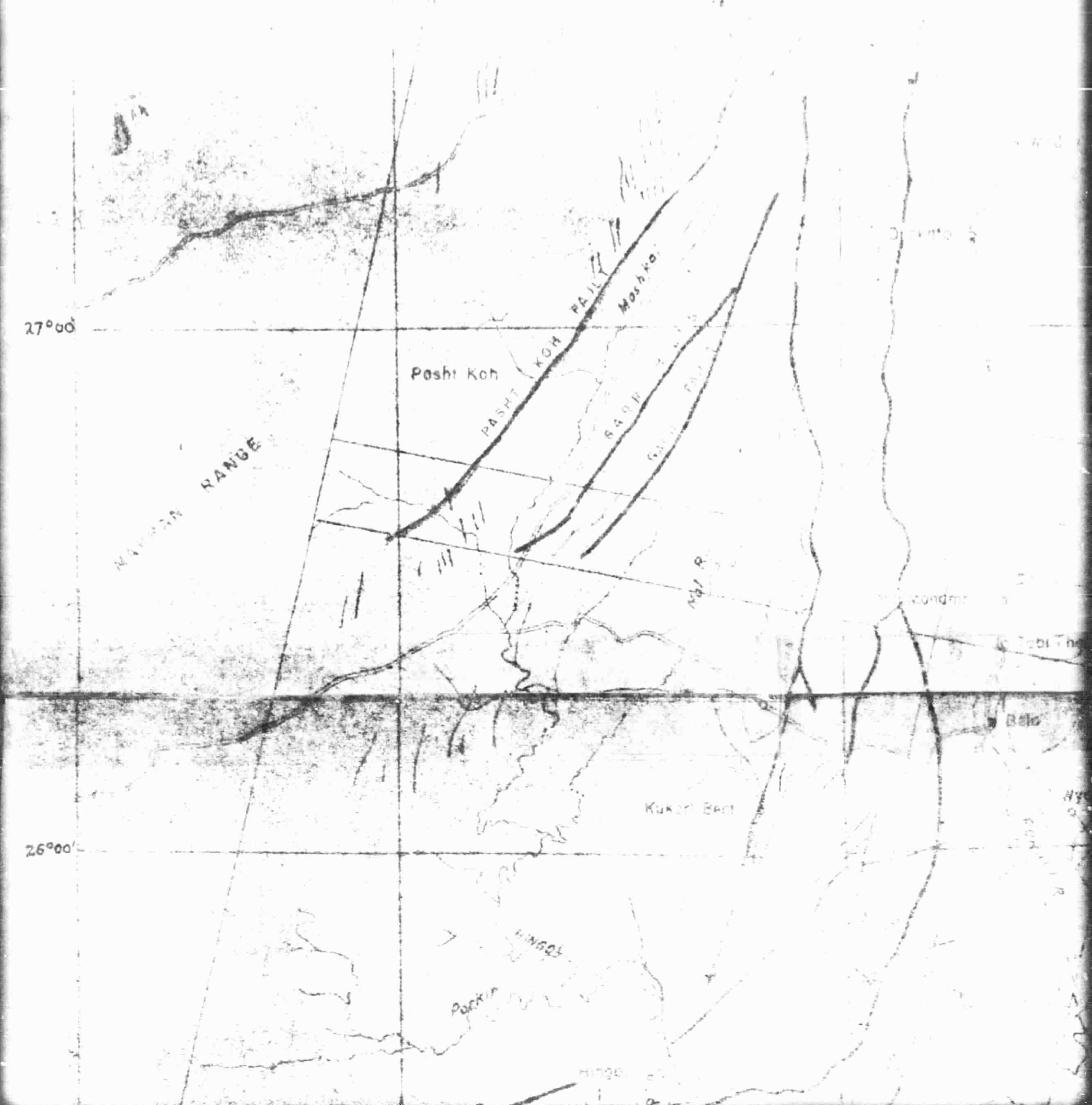
1. Hunting Survey Corporation, Canada, 1960. — Reconnaissance Geology of Part of West Pakistan.

2. Moores, E.M., 1973 — Geotectonic significance of Ultramafic Rocks, Earth Science Review 9 (1973) 241-256.

3. Penrose Field Conference, 1972. — Ophiolites, Geotimes, December, 1972.

Fig. 1.– Ultramafic and Mafic complex of part of Bela area, Pakistan.

Formation/Group	Lithology	AGE
Alluvium	Sand and Silt	Recent
Sub Recent	Gravel, Sand and Silt	Sub-Recent
Parh Group (Bala Volcanics and sedimentary rocks)	Lava inter-layered with sedimentary rocks. Lava is basaltic with well developed pillow structure, grayish green, olive or greenish gray cryptocrystalline, Sedimentary rocks include limestone and shale. Limestone is cream light green, weathers to yellowish brown, thin to medium bedded. Shale is green, buff orange, blue gray, ferroginous brown or black.	Cretaceous
Bela Mafic complex	Basalt inter-layered with agglomerate and sill like bodies of gabbro. Basalt is dark grayish green, olive, greenish gray or dark gray on fresh surface and rusty brown or greenish gray on weathered surface, cryptocrystalline with feldspar laths and some olivine/pyrexone crystals. Agglomerate consist of sub-angular to sub-rounded fragments of porphyritic volcanic rock in a basaltic matrice. Gabbro is in the form of sill like bodies. It is equigranular, holo-crystalline, medium to coarse, grained, felsic and mafic ratio is 30:60 to 60:30	Cretaceous
Porali Ultera-complex	Discontinous peridotite bodies, highly surpentinized, greenish black, coarse grained, olivine predominant more than 85percent with accessory chromite, rarely shows priliminary layering; with xenoliths of recrystallized limestone. Contact is discordant or faulted.	Cretaceous
Windar Group	Limestone with subordinate interbedded shale and few sandstone beds. Limestone is dark gray to black on fresh surface, weathers to light brown and blue gray, hard, compact, beds variable in thickness from few inches to few feet. Shale is light earthy brown, ferruginous brown, earth blue gray, grey and black, weathers to light brown, blue gray and rusty brown, hard splintery and calcareous, sandstone is light brown, reddish brown or white, weathers to dirty white, pink or cream or light rusty brown, very hard and compact, beds range in thickness from 2 to 6 feet.	Jurassic



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