[redacted]

[redacted]

Report No.9

KH-4B SYSTEM CAPABILITY

APPRAISAL OF GEOLOGIC VALUE FOR MINERAL RESOURCES EXPLORATION

MARCH 1971

Author: [redacted]

[redacted]

~~TOP SECRET~~

~~NO FOREIGN DISSEMINATION~~

[redacted]

Total No. of Pages 50
Copy No [redacted]

Report No.9

KH-4B SYSTEM CAPABILITY

APPRAISAL OF GEOLOGIC VALUE FOR MINERAL RESOURCES EXPLORATION

MARCH 1971

Author: [redacted]

~~TOP SECRET~~

~~NO FOREIGN DISSEMINATION~~

SPG-71-013

HANDLE VIA
~~TALENT-KEYHOLE~~
CONTROL SYSTEM ONLY

SEP 01 1971

CONTENTS

FIGURES

1. INTRODUCTION

As part of a continuing investigation of the value of satellite photography, 800 feet of SO-242 was flown on mission 1108-2. SO-242 is a relatively new "high resolution" color film especially built for use in satellite and high flying aircraft systems. This film was flown at the end of mission 1108. Further, the two stereo cameras on the KH-4B System allowed us to acquire high resolution black and white coverage concurrent with the color. Unfortunately, the resolution of the color photography was not as good as hoped, due primarily to the poor color correction of the KH-4B lenses. NPIC did an evaluation of this photography and concluded,* in part, that:

1. The primary constraint on using SO-242 in this system is the incompatibility between the intelligence community requirements and the spatial resolution afforded by SO-242 at this scale.
2. The difference in ground resolution between the color and black and white material is approximately 2:1 in favor of the black and white.
3. Except for its stereo contribution, the color material was of no apparent value to first or second phase analysis.
4. Color photography as provided by this system is expected to contribute most to regional, agricultural, and geological studies.

The first three conclusions relate, of course, primarily to the military oriented intelligence community. That is, order of battle, missile readiness, etc. The last conclusion was, in our view, of significance to the nonmilitary intelligence community, such as the Offices of Basic and Geographic Intelligence and Economic Research in the CIA. It was, therefore, with these offices in mind that this study was undertaken. The purposes of this somewhat limited study were, therefore, to:

1. Evaluate the information content of color versus black and white for one type of natural resources task
2. Evaluate the potential of the KH-4B System for resources exploration
3. Perform sufficient analysis to indicate the potential advantages of color photography for geographic/economic intelligence purposes.

Review of the photography indicated that excellent cloud free coverage of the Tsaidam Basin in China and of Southern Russia had been obtained, and that these areas possessed interesting geological features. It was, therefore, decided to concentrate on the value of this photography for

---

*[redacted] Photographic Evaluation Report, Special Study: SO-242 Evaluation, Mission 1108, July 1970.

mineral resources exploration. With this goal in mind, a contract was arranged with a commercial petroleum and mineral exploration firm of geologists [redacted] Contract support was also provided by Itek Corporation, Lexington, Massachusetts.

[redacted] were instructed to review the photography, prepare detailed geological maps and prepare an analysis on the mineral resources similar to that which would be done for another commercial customer (such as an oil company). This they have done, and this is the final report of that study.

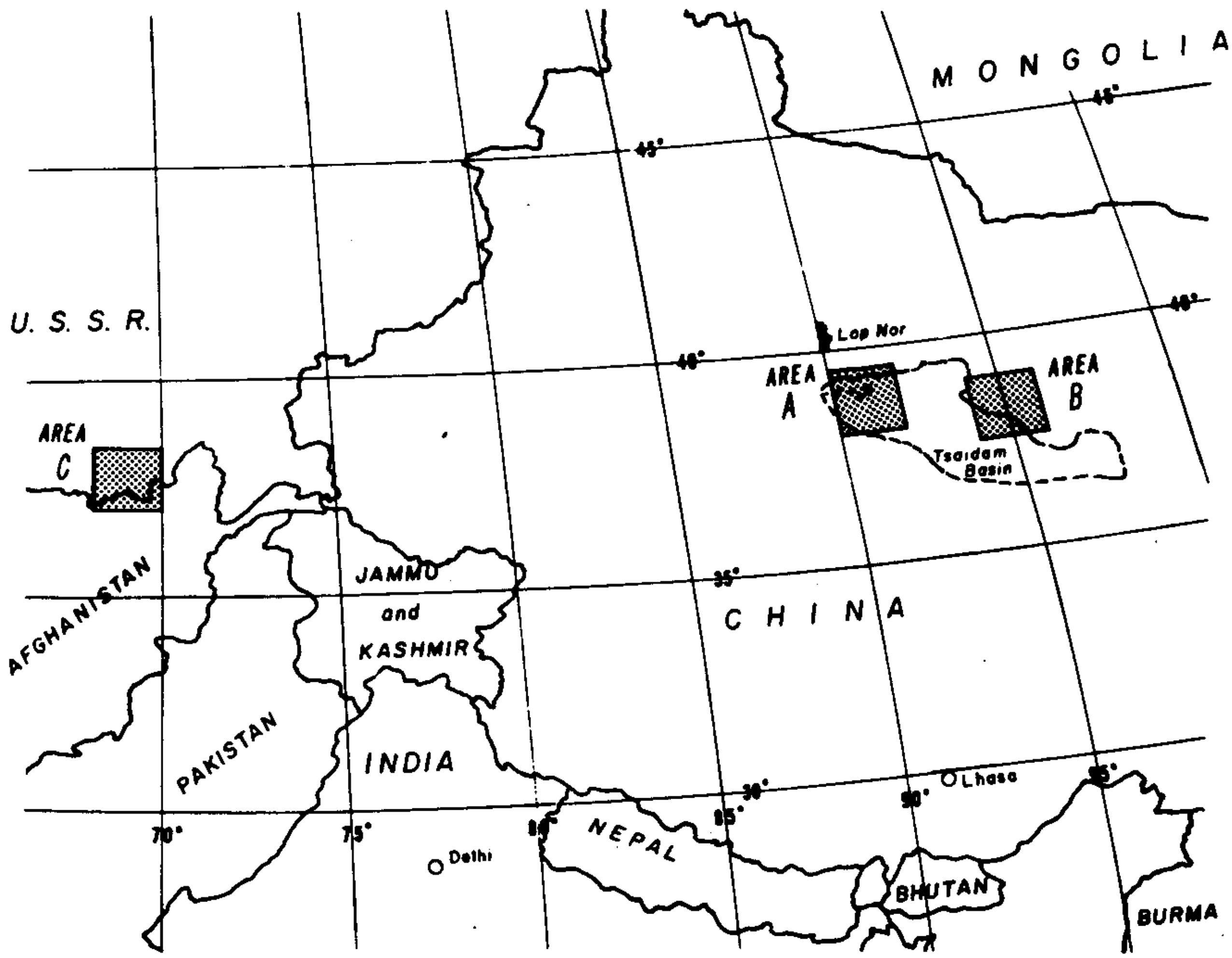


Fig. 1-1 — Index map showing three study areas

2. GEOLOGIC EXPLORATION PRINCIPLES

Mineral deposits and fossil fuel resources occur at or beneath the earth's surface in irregular deposits under varying geologic conditions. Frequently these accumulations occur under conditions that can be relatively accurately predicted by an experienced exploration geologist.

Geologic investigation differs from conventional photo intelligence in one important respect. Instead of an expert searching for a specific feature, recognizing and pinpointing it, then describing it . . . the geologist must analyze the entire area and record all his findings on a map. Then, and only then, is he able to fully analyze geologic conditions and make accurate interpretations.

Thus, the exploration geologist, in searching for "hidden" mineral deposits, must first prepare a basic geologic map to guide him. The conventional geologic map contains substantive geologic information of two basic classes: (1) rock type, and (2) structure. When interpreted correctly, this map provides clues to the most likely areas for accumulation of mineral deposits.

Conventional geologic maps are prepared by ground parties traversing an area and taking rock samples at numerous localities. The rock type (lithologic description, geologic age and formation name, if possible) and structural conditions at each locale are plotted onto a base map. These data are then extrapolated across the areas not traversed by the ground parties and the map is thus completed.

2.1 STANDARD PHOTOGEOLOGIC TECHNIQUES

Photogeologic mapping has been used for the past 30 years to augment ground geologic mapping. It is now an accepted and fundamental tool for mineral and petroleum exploration and has been found to greatly reduce the time and expense of ground parties. Its main advantage is the enlarged vertical perspective where all areas, not just those that can be readily reached on foot, are analyzed in all their geologic detail.

Photogeologic mapping utilizing space photography enlarges this perspective even more. Using the KH-4B System, this is achieved without unduly sacrificing ground resolution necessary for reliable photogeologic mapping.

According to Gilluly, Waters, and Woodford*:

> "A geologic map is a valuable economic tool, useful in locating supplies of oil, water, coal, iron ore, and other substances buried beneath a cover of soil and rocks. Though such valuable prizes are completely hidden beneath the

---

* Gilluly, J., Waters, A., and Woodford, A., "Principles of Geology," Freeman, San Francisco, California, 1968, pp 2 and 88.

surface, a geologic map often reveals where tunneling or drilling will be successful. The accuracy of such predictions has been proved again and again by discoveries of valuable ores, coal, and petroleum. Geologic maps are indeed the indispensable foundation of all geology—basic to our understanding of all subsurface processes, . . ." "On the international scene, the power and wealth of a nation is largely determined by its endowment of useful minerals, its skill in finding and utilizing them, or in obtaining needed supplies from other lands. In this age of political unrest and readjustment among nations, the vast accumulation of petroleum in such little-industrialized nations as Iran, Saudi Arabia, Iraq, and Kuwait is a potent force in world politics. We shall be wiser in world affairs if we know where and why petroleum occurs, how it is discovered, and how its quantity underground may be estimated."

Photogeologic mapping involves two basic functions: (1) differentiation of rock type, and (2) structural mapping.

2.1.1 Differentiation of Rock Type (lithologic/stratigraphic mapping)

This involves differentiating the various rock units exposed at the surface. In a virtually unmapped area of the world, this will involve distinguishing only between the basic rock types, as follows: (1) igneous (intrusive-granite, extrusive-basalt, etc.); (2) sedimentary (sandstone, shale, limestone, etc.); and (3) metamorphic (schist, gneiss, slate, marble, etc.). Distinguishing between these gross rock units is generally not too difficult for an experienced photogeologist. This is because each basic type usually exhibits an identifying "signature" such as color, texture, land form pattern, etc.

A more useful map will be prepared however, when some ground truth is available (see Section 3.2). Information such as lithologic descriptions of various land specimens from the various formations will be most useful, as will any information regarding the geologic age of individual units.

2.1.2 Structural Mapping

This involves mapping the structural relationships of the various rock units. Structural features, such as folds (anticlines, synclines, monoclines), faults (normal, reverse, thrust, etc.), fractures, joints, etc., are often better observed from the vertical stereoscopic perspective than from the ground. Comprehensive mapping of the structural features permits a proper understanding of the chronology of events affecting the subject area.

2.2 ECONOMIC ASSESSMENT

Interpretation of the geologic map is the next important step. What does all this information mean economically? The exploration geologist looks for certain clues to guide him to hidden mineral or petroleum deposits. For instance, the petroleum exploration geologist knows that oil is found in sedimentary basin areas. He restricts his study to these areas and does not search the mountainous hard-rock (igneous and metamorphic) regions. He knows that for the sedimentary basin area to hold economic petroleum deposits, it must contain: (1) source beds (generally marine shales), (2) reservoir beds (usually porous sandstones or limestones), and (3) traps (many types—the most common are anticlinal folds or faulted anticlines). After he has ascertained that conditions (1) and (2) above are met for an area, he focuses his attention toward looking for traps. Surface geological maps are extremely useful for this purpose because many deep-seated structures are reflected in the structural conditions revealed at the surface.

For mineral (other than petroleum) exploration, however, he searches not only the sedimentary basin areas, but more particularly the mountainous "hard-rock" regions, depending on the types of minerals desired. He knows, for instance, that certain metallic deposits are often found in the vicinity of igneous intrusive activity, strong metamorphism, and faulting. Therefore, he searches for significant granitic intrusions within metamorphic rock regions and major fault zones. He does not always, however, restrict his search to the hard-rock regions because many nonmetallic mineral deposits (potash, gypsum, etc.) occur in sedimentary environments.

This page left intentionally blank.

3. METHODS OF INTERPRETATION

3.1 COMPILATION AND INTERPRETATION PROCEDURES

Mapping of the three areas under consideration was achieved in the following sequence: (1) Area A—NW Tsaidam Basin, (2) Area C—Kafirnigan-Pyandzh Area, and (3) Area B—NE Tsaidam Basin. This was a matter of convenience rather than design, since that is the order in which the necessary reference and mapping materials became available.

The compilation and interpretation procedures varied slightly from area to area, because of differences in the available base map control, geologic references, and nature of the KH-4B materials. As a result of following these varied procedures, which are discussed in more detail below, it was possible to develop a preferred (optimum) set of procedures for future mapping projects.

For each area mapped, it was necessary to use photography from both the: (1) convergent panoramic (PAN) camera, and (2) the DISIC framing camera. The PAN photography was used for making the geologic interpretations. The DISIC photography was used for construction of the base maps and compilation of the geologic annotations.

For the purposes of these studies, the optimum mapping scale was determined to be 1:250,000. Each area embraces slightly less than 12,000 miles and includes 2 degrees of longitude and 1 ½ degrees of latitude. This is slightly larger than the conventional "2° × 1°" format of most 1:250,000 scale maps.

3.1.1 Procedures Used for Area A

Area A is bounded by Latitudes 38°00' N and 39°30' N and Longitudes 90°00' E and 92°00' E. A preliminary (pencil compiled) planimetric map of the subject area was constructed on 0.003-inch Herculene film to serve as a base for the photogeologic mapping. This was prepared, due to the lack of available up-to-date 1:250,000 scale topographic maps, in a make-shift manner as follows. A geographic coordinate network of 15-minute intervals was laid out using the Universal Transverse Mercator Projection. A 1:1,000,000 scale topographic map (ONC Chart) was photographically enlarged to the mapping scale of 1:250,000. By overlaying the control grid film onto this enlargement, a preliminary planimetric base map was generated by lightly tracing the major drainage network, roads, railroads, town, and additional cultural data. This provided the gross "horizontal control" for subsequent plotting of geologic detail from the space photography.

Because of the DISIC failure on mission 1108-2 before the SO-242 film was exposed in the panoramic camera, this imagery was not available. The void was filled, however, by bringing together comparable DISIC coverage from previous missions. This DISIC photography (missions 1102 and 1106) was enlarged (approximately 8 ×) into working prints at the 1:250,000 scale. The adjacent DISIC frames were similarly enlarged and cut into strips roughly equivalent to the width of two panoramic frames. This provided a crude but effective way to obtain stereoscopy. In this stereoscopic mode, detailed drainage patterns and other topographic and cultural data were plotted in colored pencil onto the enlarged DISIC print. Once completed, these drainage patterns and related cultural information were transferred to the planimetric base film overlay which was held in correct position by the gross drainage patterns plotted in the base film. This completed the planimetric base map preparation phase of the project.

Photogeologic interpretation of the panoramic photography was accomplished utilizing a Richards GFL-940 MCE Light Table mounted with a Bausch & Lomb zoom 70 Microscope modified with a Richards Stereodapter. In this way, the black and white and color records were transported in parallel across the light table and the imagery studied in stereoscopic perspective, one eye viewing the color record, the other the black and white. In this process, it soon became evident that color and stereo are essential requirements to extract the maximum amount of geologic information. Loss of one or the other results in a significant reduction in information content.

Plotting and transferring the geologic interpretations to the base map was a somewhat difficult and cumbersome process. The geologic information observed on the 3404 and SO-242 records had to be visually plotted onto the DISIC print. The adjacent DISIC strips were used to obtain the correlatable image in stereo. To say the least, this was not the most effective way to interpret and plot the observed geologic information.

3.1.2 Procedures Used for Area B

Area B is bounded by Latitudes 37°30' N and 39°N and Longitudes 94°E and 96°E. Preparation of the planimetric base map was achieved utilizing essentially the same procedures as for Area A.

The geologic interpretation and compilation procedures for Area B, however, were considerably improved over those for Areas A and C. The Area B study was begun last, and by this time it was possible to obtain transformed (rectified) and enlarged (2×) records of the PAN photography. This was accomplished by the Aeronautical Chart and Information Center (ACIC) using the Itek Gamma I Rectifier. These materials were placed in parallel on a standard light table and interpretations were made using an Old Delft scanning mirror stereoscope. Geologic annotations were made directly to acetate overlays, which were later transferred to the preliminary planimetric film by use of a scale-changing Kail Reflecting Projector. These procedures precluded the laborious, inefficient and often inaccurate process of transferring mental images to the DISIC print. Moreover, they allowed for discernment and annotation of considerably more geologic detail than on the earlier studies. It is an understatement to say the the use of the enlarged and transformed PAN imagery is the more desired procedure.

3.1.3 Procedures Used for Area C

Area C is bounded by Latitudes 37°00' N and 38°30' N and Longitudes 68°00' E and 70°00' E. The mapping and compilation procedures utilized were essentially the same as for Area A with one noteable exception: horizontal control was good. It was not necessary to blow up a small scale 1:1,000,000 map for this project. Classified 1:250,000 scale AMS topographic map sheets were obtained for this area through the assistance of CIA personnel. In this instance, the topographic maps were overlayed by the geographic control grid and the gross planimetric control was lifted off directly. The DISIC photography was enlarged to scale and the detail matched perfectly, confirming that the AMS topographic sheets were of very recent vintage and most accurate.

3.2 BACKGROUND RESEARCH

An effective photogeologic evaluation is always significantly enhanced when some basic geologic "ground truth" is available. The type of information most helpful is rock-type (lithologic) descriptions of the various rock units present and their geologic age determinations. From this basic data, a more detailed geologic map can be prepared.

In many areas (as is the case in most of the continental United States) published geologic maps provide an excellent foundation upon which to build a detailed and comprehensive photogeologic study. This fundamental data can be extrapolated to an extensive degree using the space photographs. Thus, the ground-derived information taken from several localities can be used to trace the geologic phenomena across the entire area in question including many locales never visited on foot by man.

In many regions, geologic maps are either nonexistent or are nothing more than small scale compilations of wide spread observations and are sometimes of questionable accuracy. In areas such as these, the effectiveness of the evaluation will be greatly dependent on the interpreter's degree of experience in photogeologic mapping.

A moderately extensive geologic research effort was undertaken for the three study areas under consideration. Since these areas lie within Iron Curtain countries, the search could not be conducted by the geologists working on the project using standard scientific research procedures without unduly risking a breach of security. Therefore, the research effort was conducted with the assistance of the Office of Basic Geographic Intelligence of the CIA.

A limited amount of useful reference material was found to be available for the subject areas. It is possible that additional published and unpublished reference materials exist; however, the necessity to adhere to strict security procedures, as well as lack of time, precluded a thorough and comprehensive research effort.

This page left intentionally blank.

4. AREA A—NW TSAIDAM BASIN

4.1 GENERAL GEOLOGY

The primary reference found for Areas A and B, the Tsaidam Basin, was "The Geology of China" by Ch'ang Ta.* This publication contained the following: (1) very small scale sketch map of the geologic outcrop pattern (see Fig. 4-1), (2) generalized descriptions of the rock types, and (3) a brief discussion on the regional structure in the Tsaidam Basin Region. Although the information contained herein is meager, it provided the foundation upon which the information revealed by the space photography was applied.

Fig. 4-2 is a photographic reduction of the complete photogeologic map of Area A.

According to Ch'ang, the Tsaidam Basin belongs to the vast "NW Hercynian Zone of Fold" of northern China. The basin is shaped like a rhomb with a broad west end and a narrow eastern end. It is surrounded by moutain ranges. Ch'ang says:

> "The Tsaidam Basin has very rich underground treasures. It also has fertile soil and suitable agriculture and pastery climate. The area is populated mostly by our national minorities. Today, the Socialist sunlight has already shown on the good earth of the Tsaidam. We have the responsibility as well as the confidence to have this piece of our land built into a greater center of the future."

4.2 ROCKS EXPOSED

Five basic rock units are recognized by Ch'ang in the Tsaidam Basin region. Ch'ang's descriptions are summarized in the following paragraphs. The letter symbols in parentheses refer to the symbols used on the photogeologic map (Fig. 4-2).

4.2.1 Pre-Sinian Metamorphic System (PC or PCg)

The photogeologic interpretation indicates that this might include Precambrian metamorphic and/or granitic rocks. The metamorphic sequence occurs in the northwest part of the mapped area, along the northern edge of the Altin-Tagh Mountains. Several large intrusive areas in the northwest and the western part of the project are designated as Precambrian (?) granite. It is probable, however, that these intrusive areas are much younger than Precambrian in age.

---

* Ch'ang Ta, "The Geology of China," Joint Publication Research Service, JPRS no. 19,209, 16 May 1963.

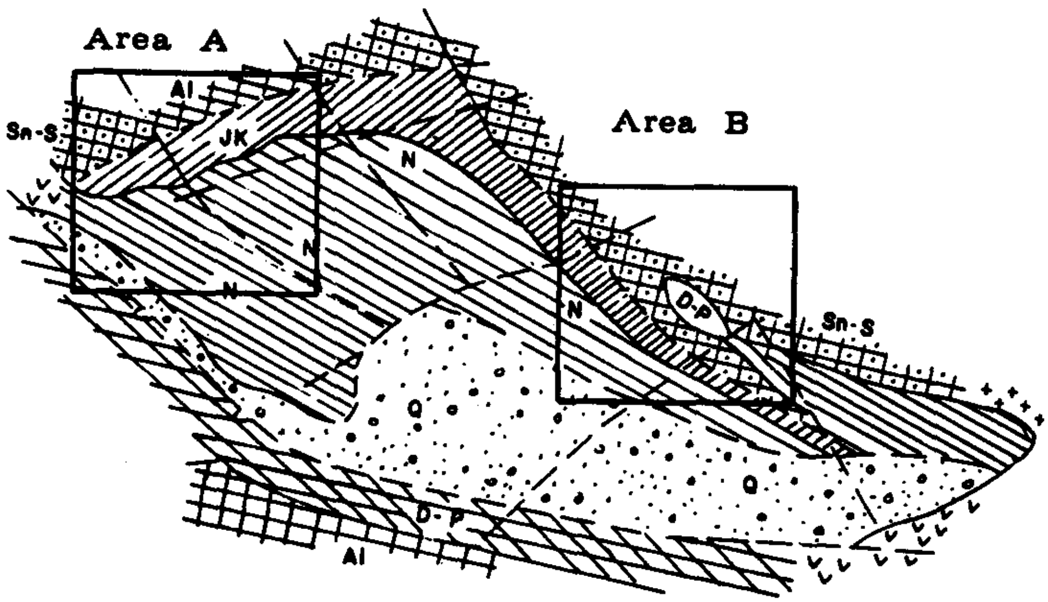


Fig. 4-1 — Outcrop map of the Tsaidam Basin (after Ch'ang Ta)

~~TOP SECRET~~
~~NO FOREIGN DISSEMINATION~~

[redacted]

ROCKS EXPOSED

QUATERNARY -
- Lacustrine and fluvial deposits
- Sand dunes
- Terrace deposits, colluvium, fans
- Quaternary undifferentiated including alluvial, lacustrine, aeolian and bolson deposits

TERTIARY -
- Volcanics
- Kansu System

CRETACEOUS JURASSIC - Jurassic Cretaceous Systems

PERMO-CARBONIFEROUS (incl. DEVONIAN) - Devonian through Permian Systems

LOWER PALEOZOIC - Nan Shan metamorphic rock series

PRECAMBRIAN
- Pre Cambrian metamorphic rock series
- Granitic rocks, Precambrian (?) in age (Probably includes younger intrusive rocks)

GEOLOGIC SYMBOLS

- Bedding horizontal
- Dip and strike, moderate inclination
- Dip and strike, steep inclination
- Strike of bedding, foliation or schistocity
- Possible outcrop area
- Formational contact, dashed where indefinite
- Key bed
- Contact zones, between apparently different rock units
- Color alteration zones
- Faults, lineaments, fractures, joints
- Anticline, arrow denotes plunge, apex indicated
- Syncline, arrow denotes plunge
- Dark toned area

PHOTOGEOLOGIC EVALUATION MAP
of the
N.W. TSAIDAM BASIN AREA
SINKIANG UIGHUR and TSINGHAI PROVINCES, CHINA

PREPARED BY
Itek CORPORATION, Lexington, Mass.
TROLLINGER-GOSNEY & Assoc. Inc., Denver, Col.

DATE JUNE 1970

Fig. 4-2

~~TOP SECRET~~
~~NO FOREIGN DISSEMINATION~~

HANDLE VIA
~~TALENT - KEYHOLE~~
~~CONTROL SYSTEM~~

4.2.2 Lower Paleozoic System (Nan-Shan metamorphic rock series—LPm)

This is the "ancient metamorphic rock series" consisting mainly of slates, phyllites, schist, and various types of gneiss. It forms the main rock unit of the northern Altin-Tagh Mountains and occurs in the Kunlun Shan and Ch'i-lien Shan areas. In the latter area, this is called the Nan-Shan system.

4.2.3 Marine Devonian Through Permian Systems (D-P)

This sequence includes more than 2,150 meters of calcareous shale, shale, sandstone, argillaceous limestone, black schist, and light and dark gray limestone. Similar to the South China marine sequence, it occurs along the northern edge of the Kunlun Shan Mountains forming the southern flank of the basin. Within the project area, this sequence is also interpreted to be present in the foothills of the southern Altin-Tagh Mountains in the west central part of the project. A large inferred granite intrusion is mapped here, designated as "PCg" on the map. It is, however, more likely to be post-Permian in age.

4.2.4 Jurassic-Cretaceous System (JK)

This is a continental facies lake basin sequence. It consists of a lower interval, from 900 to 2,600 meters thick of grayish-green conglomerate, sandstone, black shale, and some coal beds. The Cretaceous system consists of as much as 1,800 meters of conglomerate, green sandstone, and purple shale. The Jurassic-Cretaceous beds crop out in the southern foothills of the Altin-Tagh Mountains and form the outer sedimentary rim of the Tsaidam Basin.

4.2.5 Tertiary Kansu System (Tk)

This is a continental facies sequence that represents the most widely distributed and thickest rock unit within the Tsaidam Basin proper. It consists of from 3,000 to 6,000 meters of relatively thin-bedded conglomerate, sandstone, shale, and gypsum strata. This sequence varies greatly in thickness in different parts of the basin, being thickest in the southeast part.

Above the Kansu System are the Quaternary fluvio-lake accumulations. Quaternary deposits mapped include: lake beds (Ql), sand dunes (Qsd), terrace deposits (Qt), and undifferentiated materials (Q), including alluvium, colluvium, fans, bolson, and aeolian deposits.

In addition to the five basic rock units described above, Ch'ang reports the presence of various igneous bodies, including Caledonian and Hercynian age granites. On the photogeologic map, all apparent intrusive igneous rocks are labeled "PCg." Most of these are probably younger than Precambrian age. Along the northern edge of the Altin-Tagh Mountains a series of dark-toned, resistant beds appear in the stream cuts. These appear to be relatively young (Tertiary ?) volcanic rocks.

4.3 STRUCTURE

A majority of the structural features in the vicinity of the project are aligned toward the west-northwest. The Tertiary beds are considerably deformed into elongated, faulted anticlines and synclines. The Jurassic-Cretaceous rocks exhibit long-axial box and comb folds. The older rock sequences adjacent to the basin exhibit relatively complex folding and faulting with the dominant trends oriented toward the west-northwest.

Ch'ang reports that rift faults are the Tsaidam's most characteristic feature. These are reportedly of the high-angle reverse type, where the older rocks are thrust upon the younger.

Most major faults and fault systems are aligned toward the west-northwest, generally parallel with the Kunlun Shan and Ch'i-lien Shan Mountains.

A notable exception to this is the outlining structures of the Altin-Tagh Mountains. This range is anomalously aligned toward the northeast and is bounded by major faults. This is probably a relatively young fault system since the strike of the interior folds within the range and schistocity of the older metamorphic rocks are generally aligned toward the older, west-northwest direction.

The geologic history and chronology of geologic events is postulated by Ch'ang. It is beyond the scope of this report to presume to question his findings, at least not until the adjacent areas are studied in more detail.

4.4 ILLUSTRATIONS

The following examples depict some of the more important geologic features revealed by the photogeologic evaluation in the NW Tsaidam Basin Area. They illustrate the value of the KH-4B imagery as well as the effectiveness of the techniques used. Their location is depicted on Fig. 4-2.

Fig. 4-3 is a dual illustration (3404 and SO-242 records) including an interpretation overlay showing the "contact" (interface) between two major Tsaidam rock units, i.e., the lower Paleozoic metamorphics (more resistant, darker colored) and the younger Jurassic-Cretaceous continental sediments (red and reddish-brown banding). Note how the contact is virtually indistinguishable on the black and white photograph, yet easily depicted on the color film. The dark-toned areas might be indicative of basic intrusive igneous rocks. Mineralization might occur along these interfaces, and along the traces of the numerous faults and fractures within the area. The fault zone on the right represents the eastern-most end of the northeastward-trending "major fault zone" rimming the Altin-Tagh Mountains.

Fig. 4-4 is a 3404 record showing a classic anticlinal structure within a central part of the basin proper . . . the "oil patch." Fig. 4-5 is the SO-242 companion photo of the same area. This well developed structural feature is mapped in thin-bedded Tertiary Kansu strata. The individual beds within this unit are essentially the same color, and hence the SO-242 color photography does not materially enhance the interpretation. This classic anticlinal fold is the type of "trap" that oil geologists continually seek. The circular, arcuate patterns that appear like rings around a tub are, in reality, individual rock layers that have been arched into an anticlinal upwarp and beveled off by erosion. The black dots in the crestal part of the fold are oil wells of the Yuchuantze Oil Field. These, found as a pleasant surprise during the interpretation, indicate that: (1) this is a petroliferous providence (petroleum source rocks and reservoir beds are present in the basin), and (2) that the photo resolution is more than adequate for geologic mapping purposes.

Fig. 4-6 is a schematic cross-sectional drawing of the anticlinal structure at the Yuchuantze Oil Field. No specific oil production data is available for this field, but no doubt the oil comes from porous sandstone reservoir beds within the Kansu sequence.

In the typical oil producing region, oil is believed to be formed in the basin deeps from marine shales and is squeezed by pressure into more porous rocks such as sandstone or limestone beds. Water is also often present and, being heavier than oil, pushes the oil up the dip of the porous reservoir bed. If the layer above the reservoir bed is impermeable (the cap rock), the oil continues to move within the reservoir bed up dip until it is trapped in the crest of an anticlinal upwarp, or similar trap.

Fig. 4-7 is a stereo pair (3404 and SO-242 records) including an interpretation overlay showing a large uplifted anticlinal fold of the box type mapped in the Jurassic-Cretaceous beds along the outer margin of the Tsaidam Basin. The reddish-brown color of the strata is typical of this continental sequence and provides clues regarding the lithologic character of the various strata. Note that these color signatures are lacking in the 3404 record. The stereo pair here gives good evidence of the need for three-dimensional depth perception for accurate photogeologic structural mapping. Note the deep river canyon cut by erosion across the crest of the fold.

4.5 MINERAL RESOURCES

According to Ch'ang, the Tsaidam region offers considerable mineral resources potential. The Tsaidam Basin proper contains thick Mesozoic-Cenozoic oil bearing deposits. Numerous oil seepages have been reported. Other potential mineral resources indicated by Ch'ang are: various metallic mineral deposits, as indicated by the presence of various acidic to basic igneous rock bodies in the mountainous regions adjacent to the basin; coal in the Mesozoic and Cenozoic strata; and salt, soda, and gypsum in the basin interior.

The following general statements are made with respect to the possible mineral and petroleum potential of the subject area in light of the photogeologic study.

4.5.1 Petroleum [redacted]

Several producing oil fields are known in the Tsaidam Basin, including the Yuchuantze Oil Field discussed above. No production information was available for the Yuchuantze field. However, the following data for the Leng-Hu Oil Field was found in an [redacted] the Leng-Hu Oil Field, located at about Latitude 38°50' N and Longitude 93°00' E (midway between Study Areas A and B) was discovered in 1958. It produces from a "swell" of about three east-west trending elongated anticlines from numerous, very thin (1 to 3 meters) sandstone layers of Tertiary Oligocene age (Kansu) at depths of about 1,000 meters. Each anticline is about 5 kilometers long and is complicated by numerous faults. The quality of the oil is good. Numerous wells have been drilled but few produce commercially. This is due to a high water/oil production ratio. In 1959/1960, the total output of the Tsaidam Basin was 700 tons (approximately 5,200 barrels) of crude oil per day.

The petroleum potential of Area A is restricted to the sedimentary basin in the southeast part of the map sheet, i.e., that part of the area covered by Tertiary Kansu and Jurassic-Cretaceous rocks. The Yuchuantze Oil Field produces from but one of about nine closed anticlinal folds mapped in the Tertiary rocks within Area A. All of these similar folds can be expected to be prolific in relation to the present production. One of these folds, positioned at approximately Latitude 38°20' N and Longitude 91°30' E, is much better developed than the producing structure. This fold is about 35-kilometers long and 10-kilometers wide, many times larger than the producing Leng-Hu Field east of this area.

It is possible that some of the box-type anticlinal folds mapped in the Jurassic-Cretaceous beds along the margin of the basin might also prove productive, although the sedimentary section will be thin.

[redacted]

[redacted]

[redacted] [redacted]

TOP SECRET TOP SECRET

NO FOREIGN DISSEMINATION NO FOREIGN DISSEMINATION

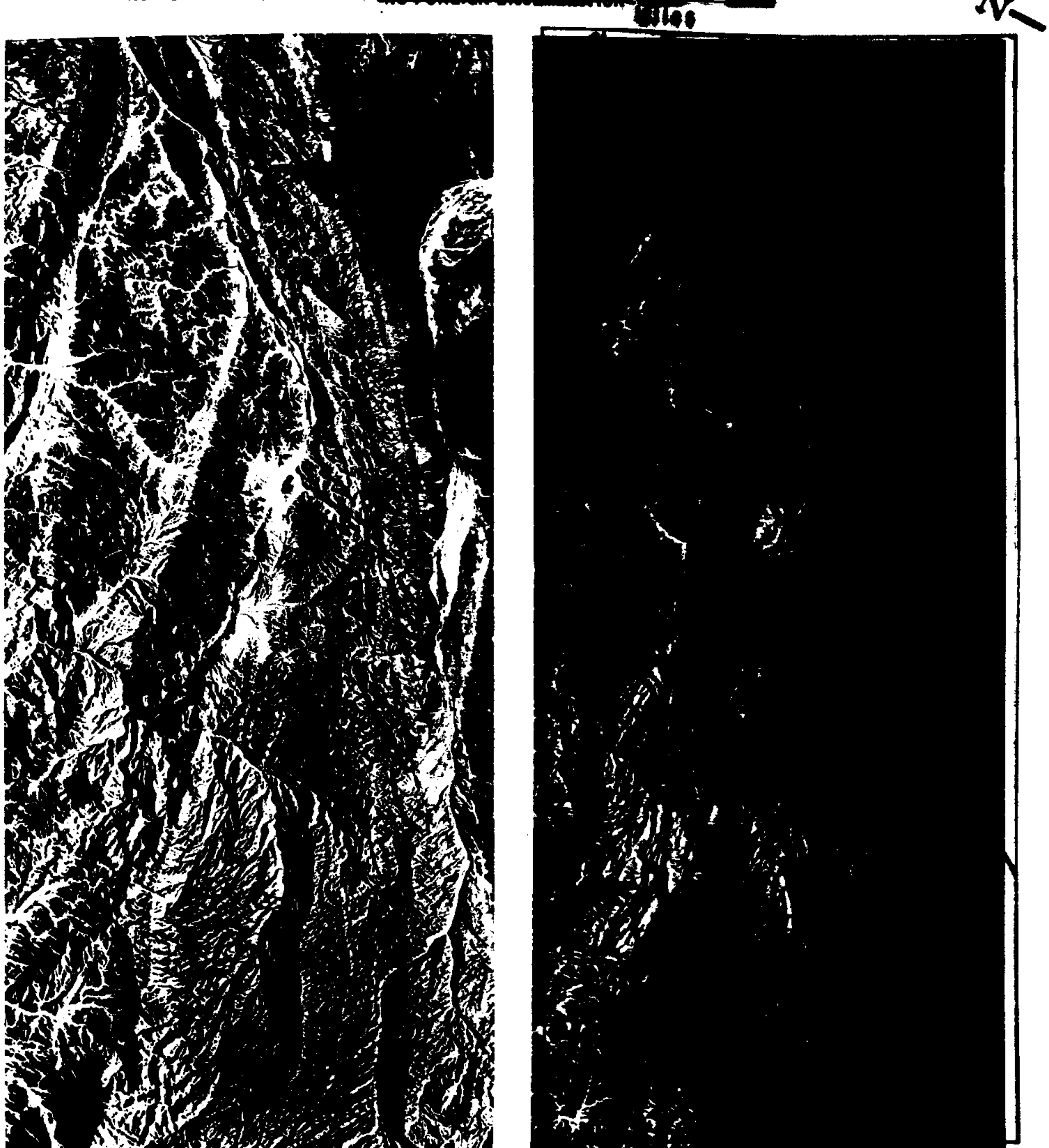


Fig. 4-3 — 3404 and SO-242 records showing contact between two major Tsaidam rock units (lower Paleozoic metamorphics and Jurassic-Cretaceous sedimentaries)

Fig. 4-3 — Geologic overlay

TOP SECRET

NO FOREIGN DISSEMINATION

HANDLE VIA
TALENT-KEYHOLE
CONTROL SYSTEM ONLY

Fig. 4-4 — 3404 record showing classic anticlinal structure

[redacted]

TOP SECRET

NO FOREIGN DISSEMINATION

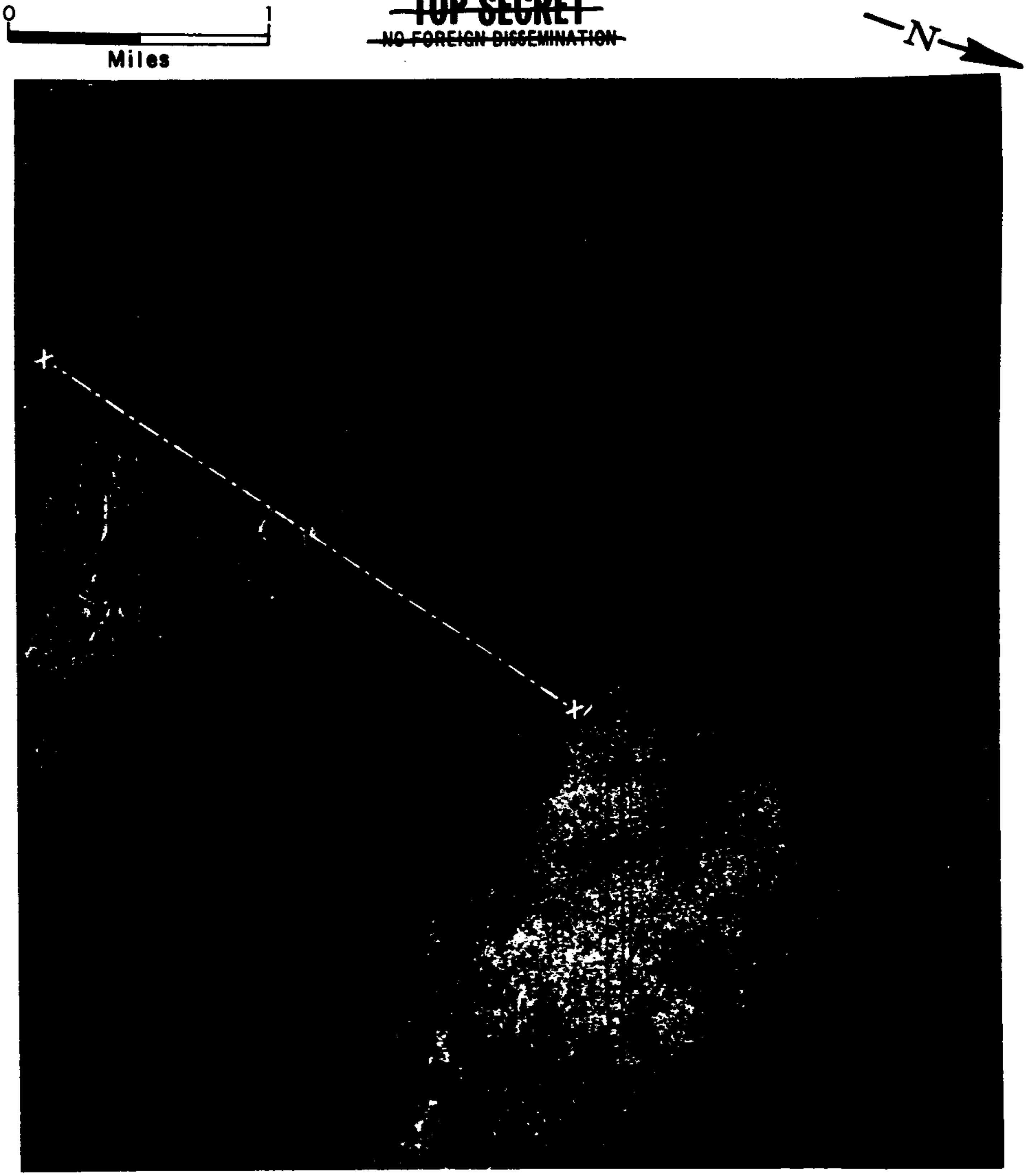


Fig. 4-5 — SO-242 record showing classic anticlinal structure

TOP SECRET

NO FOREIGN DISSEMINATION

HANDLE VIA
TALENT-KEYHOLE
CONTROL SYSTEM ONLY

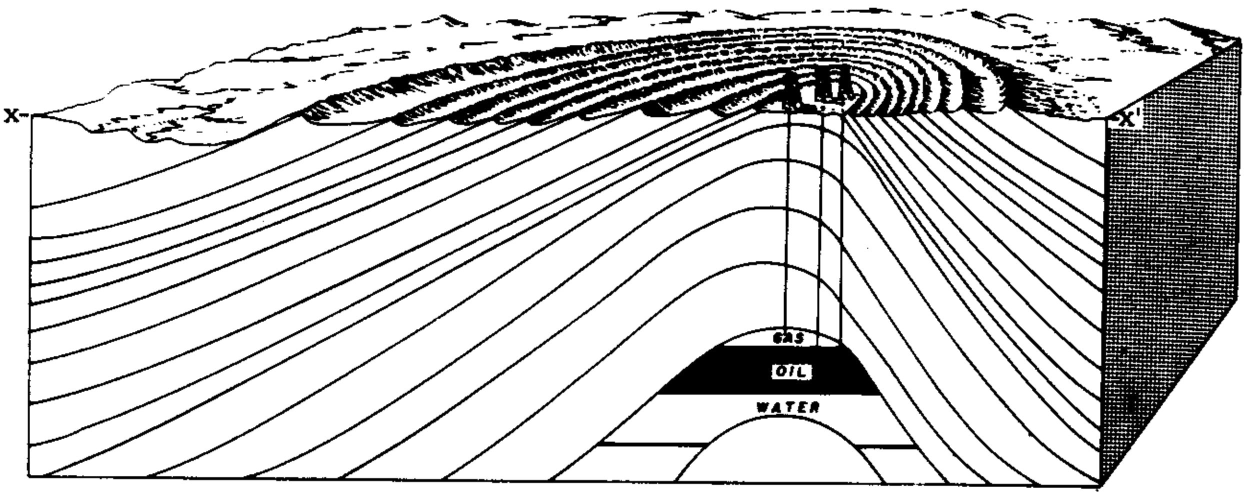


Fig. 4-6 — Schematic drawing—cross section of anticlinal structure, Yuchuantze oil field

[redacted]
TOP SECRET
NO FOREIGN DISSEMINATION

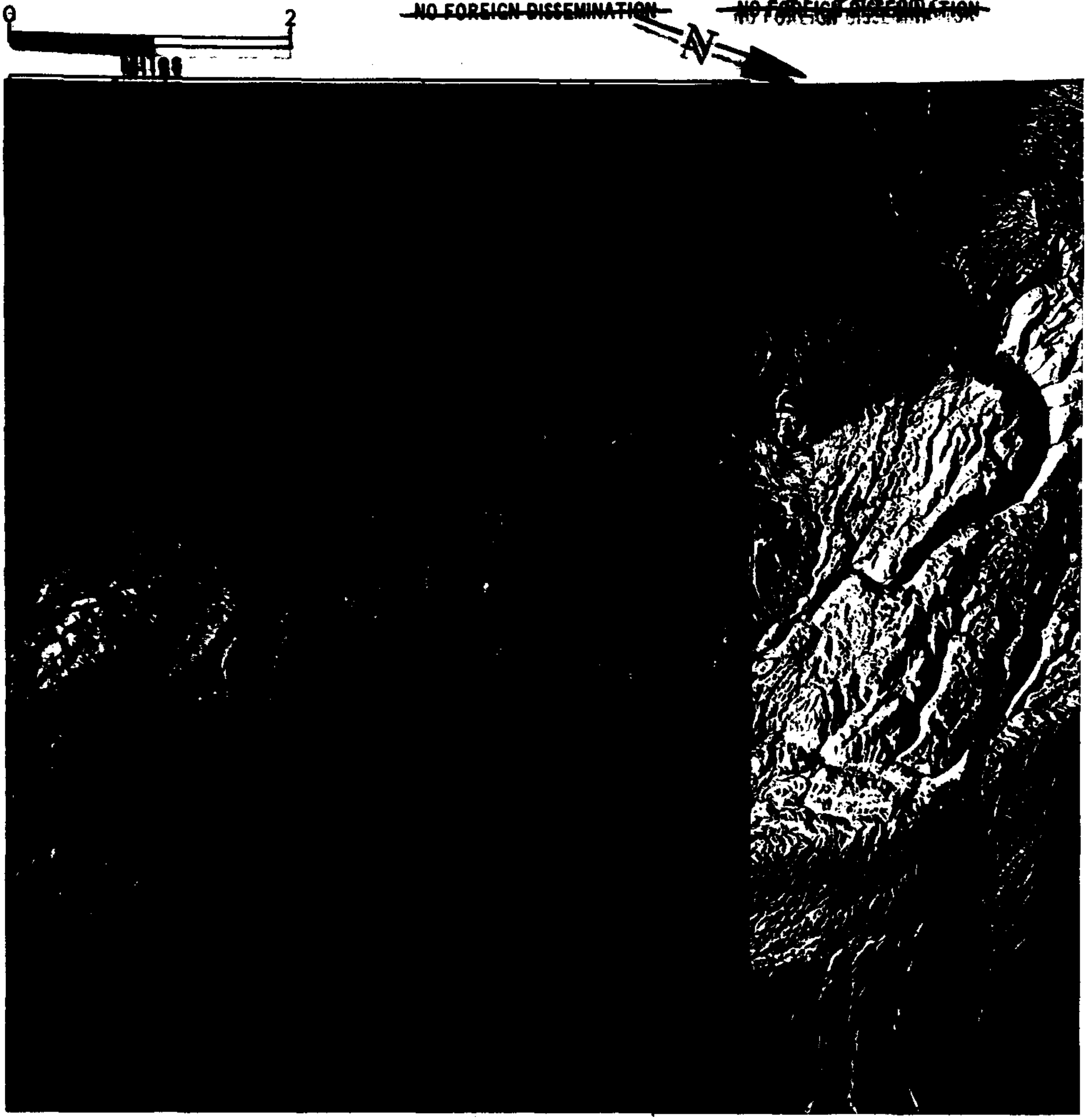


Fig. 4-7 — SO-242 and 3404 stereo pair showing box type anticlinal fold—basin margin

Fig. 4-7 — Geologic overlay

4.5.2 Metallic Minerals

Gold and silver deposits of unknown economic value have been reported* to the west and east of the project. Ch'ang recognizes metallic mineral potential in the vicinity of various igneous rock bodies within the metamorphic rock sequence. From this study, the most favorable areas appear to be along the major fault zones, particularly the northeastward-trending major fault zone crossing the central part of the project, and along the outer edges of the granitic or "PC" zones. The dark-toned areas within the Lower Paleozoic sequence might also prove to be favorable areas for metallic mineral concentrations.

4.5.3 Nonmetallic Minerals

Commercial coal bearing beds are reported to occur along the outer edges of the basin within the Jurassic-Cretaceous sequence. Salt, potash, and gypsum in commercial quantities are likely to be found in the vicinity of the modern interior lake basins.

4.5.4 Other

No doubt other mineral possibilities exist in the subject area. The full potential can be thoroughly evaluated by more detailed photogeologic analysis in conjunction with additional ground truth.

---

*United Nations, "Mineral Distribution Map of Asia and the Far East," 1:5,000,000, 1963.

5. AREA B—NE TSAIDAM BASIN

5.1 GENERAL GEOLOGY

The general geologic conditions of the NE Tsaidam Area are similar to those of Area A, the NW Tsaidam Basin Area. As was the case for Area A, "The Geology of China" by Ch'ang Ta * provided the primary reference used for the mapping of Area B.

Fig. 5-1 is a photographic reduction of the completed photogeologic map of Area B.

5.2 ROCKS EXPOSED

The five basic rock units recognized by Ch'ang, described in Section 4.2, occur in Area B as well as Area A. Ch'ang's sketch map, Fig. 4-1, shows the generalized distribution of these rock units over the subject area.

For the photogeologic mapping of Area B, all apparent intrusive igneous rocks were labeled "gr." This undoubtedly includes basic intrusive igneous rocks as well as granites. No attempt has been made at age determination of these rocks.

5.3 STRUCTURE

The area under consideration includes an appreciable segment of the northeast edge of the Tsaidam Basin. The southwestern one-third of the map sheet falls within the basin proper. The remainder of the area is characterized by strongly deformed mountain ranges composed principally of the Lower Paleozoic metamorphic series.

Within the basin, the Tertiary Kansu beds are deformed into elongated faulted anticlines and synclines. Most of these structural features are characteristically aligned, like those of Area A, toward the northwest. In several places, however, east-west trending fault or fracture zones appear to intersect these dominant trends at an angle. The Tertiary folds appear to be more open to the west, becoming tighter and more faulted as the margin of the basin is approached.

In many places the Tertiary rocks are covered by a light veneer of sand dunes, obscuring the underlying structural details. It is possible therefore that more structural folds are present than mapped.

The Jurassic and Cretaceous beds outlining the basin edge are more strongly deformed than in Area A to the west. The folds are tighter and often pass laterally into faults or fault zones.

The older rock sequences adjacent to the basin exhibit complex folding and strong faulting with the dominant trends oriented toward the northwest. A secondary east-west set of fault trends is in evidence in several places within the area.

---

*Op cit.

Major fault zones appear to outline the margins of most of the dominant mountain ranges within the area. These are probably of the high-angle reverse type, with the older rocks thrust upon the younger. The contact relationship between the Lower Paleozoic metamorphic rocks and the Jurassic-Cretaceous basin sediments is probably of this type.

A number of igneous intrusive bodies are mapped within the mountain ranges. These are postulated on the basis of their land form, texture, and color characteristics and appear to interrupt the characteristic metamorphic terrain. These probably include basic igneous rocks as well as granite; their relative ages cannot be determined on the basis of the evidence revealed by the photogeologic study.

The northwestern corner of the project area is a topographically low region covered by various Quaternary deposits. Although no Tertiary or Mesozoic rocks were observed here, it is possible that they are present beneath the superficial deposits and that this area represents an isolated, structural re-entrant of the Tsaidam Basin proper.

5.4 ILLUSTRATIONS

The following examples depict some of the more interesting geologic features revealed by the photogeologic evaluation in the subject area. Their location is depicted in Fig. 5-1.

Fig. 5-2 is a dual illustration (3404 and SO-242 records) including an interpretation overlay showing the contact zone between the Lower Paleozoic metamorphic rocks (dark-toned, mottled, and highly fractured) and the younger Jurassic-Cretaceous sedimentary strata (red, gray, and reddish-brown banding). Note how the distinct color banding highlights the tight folds in the younger beds. Within the older rock sequence, mineralization might occur along the interfaces between the light and dark banding and along the major fault traces.

Fig. 5-3 is a dual illustration (3404 and SO-242 records) and an interpretation overlay showing a possible mineralized zone along a prominent fault or dike. Note the white bleached-out alignment within the dark-toned Lower Paleozoic metamorphic host rock. An area of igneous intrusion is postulated on the upper right. Mineralization might also exist along the interface between the postulated igneous intrusive rock and the metamorphic host rock, as well as along the more prominent fault and fractures. Zones of intersection between the major fracture zones might be the most favorable areas for mineralization.

Fig. 5-4 is a dual illustration (3404 and SO-242 records) and an interpretation overlay of an apparent mineralized area in the vicinity of an igneous intrusion and fault zone. Note the high-standing, dark-toned area in the lower part of the photograph, interpreted to be an area of basic intrusive igneous rocks. This area, occurring within the Lower Paleozoic metamorphic host rock, is encircled by arcuate, annular streams. This is indicative of the uplift and resistant nature of the igneous intrusion. Along the northern edge of the igneous body is a prominent fault zone, oriented in a northwest-southeast direction. Within this zone are numerous areas exhibiting a brick-red staining, distinctly visible on the color film but indistinguishable on the black-and-white record. The red staining suggests a high concentration of iron oxide, possibly accompanying a concentration of other heavy metallic minerals. Note the faint red staining within the alluvium of the main river flood plain. The smaller streams obviously carry the heavy minerals to the main river, dropping their load on the near bank as they reach the lower level. Note the snake-like outcrop in the upper right corner of the photograph. This is interpreted to be a linear zone of folded sedimentary rocks, possible of Devonian-Permian age (designated D-P).

~~TOP SECRET~~
~~NO FOREIGN DISSEMINATION~~

[redacted]

SEDIMENTARY ROCKS

QUATERNARY

TERTIARY

CRETACEOUS
JURASSIC

PERMO-
CARBONIFEROUS

LOWER
PALEOZOIC

GEOLOGIC SYMBOLS

CULTURAL SYMBOLS

PHOTOGEOLOGIC EVALUATION MAP

of the

N.E. TSAIDAM BASIN AREA

TSINGHAI and KANSU PROVINCES, CHINA

PREPARED BY

Itek CORPORATION, Lexington, Mass. &
TROLLINGER - GOSNEY & Assoc. Inc.,
Denver, Colo.

DATE: MARCH 1971

Fig. 5-1

~~TOP SECRET~~

HANDLE VIA
~~TALENT KEYHOLE~~

Fig. 5-5 is a stereo pair (3404 and SO-242 records) including an interpretation overlay showing an apparent mineralized area in the vicinity of an igneous intrusion and fault zone. This example is located immediately northwest of Fig. 5-4. It lies along the same fault trend as in Fig. 5-4 and exhibits similar igneous activity and mineralization. This might be only part of a regional northwest-trending mineralized zone along the northeastern edge of the Humboltd Shan, in the northeast corner of the map sheet. The stereo pair depicts the strong relief in the mountains bordering the Tsaidam Basin. It also points out the usefulness of stereoscopy for accurate photogeologic mapping.

5.5 MINERAL RESOURCES

The following general statements are made with respect to the possible petroleum and mineral potential of Area B in light of the evidence revealed by the photogeologic study.

5.5.1 Petroleum

The southwest one-third of the subject area has good petroleum potential. Only that part of the area covered by Tertiary Kansu rocks is considered prospective however. The Jurassic-Cretaceous sequence appears to be too strongly deformed to be prospective. Several broad anticlinal folds mapped within the Tertiary Kansu rocks are considered most favorable as traps for the accumulation of hydrocarbons. Those nearer the southwest edge of the mapped area are broader and appear to be less fault controlled than those situated near the basin margin.

The broad topographically low area in the northwest corner of the map sheet should not be totally discounted for possible petroleum accumulations. This might be an isolated arm of the Tsaidam Basin and might contain fairly thick sequences of Mesozoic and Tertiary rocks beneath the unconsolidated Quaternary materials.

5.5.2 Metallic Minerals

The mountainous region of Area B offers excellent potential for metallic mineral concentrations. Most of the mountain ranges are composed of Lower Paleozoic metamorphic rocks and have undergone repeated and complex deformation. Considerable igneous intrusive activity is apparent in many areas. The margins of most of the ranges are outlined by major fault zones. The most prospective areas are along the major fault zones and at their points of intersection with secondary fault or fracture belts. The contact, or interfaces, between the postulated intrusive igneous rocks and the Lower Paleozoic metamorphic sequence are likewise most prospective.

Of particular interest are: (1) the northwest-trending mineralized fault zone in the northeast corner of the area, as depicted by Figs. 5-4 and 5-5; (2) the possible mineralized zone shown in Fig. 5-3; and (3) the numerous areas of apparent alteration indicated on the photogeologic maps.

5.5.3 Nonmetallic Minerals

Commercial coal beds might exist in a few places within the Jurassic-Cretaceous sequence rimming the basin proper. Salt, potash and gypsum might be found in commercial quantities in the vicinity of the modern interior lake basins.

5.5.4 Other

No doubt other mineral possibilities exist in the area. This study could be improved immeasurably with any additional ground truth available, such as, any other previous mining activities, information on the composition of some of the rock suites within the Lower Paleozoic metamorphic sequence, etc.

[redacted] [redacted]

TOP SECRET TOP SECRET

NO FOREIGN DISSEMINATION NO FOREIGN DISSEMINATION

5

Miles

N

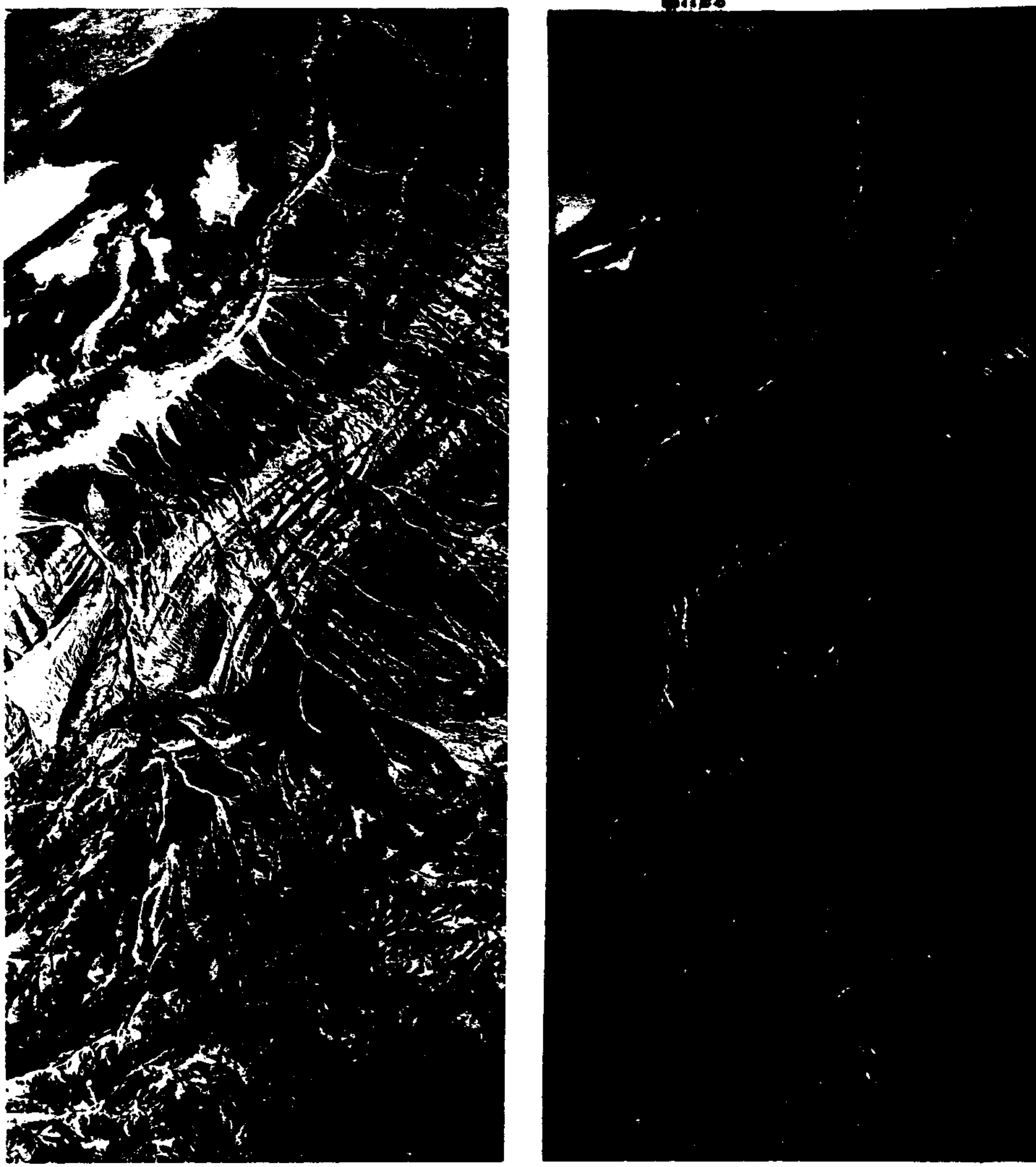


Fig. 5-2 — 3404 and SO-242 records showing contact zone and tight fold structures in Jurassic-Cretaceous

Fig. 5-2 — Geologic overlay

TOP SECRET

NO FOREIGN DISSEMINATION

HANDLE VIA

TALENT-KEYHOLE

CONTROL SYSTEM ONLY

[redacted] [redacted]

TOP SECRET TOP SECRET

NO FOREIGN DISSEMINATION NO FOREIGN DISSEMINATION

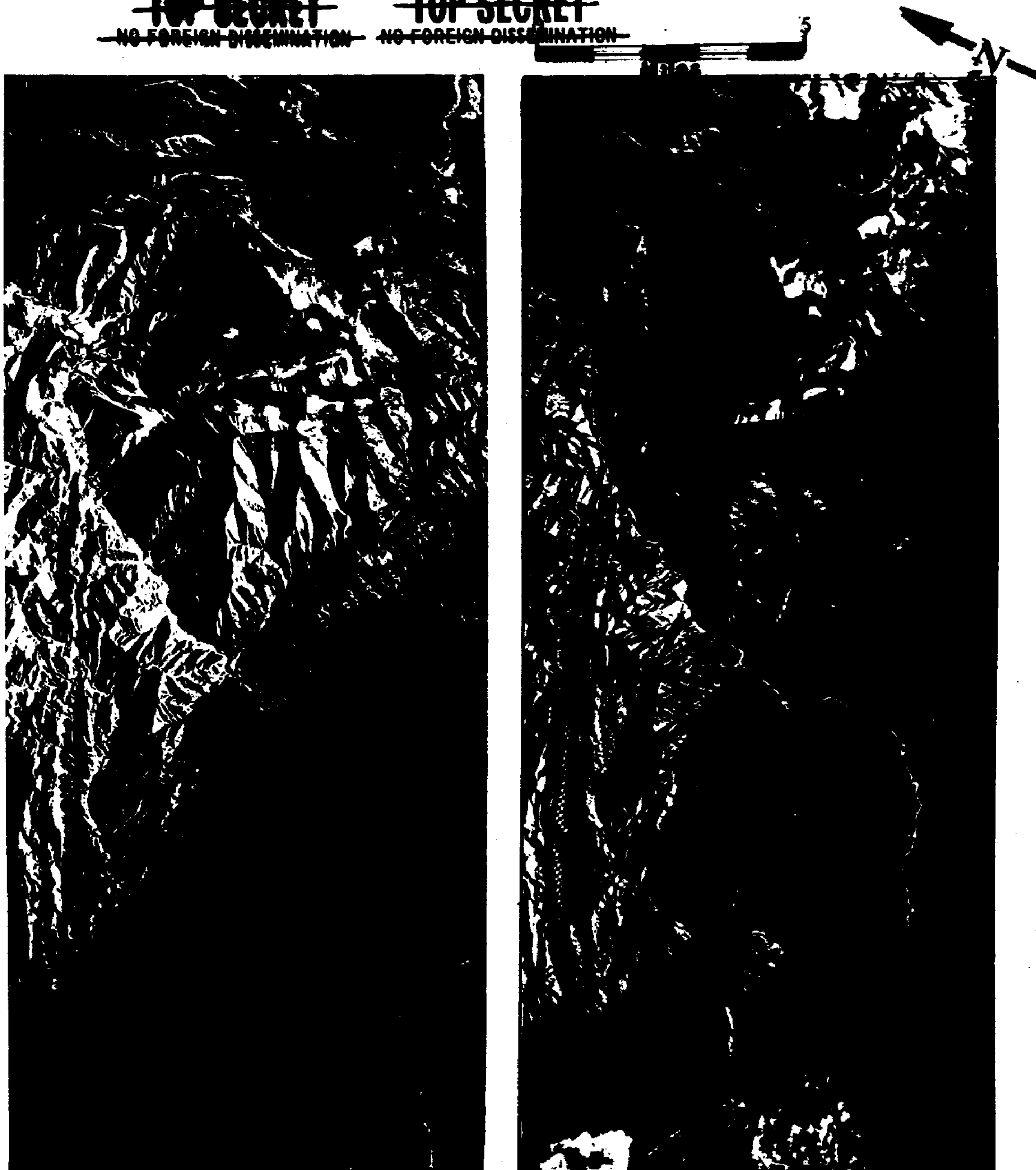


Fig. 5-3 — 3404 and SO-242 records showing possible mineralized zone along fault or dike

Fig. 5-3 — Geologic overlay

TOP SECRET

NO FOREIGN DISSEMINATION

HANDLE VIA
TALENT-KEYHOLE
CONTROL SYSTEM ONLY

This page left intentionally blank.

[redacted]

TOP SECRET

NO FOREIGN DISSEMINATION

[redacted]

TOP SECRET

NO FOREIGN DISS[redacted]

Fig. 5-4 — 3404 and SO-242 records showing apparent mineralization (red stains) in vicinity of igneous intrusion

Fig. 5-4 — Geologic overlay

TOP SECRET

NO FOREIGN DISSEMINATION

HANDLE VIA
TALENT-KEYHOLE
CONTROL SYSTEM ONLY

This page left intentionally blank.

[redacted]
TOP SECRET
NO FOREIGN DISSEMINATION

[redacted]
TOP SECRET
NO FOREIGN DISSEMINATION

Fig. 5-5 — 3404 and SO-242 stereo pair showing apparent mineralization (red stains) in vicinity of igneous intrusion

Fig. 5-5 — Geologic overlay

This page left intentionally blank.

6. AREA C—KAFIRNIGAN-PYANDZH AREA

6.1 GENERAL GEOLOGY

The Kafirnigan-Pyandzh Area falls principally within the Tadzhik Region of the USSR but includes on the south a small part of Afghanistan. The project name relates to the Kafirnigan River, which crosses the western part of the area, and on the south the Pyandzh River, separating Afghanistan from the USSR.

The background research effort was most fruitful for this study. Personnel from OBGI in Washington, D. C. located and provided an excellent geologic reference for the project, i.e., Terrain Atlas, Kafirnigan Area, USSR (C), 1969, sponsored by the Advanced Research Projects Agency, ARPA Order No. 485. The Atlas was produced to provide earth-science data for evaluating the geologic environment in terms of its potential for secret underground nuclear testing. The report is based largely on previously published earth-science data, and its great value was the synthesis and interpretation of the basic information. Although this reference only covers the northwest part of the area, the ground truth it provided proved an excellent guide to the mapping of the area as a whole.

According to the ARPA Report, the subject area lies within the Tadzhik Depression in the eastern part of the vast Scytho-Turanian Platform. It contains a very thick sequence of Mesozoic and Tertiary sedimentary rocks, marine below and continental at the top. The formations were subject to Alpine folding which in this area culminated in late Tertiary time. Linear elongated folds, associated with high-angle reverse faulting were produced, resulting in a rugged linear terrain. The ridges are closely spaced in the north and tend to diverge farther south. This phenomenon, resembling the spreading fingers of a hand, is called the Tadzhik Virgation.

6.2 ROCKS EXPOSED

Geologically this area is quite different from the Tsaidam Basin. The rocks exposed are entirely of the sedimentary type and no igneous or metamorphic (hard rock) areas are exposed. The sedimentary sequence includes rocks of Jurassic, Cretaceous, and Teritary ages overlain in places by various Quaternary deposits. The sequence is characterized by seven individual formations (or units), each of which has its own identifying lithologic characteristics. The stratigraphic sequence, from oldest to youngest, is as follows.

6.2.1 Upper Jurassic Undifferentiated—(Ju)

This is the oldest sequence in the project. It includes gypsum with thin beds of gypsiferous claystone, and local rock-salt beds (20 to 30 meters exposed). Most exposures are associated with major reverse faults and often occur below an irregular boundary marked by dome-like swellings separated by saddles reflecting in the overlying younger strata.

6.2.2 Lower Cretaceous Undifferentiated—(K_1)

This is relatively a thick complex of interbedded red claystone and red and gray sandstone, laterally very variable in lithology and in thickness of individual lithologic units. The total thickness remains rather constant however, from 500 to 700 meters. This sequence is commonly exposed below the Upper Cretaceous in the eroded, eastern flanks of the mountain-forming anticlines.

6.2.3 Upper Cretaceous Undifferentiated—(K_2)

This sequence includes largely grayish-claystone commonly interbedded with sandstone or limestone with occasional interbeds of gypsum, capped in places by a thin sequence of interbedded limestone and gypsum. The thickness varies from 400 to 1,300 meters. These beds are generally exposed in the relatively steep east-facing slopes of the mountain ranges, below the Bukhara limestone cap rock.

6.2.4 Bukhara Limestone (Paleocene)—(Tb_1)

This is a hard dense gray limestone with dolomite and gypsum interbeds. This dark-toned, resistant formation is the main ridge-former, capping the crests of nearly all of the anticlinal mountain ranges within the region.

6.2.5 Eocene-Lower and Middle Oligocene Undifferentiated—(Tc)

This sequence is composed primarily of vari-colored marine claystone with occasional beds of limestone, marl, and sandstone. It ranges in thickness from 365 to 500 meters. It is typically light-toned and moderately resistant, oftenforming V-shaped hogbacks along the western flanks of the Bukhara anticlinal ridges.

6.2.6 Bol'dzhuan Formation (Upper Oligocene-Lower Miocene)—(Tbs)

This is a continental facies sequence composed of maroon, wine-red, or brick-red sandstone and siltstone, often including claystone. Its thickness varies greatly from 220 to 1,000 meters. It usually crops out in bands of varying widths, indicating considerable variation in thickness, on the western mountain slopes above the more resistant marine rocks of the Tc unit.

6.2.7 Garauty Formation (Miocene)—(Tg)

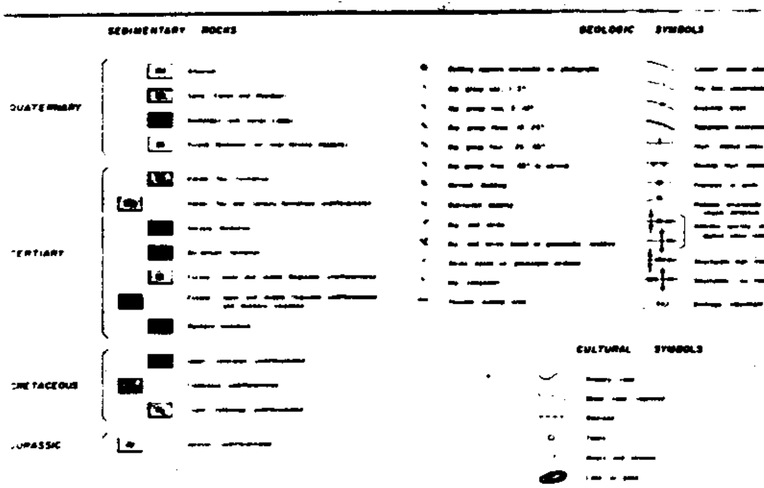
This is a continental sandstone and siltstone sequence, generally light brown to tan in color. It varies in thickness from 435 to 1,800 meters and rests on the eroded upper surface of the Bol'dzhuan formation, generally along the gentle western dip-slopes of the mountain ranges.

Most of these rock units are considerably mantled by various Quaternary deposits, the most widespread of which is the Dushanbe and Ilyak Series, a thick loess deposit.

Although the ARPA Report, from which the above descriptions are summarized, only covers the northwest part of the area under consideration, the ground truth it provided proved an excellent guide to the mapping of the entire area. From the lithological descriptions above, it was possible to identify the various formations outside the area of the ARPA Report and map the entire area, probably more accurately than it had ever been done before. Fig. 6-1 is a photographic reduction of the photogeologic map.

Photogeologic Evaluation Map
Kafirnigan - Pyandzh Area, U.S.S.R., Afghanistan

~~TOP SECRET~~
~~NO FOREIGN DISSEMINATION~~



PHOTOGEOLOGIC EVALUATION MAP

of the

KAFIRNIGAN - PYANDZH AREA

UZBEKSKAYA and TADZHIKSKAYA PROVINCES, U.S.S.R.
and
KUNDUZ PROVINCE, AFGHANISTAN

PREPARED BY

Itek CORPORATION, Lexington, Mass. &
TROLLINGER - GOSNEY & Assoc. Inc.,
Denver, Colo.

DATE: OCTOBER 1970

Fig. 6-1

~~TOP SECRET~~
NO FOREIGN DISSEMINATION

HANDLE VIA
~~TALENT KEYHOLE~~

6.3 STRUCTURE

The regional structure of the subject area is relatively simple. In detail it is complicated and only partly understood. The linear, subparallel elongated folds of the region are generally outlined on the east by long, probably high-angle, reverse faults, down-thrown on the east. These faults cut all formations of Tertiary age or older and commonly form rugged fault scarps. A number of normal faults of considerable length were mapped along the west edge of some of the major structures. These linear faulted anticlines are closely spaced in the north but tend to diverge and become more open farther south. In the northern part of the subject area, several east-west trending strike-slip faults were found. These appear to be left-lateral structural features associated with the northern zone of major structural change.

6.4 ILLUSTRATIONS

The following examples depict some of the more important stratigraphic and structural features revealed by the photogeologic evaluation within the subject area. These, more than any others, vividly portray the value of color for photogeologic mapping with the KH-4B System. Their locations are depicted on Fig. 6-1

Fig. 6-2 is a dual illustration and interpretation overlay depicting graphically the value of color for distinguishing between the various rock formations within a given area. The black and white photograph on the left is useful up to a point. The bold mountain-forming Bukhara limestone is easily identified by its topographic prominence, as it forms the "backbone" of most of the linear mountain ranges in the region. Likewise, the Eocene claystone unit, labeled "Tc," is identifiable by its V-shaped hogback ridges. Above these marine units the stratigraphic sequence changes to a continental facies. The change in color reflects this characteristic. Note the deep maroon-red color of the Bol'dzhuan formation and how easily it can be distinguished from the overlying Garauty formation on the SO-242 color imagery. This contact (interface) is virtually indistinguishable on the 3404 record on the left. The deep red signature of the Bol'dzhuan formation proved to be the most reliable mapping marker within the project.

Fig. 6-3 is a dual illustration and an interpretation overlay showing essentially the same part of the stratigraphic section as in Fig. 6-2. Observe the continuity of formational color and topographic characteristics. Note how the prominent backbone of the mountain ridge is formed on the characteristic Bukhara limestone. The west flank is the dip-slope and the east flank is the rugged and highly-faulted obsequent slope. The Lower Cretaceous rocks beneath the Bukhara are relatively easily eroded and do not display recognizable identifying characteristics.

Fig. 6-4 is a stereo-pair and an interpretation overlay depicting an elongated, faulted anticline along the west edge of the study area. The bold Bukhara limestone forms the backbone of the anticlinal mountain range. The V-shaped hogbacks etched by erosion on the "Tc" unit encircle the prominent uplift. The reddish-hued Bol'dzhuan formation is apparent on the west flank, even though it is heavily mantled by Quaternary loess deposits.

This structure typifies the characteristic structural forms found within the area. The linear faulted anticlinal ranges broaden toward the south and become more prospective for the entrapment of hydrocarbons. To the north they become tighter and more highly faulted, thus diminishing their petroleum potential.

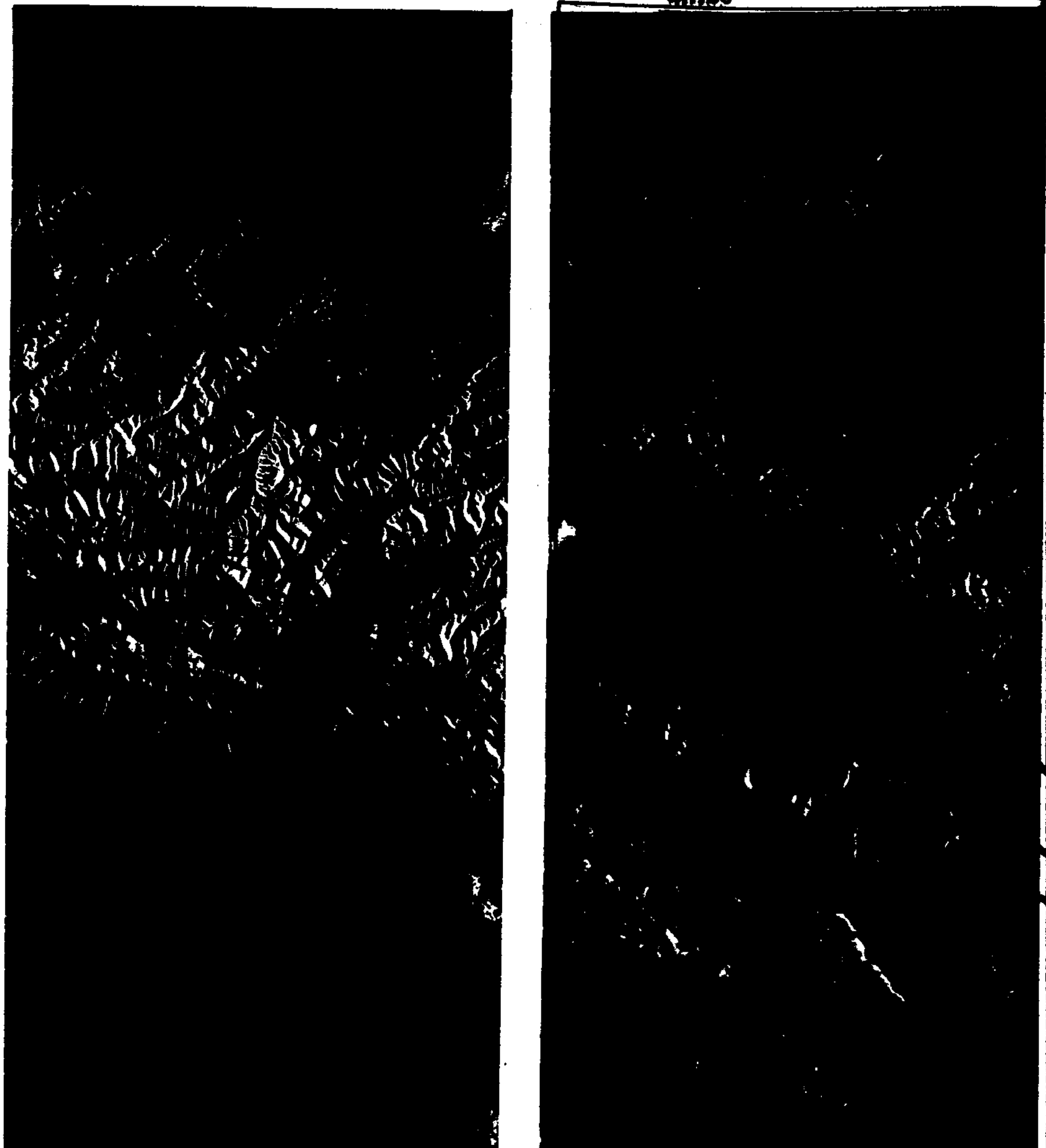


Fig. 6-2 — 3404 and SO-242 records showing typical sedimentary section, Kafirnigan—Pyandzh area

Fig. 6-2 — Geologic overlay

6.5 MINERAL RESOURCES

As a result of the photogeologic mapping together with the information contained in the ARPA Report, the following general statements can be made with respect to the mineral and petroleum potential of the area.

6.5.1 Petroleum and Natural Gas

Oil and gas are being produced from anticlinal structures east and west of the study area. No production data has been obtained for these fields. The numerous elongated anticlinal folds of the region are excellent prospects where closure exists and where faulting is not too severe. Therefore, the southern part of the area is most prospective since the folds broaden in that direction.

6.5.2 Metallic Minerals

The potential for metallic minerals within the region is not known. No igneous or metamorphic rocks have been reported in the area. The greatest potential for metallic mineral concentrations would likely be along the northern margin of the area where the structural deformation is known to be strongest.

6.5.3 Nonmetallic Minerals

Some local bituminous coal deposits are mined north of the area, but the coal potential for most of the region is slight. Sand, gravel, and loess deposits are plentiful from the various Quaternary materials widely distributed across the area. Brick clay is likely abundant from the upper Cenozoic and Quaternary deposits. Lime, marl, dolomite, and building stone is plentiful from the Bukhara and "Tc" formations. Gypsum and rock salt are available from the Jurassic and Cretaceous outcrops as well as the Bukhara limestone.

6.5.4 Other

Although doubtless other mineral possibilities exist for the area, they cannot be realistically appraised without additional ground truth.

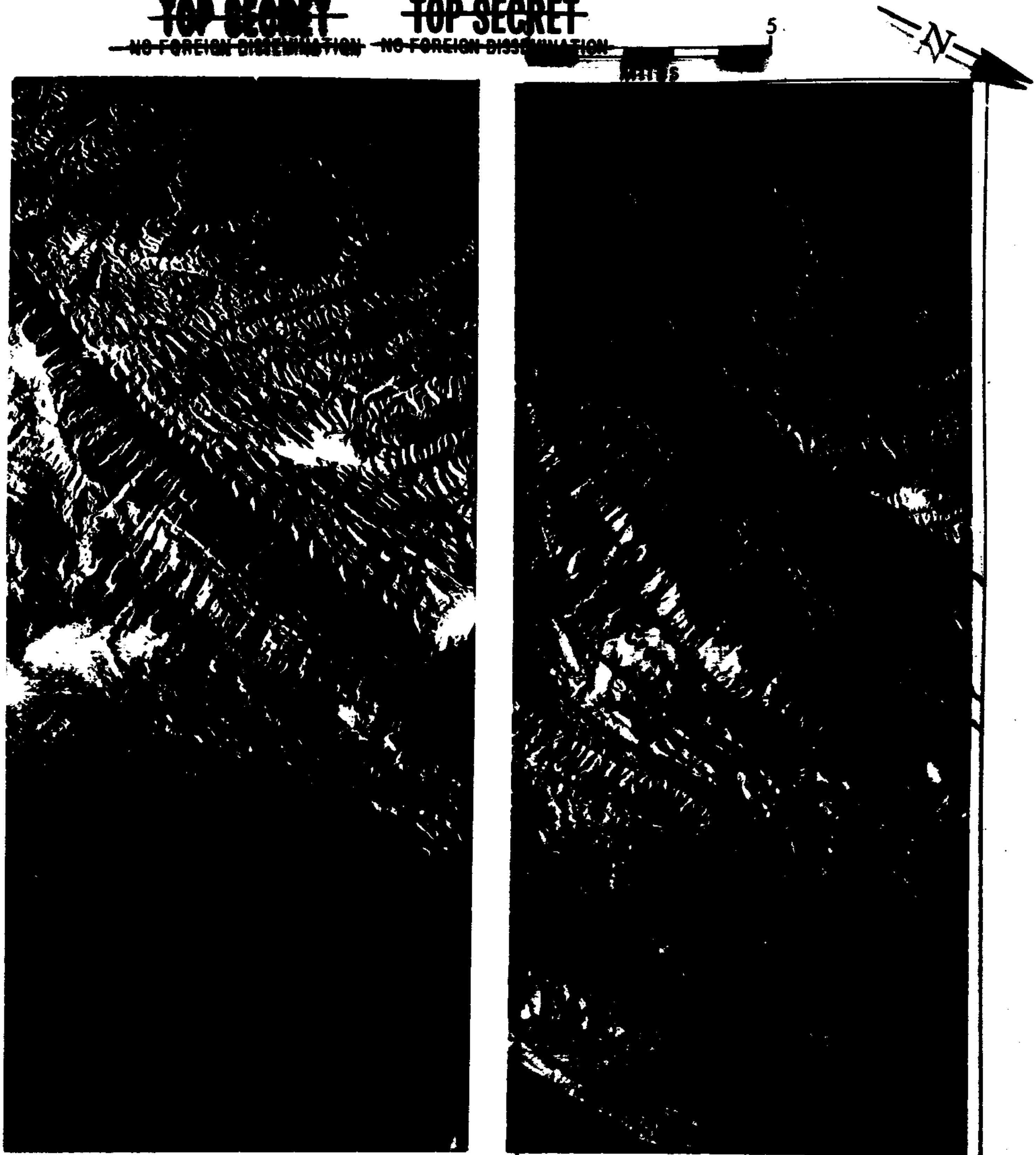


Fig. 6-3 — 3404 and SO-242 records showing sedimentary section, Kafirnigan—Pyandzh area

Fig. 6-3 — Geologic overlay

This page left intentionally blank.

[redacted]
TOP SECRET
NO FOREIGN DISSEMINATION

Fig. 6-4 — SO-242 and 3404 stereo pair showing faulted anticlinal structure

Fig. 6-4 — Geologic overlay

This page left intentionally blank.

7. CONCLUSIONS

The following conclusions have been reached from the foregoing study.

7.1 EFFECTIVE PHOTOGEOLOGIC MAPPING CAN BE ACHIEVED USING THE KH-4B SYSTEM

The results of the three photogeologic mapping projects indicate that the KH-4B System, originally developed for military intelligence purposes, is uniquely well suited to photogeologic mapping. The completed photogeologic maps are immediately useable for assessing the mineral and petroleum potential of the subject areas. They could be presently used, if feasible, to make new mineral discoveries. The quality of the maps, however, could be improved by employing the best aspects of interpretation and compliation learned from these initial studies.

Comparing these studies with conventional photogeologic mapping projects provides some interesting insights into the efficiency of using the KH-4B materials. In total area, these three studies embrace approximately 36,000 square miles. A standard photogeologic study using conventional aerial photography at the basic approximate scale of 1:40,000 would require an experienced photogeologist to expend approximately 3 man-years and would require him to analyze about 3,600 aerial photographs. This is compared with him using approximately 72 PAN images and expending about 3 months to achieve essentially comparable results using the KH-4B System. This is to say that a photogeologic study using the KH-4B material would require from 10 to 15 percent expenditure of time and money as compared to using conventional aerial photography.

For regional photogeologic mapping, the main advantages of the KH-4B System are: (1) overall synoptic view, (2) polar orbit (no inaccessible areas), (3) stereoscopic perspective, (4) vertical (rectified), (5) resolution, and (6) color. The first four of these, while important, are not necessarily indigenous to this system but are typical of other space photography systems. The unique qualities of the KH-4B System, resolution and color, are most important, as discussed below.

7.2 THE VALUE OF COLOR CANNOT BE OVERSTATED

For photogeologic mapping, the use of color photography has distinct advantages over black and white. Color provides: (1) easier differentiation between rock types; (2) more accurate tracing of individual sedimentary beds; (3) more definitive clues as to the exact nature of lithology (rock type), and hence is far more valuable in areas of limited ground truth; (4) better identification of specific formation signatures, and (5) oxidation halos and discoloration zones indicative of possible mineralization.

It is recognized that the use of the SO-242 color film has resulted in reduced resolution from the 3404 operational standard. For photogeologic analysis, however, this loss of resolution is insignificant when compared to the interpretive value gained by color. Resolution of 20 to 30 feet is entirely adequate for most regional photogeologic mapping projects, and the SO-242 color film easily meets that standard. By using both the 3404 and SO-242 film in a stereoscopic mode, as was done for this study, the advantages of both are obtained with very little sacrifice of the useful qualities of each type.

7.3 THE KH-4B SYSTEM REPRESENTS AN IMPORTANT BREAKTHROUGH FOR NATIONAL RESOURCES EXPLORATION

The economic and political impact of this cannot be overstated. While the world-wide demand increases dramatically for minerals and fossil fuels (those resources in fixed supply), our ability to locate and harvest these hidden deposits lags far behind.

Experts agree that exploration from space offers a potential breakthrough in large scale explorationtechniques. Virtually every major exploration advance inthe last 20 years has been on-the-ground detectors of one sort or another. These are detailing geophysical tools, whose use is very expensive in relation to area analyzed, and must be used selectively. A prerequisite to their proper and efficient use is a conduct of effective preliminary reconnaissance studies to localize areas of most promise.

Exploration from space provides an enlarged prospective, a previously unattainable synoptic view of the earth. Though the geologists' discipline is a study of the earth, until now he has never seen it. With his vision broadened from this space perspective, he is enabled to search for oil provinces instead of oil fields and mineral districts instead of mineral deposits.

The barrier of inaccessibility has been broken. No area is inaccessible or too remote for the polar-orbiting satellite. Now the entire earth is the geologist's true laboratory. The dramatic oil discovery at Prudhoe Bay, north of the Arctic Circle in Alaska, and the subsequent $900 million investment in adjacent land by oil companies indicate that no areas are too remote for raw materials exploration.