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A Guide to the TECTONIC MAP OF INDIA

1 : 2,000,000

1968

PUBLISHED BY THE OIL & NATURAL GAS COMMISSION
DEHRA DUN, INDIA

A Guide to the

TECTONIC MAP OF INDIA

(1 : 2,000,000)

1968

PUBLISHED BY THE OIL AND NATURAL GAS COMMISSION, DEHRA DUN, INDIA

TECTONIC MAP OF INDIA

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THE SAN MIGUEL MINE

This is a report on a preliminary examination of the San Miguel copper mine, 11 miles south east of Cuba, in Sandoval County, North-Central New Mexico.

Summary and Conclusion

The property in its present condition is an excellent prospect. The ore exposed warrants construction of a small leaching plant. By doing some exploratory drilling to arrive at an expanded ore estimate a larger plant might be indicated. The present price of copper gives more than a sufficient margin for return of capital plus a profit.

Location and Title

The principal operations have been conducted on the San Miguel claim, the central of the three which make up the patent group #1804, in Section 24, T 19 N, R 1 W, NMPM. The others are the Palmer and the Copper Queen; the three occupy a little less than 60 acres. This group constitutes the principal workings in this San Miguel District of Sandoval County. The owner is J. B. Pope, of Pittsburgh, Pa. who has 2/3 of the title and represents the remaining 1/3, a member of his family. Taxes are paid to date, and no liens or mortgages are in sight. He offers an ordinary lease with an option to buy.

History

The early day production could be arrived at by going thru the records at the State Bureau of Mines. These discoveries were made in the 1880's, and old slag piles scattered on the flats below attest to crude smelting operations. The patent to these claims was issued in

1919. A tumble down structure that must have been a sorting plant is on the San Miguel claim. One would judge the timbers of this structure to be about that old. The patent plat shows two cross cut tunnels into the formation, and a small amount of lateral drifting. No doubt this was selective mining.

Later day open pits, dozed out on the outcrop in 1955-56 did not encounter any of the old underground workings. The portals of the two tunnels are caved and filled with rubbish. They show evidence of being caved further in, and present a difficult job of reopening. The level of these tunnels is at least 200 feet below the pits.

Geology and Related Features

This is known as "Red Beds Copper", a term describing ores which are found in sandstones and conglomerates which lie above certain red clays and shales. In this area the Red Beds are the Chinle formation, of Triassic Age, which is widespread thruout the Four Corners country. Immediately on top of the red beds lies the Agua Zarca sandstone, also of Triassic age. Here is where the copper ore are found.

Two conditions are necessary for ore deposition: 1) a permeable host rock, as this coarse Agua Zarca sandstone and conglomerate is, and 2) a mineralizer, which is generally a fault, the avenue for the mineral solution to travel from the parent magma. Both conditions are present at the San Miguel mine. The ore was discovered on the top and flank of an anticline, which is the demonstrated locale of copper and uranium ores, a form of trap.

The copper minerals which entered the sandstone are now seen as the green and blue cement material, malachite and azurite, between thepebbles and grains. None of the pebbles are penetrated or altered by the copper minerals, indicating that this was a low temperature action. Very little secondary migration has taken place after the original deposition. The impervious red shale beneath is a sharp bottom to the ore. The lateral extent of the ore shoot is yet to be determined.

The outcrop of the sandstone going southerly is covered by granite wash which has come down from San Miguel Peak to the east. This wash was too deep for the early prospectors to dig by hand, and the 1955 operators stripped only a small area around the known outcrop. So the extent of the mineral to the south is obscure. On the north the limits are established by a sharp gulley cutting across the strike of the formation. The dip is 45 degrees westerly and the strike is SSE, the sandstone being 30 or more feet thick.

The region is noted for the Nacimiento Fault which extends for 30 miles in a north-south direction, showing up-ended sedimentary beds and scarps along the western front of the San Pedro and Nacimiento Mountains. It is only reasonable to believe that this tremendous movement induced the mineral action along this front. Other promising copper properties are along this faulted region, none of which have been developed or worked out. The Eureka and O.L. & H. groups will undoubtedly receive development in the near future.

Ore Characteristics

The last operators shipped crude ore which averaged 1.62% copper. Their shipments suffered from dilution with waste. Smelter records give a total of 1,500 tons. The best shipment was 40 tons @ 3.42%; the poorest was 63 tons @ 1.07%. This average of 1.62% is more than sufficient grade, since we know the operators in a similar ore at Page, Arizona, are making a profit of 50¢ a ton on 0.60% ore.

Sulfuric acid in dilute solutions attacks and disintegrates this ore, since the cement material is the copper mineral itself. Experience with similar ores in the Southwest indicates a 95% extraction by the acid leach method. Copper is recovered as cement copper by precipitation with scrap iron. The results of a flotation test by the State Bureau of Mines at Socorro are pending. The metallurgist at this institution is of the opinion that this ore will respond to this treatment successfuly. A copy of his leaching test is included.

Call this at least 6000 tons
H.E.C.

Operation and Recommendations

At least 4000 tons of ore are scattered in various piles about the property. This could be screened and hand sorted to get a couple carloads of crude shipping ore, probably going at 3½% copper.

Or a leaching plant could be set up, with the feed generated by these ore piles plus new ore from the open pits. Mining costs, using rippers, dozers and loaders, should be well below $2.00 per ton. Leaching costs would depend on the cost of the water used, but would less than $3.00 per ton.

Oil drillers discovered an aquifer in Section 21, SE¼, of this

There is another good dump at the Pit on the Palmer claim.

same township, which establishes a water supply within reasonable distance. A study would have to be made on the choice of pumping water up to the mine, or hauling the water up, or hauling the ore down to the well, either by truck or tram line. Either procedure would entail about 1 mile of new hillside road, plus swamping out about a mile of old pack trail.

It seems best to do sufficient exploratory drilling, which could be done for less than $10,000.00, to evaluate the entire ore body, and then plan an installation to suit, before establishing a leaching plant for the new ore as well as the dump ore.

All this might entail a surface installation to leach the easily taken ore on the dumps and in the pits, followed by a system of leaching the mineral in place in the steeply dipping sandstone bed, gathering the pregnant solution in a lower tunnel. The topography is suited for this. Or the lower tunnel site could be utilized for entry using conventional mining methods.

The present long road could be rehabilitated and used until this preliminary work was done. At that point the construction of a new road might be justified. The total expenditure depends upon the decision resulting from the exploratory drilling.

Harry E. Coppin

Harry E. Coppin

New Mexico Registration 3352

GRESHAM GEOPHYSICAL CORPORATION

GEOLOGICAL RECONNAISSANCE OF THE HASSAYAMPA PLAIN AND ADJACENT AREAS MARICOPA COUNTY, ARIZONA

S. C. Brown Geologist

S.C.B. Copy

Exploration Program
Smith Proposal

(1)

1. Map Geology Rock Types
2. Map Geological structures — faults, dikes & other topographic feature; dip, strike, { Project in from Surrounding Intrus Vulcan — Belmont, etc
3. Plane-table location of Seismometer from pre-flagged Sec. Corners
4. Inventory water wells, analyze chemistry of waters, Temperature
5. Geochemical survey over 160 Ac & Analyze.
6. Prepare base maps, Geol & Str. dips, strikes, etc
7. Plane table all wells, power lines & other pertinent feature
8. Prepare reports sufficient detail for ERDA approval.
9. Gresham A. Seismometer Map & Results
   B. Gravimeter Map. (Ariz State Univ.)

---

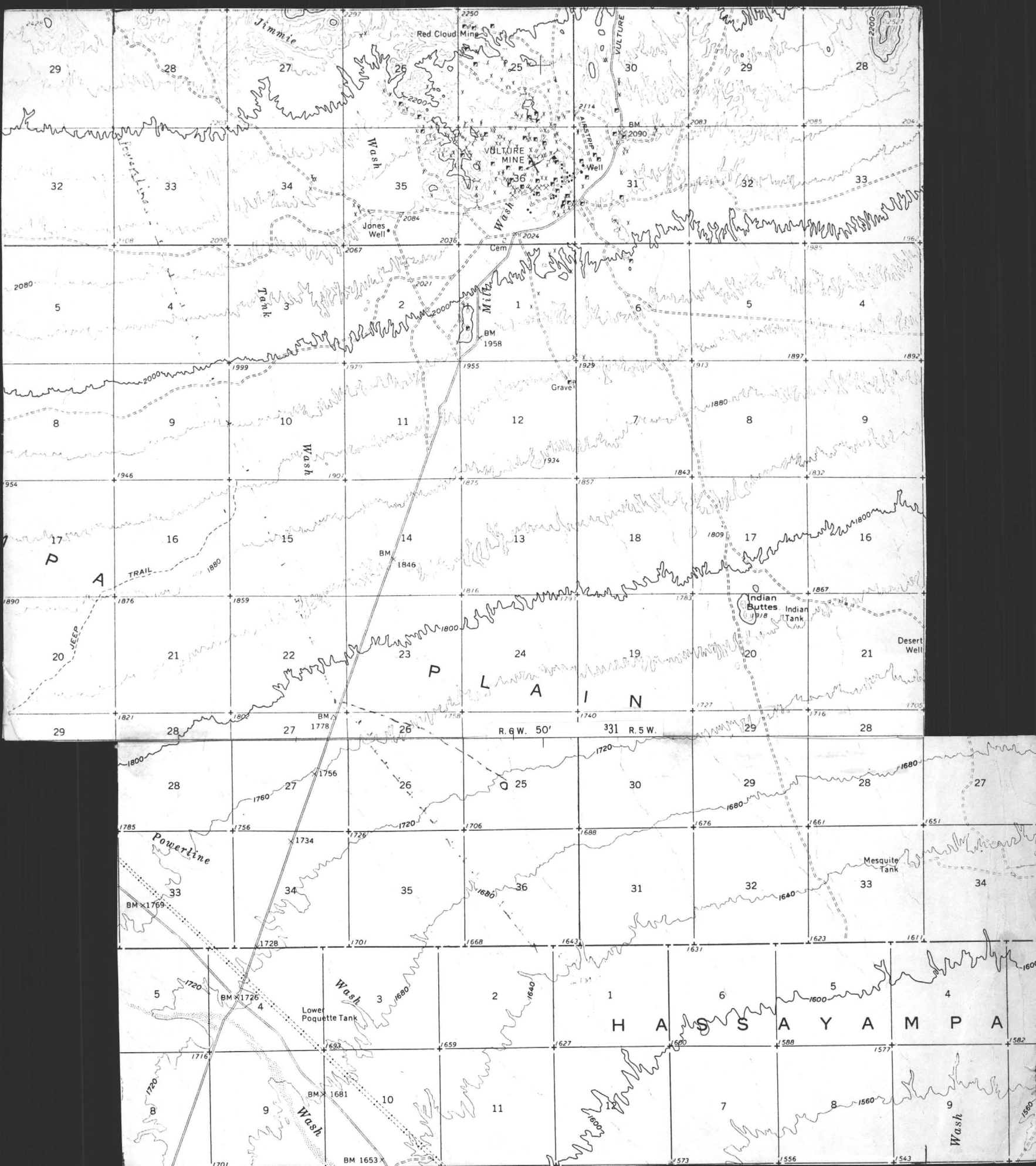
10. Study Photos & Ests from Bur. of Rec. in Phx.
11. Get data from AK DOSS — State Land Dept. if available.
12. Prepare X-sections if possible from Geol & Str. Maps

Maps

1. Study Source of GW Recharge
2. Water Flow Map - Direction
3. Depth to Basement Map
4. Str. Contour Top pre-C
5. Loc. of wells w/ Logs when available (USGS)
6. Probable heat source.
7. Water Table Map.
8. Hydro & Geochemical maps
9. Acquire as much published data as possible, prepare & fill in with field investigation
10. Thermal Gradient Map.

Field equipment needed & office space.

1. Geophysical
2. Plane-Table
3. Walkie-Talkie
4. Rock & water sample containers


Jimmie
Wash
Red Cloud Mine
VULTURE
AIRSTRIP
BM 2090
VULTURE MINE
Well
Jones Well
Cem
Tank
Wash
Milk
BM 1958
Grave
Wash
BM 1846
TRAIL
JEEP
Indian Buttes
Indian Tank
Desert Well
P A L A I N
R. 6 W.
50'
31
R. 5 W.
BM 1778
Powerline
Mesquite Tank
BM 1769
BM 1726
Lower Poquette Tank
Wash
H A S S A Y A M P A
BM 1681
Wash
BM 1653
Wash

PROPOSED PLAN AND METHODS FOR DILIGENT EXPLORATION

Re: A 9751, A 9752 & A 9754

Gary G. Smith, Frances D. Smith and Conrad D. Clement propose to use the plan and methods described below in order to evaluate acreage described in geothermal lease applications as follows:

A 9751 - T. 5 N., R. 6 W., GSR Mer., Arizona

Sec. 11, All;
Sec. 12, All;
Sec. 13, All;
Sec. 14, All.

totaling 2,560.00 acres

A 9752 - T. 5 N., R. 5 W., GSR Mer., Arizona

Sec. 18, Lots 1 thru 4, E½W½, E½ (All);
Sec. 19, Lots 1 thru 4, E½W½, E½ (All).

T. 5 N., R. 6 W., GSR Mer., Arizona

Sec. 23, All;
Sec. 24, All.

totaling 2,599.92 acres

A 9754 - T. 5 N., R. 6 W., GSR Mer., Arizona

Sec. 26, All;
Sec. 34, All;
Sec. 35, All.

totaling 1920.00 acres

The methods described are in the approximate sequence in which the methods will be used. However, each succeeding step in the evaluation sequence depends upon favorable responces from the steps preceding it. In the event a number of these methods indicate that a potentially economical reservoir is not present, further work will be terminated and the leases will be surrendered.

THE EVALUATION PROCEDURE

1. Preliminary geologic and geochemical reconnaissance: This will provide a broad look at the surrounding area acquainting survey personnel with the geology, hydrogeology, topography, vegetation and access.

2. Passive seismic survey: This is a reconnaissance survey giving information on geology and hydrogeology of the area.

3. Detailed geochemical survey; A detailed study of the hydrogeology and hydrochemistry of the area.

4. Gravity survey: This survey will be used to locate favorable geologic anomalies.

5. Resistivity survey: If previous steps show favorable indications, this survey will be used in an attempt to locate potentially hot reservoirs.

6. Temperature gradient and heat flow survey: A detailed survey used to investigate anomalies indicated in previous surveys.

7. Geothermal test well or wells: Should the preceding surveys be positive, a geothermal test well or wells will be drilled. Further development will depend on the success of the geothermal test well.

The time at which each of these surveys will be executed depends upon weather, availability of contract crews, administration difficulties, the speed of data processing, etc. Surveys 1 thru 4 involves no disturbance to the environment and are considered "casual use" (43CFR 3209.9-5 (d). Surveys 5 thru 7 may involve some disturbance where survey lines may require off road travel.

With respect to 43CFR 3210.2-1(d) second paragraph, in our exploration operations, we will comply with the terms and conditions specified in the Notice of Intent covering fire preventionand control, soil erosion, water pollution, etc. A copy of form 3200-9 containing these terms and provisions is attachec. It should be noted that our Notice of Intent specifically excludes all drilling operations. No drilling operations are contemplated until a lease has actually been granted on the subject lands. With respect to exploration of a casual nature as described in 43CFR 3209.0-5(d), we will use guidelines those terms and conditions in the Notice of Intent which apply.

As a further effort to minimize disturbance in the subject area, we shall endeavor to complete surveys as rapidly as possible.

Gary G. Smith

Frances D. Smith

Conrad D. Clement

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

A GEOTHERMAL STUDY

GEOLOGICAL RECONNAISSANCE OF THE HASSAYAMPA PLAIN AND ADJACENT AREAS MARICOPA COUNTY, ARIZONA

For:

Mr. Gresham R. T. Clacy, President
GRESHAM GEOPHYSICAL CORPORATION

By:

Silas. C. Brown, Geologist
Phoenix, Arizona
March 1976

REGISTERED GEOLOGIST
CERTIFICATE NO. 4702
SILAS C. BROWN
Date Signed 4-1-76
ARIZONA, U.S.A.

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

A GEOTHERMAL STUDY

GEOLOGICAL RECONNIASSANCE OF THE HASSAYAMPA PLAIN AND ADJACENT AREAS MARICOPA COUNTY, ARIZONA

INTRODUCTION

At the request of Mr. Gresham Clacy, President, Gresham Geophysical Corporation, a geological reconnaissance survey was made of the Hassayampa Plain and the adjacent mountain areas. The primary purpose was to determine the extent of faulting and volcanism which might be favorable for geothermal test wells.

The contact between the Quaternary-Tertiary valley fill and the basement rocks was not shown on the base map. please refer to the Geological Map of Maricopa County if these data are needed.

LOCATION & ACCESSIBILITY

The area studied included the Hassayampa Plain, the Vulture Mountains and the northeastern flank of the Belmont Mountains. More specifically, the area covered includes Townships 4 to 7 North, Ranges 5 to 8 West, Maricopa County, Arizona. The approximate center of the area of interest lies about 15 miles southwest of Wickenburg and is easily accessible by a well maintained gravel road.

Two major power lines pass through the Hassayampa Plain.

Elevations range from about 1600 feet above sea level in the Plain to 3658 feet above sea level on Vulture Peak.

GENERAL GEOLOGY

The mountain areas consist of a highly complex series of Igneous and Metamorphic rocks of pre-Cambrian age and Volcanic extrusives of Cretaceous-Tertiary and Quaternary age.

In the Vulture Mine area, which is highly faulted, the contacts between the various rock types vary widely in size and character. The most predominent rocks consist of hornblende schist, granite, gneiss, rhyolite and andesite. Near the Vulture Mine, granite (batholithic) has intruded into the volcanic rocks.

Vulture and North Caballero Peaks are volcanic centers from which the Laramide flows orginated. These rocks are rhyolite and andesite in composition. Black Butte, situated on the western end of the Vulture Mountains, consists of Quaternary basalt flows over older Cretaceous-Tertiary volcanics and basement rocks.

The Hassayampa Plain consists of Quaternary-Tertiary sands, silts, conglomerates and clay beds that vary widely in thickness laterally and makes correlation of wells difficult. These sediments range from zero thickness at its contact with the basement complex in the mountains to over 1200 feet thick in the southeastern part of the Plain.

FAULTS & STRUCTURE

Several major faults having over 300 feet of displacement are present in the area. The two prominent faults; Black Butte with ± 600 feet of displacement to the northeast and Talmage with ± 700 feet of displacement to the east, were projected under the Hassayampa Plain.

Many other faults are present and of sufficient size to help control geothermal concentration, particularly where they are closely associated with the volcanic centers in the Vulture Mountains.

The Astor fault has a displacement of ± 300 feet with its downdrop side to the east and the East fault with ± 550 feet of displacement to the west. The downdrop fault block between the Astor and East faults forms a Graben. The Schoolhouse fault is supposedly present in the Graben but it was not observed on the surface.

Many smaller faults were observed having varying amounts of displacement. At Black Butte, a fault having about 150 feet of displacement with its downdrop side to the east, trends N-S to N5°W. It intersects the larger Black Butte fault on the northeast side of Black Butte.

The Coyote faults, on the northeastern flank of the Belmont Mountains, have unknown displacements but the downdrop side appears to be to the northeast. These faults have a fairly wide disturbed zone and may prove of major significance. Much more detailed field work would be necessary to outline their magnitude and their real significance related to geothermal prospects.

The Talmage fault at the Vulture mine was projected S 10° E to intersect the projected S 60° E Black Butte fault under the Hassayampa Plain. The intersection point os these two faults lies less than a mile northeast of the hot water well in Sec. 25-T5N-R6W. A straight-line projection is most acceptable where surface data are lacking, however, there is no assurance that the faults will maintain the same trend over long distances. Geophysical work in the vicinity of the hot water well indicates the fault trends may have shifted southwestward of the straight-line intersection point.

GENERAL

The hot water well in Section 25-T5N-R6W has a temperature of 135°F at the flow pipe. The aquifer was reported at a depth of 419 feet immediately below a caprock. The well apparently is fault related based upon the data gathered. The caprock could also be travertine deposits which formed around the vent of an old hot water spring to be later covered by valley fill sediments. The old spring probably had its source along a deep-seated fracture zone.

A third possibility is the presence of a volcanic plug which did not reach the surface or was subsequently covered by younger sediments. The aquifer being in sedimentary rocks rather than volcanics tends to weaken this theory.

The well was a significant discovery regardless of its geological setting as it is indicative of a possible geothermal field with economic potential in the area.

GEOLOGICAL REPORT

OF THE

CHIMNEY ROCK LEASE

SAN JUAN COUNTY, NEW MEXICO

BY

SILAS O. BROWN

MARCH 28, 1956

P. O. Box 1240
Durango, Colorado
March 28, 1956

CHIMNEY ROCK LEASE

SAN JUAN COUNTY, NEW MEXICO

INTRODUCTION

The Chimney Rock lease is situated in the Navajo Reservation about seven miles northeast of Shiprock, New Mexico. The lease contains 3360 acres in Township 31 North, Range 17 West, NMPM., San Juan County, New Mexico.

A detailed plane-table survey was made between March 17 and 22, 1956. Four lensing, concretionary and limy sandstone horizons in the Mancos formation were used during the mapping. The elevations were reduced to a common datum plane on the final map. No attempt was made to carry the plane-table survey more than one mile south of the lease, this being sufficient to evaluate the block.

STRUCTURE AND GENERAL GEOLOGY

The main structural high is situated about 1½ to 2 miles south of the lease. A low but broad high is indicated in sections 22 and 23. Due to the nature of the lensing sands no surface control was available on the critical part of the structure in section 26. Projections of structural elevations on the survey points all indicate the closure as outlined. No faults were observed in the Mancos shale or in the Mesaverde sandstone which crops out to the east.

The trend of the structural high centering in sections 22 and 23 lies in the more favorable northwest direction to conform with the old line of folding. Its position also lines up with the Blue Hill Paradox gas production and the Mancos Creek oil of the Dakota and Mancos formations. This trend can also be extended to the southeast through known Cretaceous production. The formation and the accumulation of oil and gas took place during the time of deposition and subsequent folding during Paleozoic periods. This northwest-southeast trend parallels the Uncompahgre uplift which lies on the northeast side of the Paradox salt basin.

Laramide and younger folds have a north or northeast trend and are considered of secondary importance. These younger folds do not necessarily reflect the older structures in which the oil had already formed and migrated. It is apparent that very little migration took place from the older to the younger traps.

Besides the Paradox and older objectives, the Dakota and lensing sands of the Mancos formation are favorable for the accumulation of oil and/or gas in commercial quantities. These horizons are expected to be only 5 to 10 feet in thickness with a sharp oil-water demarkation line, therefore, very careful drilling and completion methods are pertinent.

Porosity is a major problem in the Paradox horizon but any shows, regardless of the amount of porosity should be treated with acid and fracked. A study of other producing fields in the general area indicated that the porosity is situated along the north side of the anticlinal structures. This fact should influence the location of a test well on the Chimney Rock lease.

Based upon other wells in the immediate vicinity, the expected formations, tops and potentialities are as follows:

Formation		Expected Top		Oil & gas potentalities
Mancos	-----	Surface	-------	no
Tocito	-----	640'	-------	Oil - fresh water @670'
Dakota	-----	1300'	-------	Oil - fresh water
Morrison	-----	1480'	-------	no
Todilto	-----	2545'	-------	no
Entrada (Incl. all Jurassic)	-----	2580'	-------	?
Chinle	-----	3115'	-------	no
Cutler	-----	4145'	-------	no
Rico	-----	?	-------	?
Hermosa				
Upper	-----	5915'	-------	Oil ? & gas ? @ 6540'
Paradox	-----	6790'	-------	Oil and gas
Lower	-----	7435'	-------	?
Molas	-----	7750'	-------	no
Mississippian	-----	7890'	-------	Oil ? & gas ? - salt water

GENERAL DISCUSSION

A study of the Three States #1-A Navajo well in section 27-31N-17W., indicated possible oil production in the Tocito at about 670 feet. The top of the Tocito is picked at a depth of 638 feet. The oil sands are thin but if proper water shut-off is possible, then small production can be expected.

The Dakota top is picked at 1295 feet. Although Schlumberger electrical log shows little or no development of the S.P. curve, it is believed that commercial production is possible in the 5 to 10 foot porous zones near its top. The problem again is getting a proper water shut-off to prevent the flooding of the oil sand.

The Three States well also had lost circulation at 6541 feet which was not tested. This zone should be cored to check for shows and porosity.

Many good shows were reported in the Paradox member of the Hermosa formation. These shows should have been cored and tested and subsequently treated with acid and frack.

The Mississippian formation, which was topped at 7890 feet, showed good porosity but it made salt water on a drill stem test. A well on structure should test the Mississippian formation despite the results of the Three States well.

WATER FOR DRILLING

Water for drilling purposes is available at the Continental # 1 well in section 34-31N-17W., about 2 3/4 miles south of the proposed location. This well flows in excess of 750 barrels per day from the Tocito formation. An earth tank takes the overflow from the well and its storage capacity is estimated at about 50 barrels. This is an Indian Service well and permission must be obtained prior to its use. In the event this is impossible, water is obtainable at Shiprock from the San Juan River about 11 road miles to the south.

LOCATION AND RECOMMENDATIONS

Based upon the above facts and assumptions it is recommended that a test well be drilled in the NE NW NE Sec. 22-T31N-R17W. Only minor dozer work will be necessary to condition the existing roads suitable for moving in heavy drilling equipment.

It is further recommended that the test well penetrate the upper 100 feet of the Mississippian rocks. The depth of the well to test that section would be about 8000 feet deep.

Silas C. Brown
Geologist

Metal Mining in Utah

SINCE THE DEPRESSION

AND

THROUGH THE POST-WAR YEARS, 1935 TO 1950

A Statistical Survey

BY

C. E. NEEDHAM
ALFRED M. BURANEK

Circular No. 37

Prepared and Released under the Sponsorship of

THE UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

College of Mines and Mineral Industries

MINES BUILDING

SALT LAKE CITY, UTAH

June, 1950

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

The Utah Geological and Mineralogical Survey was authorized by act of the Utah State Legislature in 1931; however, no funds were made available for its establishment until 1941 when the State Government was reorganized and the Utah Geological and Mineralogical Survey was placed within the new State Department of Publicity and Industrial Development where the Survey functioned until July 1, 1949. Effective as of that date, the Survey was transferred by law to the College of Mines and Mineral Industries, University of Utah.

The *Utah Code Annotated 1943, Vol. 2, Title 34,* as amended by *chapter 46 Laws of Utah 1949,* provides that the Utah Geological and Mineralogical Survey "shall have for its objects":

1. "The collection and distribution of reliable information regarding the mineral resources of the State."

2. "The survey of the geological formations of the State with special reference to their economic contents, values and uses, such as: the ores of the various metals, coal, oil, shale, hydro-carbons, oil, gas, industrial clays, cement materials, mineral waters and other surface and underground water supplies, mineral fertilizers, asphalt, bitumen, structural materials, road-making materials, their kind and availability; and the promotion of the marketing of the mineral products of the State.

3. "The investigation of the kind, amount, and availability of the various mineral substances contained in State lands, with a view of the most effective and profitable administration of such lands for the State.

4. "The consideration of such other scientific and economic problems as, in the judgment of the Board of Regents, should come within the field of the Survey.

5. "Cooperation with Utah state bureaus dealing with related subjects, with the United States Geological Survey and with the United States Bureau of Mines, in their respective functions including field investigations, and the preparation, publication, and distribution of reports and bulletins embodying the results of the work of the Survey.

6. "The preparation, publication, distribution and sale of maps, reports and bulletins embodying the reults of the work of the Survey. The collection and establishment of exhibits of the mineral resources of Utah.

7. "Any income from the sale of maps and reports or from gifts or from other sources for the Survey shall be turned over to the State Treasurer and credited by him to a fund to be known as the Survey Fund to be used under the direction of the Director of the Survey for publication of maps, bulletins or other reports of investigation of the Geological and Mineralogical Survey."

The Utah Geological and Mineralogical Survey has published maps, circulars, and bulletins as well as articles in popular and scientific magazines. For a list of such publications or for other information concerning the geological and mineralogical resources of Utah address:

Director, UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
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By Alfred M. Buranek and C. E. Needham

For the convenience of those needing the Directory, we have prepared and conveniently folded in a pocket inside the back cover a Mineral Resource Map of Utah. All important producers and consumers of Utah minerals, metals, and nonmetallics are classified and listed in the bulletin under each respective product. Price $1.00

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By Alfred M. Buranek — Free Upon Request

REPRINTS of a summary by Arthur L. Crawford published by Chemical and Engineering News (Vol. 27, p. 3017, 1949) on Utah Raw Materials of interest to the Chemical Engineer. Free Upon Request

METAL MINING IN UTAH

SINCE THE DEPRESSION

AND

THROUGH THE POST-WAR YEARS, 1935 TO 1950

A STATISTICAL SURVEY

by

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INTRODUCTION

For the decade 1937-47, the gist of the data set forth in the following pages was originally presented by Mr. Buranek at a hearing of the National Resources Economic Subcommittee on Public Lands held in Denver, Colorado, February 3, 4, and 5, 1948, under the chairmanship of U. S. Senator George W. Malone of Nevada.

Mr. Buranek was then one of the geologists for the Utah Geological and Mineralogical Survey which at that time was a part of the Raw Materials Division of the Utah State Department of Publicity and Industrial Development. Dr. Needham, who collaborated in furnishing the data was then as now Supervising Engineer, Salt Lake Section, Metal Economics Branch, United States Bureau of Mines.

Continued demand for this information is justification for its being brought up to date and published as a circular of the Utah Geological and Mineralogical Survey.

Arthur L. Crawford,
Director.

METAL MINING IN UTAH

A STATISTICAL SURVEY

GENERAL STATEMENT

During the period 1935-1949, metal mines in Utah declined from 235 in 1935 to 90 in 1946, rose to over 120 in 1947 and 1948, then dropped to about 100 in 1949. Although the greatest decline has been in the number of mines (both lode and placer) producing gold and silver ores, base-metal mines also have declined markedly in number, except for those producing zinc-lead ores; these reached a high point in 1948 for the period

The decline in straight gold mining has been due largely to the closing of gold mines during World War II, followed in the postwar period by shortages of labor and materials, high taxes, and increased costs of labor and supplies, coupled with a fixed price for gold. The result has been a pronounced reduction in the purchasing power of the gold ounce. This is always a very strong factor in the rise or fall of gold output. Utah's high position as a gold-producing state is therefore due to the recovery of gold as a by-product in the treatment of base-metal ores, and not to the mining of straight gold ores.

The decline in the number of mines producing silver ore has not been as great as in those producing gold ore. Following increases in the mint price of silver in 1946 and 1947, the number rose appreciably in 1947-48, but declined sharply in 1949. It appears, therefore, that a considerably greater increase in the price of silver would be required to bring in marginal silver mines or to accelerate the production of silver from complex lead-zinc ores. Consequently, silver in Utah, like gold, continues to be principally a by-product of base-metal mining.

Declines in base-metal output from 1943 through 1946 resulted largely from labor shortages, work stoppages, rising costs on virtually every item used by the industry, increased wage scales, continued high taxes, and lack of ore development during the war, even though prices trended generally upward during the period.

During 1947, conditions became much more stable, and many factors affecting base-metal production were greatly improved. As a result, output of base-metal ores rose to one of the highest figures in Utah history. The number of lode mines (exclusive of manganese mines) operating in the State rose from 88 in 1946 to 118 in 1947.

Expiration of the Premium Price Plan on June 30, 1947, caused only two or three mines to close, but operations at some properties were curtailed or shifted to different ore. Output of metals was not greatly affected.

Stimulated by further increases in the prices of copper, lead, and zinc, production of these metals in Utah in 1948 continued to rise. The record production however was halted late in October, when the Utah Copper Mine, of the Kennecott Copper Corporation, in Bingham Canyon was closed by a work stoppage for the remainder of the year. As a result, State output of copper for the year was considerably less than in 1947.

The Utah 1949 declines in the production of ore and in all five metals were attributable to two main factors: the work stoppage at the Utah Copper mine, in effect until February 7, and the sharp drop in base-metal prices beginning in March and continuing well into summer. Unstable markets for base metals not only resulted in closing several mines but in curtailing production at others through reductions in labor force or through a reduction in the work-week from 48 to 40 hours.

TABLE I

MINES PRODUCING GOLD, SILVER, COPPER, LEAD, ZINC, AND MANGANESE IN UTAH, 1935-49

MINES PRODUCING	YEAR														
	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Gold ore	59	44	42	50	41	33	24	19	11	9	10	11	10	8	5
Gold-silver ore	23	14	24	20	24	36	33	27	30	23	14	14	19	23	16
Silver ore	43	48	32	29	30	36	34	21	28	24	23	18	31	32	19
Copper ore	17	9	23	14	15	12	19	16	10	14	15	13	19	13	13
Lead ore	88	76	88	79	77	86	75	40	31	29	33	33	51	62	39
Lead-copper ore	2	--	--	--	1	3	4	1	4	--	--	4	--	1	--
Zinc ore	--	--	1	1	--	1	4	7	7	6	6	6	8	5	3
Zinc-lead ore	24	25	32	31	30	40	31	41	37	31	28	30	36	45	38
Zinc-lead-copper ore	--	--	--	--	--	--	--	--	--	--	--	--	4	1	3
Total, above mines	203*	171*	189*	183*	175*	191*	167*	123*	110*	97*	89*	88*	118*	118*	93*
Placers	31	28	14	22	11	21	12	6	1	--	--	1	2	2	2
Manganese ore	--	1	1	--	2	1	1	4	3	1	--	--	--	--	--
Manganiferous ore	1	5	3	--	5	7	6	1	1	2	3	1	4	2	4

* A mine producing more than 1 class of ore is counted but once in arriving at total for all classes.

TABLE II

AVERAGE PRICES OF GOLD, SILVER, COPPER, LEAD, AND ZINC, 1935-49.
(U. S. Bureau of Mines)

YEAR	GOLD (ounce)	SILVER (ounce)	COPPER* (pound)	LEAD* (pound)	ZINC* (pound)
1935.....	$ 35.00	$0.71875	$0.083	$0.040	$0.044
1936.....	35.00	.7745	.092	.046	.050
1937.....	35.00	.7735	.121	.059	.065
1938.....	35.00	.646	.098	.046	.048
1939.....	35.00	.678	.104	.047	.052
1940.....	35.00	.711+	.113	.050	.063
1941.....	35.00	.711+	.118	.057	.075
1942.....	35.00	.711+	.121	.067	.093
1943.....	35.00	.711+	.130	.075	.108
1944.....	35.00	.711+	.135	.080	.114
1945.....	35.00	.711+	.135	.086	.115
1946.....	35.00	.808	.162	.109	.122
1947.....	35.00	.905+	.210	.144	.121
1948.....	35.00	.905+	.217	.179	.133
1949.....	35.00	.905+	.197	.158	.124

* Yearly average weighted price of all grades of primary metals sold by Producers.

1942-1947

Price includes bonus payments by Metals Reserve Co. for over-quota production;

Premium Price Plan expired on June 30, 1947.

TABLE III

YEARLY AVERAGE PRICES, 1935-1949.

(Engineering and Mining Journal)

YEAR	GOLD (PER TROY OUNCE)	SILVER (PER TROY OUNCE)		COPPER (PER POUND)		LEAD, COMMON (PER POUND)		ZINC PRIME WESTERN (PER POUND)
	U. S. MINT	U. S. MINT	FOREIGN NEW YORK	DOMESTIC	EXPORT	NEW YORK	ST. LOUIS	ST. LOUIS
1935	$35.00	0.71875	0.64273	0.08649	0.07538	0.04065	0.03915	0.04328
1936	35.00	.7745	.45087	.09474	.09230	.04710	.04560	.04901
1937	35.00	.7735	.44883	.13167	.13018	.06009	.05859	.06519
1938	35.00	.6464+	.43225	.10000	.09695	.04739	.04589	.04610
1939	35.00	.6787+	.39082	.10965	.10727	.05053	.04903	.05110
1940	35.00	.7111+	.34773	.11296	.10770	.05179	.05029	.06335
1941	35.00	.7111+	.34783	.11797	.10901	.05793	.05643	.07474
1942	35.00	.7111+	.38333	.11775	.11684	.06481	.06331	.08250
1943	35.00	.7111+	.44750	.11775	.11770	.06500	.06350	.08250
1944	35.00	.7111+	.44750	.11775	.11700	.06500	.06350	.08250
1945	35.00	.7111+	.51928	.11775	.11700	.06500	.06350	.08250
1946	35.00	.808	.80151	.13820	.14791	.08109	.07957	.08726
1947	35.00	.905+	.71820	.20958	.21624	.14673	.14470	.10500
1948	35.00	.905+	.74360	.22038	.22348	.18043	.17843	.13589
1949	35.00	.905+	.71930	.19202	.19421	.15346	.15172	.12144

TABLE IV

MINERAL PRODUCTS OF UTAH

(a)

1935-1939

PRODUCTS	1935		1936		1937		1938		1939	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Asphalt (Native), short tons	35,829	$ 751,226	33,731	$ 840,103	38,171	$ 983,628	28,650	$ 655,644	37,364	$ 1,059,034
Clay										
Products	α	α	-------	567,624	--------	619,950	------	610,883	------	668,717
Raw. . . . . short tons	15,817	121,778	α	α	α	α	21,419	90,790	29,468	111,414
Coal . . . . . short tons	2,946,918	6,091,000	3,246,565	6.619,000	3,809,476	8,648,000	2,946,951	6,875,000	3,284,904	7,019,584
Coke . . . . . short tons	120,857	α γ	129,963	α γ	156,316	α γ	140,181	α γ	197,526	α γ
Copper . . . . . pounds	129,515,217	10,749,763	252,434,000	23,223,928	411,988,000	49,850,548	216,252,000	21,192,696	343,780,000	35,753,120
Fluorspar. . . . . short tons	180	α	700	α	431	α	370	α	385	α
Gold . . . . . Troy ounces	184,760	6,466,593	223,444	7,820,540	322,759	11,296,565	200,630	7,022,050	277,751	9,721,285
Gypsum (crude) . . short tons	α	α	40,275	266,854	46,197	46,197	43,144	45,823	58,146	65,269
Iron Ore, ... long tons	161,010	α	154,191	376,300	188,794	α	169,947	α	262,087	α
Lead . . . . . short tons	63,510	5,080,767	69,886	6,429,512	89,458	10,556,044	65,657	6,040,444	67,634	6,357,596
Lime . . . . . short tons	15,957	152,586	30,986	272,431	46,670	319,517	25,748	184,390	38,437	268,557
Manganese Ore. . . short tons	-------	------	------	------	32	297	------	------	50	α
Manganiferous Ores, short tons	190	α	4,609	34,650	3,436	25,771	------	------	262	1,550
Natural Gas . . M cubic feet	98,000	22,000	92,000	19,000	2,366,000	471,000	4,277,000	937,000	4,854,000	1,033,000
(estimated value at wells)										
Natural Gasolene. . . gallons	-------	------	------	------	367,000	19,000	623,000	28,000	500,000	26,000
Ores (crude):										
Copper. . . . . short tons	6,530,569	δ	13,774,589	δ	23,197,017	δ	12,032,385	δ	19,602,472	δ
Gold and Silver. short tons	635,171	δ	572,821	δ	485,152	δ	560,361	δ	838,897	δ
Lead. . . . . short tons	78,332	δ	88,080	δ	152,691	δ	94,883	δ	77,072	δ
Lead-Copper. . . short tons	11	δ	------	------	------	------	------	------	4,951	δ
Zinc . . . . . short tons	-------	------	------	------	173	δ	83	δ	------	-------
Zinc-Lead. . . . short tons	527,513	δ	562,402	δ	743,242	δ	560,948	δ	(570,705	(δ
Zinc-Lead-Copper short tons	-------	------	------	------	------	------	------	------		
Pumice . . . . . short tons	-------	------	------	------	------	------	------	------	------	------
Radium (refined) . milligrams	α	α	α	α	------	------	------	------	------	------
Salt. . . . . short tons	57,625	163,639	56,480	168,706	69,696	205,328	61,959	192,495	68,100	202,244
Sand and Gravel . short tons	1,811,105	1,030,687	2,267,808	1,352,296	2,345,451	1.158,387	2,775,005	1,263,722	2,218,678	1,100,013
Silver. . . . . Troy ounces	9,206,329	6,617,049	9,997,645	7,743,176	12,869,117	9,954,262	9,682,732	6,259,544	10,758,657	7,302,846
Stone. . . . . short tons	215,230	169,865	422,230	230,067	453,540	315,985	709,430	890,249	700,610	444,856
Sulphuric Acid. . short tons	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ
Pig Iron. . . . . short tons	-------	------	------	------	α γ	α γ	α γ	α γ	α γ	α γ
Tungstem Ore . . . short tons (60% concentrates)	-------	------	------	------	24	α	7	α	γ	α
Vanadium . . . . . pounds	-------	------	------	------	ε	ε	ε	ε	ε	ε
Zinc. . . . . short tons	37,107	2,737,399	36,192	3,619,200	48,001	6.240,130	33,658	3,231,168	34,526	3,590,704
Miscellaneous	-------	4,005,802	------	4,390,617	------	8,186,541	------	7.046,700	------	9,355,393
Total Values, Eliminating Duplications	-------	41,933,136	------	61,209,302	------	105,652,422	------	59,236,355	------	80,127,521

α Value included inder "Miscellaneous"; also included under "Miscellaneous" are values for antimony, arsenic, bentonite, bismuth, bitumen, (natural sulphonated), cement, diatomite, fuller's earth, gems and precious stones, magnesite, mercury, mica, molybdenum, petroleum, potash, sodium sulphate, sulphur, uranium.

β Figures not available.

γ Value not included in total value for State.

δ Not valued as ore; value of recoverable metal content included under metals.

ε Included with uranium,

TABLE IV

MINERAL PRODUCTS OF UTAH

(b)

1940-1944

PRODUCT	1940		1941		1942		1943		1944	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Asphalt (native) short tons	32,000	$ 776,171	36,476	$ 856,966	40,078	$ 912,163	76,987	$ 1,390,485	α	α
Clay:										
Products.	------	630,523	------	758,000	------	1,000,000	------	1,000,000	------	α
Raw. . . . . short tons	27,506	98,153	25,366	54,019	29,359	57,395	17,905	43,465	26,152	$ 65,208
Coal . . . . . short tons	3,575,586	7,871,939	4,076,779	9,509,973	5,516,849	14,271,221	6,665,936	19,977,743	7,119,261	22,032,130
Coke . . . . . short tons	226,347	α γ	246,851	α γ	264,933	α γ	324,829	α γ	760,874	α γ
Copper . . . . . pounds	463,728,000	52,401,264	533,676,000	62,973,768	613,382,000	74,219,222	647,978,000	84,237,140	565,150,000	76,295,250
Fluorspar . . . . short tons	142	α	748	α	1,018	α	51	α	3,466	α
Gold . . . . . .Troy ounces	355,494	12,442,290	356,501	12,477,535	391,544	13,704,040	390,470	13,666,450	344,223	12,047,805
Gypsum (crude) . . short tons	45,421	60,105	61,813	78,147	48,574	60,259	α	α	α	α
Iron Ore . . . . . long tons	326,500	α	355,006	α	319,834	α	911,839	α	1,540,594	1,742,876
Lead . . . . . short tons	75,688	7,568,800	69,601	7,934,514	71,930	9,638,620	65,257	9,788,550	52,519	8,403,040
Lime . . . . . short tons	49,413	306,357	56,221	352,306	57,609	392,912	59,811	407,753	51,202	379,550
Manganese Ore. . . short tons	27	α	43	α	970	21,650	91	3,083	30	α
Manganiferous Ore short tons	2,102	13,134	551	2,940	78	α	18	α	32,141	α
Natural Gas. . . M cubic feet (estimated value at wells)	5,124,000	11,063,000	5,562,000	1,145,000	5,163,000	1,079,000	4,464,000	962,000	6,223,000	1,535,000
Natural Gasoline . . gallons	722,000	28,000	808,000	45,000	775,000	39,000	666,000	35,000	924,000	50,000
Ores (crude):										
Copper . . . . . short tons	26,301,745	δ	30,442,402	δ	33,611,061	δ	35,999,656	δ	29,930,659	δ
Gold and Silver. short tons	795,123	δ	622,650	δ	434,234	δ	352,475	δ	241,337	δ
Lead . . . . . short tons	65,072	δ	77,979	δ	75,758	δ	48,658	δ	15,926	δ
Lead-Copper. . . short tons	8,510	δ	5,276	δ	41	δ	53	δ	-----	-----
Zinc . . . . . short tons	26	δ	2,302	δ	16,710	δ	231,845	δ	95,968	δ
Zinc-Lead. . . . short tons	768,870	δ	798,864	δ	841,837	δ	753,930	δ	656,065	δ
Zinc-Lead-Copper, short tons			1,344	δ	2,014	δ	114	δ	250	δ
Pumice	------	------	------	------	------	------	------	------	------	-----
Radium	------	------	------	------	------	------	------	------	------	-----
Salt . . . . . short tons	71,472	191,263	107,079	196,413	110,870	290,040	169,810	562,293	119,809	368,500
Sand and Gravel . short tons	1,899,563	582,708	2,760,025	935,371	3,874,841	2,079,302	2,536,518	1,322,544	2,468,535	1,736,102
Silver . . . . . .Troy ounces	12,172,299	8,655,857	11,395,485	8,103,456	10,574,955	7,519,968	9,479,340	6,740,864	7,593,075	5,399,520
Stone . . . . . short tons	1,024,660	693,127	408,140	340,551	285,170	318,261	390,480	416,821	363,880	363,285
Sulphuric Acid . . short tons	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ
Pig Iron . . . . . short tons	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ	α γ
Tungsten Ore . . . short tons (60% concentrates)	14	α	30	40,911	29	41,511	21	37,042	9	13,700
Vanadium . . . . . pounds	ϵ	ϵ	119,331	α	1,075,596	α	833,680	523,117	287,045	261,765
Zinc . . . . . short tons	43,788	5,517,288	42,049	6,307,350	45,543	8,470,998	46,896	10,129,536	38,994	8,890,632
Miscellaneous	------	10,431,709	------	16,048,855	------	18,136,720	------	20,411,497	------	28,663,544
Total Value, Eliminating Duplications. .	-----	104,392,989	------	122,386,873	------	147,073,924	------	164,150,000	------	149,558,000

α Value included under "Miscellaneous"; also included under "miscellaneous" are values for antimony, arsenic, bentonite, bismuth, bitumen (natural sulphonated), cement, diatomite, fuller's earth, gems and precious stones, magnesite, mercury, mica, molybdenum, petroleum, potash, sodium sulphate, sulphur, and uranium.

β Figures not available.

γ Value not included in total value for State.

δ Not valued as ore; value of recoverable metal content included under metals.

ϵ Included with uranium.

TABLE IV

MINING PRODUCTS OF UTAH

(c)

1945-1949

PRODUCT	1945		1946		1947		1948		1949	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Asphalt (native) short tons	83,123	$ 1,414,422	96,974	$ 1,615,368	99,192	$ 1,987,049	α	α	β	β
Clay:										
Products	-----	α	-----	α	-----	1,210,000	α	α	β	β
Raw. . . . . short tons	55,395	90,295	105,621	199,775	181,876	297,520	α	α	β	β
Coal . . . . . short tons	6,679,063	22,798,321	5,994,013	21,448,859	7,428,699	29,211,722	6,716,000	ε) $30,289,000	β	β
Coke . . . . . short tons	735,511	α γ	492,367	α γ	1,043,465	α γ	1,247,087	α γ	β γ	β γ
Copper . . . . . pounds	452,752,000	61,121,520	228,568,000	37,028,016	533,066,000	111,943,860	454,014,000	98,520,038	394,490,000	$77,714,530
Fluorspar . . . . short tons	2,973	α	2,370	α	1,730	α	9,166	α	β	β
Gold . . . . . Troy ounces	279,979	9,799,265	178,533	6,248,655	421,662	14,758,170	368,422	12,894,770	314,058	10,992,030
Gypsum . . . . . short tons	α	α	α	α	α	α	α	α	α	β
Iron Ore . . . . . long tons	1,925,572	2,170,334	1,321,334	1,372,109	2,821,293	2,860,739	3,233,122	3,296,058	2,580,000	ϕ) 3,125,000
Lead . . . . . short tons	40,817	7,020,524	30,711	6,694,998	49,698	14,313,024	55,950	20,030,100	53,070	16,770,752
Lime . . . . . short tons	47,484	353,671	29,057	271,526	47,096	366,127	40,635	52,859	α	β
Manganese Ore	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Manganiferous Ores, short tons	5,001	α	7,903	α	7,198	α	2,694	α	α	β
Natural Gas M cubic feet (estimated value at wells)	6,562,000	332,000	4,252,000	213,000	6,040,000	324,000	6,610,000	397,000	α	β
Natural Gasoline. . . gallons	867,000	52,000	578,000	35,000	685,000	47,000	640,000	64,000	α	β
Ores (crude):										
Copper. . . . . short tons	23,978,159	δ	12,471,208	δ	29,021,293	δ	24,458,362	δ	20,924,274	δ
Gold and Silver . short tons	147,691	δ	79,875	δ	171,741	δ	215,712	δ	171,635	
Lead . . . . . short tons	24,305	δ	11,700	δ	27,194	δ	27,416	δ	20,304	δ
Lead and Copper. short tons	-----	-----	1,236	δ	-----	-----	β	δ	-----	-----
Zinc . . . . . short tons	104,499	δ	105,222	δ	94,685	δ	46,136	δ	33,705	δ
Zinc-Lead . . . . short tons	468,530	δ	578,450	δ	1,066,614	δ	992,717	δ	842,441	δ
Zinc-Lead-Copper short tons	-----	-----	-----	-----	1,587	δ	1,565	δ	1,108	δ
Pumice . . . . . short tons	-----	-----	-----	-----	7,500	30,000	7,618	30,472	β	β
Radium . . (refined) milligrams	α	α	10	185	α	α	α	α	β	β
Salt . . . . . short tons	122,997	363,997	121,699	339,505	113,285	340,028	113,770	429,494	β	β
Sand and Gravel . short tons	2,147,910	1,280,578	1,653,010	992,083	2,945,943	1,612,354	2,278,184	1,368,562	β	β
Silver . . . . . Troy ounces	6,106,545	4,342,432	4,118,453	3,327,710	7,780,032	7,040,929	8,045,329	7,281,429	6,724,880	6,086,356
Stone . . . . . short tons	215,400	318,254	404,370	591,940	178,680	368,255	279,660	477,654	β	β
Sulphuric Acid	α γ	α γ	α γ	α γ	α γ	α γ	α	γ	β	β
Tungsten Ore (60%) short tons	ε	7,048	27	α	α	α	γ	α	β	β
Vanadium . . . . . pounds	97,572	58,154	63,188	37,370	48,949	α	α	α	β	β
Zinc . . . . . short tons	33,630	7,734,900	28,292	6,903,248	43,673	10,568,866	41,490	11,036,340	40,670	10,086,160
Miscellaneous	-----	28,357,793	-----	24,794,199	-----	49,304,670	-----	74,453,754	-----	β
Total Values, Eliminating Duplications . .	-----	127,961,000	-----	95,506,000	-----	206,970,000	-----	ϕ) 204,752,000	-----	ϕ) 168,000,000

α Value included under "Miscellaneous;" also included under "Miscellaneous" are values for antimony, arsenic, bentonite, bismuth, bitumen, (natural sulphonated), cement, diatomite, fuller's earth, gems and precious stones, magnesite, mica, mercury, molybdenum, petroleum, potash, sodium sulphate, sulphur, and uranium.

β Figures not available.

γ Value not included in total value for the State.

δ Not valued as ore: value of recoverable metal content included under metals.

ε Included with uranium.

ϕ Partly estimated.

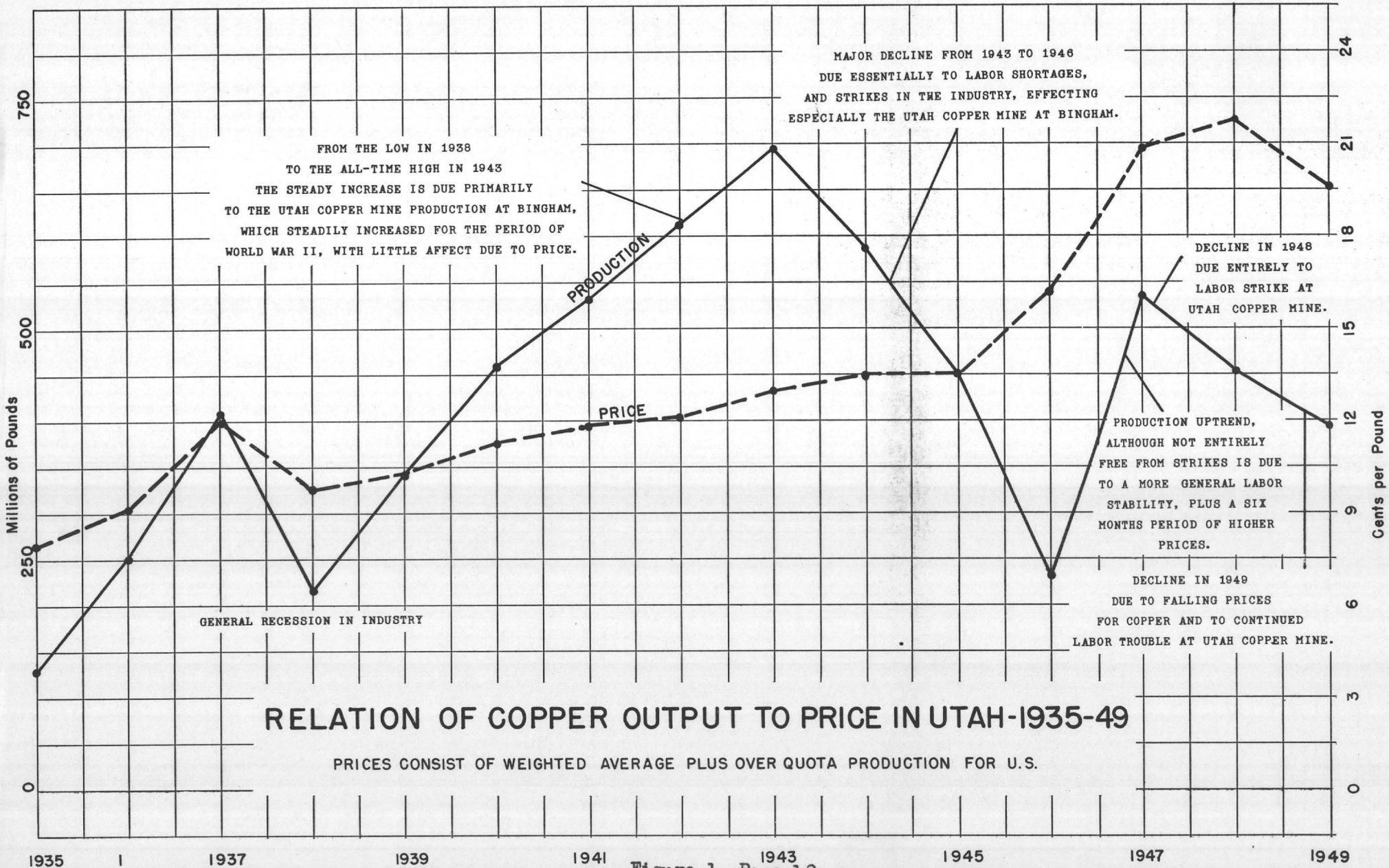


Figure 1, Page 12

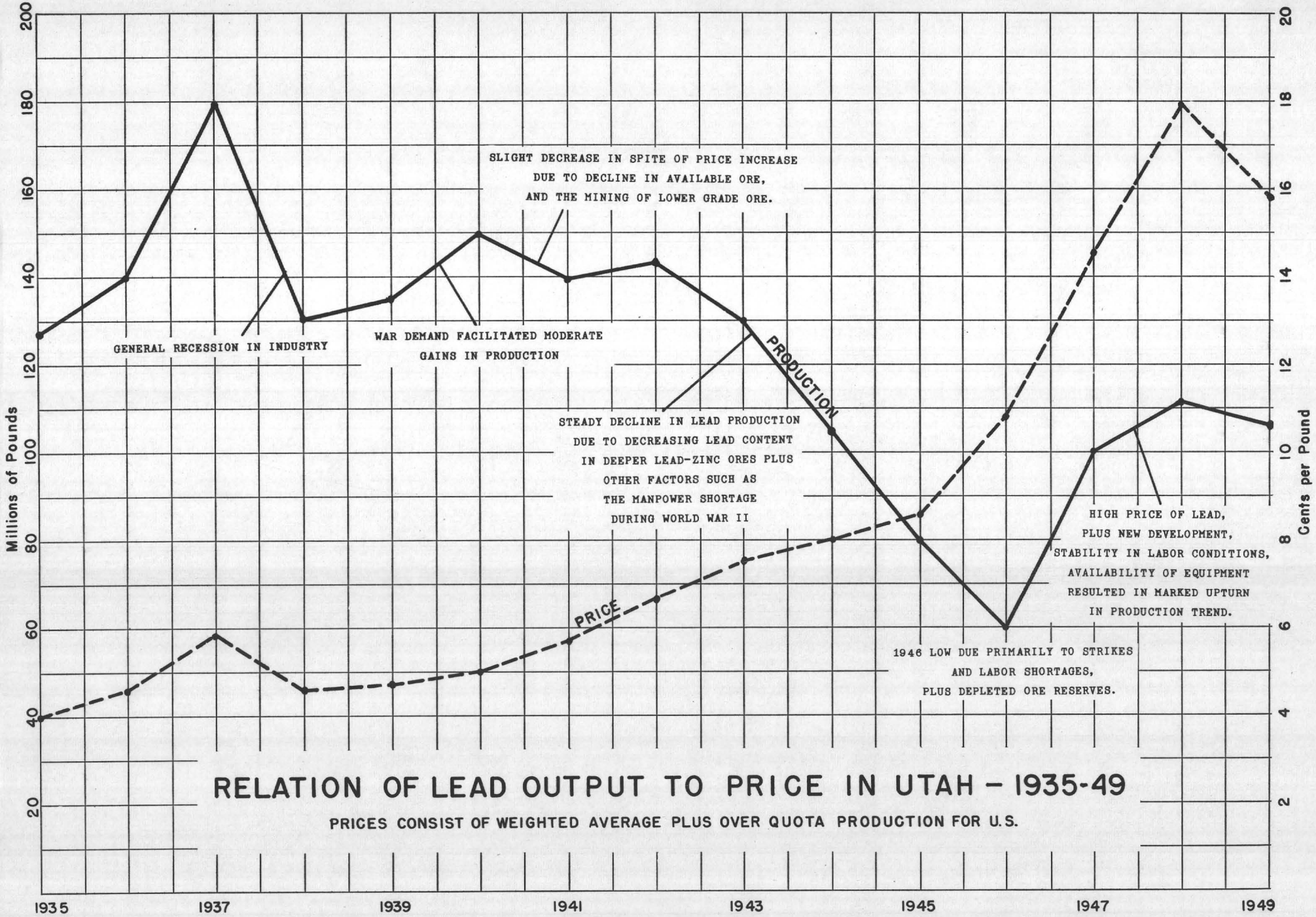


Figure 2, Page 13

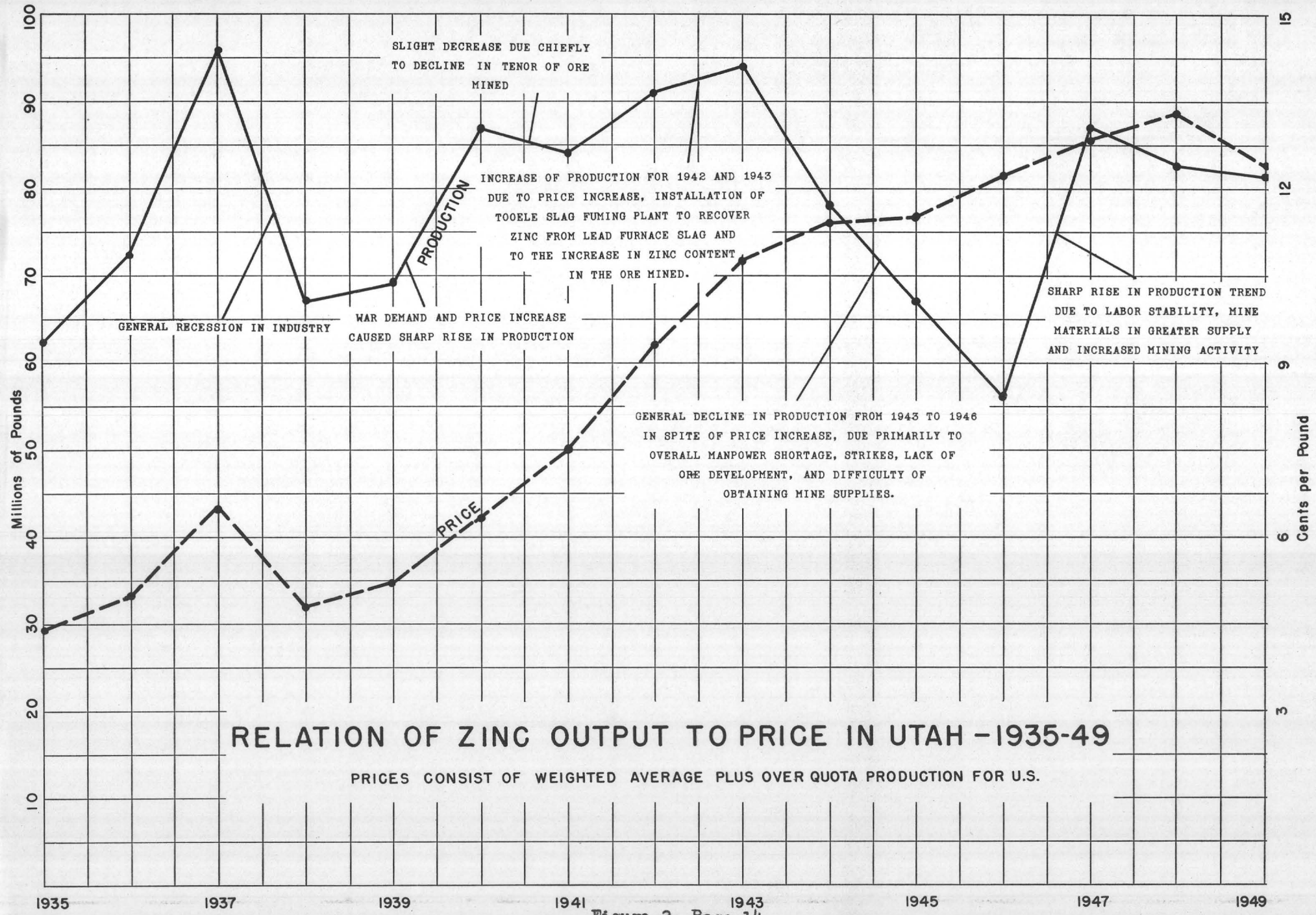


Figure 3, Page 14

SIGNIFICANT CONCLUSIONS

From the information presented in the foregoing text, charts, and tables, the following conclusions appear significant:

1. The number of mines in Utah producing gold ore reached an all-time high about the middle 1930's when the price of gold was increased to $35 per ounce and all production costs were low. The pronounced decline in number since that time has resulted from greatly increased costs of labor and supplies, heavier taxes, wartime regulations and deterioration of properties, and high costs for mine rehabilitation, plus a fixed price for gold. Therefore, straight gold mining in the State cannot recover its former status unless many of the above factors are changed, so that the purchasing power of the gold ounce can rise far above its present position.

2. The number of mines in Utah producing silver ore has tended to conform in considerable degree to the price of silver, although many years show exceptions to this generalization. The period from 1940 through 1945, with its wartime disturbances and a fixed price for silver, was an unstable one for silver mines in Utah. Increases in the price of the metal in 1946 and 1947 were accompanied by slight increases in the number of mines producing silver ore, but the gain is not considered to be of great duration. Therefore, increased interest in straight silver mining in Utah must await more favorable economic factors.

3. Copper output in Utah is dominated by one large mine; consequently, changes in the number of mines producing copper ore are of little significance. The price of copper has been a commanding factor in production, but other factors during the period under discussion have been wartime demands, labor supply and labor relations.

4. Utah's lead output is derived largely from zinc-lead ore rather than from lead ore; therefore, the two types of ore must be considered together. From 1935 through 1940, a close relation existed between price of lead and lead output, and number of mines producing lead and zinc-lead ores. From 1941 through 1945, increases in the price of lead were not sufficient to overcome other unfavorable factors, and both output of the metal and number of mines trended generally downward. The price of lead climbed sufficiently in 1946 so that the number of lead and zinc-lead mines increased slightly and output of lead also would have gained, except for labor strikes. The upward trend in price, output, and number of mines continued through 1947 and 1948, but the sharp decline in lead price in 1949 brought corresponding reductions in lead output and number of mines producing lead and zinc-lead ores.

5. As with lead, zinc output in Utah comes principally from zinc-lead ores with considerable production from zinc ore and old zinc slag. From 1935 through 1940, the curves for zinc price, output and number of mines producing zinc and zinc-lead ore agree rather closely. From 1941 through 1948, the agreement is less evident and in five of the years output dropped in spite of rising prices, although much production was lost in 1946 because of labor strikes. In 1949 prices, output, and number of mines all declined.

6. From a study of the graphs on copper, lead and zinc and the relation of metal production to prices, it is evident that, because of complex economic factors, mush higher prices for base metals have been needed since 1941 to draw out peak production in Utah, than was true in former periods.

7. Table IV, showing quantity and value of all mineral production in Utah from 1935 to 1950, demonstrates the high rank of metals in the State's mineral industries. Although it is very probable that most of Utah's non-metallic industries will expand in the future, it seems safe to assert that the State's basic industry for many years to come will continue to be metal mining and processing.

May 11, 1953 BIG INDIAN MINING DISTRICT Silas C. Brown

San Juan County, Utah

BIG INDIAN MINING DISTRICT

San Juan County, Utah

Location: Sections 13 and 14, T. 30S, R. 24E, San Juan County, Utah.

GENERAL

A field check was made on three mineral claims in the Big Indian area on May 8, 1953. These claims are named Mike, Norine and Maxine respectively.

STRUCTURAL

These claims are situated on the top and west flank of a steeply dipping monocline. The surface rocks have an approximate N-S strike and dip 7° toward the west.

GEOLOGIC

The Wingate sandstone of Jurassic age crops out and forms the top of the westward dipping hogback. Due to lensing and erosion, the Wingate ranges between 175 and 275 feet in thickness.

Immediately below the Wingate lies the Chinle formation of Triassic age which consists of red, gray and green shales, buff to brown sandstones and conglomerates near its middle and base, and minor gray to buff limestones at or near its base. It is in this lower zone that the major ore body is found.

It is believed that the Shinarump conglomerate is either missing in the Big Indian area or is present only in small patches. More detailed field studies would be necessary to outline its presence. The presence of limestones in the ore body is indicative of Chinle and is sufficient proof that the ore is not from Shinarump as previously thought. The Shinarump is basically a continental deposit of sand and conglomerate throughout the Four Corners area and limestones are never present in that type of sedimentation with the exception of a few fresh water types. Good accumulation of Uranium and other ores are found in the Shinarump in many places. Where the Shinarump is well developed, the possibilities of rather widespread mineralization can be expected.

The Moenkopi lies unconformably below the Chinle formation in this area. Some spotty mineralization has been reported in the Moenkopi in the Four Corners area, however, the formation is mentioned here merely to outline the stratigraphic sequence at this immediate vicinity.

RECOMMENDATIONS AND DISCUSSION:

It is recommended that three holes be drilled through the lower Chinle formation. All three holes are expected to be about 500 feet deep. The first hole should be drilled somewhere south of the middle of the Norine claim. The terrain will be a major factor in making the exact location for the test. The location of the other two holes would depend upon the results of the first hole.

The approved procedure is to drill with a regular rock bit to a greenish conglomerate near the top of the ore body then diamond core through the prospective horizon. The price per hole is $4.00 per foot contracted. Three 500-foot holes at $4.00 per foot totals $6000, however it is believed that 50 to 75 feet can be eliminated by drilling in small canyons which bisect the claims. The cost of road building versus savings in drilling costs must be considered when making locations.

After the holes are drilled the Atomic Energy Commission will run a Gamma ray log upon request on each hole free of charge to the operator. The Gamma curve reflects radioactivity in comparative quantities.

If ore in commercial quantities and qualities is blocked out by core drilling a decision must be made as to the probability of sinking a shaft or cutting a tunnel. The advantage of a tunnel is its cheaper cost per foot and being able to mine the poorer grades of ore as it is cut. Maintenance costs after completion is another factor which appears to favor tunneling.

The only logical place to start a tunnel is in the southwest corner of the Maxine claim where the mineralized zone is exposed on the west side of Gypsum Valley. Before a decision is made a mining engineer should be consulted regarding costs of tunnels versus shafts.

Silas C. Brown

May 11, 1953

SCB:O

REPORT

ON THE WARREN AND SALAZAR TESTS

TOWNSHIP 25 NORTH, RANGES 6 & 7 WEST

LARGO LEASES, RIO ARRIBA COUNTY

NEW MEXICO

Durango, Colorado
July 1, 1955

Silas C. Brown

P. O. Box 1240
Durango, Colorado
July 1, 1955

REPORT

ON THE WARREN AND SALAZAR TESTS

TOWNSHIP 25 NORTH, RANGES 6 & 7 WEST

LARGO LEASES, RIO ARRIBA COUNTY

NEW MEXICO

GENERAL

The above described tests were examined in the field and compared with other producing wells and abandoned tests in the vicinity. The electric logs of these four tests were brought to our offices in Durango for study with other logs and data covering an area embracing approximately 900 square miles.

Regional, structural and stratigraphic geological data indicate generally unfavorable conditions for commercial gas production from the Pictured Cliffs formation in Township 25 North, Range 7 West with the exception of the small local area in Sections 13 and 24 where local sand development is favorable. The Pictured Cliffs sandstone is poorly developed in Sections 4 and 5, where the three Warren wells were drilled.

We believe that more favorable conditions for commercal gas from the Pictured Cliffs formation will be found in Township 25 North, Range 6 West, probably northeast of an arbitrary line drawn from the northwest corner to the southeast corner of that same township. Due to the nature of the stratigraphic changes, the arbitrary line will no doubt be uneven and gas potentials will vary.

RECOMMENDATIONS

We recommend:

1. No drilling at this time on the Warren, et.al. leases in:
   a. Sections 19 & 20, Township 26 North, Range 7 West.
   b. Sections 5 & 6, Township 25 North, Range 7 West.
   C. Sections 23, 24, & 26, Township 24 North, Range 7 West.
2. The drilling of one or more wells to the Pictured Cliffs formation on the block in Township 25 North, Range 6 West. The first test should be located in Section 22 of that Township.

Due to the projection of the sand conditions and other pertinent data, we believe it possible to get fair to good commercial wells in the Pictured Cliffs formation at or near Section 22. It is possible to have local unfavorable sand and water conditions, but these are expected to be quite localized and small. The leases in Sections 21, 22, 23, 26, 27 & 34, Township 25 North, Range 6 West appear to be the most favorable for commercial production of gas from the Pictured Cliffs formation if properly drilled and completed.

After production is established from the Pictured Cliffs formation under the above lease, we would like to propose one or more experimental tests to investigate the possibility of oil and/or gas from certain deeper horizons at selected locations. This objective would constitute an entirely new project which may be delayed if the Warren et. al. leases do not require immediate drilling.

The "Harkins" lease in Township 24 North, Range 7 West lacks data for proper evaluation at this time. By projections of sand development and water encroachment lines, the Pictured Cliffs formation does not appear too favorable for commercial production of gas.

DRILLING AND LOGGING PROCEDURE

The Pictured Cliffs formation, at the proposed location in Section 22, Township 25 North, Range 6 West, should be drilled with gas or compressed air. If it is not possible or economical under wildcat conditions, the first well should be drilled with rotary equipment using proper muds to about 1 to 3 feet into the top of the Pictured Cliffs sandstone group. Before setting and cementing casing, the open hole should be logged by Schlumberger or Lane-Wells. Both logs would be preferable. For proper evaluation of the data it is advisable to have Schlumberger's resistivity and self potential logs and the Lane-Wells Gamma and Neutron logs. After setting and cementing the casing, the cement should be allowed to set for 72 hours, during which time the rotary rig can be moved and a spudder rig set-up. The spudder rig should bail the hole dry to test the cement job. If there are no casing or plug leaks, the spudder should drill the plug, bail the hole dry again and test for water in the upper Pictured Cliffs. If the test is dry, the spudder should drill deeper at five feet intervals and continue testing for water or gas. We recommend for this drilling the use of crude oil wich can be purchased locally or at Chromo, Colorado for $2.25 to $2.60 per barrel. Use only enough oil in the hole to cover the tools about 30 to 40 feet. If necessary, use a sand pump to pick up the cuttings. All precautions should be taken to eliminate fire hazards at the rig due to gas flowing from the hole and also due to gas-cut oil when the bailer and sand pump are dumped. Log the bottom of the hole with Lane-Wells gamma and Neutron curves and overlap the first logging run substantially.

After completing the first well as a gas well, it might be more economical

and quicker to drill in subsequent wells using gas. Drilling with gas should be done by using a conventional core bit, thus obtaining cores which may be examined for lithology, porosity and permeability. As the sand-frack method is being improved it may be possible to drill the complete hole with rotary and frack through the mud cake. This method should only be used in proven fields and is being used in certain area at the present time.

DRILLING CONTRACTORS

The "turn-key" basis drilling contract with the Totah Drilling Company on the Warren #3 well is a fairly reasonable agreement for a wildcat test. The "turn-key" contract is some protection in a wildcat area but supervision by a geologist is necessary at all times during the testing of the objective horizons. There is too much tendency to punch a hole in the ground without the delays for proper tests and proper completions.

Besides the Totah Drilling Company, the following contractors have been recommended by the various independents and companies in the San Juan Basin:

1. Carroll Drilling Company, Farmington, New Mexico
2. Great Western Drilling Company, Box 608, Farmington, N. Mex.
3. H. B. Lynn Drilling Corp., 413½ W. Main Farmington, N. Mex.

GAS PURCHASE AGREEMENT

The Gas Purchase Agreement with the El Paso Natural Gas Company is considered standard throughout the basin for Pictured Cliffs gas. Provisions have been made for the Seller to install separators and other

devices to remove and retain all oil and other hydrocarbons normally separated from the gas. This agreement is considered fair by the profession.

RESERVE ESTIMATES

Due to the changing sand conditions, the lack of wells in certain areas and other pertinent data, no reliable reserve estimates can be made at this time.

Silas C. Brown

SILAS C. BROWN
Consulting Geologist

THE SPRECHER URANIUM PROSPECT

McKinley County, New Mexico

Introduction

The field reconnaissance work of the Sprecher, et al. properties, which consists of Section 36, Township 16 North, Range 18 West, N.M.P.M., McKinley County, New Mexico, was conducted on October 30 and 31, 1953. Since the survey was of a reconnaissance nature a detailed map of the area was not made and apparently is not available.

Evidence of Uranium ore enrichment was noted in the Dakota coal horizon and in probable Morrison sandstones immediately below the Dakota formation. None of the shows within the area outlined was of commercial quantity or quality, but more exploration work with the bulldozer or core drill may outline commercial ore bodies.

Geology and Discussion

The Morrison formation (Jurassic) is exposed in the southeastern part of Section 36, Township 16 North, Range 18 West. Going toward the northwestern part of the same section, the Dakota, Mancos and Mesaverde formations (Cretaceous) are exposed.

The Morrison formation is considered an objective exploratory horizon based upon enrichment found in "Gragg Rock", a boulder which had fallen from the Dakota-Morrison cliffs. The boulder is either of Morrison age or is from a transition zone between the Morrison and the overlying Dakota formation. More exploration work should be conducted along the Dakota-Morrison contact zone.

The main zone of enrichment in the area studied is in the "Coal horizon" of the Dakota formation (see sketch section). Commercial ore has been mined from this zone at the Hyde Mine in Section 12, Township 15 North, Range 18 West, about one and one-quarter miles south of Section 36. Extending along the same Dakota outcrop northward from the Hyde Mine are two spots which gave a higher gamma count than the normal background count, but neither appeared to be of commercial intensities. These "hot" spots are, however, places where more exploration work should be conducted.

Any sand development in the Mancos formation should be checked with the scintillator but very little sand development was observed in the Mancos in Section 36.

The Mesaverde sands which occur in the extreme northwestern part of Section 36 should also be checked with the scintillator; especially those areas where the sandstone beds thicken rapidly, indicating channeling.

Many geological features occur in the area which are favorable for the occurrence of Uranium ores in commercial quantities and quality. First, the steep hogback is a zone of weakness along which Uranium ores may have migrated upward from deeper sources. There is no evidence of faulting at the surface, however, the steeply dipping beds may be faulted with depth. Primary and secondary Uranium ores are generally found near these zones of weakness and the secondary ores are found in diminishing quantities away from the source.

Second, sand development in the Morrison, Dakota and the Mesaverde formations, especially where channeling is present, is favorable for deposition of Uranium ores.

Third, and probably the most important fact, is the presence of some enrichment in the area even though that at the surface is not of marketable value. The surface indications at the Hyde mine to the south were not commercial at the surface either, but the ore value increased to commercial percentages with depth. Therefore, these enriched areas are the obvious places to start exploration work for possible richer ore bodies with depth.

Recommendations and Conclusions

To summarize: The presence of a zone of weakness, the apparent channeling of the sandstone beds and the presence of some local enrichment indicate that the area should be further explored.

It is recommended that the Dakota "coal" horizon be thoroughly explored with the scintillator and the enriched zones be bulldozed to check the possibilities of richer ores with depth. Because of the high angle dip of the beds, especially in the southern part of Section 36, only a limited number of core holes are recommended near the outcrop area. If the bulldozer work opens up richer ore than that at the surface then core holes may be planned to test the horizon at depths below the limits of the dozer.

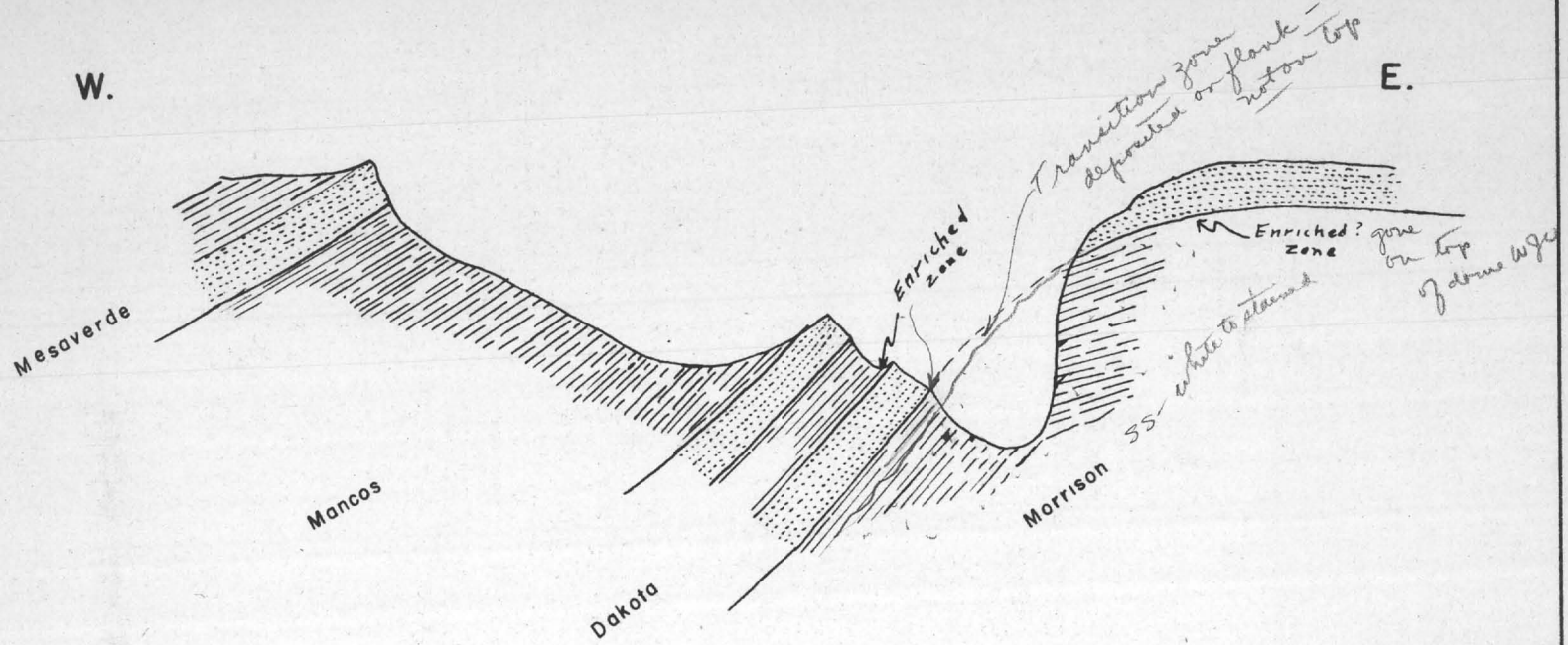
Going eastward in Section 36 where the Dakota beds cap the mesa, spot core drilling should be attempted. This coring campaign should test the Dakota and about the upper 25 feet of the Morrison for the possibility of enrichment in that horizon.

If enrichment is found in any of the exploratory holes then offset holes within a radius of 100 feet should be drilled to outline the limits of the ore body. The cores and cuttings should be checked with the scintillator as the hole is being drilled. Good representative samples of the "hot" cores and/or cuttings should be collected and an analysis be made of each. The thickness and richness of an ore body must be outlined for proper evaluation.

Respectfully submitted

Silas C. Brown

Durango, Colorado
March 6, 1954



SKETCH CROSS-SECTION

IN GENERAL AREA OF

Sec. 36-16N-18W

McKINLEY COUNTY, NEW MEXICO

May 11, 1953

WHITE CANYON AREA

San Juan County, Utah

Silas C. Brown

WHITE CANYON AREA

San Juan County, Utah

Re: A submittal by Mr. W. W. Goforth, et al, pertaining to 102 Mineral Claims in the White Canyon area, San Juan County, Utah.

A rapid field check was made on the above claims on May 7, 1953. A more thorough study would be necessary before its Uranium possibilities could be ascertained. Two areas were noted where medium grade Uranium ore (Est. 0.20%) could probably be mined.

Mineralization is found predominantly in the Shinarump conglomerate with some apparent mineralization in the basal member of the Chinle formation. This is the same zone from which the main ore body is mined at the Happy Jack mine about 5 miles to the southwest. In almost every case where Uranium minerals are found they are inter-related with copper ores such as Malachite and Azurite. Vanadium is conspicuously absent in this part of the White Canyon area as compared to Gypsum Valley (Big Indian area) where Vanadium is the major by-product.

Topographically, the ore zone lies within 300 feet of the top of high mesas. The beds dip toward the west about 2 to 3 degrees so any tunnel along the ore horizon would have only a slight incline. A recently completed road makes most of the area accessible.

Recommendations:

If these claims can be acquired without an output of cash, it is recommended that $1000 to $1500 be spent on tunnels to check the extent and richness of the "hot" areas noted during the reconnaissance survey.

It has been suggested that a flight be made over the area using a scintillometer to see if "hot" areas can be detected. Good prospects have been located by this method and should certainly be considered.

The reconnaissance field check did not indicate "hot" areas of any magnitude, although they may be present within the area submitted. Due to the large thickness of overburden, core drilling is considered impracticable for haphazard drilling unless some good prospective areas can be detected first. The flying scintillometer may be the answer to this. It is possible to detect more favorable areas by a more detailed field study but this would constitute an outlay of $500 to $1000 which may or may not pay off.

Based upon the above discussion, it appears that a flight over the area with a scintillometer together with limited tunneling in the "hot" areas noted would be the cheapest and most practical way to evaluate the area at this time.

Silas C. Brown

Silas C. Brown

May 11, 1953

SCB:O

6-11-77

(1)

Chas. Bearup - DOZK Prospect
Sec 14 T2S, R14E Gila Co. Ariz

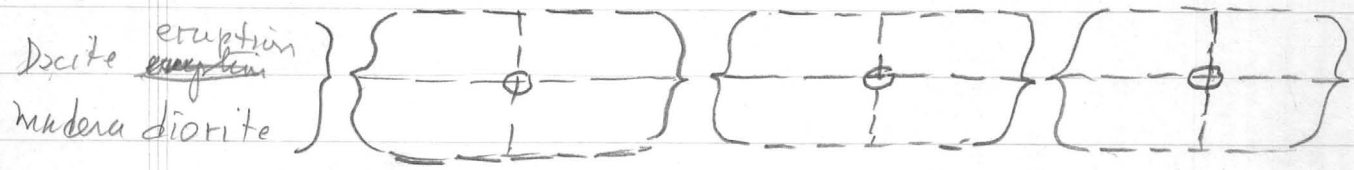
1. Main Ofc: Prim Schist - Gen Str. N 30-60 E
   Gen Dip N10 45-85° NW

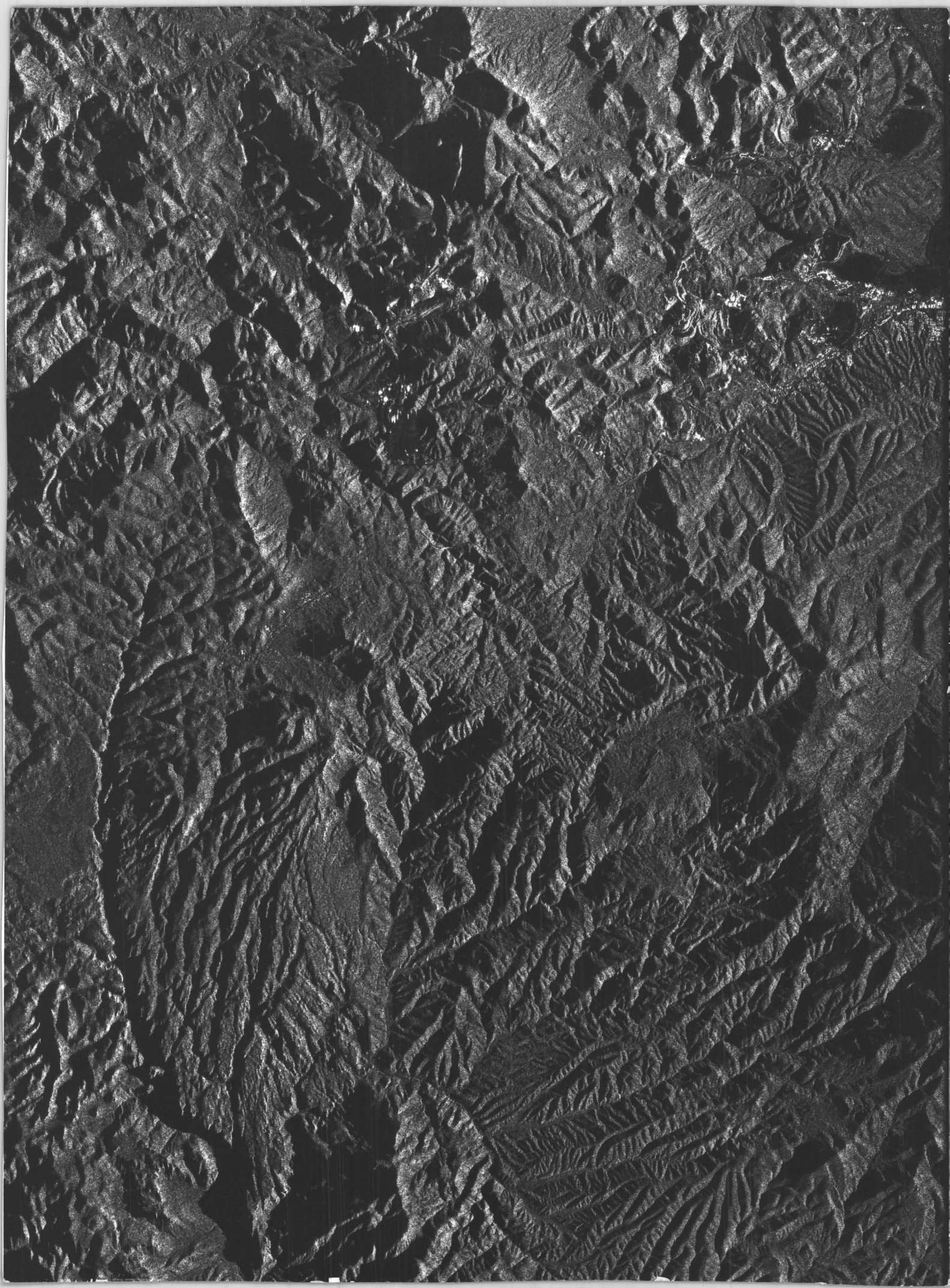
2. Faults - Parallel or roughly parallel with the strike of the bedding
   Same str & dip - locally contorted due to Gr. intrusives (Iron Cinnon prospect)

3. Schist may be highly contorted locally due to intrusion of Solitude granite, diabase, Schultze granite & ~~Kiss~~ gr. porphyry dike - which took place during the Laramide orogeny in late Cretaceous or Early Tertiary time - "Laramide Revolution"

4. Mineralization took place after the intrusion of the Schultze granite stock & probably was the culminating event of the igneous activity that accompanied this orogeny (and Laramide Rev.)

5. Faults are hard to recognize unless Mineralization





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USGS EROS DATA CENTER

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040-035

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XIII Congress of the
International Society for Photogrammetry
Helsinki, 1976

Commission III
Working Group "Geometry of Remote Sensing"
Presented Paper

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Side-Looking Radar Mosaicking Experiment

A numerical sequential radar block adjustment resulted in improved accuracy in the mosaicking of radar images.

(Abstracts on next page.)

INTRODUCTION

CURRENTLY PRODUCED side-looking radar image mosaics were accurate to within an RMS point error of about ±150 m. This was concluded from a unique set of 24 overlapping side-looking radar strips flown over a well-mapped area of more than 90,000 km² covering parts of Ohio, West Virginia, Virginia, and Kentucky. The topographic maps at a scale 1:24 000 that covered the imaged area permitted an analysis of the errors of individual radar images and of the final radar mosaics.

We have taken advantage of this extensive radar coverage of well-mapped terrain to analyze the accuracy of some of the radar mosaicking methods that are currently applied. We have attempted to obtain some quantitative insight into the effect of the density and distribution of ground control points on the accuracy of the final radar mosaic.

The data confirm the expectation that a numerical sequential radar block adjustment provides results that are significantly more accurate than those obtainable from a direct mosaicking process based on tielines (resulting in so-called semi-controlled mosaics). We also conclude that the use of tielines cannot very well be justified by either the mapping accuracy, or by the convenience of the mosaicking process.

These conclusions are developed in a series of numerical experiments based on measurements of pricked points in the common areas of overlapping radar strips. We will describe the image data and measurements and follow this with an outline of presently applied radar mosaicking procedures. The discussion of the achieved results will then provide the evidence on which the above conclusions are based.

IMAGE DATA AND MEASUREMENTS

An area of about 400 × 250 km² in Ohio, West Virginia, Virginia, and Kentucky (Figure 1) was imaged using the Goodyear Aerospace Corp. GEMS 1000 synthetic aperture radar system which is operated aboard an inertially guided Caravelle twin jet of Aero Service Corporation. Ground resolution of the images is about 12 × 12m². As in most missions with this system, the aircraft flies at an altitude of about 12 km and follows the meridian within the accuracy of the inertial guidance system. The imagery employed in the mosaicking experiment was thus acquired in north-south oriented flight lines, with the radar looking west. A side-lap of 20

* NAS-NRC Resident Research Associate

ABSTRACT: *A block of 24 overlapping synthetic aperture side-looking radar images flown over a well-mapped area of about 90,000 km² covering parts of Ohio, West Virginia, Virginia, and Kentucky provided an opportunity to evaluate the mapping accuracy achieved in current radar mosaicking projects. The maps of scale 1:24 000 that are available in the imaged area permitted the study of the geometric errors of the radar mosaics and of individual radar strips. An estimate was obtained for the effect of the distribution and density of ground control points and for the accuracy of different mosaicking methods that are currently employed with synthetic aperture radar images. It is shown that a successful radar mosaicking process requires the elimination of image errors of up to several kilometers. These errors are introduced as a result of the limited precision of the inertial aircraft navigation. An example of a radar mapping effort in which the navigation errors could be eliminated is presented. The resulting radar mosaics have residual* RMS *mapping errors of planimetry of about ± 150 m.*

ZUSAMMENFASSUNG: *(Ein Experiment ueber die Herstellung von Radar-Bildplaenen Ein Gebiet von etwa 90 000 km² in Teilen Ohios, West Virginias, Virginias und Kentuckys wurde durch ein Radarsystem mit synthetischer Antenne abgebildet, sodass ein Block von 24 ueberlappenden Seitwaerts-Radar Bildern erhalten wurde. Diese Daten ermoeglichen ein Experiment zur Emittlung der Kartiergenauigkeit, die in gegenwaertigen Radarprojekten erreicht wird. Die Karten im Masstab 1:24,000, welche im aufgenommenen Gebiet. . . . Untersuchung der geometrischen Verformungen einzelner Bildstreifen und der Bildmosaike. Weiters kann der Zusammenhang zwischen der Kartiergenauigkeit, der Dichte und Verteilung von geodaetischen Kontrollpunkten sowie einiger Methoden der Bildplanerstellung untersucht werden. Die Arbeit zeigt, dass die urspruenglichen Radarbildstreifen Verformungen bis zu einigen Kilometern haben koennen, die durch die beschraenkte Genauigkeit der Flugzeugtraegheitsnavigation verursacht werden. Es wird jedoch gezeigt, dass diese Fehler in der Herstellung von Radarbildplaenen durch eine numerische Blockausgleichung eliminiert werden koennen, sodass die verbleibenden mittleren Fehler der Radarbildplaene etwa ± 150 m betragen.*

RESUME: *Un radar à ouverture synthétique a été utilisé pour imager une surface bien cartographiée d'environ 90 000 km² couvrant en partie les états d'Ohio, Virginie de l'Ouest, Virginie et Kentucky. Un groupe de 24 images a permis d'évaluer la précision cartographique atteinte dans les mosaiques d'images radar. Des cartes à l'échelle de 1:24 000 qui sont disponibles pour la région, ont permis l'étude des erreurs géométriques des mosaiques et des images simples. Une estimation des effets de la distribution et de la densité des points d'appui a été obtenue, ainsi qu'une estimation de la précision des différentes méthodes de construction des mosaiques, qui sont employées pour le radar à ouverture synthétique. Il est demontré qu'une procédure exacte pour une mosaique d'images radar nécessite l'élimination d'erreurs jusqu' à plusieurs kilomètres. Ces erreurs résultent de la précision limitée du système de navigation a inertie de l'avion. Cette contribution présente un exemple de cartographie au moyen d'un radar. Dans cet exemple les erreurs de navigation ont pu être éliminées. Les mosaiques finales ont une erreur planimétrique d'environ 150 m.*

control is available, then the mapping accuracy reduces somewhat, although not dramatically (Figure 3, cases *(c), (f), (h)*). It appears that control along the perimeters in the flight direction is more essential than across the flight direction. Along-track scale is well transferred across adjacent strips, but the effect of the strip's curvature can be eliminated only by at least one linear array of control points in the flight direction.

COST

In a comparison of the effort that would have to be expended for the various mosaicking techniques, it seems obvious that a lack of consideration of ground control points would result in a less expensive mosaicking effort. The same seems to hold for an approach based on tielines, only adding the extra effort of acquiring the tielines. In both cases, however, unrectified images have to be mosaicked and therefore an expensive iterative trial-and-error process is required to produce photographic paper prints appropriate for mosaicking.

The numerical adjustment of the radar block that is presented in this paper required less than 1 per cent of the total mapping expense. This had to be spent for measurements and data processing, but resulted in exact prescriptions to the operator of the image correlator and to the photographic laboratory for rectification of the images. This permitted saving the expense of an iterative trial-and-error process that would have been required had no numerical adjustment been carried out. We believe that the savings outweigh the investment in the numerical method and conclude that the presented numerical approach to mosaicking is not only more accurate, but could well be even less expensive than the method employing tielines.

The SHORAN-based radar mosaicking method remains, then, as the only one to require sizeable additional expenses. In the present case this would perhaps have amounted to a maximum of 15 per cent of the total mapping effort. We believe, however, that this would not have permitted us to achieve an accuracy and convenience of mosaicking as good as we could with the block adjustment method.

CONCLUSIONS

A side-looking radar mosaicking experiment was based on 24 strips of overlapping synthetic aperture radar images of an area in excess of 90,000 km².

The analysis of the distribution of ground control points suggests that for the sequential numerical adjustment method a regular point distribution results in the smallest mosaicking errors. If control is available only along the perimeter of the mapping area, then we conclude that the points should preferably be aligned in the flight direction.

We believe that we have demonstrated that a numerical radar block adjustment carried out prior to mosaic compilation produces results superior to an approach based merely on tielines. The overall mosaicking accuracy achieved can be represented by RMS residual errors of about ± 100 m in the flight direction, and ± 130 m across the flight direction. This coordinate direction is less accurate due to neglected effects of topographic relief.

The Schuler-periodic errors of the inertial navigation that were found in this radar survey represent the worst case yet encountered with the particular equipment used. As a result, the usefulness of the numerical method could be demonstrated with more power than if everything had been working well during the survey flight.

We find, thus, that a numerical approach to radar mosaicking produces a gain in accuracy and ease of mosaic compilation that should justify the modest investment required to take measurements and process them digitally.

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Peterson R. K. (1976) "Radar Correlator Geometric Control", Presented Paper, 13th Congress of the International Society for Photogrammetry, Comm. 3, Helsinki, Finland; Goodyear Aerospace Report GIB 9397, Litchfield Park, Arizona.

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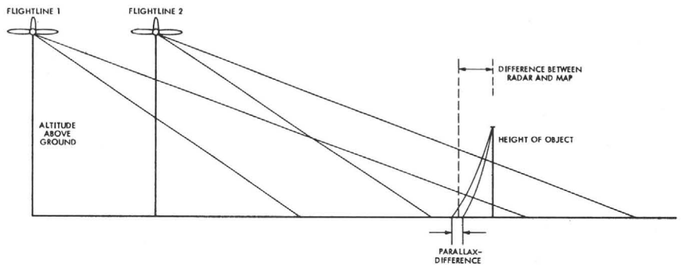


FIG. 5. Relief displacement and parallax difference in the overlap of adjacent radar images.

crepancies among adjacent radar strips (±50 m) and of the mosaic error (±130 m). However, as long as radar mapping is based on mosaicking without differential rectification, there is no point in accounting for errors due to topographic relief. But if the radar block adjustment is carried out in three dimensions instead of in planimetry only, then a preliminary study by DBA systems (1974) seems to indicate that the resulting planimetric accuracy could be significantly improved.

Discussion of Mosaicking Methods and of Point Distribution

It is quite obvious from Figure 3, that the simple mosaicking method, which only would use ground control for orientation and scaling of the mosaic, produces the least accurate results. In the case presented, the mosaicking errors amount to about ±3 km (Figure 3, case *(a)*. This probably is the lower limit for most radar mapping projects based on inertial guidance due to the fact that it results from five-hour mapping flights with excessively large Schuler type errors.

The accuracy of the tieline method of mosaicking is also clearly inferior to the results obtainable from a block adjustment (compare Figure 3, cases *(d)* and *(l)*). There are several reasons for this: Tielines provide only two bands of control, whereas a numerical adjustment can take advantage of any type of control distribution; the tielines only control the overall along-track scale of the production imagery, but not the critical effect of the radar image curvature and differential along-track scale variation; and in the tieline approach unrectified images have to be mosaicked. Actual tieline mosaicking could be less accurate than suggested in Figure 3 for the reason mentioned before. Figure 3 is the result of a numerical simulation rather than actual tieline mosaicking. Numerical treatment of accurate measurements could be more accurate than manual mosaicking.

Case *(l)* of Figure 3 presents two results. The root-mean-square errors in brackets give the accuracy of the tieline approach if no rectification of the individual radarstrips is assumed. The errors therefore reflect the effect of the large overall scale difference of 3 per cent between the across- and along-track direction. The errors given without brackets present the result if the overall affinity of 3 per cent can be detected and rectified.

The tieline case is the only one in which the X-coordinates were found to have larger errors than the Y-coordinates. No obvious explanation can be offered for this reversal of the accuracy behavior. The error in transferring points from the north-south lines to the tielines is rather large, perhaps of the order of magnitude of ±200 m, because no stereo transfer is possible; relief displacement is towards the north (X-direction). However, it is not felt that these considerations sufficiently explain the fact that errors are larger in the X-direction than they are in Y.

An analysis of various control point configurations reveals that, in a numerical approach, four control points can eliminate the large overall affine deformation of the radar block (Figure 3, case *(b)*). Furthermore, in a sequential adjustment procedure, a fairly regular distribution of control points produces the highest accuracy (Figure 3, case *(d)*), and a densification of the control network improves the results (cases *(b)*, *(i)*, *(g)*, *(d)*). If only perimeter per cent, and a pair of east-west tielines along the northern and southern perimeter, were available to tie the individual images into a coherent block.

Measurements were taken of the points in the overlap common to adjacent images to merge the individual strips, and of ground control points to transform the radar data into a map coordinate system. The common points were carefully selected and marked on the emulsion of the diapositives at a scale 1:400,000 using a Wild PUG point transfer device (estimated accuracy about ±2 μm). The image coordinates of the marked points then were measured on a Haag-Streit Coordinatograph (estimated accuracy about ±50 μm) and the map coordinates of the ground control points were scaled off the 1:24,000 maps of the area.

More than 200 different points were measured, including some 65 ground control points and a large number of tiepoints that were selected at approximately 12-cm intervals along the image strips (about 50 km on the ground) and, due to the 20 per cent overlap, were measured twice.

Radar Mosaicking Procedures

Four techniques of side-looking radar mosaicking have so far been, or are presently being, employed. The simplest method is one in which hardly any ground control points are available or used and where no preprocessing is applied. The individual radar strips are directly laid out on a mosaicking board in such a way that adjacent images fit together; but an adjustment to ground control, if available, is not carried out beyond a preliminary overall rotation, scaling, and shifting to the map coordinate system. Basically, the resulting radar mosaic is as accurate as the inner geometry of the images and the aircraft navigation permit (1 km error per hour of flight).

FIG. 1. Location of radar mapping area.

The most sophisticated and expensive radar mosaicking method thus far employed was based on continuous simultaneous SHORAN tracking of the survey aircraft from two geodetically surveyed ground stations. As a result, the position of the aircraft was determined to an absolute accuracy of about ±300m (van Roessel *et al.*, 1974). This in turn permitted the transformation of an ordered set of artificial radar image points (so called "range marks") into the map system. The transformed set of image points represents the base-map onto which the mosaic is laid out. The method was, for example, employed in the first phase of Brazil's RADAM. Although it provides information for the rectification of individual radar strips prior to mosaicking, it was soon abandoned, apparently due to cost considerations. The accuracy of the resulting mosaic is determined by the precision of the SHORAN aircraft tracking system, the effect of measuring errors, and weaknesses of the image geometry. It must therefore be expected that SHORAN controlled radar mosaicking leads to RMS errors certainly well in excess of ±300 m (van Roessel *et al.*, 1974).

Because SHORAN tracking determines the mosaicking accuracy, this has been thus far the only method for which a reliable estimate was available for the accuracy of the mapping product. For this reason, but more so because there was no SHORAN tracking provided in the acquisition of the test data, the SHORAN based method of radar mosaicking will not be numerically evaluated in this paper.

A rather frequently used mosaicking method relies on at least two or more "tielines"; these are radar image strips flown across the direction of the production imagery along the perimeter of the mapping area. A number of ground points are then surveyed or scaled off an existing map and marked on the tielines or the tielines are tracked by SHORAN. This permits their transformation into the map system. The production images are then laid out on the mosaic board to achieve a fit to the tielines and a smooth transition at adjacent image strips. The root-mean-square errors of this method have been

estimated (for SHORAN tracking of tielines) by van Roessel *et al.* (1974) to be about ± 700 m. However, it is the most widely used procedure, for example being employed in the entire radar mapping effort of Brazil (9 mil. km²), except for the initial part with complete SHORAN control of all flights. An obvious advantage of the method based on tielines is its simplicity: No numerical operations are required and the mosaic can be compiled directly. But among the disadvantages of the method are a limited accuracy, a lack of the possibility to adjust the mosaics to ground control points other than the ones imaged by the tielines, and the fact that there is no information available for the rectification of individual image strips prior to mosaicking.

The fourth method of radar mosaicking is based on a numerical radargrammetric block adjustment. Here, measurements of points in the overlap areas of adjacent images are used to tie the images into a block, and the block is transformed into a network of ground control points similar to a photogrammetric block adjustment. This method of preparing a base map for mosaicking was employed in PRORADAM, Colombia's radar mapping project of the Amazon, described in detail by Leberl (1975a). A numerical sequential adjustment of radar images using spline polynomials (first, block formation as an internal adjustment, then fit to the ground control points in an external adjustment) produces results that appeared quite comparable to or, in the case of certain constraints, even better than a simultaneous adjustment of radar images (Leberl, 1975b). It is thus the sequential method of numerical radar block adjustment that is considered in the present practical experiment in which we aim at establishing accuracy models for radar mosaicking. One can expect a numerical block adjustment to result in mosaics of high accuracy, and to produce information for the rectification of the images prior to mosaicking. For details on numerical side-looking radar block adjustment algorithms, reference is made to earlier publications (Leberl, 1975a and 1975b).

Radar Mosaicking Results

The mosaicking experiment is based on the numerical treatment of the radar image measurements and map coordinates. The first step was to tie all radar images into a block in an internal adjustment. The block was then transformed into the network of known ground control points by using a linear conformal transformation. Figure 2 presents the result with error vectors indicating that there was a significant overall affine deformation of the radar block which amounts to about 3 per cent (scale is larger in the north-south than the east-west direction). The root-mean-square (RMS) discrepancies amount to about ±3.5 km.

A portion of this deformation is artificially built into the optical correlation process to compensate for later differential paper shrinkage. The random errors of the optical correlation process generally do not contribute a significant portion to the overall errors of the final image (Peterson, 1976). Figure 3, cases *(a)* to *(k)*, present the RMS errors encountered in the check points if an interpolative correction is applied to the radar block coordinates (external adjustment). Checkpoints are those groundpoints which do not take part in the adjustment, but only serve the purpose of evaluating the accuracy. The figure illustrates the distribution of the ground points employed for computing corrections. The method of computation was with weighted moving averages (see, for example, Schut, 1970; or Leberl, 1975c).

Case *(l)* of Figure 3 specifically addresses the mosaicking results employing tielines. The results are not obtained from actually compiling a mosaic using tielines. Instead, this process was numerically simulated. First, the tielines were adjusted to the available ground control. Then the north-south lines were adjusted sequentially to the tielines and to the one previously adjusted adjacent north-south line by using a spline fit. The accuracy estimate for the tielines method might thus be too optimistic if one assumes that the numerical approach using splines is too flexible and accurate to be a valid simulation of the "damp and stick" process of mosaicking images on wet photo paper. The two sets of results for case *(l)* of Figure 3 concern two different assumptions for the numerical approach to mosaicking with tielines. This will be discussed in the next section.

Upon completion of the radar block adjustment, information is available on the discrepancies among adjacent individual radar strips and on their internal geometric errors. Figure 4 illustrates the dominant appearance of the errors of individual strips. They are slowly varying and fully explainable by the so called "Schuler-periodic" errors of the inertial navigation. These errors theoretically have a period of 84 minutes of flight and an amplitude that grows at a rate of about 1 km-per-hour or more. The numerical approach revealed that in the present example the Schuler-periodic velocity errors had amplitudes far in excess of what one must normally expect from a properly operating platform. The numerical approach permits elimination of these errors. The residuals encountered in the images after filtering of the Schuler periodic and overall errors had an RMS value of about ±50 m on the ground and included the effects of measuring errors and parallax differences due to topographic relief.

Topographic relief was not considered in this experiment. Instead, the mapping area was assumed to be flat. This has been so far a rather commonly applied assumption for radar mosaicking. Attempts to differentially rectify radar images and thus to consider topographic relief in mapping have been reported only by a U. S. military mapping research group, but have not been further pursued (Yoritomo, 1972). Effects of topographic relief, however, represent the limit of the mosaicking accuracy. Figure 5 illustrates that topographic relief creates parallax differences in the cross-track (east-west) direction that are much smaller than the overall discrepancy between a point in the radar mosaic and in the topographic map. For the example of the relief of 200 m (occurring in the present mapping experiment), the parallax difference would amount to about 50 m, but the overall relief displacement is 150 m. These are also the accuracy figures obtained for the irregular component of the dis-

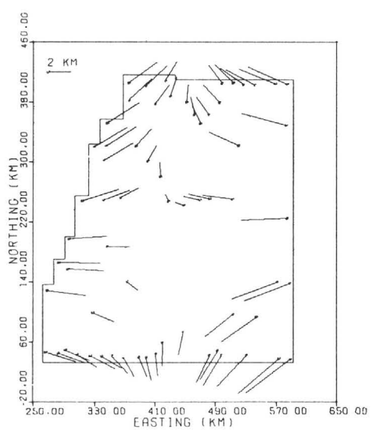


FIG. 2. Distribution of ground control points and vector representation of the discrepancies encountered between the internally adjusted block and the ground control point, prior to external adjustment.

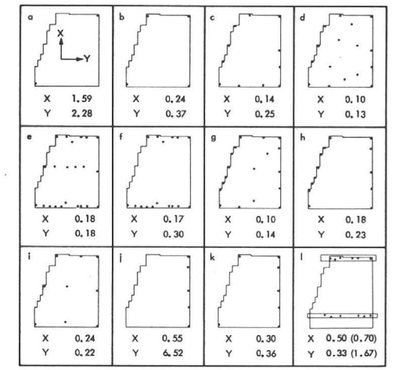


FIG. 3. Radar mosaicking results using various arrangements of ground control points (cases *(a)* to *(k)*) and an approach based on tielines (case *(l)*). The results are RMS discrepancies between radargrammetric and map coordinates of checkpoints, given in kilometers.

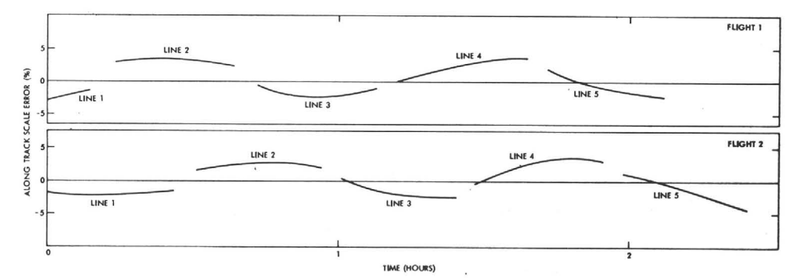


FIG. 4. Curves representing the along-track scale error of image strips acquired during two flights, each producing five flight lines.

Side-Looking Radar imagery that is available of the U. S. can be obtained by sending your request and area of interest to Goodyear Aerospace Corporation, Arizona Division, Litchfield Park, Arizona, 85340. Attn: C. A. Anderson, Dept. 408A, Building 13-2S.

There is a charge of $82.00 per lot—(a lot consists of a contact transparency and a contact print)—for photo reproduction cost. Each lot will provide one of the following:

Type 1 ≈10x30 NMI at 1:200,000 or 1:300,000
Type 2 ≈20x60 NMI at 1:400,000 or 1:480,000
Type 3 ≈30x90 NMI at 1:600,000
Type 4 ≈ 5x15 NMI at 1:100,000.

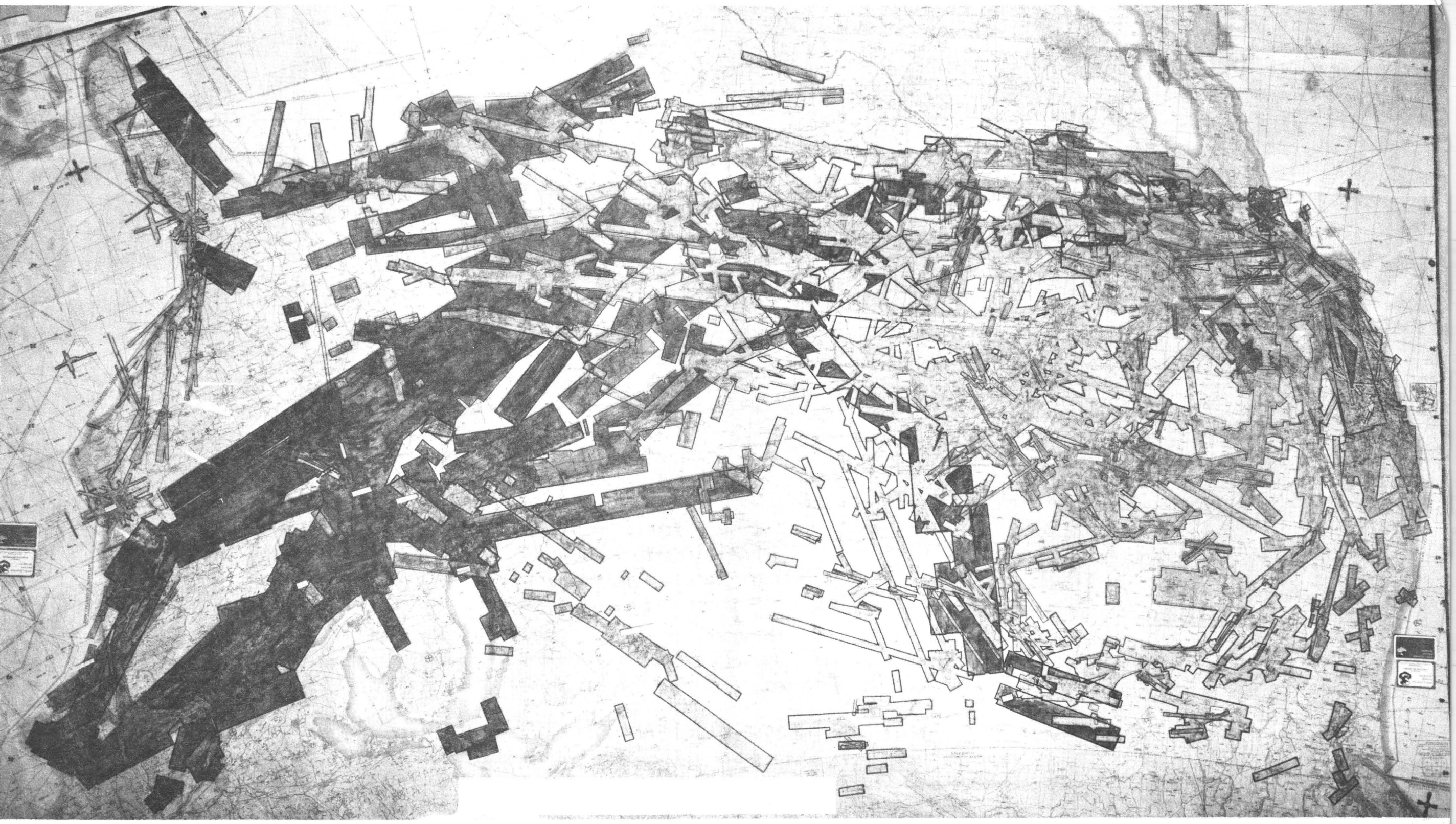
If the desired coverage of a pass exceeds the above, then additional lots will be necessary.

Additional prints or enlargements are available upon request. Price will be provided when requested.

A letter must accompany your request describing the intended use of the imagery.

A check should be made payable to Goodyear Aerospace Corporation and the order sent to me. Goodyear does not accept personal checks, therefore either a cashier's check or company check should accompany the order.

(11-77)



Preliminary Geologic Report 27-14
of the 6-3

Charles Beauty Properties 25-13
(Joe Claims) 12-6

For: 4-2

Charles R. Ward Corporation 27-14
Phoenix, Arizona 16-8

by: 3-2

Silas C. Brown, Geologist 25-13
Phoenix, Arizona 16-8
June 1977 9-5

Introduction Cont

A geological reconnaissance survey was made in the field with Mr. Charles Bearup on June 11 & 12, 1977. Because of the size of the property and limited time, most field work was confined to Section 14 - T2S - R14E. The two best prospects, the "Box" and the "Pit" are in Section 14. The Box is related to the old Doak prospect which occurs on a known fault.

Basic data were used from USGS Bulletin 1141-H and other sources. The writer assumes responsibility for the final interpretation herein.

Location and Accessibility Cont

The Bearup property (Joe Claims), which consists of 142 unpatented lode claims, is primarily situated in Section 13, 14, 15 & 16, T2S - R14E, G&SRPM, Gila County, Arizona

The terraine is rather rough with elevations ranging between approximately 3500 and 5000 feet above sea level

Niccolite – copper nickel nickel Arsenide NiAs

Assoc w/ native silver & silver arsenic minerals
pyrite, chalcopyrite & other sulphides
Qtz Barite, etc.

Violarite – a nickel sulphide (an intermediate division of sulpho-ferrite
NiS_2 belongs to pyrite group. (Bornite)

Found in pyrite & chalcopyrite in King West Mine Clark Co. Nevada

Also occur w/ cobalt, copper, silver, sphalerite & galena.
Arsenopyrite, native arsenic & Bismuth.

Native nickel – Sum 335
ores of nickel 708-712

The property is easily accessible via about 20 miles of graded road extending southwestward from Globe. Access roads on the claims proper are in fair shape, however a 4-wheel drive vehicle is necessary.

GEOLOGY AND STRUCTURE

A large part of Section 14 is covered Pinal schist which has a prevailing E-W strike and dips ranging from 15° to 55° North. This is contrary to the normal attitudes to the north and west of the property. There are many local exceptions to these general attitudes and may reflect the borders of Laramide intrusives into the older pre-Cambrian schists. The highly distorted and crumpled schist at the Box and Pit prospects appear to be fault controlled, however, this does not eliminate the large intrusive body theory. Only a deep drilling program can outline the existence of Laramide

intrusions.

The Box ~~and Pit~~ prospects is on the southern end of a fault previously mapped by N. P. Petersen. The Pit prospect is on ~~an extension~~ a projection of a parallel fault about 800 feet west of the Box fault. Both prospects showed ~~both~~ primary and secondary copper minerals. The secondary oxide ~~minerals~~ minerals observed include Malachite & azurite while the sulphides were Chalcopyrite, pyrite & bornite. ~~No silver~~ ~~Copper and~~ ore was observed, however, ~~assays~~ assays ~~made from~~ of Samples taken ~~on the dump~~ from the prospects showed all of them to contain silver in varying amounts. Zinc, lead, and iron are also present along with ~~minerals~~ other minor minerals.

Large outcrops of diabase are present and have been mapped as sills in the schist. Recent field observation indicates this to be true as the contact between the schist and diabase appeared to be conformable. Granite porphyry dikes occur in

[Cave Creek — 56 Claim 2% Nickel —:-:-:-]
C. Bearup

NW 1/4 Section 14 which has been given a Tertiary age determination which is late Laramide. Petersen believe these dikes to be separated from the main intrusive mass, however, ~~the~~ its ~~presence~~ presence alone indicates the proximity to an intrusive

Pre-Cambrian Madera diorite crops out in the SE 1/4 Section 14 and the S 1/2 Section 13. It is a light gray, medium grained, biotite-quartz diorite with abundant epidote occurring locally. The diorite could be a source of mineralization in fault zones and joints and where the dike material has been injected into the schist. Mineralization does occur in quartz veins within the diorite itself.

<u>Conclusions & Recommendations</u> <u>Oil Cap</u>

An attempt should be made to block out ore having marketable mineral value. Copper and silver are the major minerals indicated so far, but lead, zinc + gold should be

considered

A series of core holes (or down Hole Hammer) should be drilled so that samples can be collected for assay. The Box prospect appears to be the best place to start because ~~of the~~ Mineralization at the surface appears favorable. The holes should be drilled to a depth of about 100 feet ~~with~~ and spaced about 50 feet apart. The purpose of the drilling program is two-fold. First, as mentioned above, to block out ore having commercial mineral value, and secondly, to determine how the ore body occurs. A block of ore 100' x 50' x 100' = 500,000 cu. ft or about 40,000 Tons. In the event commercial ore is found on the Box prospect, ~~the~~ a similar drilling program should be set-up on the Pit prospect.

If the core drilling program ~~proves~~ blocks out commercial ore, a more detailed geological ~~work~~ survey should be made. The first survey should be made in the vicinity

~~of the blocked out ore and later extended to include the balance of the claims. Known faults should be traced~~

If the core drilling program blocks out commercial ore, a concentration mill could be designed to fit the types of minerals present. A more detailed geological survey would be advisable in the vicinity of the blocked ore and extended to include the balance of the Claims. Known fault zones are present in the N/2 Section 15 and vein material in the diorite ~~outcrops in~~ must be examined. The additional ~~field to~~ geological field work would largely depend on ~~the~~ favorable results of the drilling program.

GEOLOGICAL REPORT

OF THE

SOUTH BLUFF UNIT

SAN JUAN COUNTY, UTAH

PREPARED FOR

RENWAR OIL CORPORATION

CORPUS CHRISTI, TEXAS

By: Silas C. Brown
Geological Consultant
Durango, Colorado
July 31, 1957

GEOLOGICAL REPORT

OF THE

SOUTH BLUFF UNIT

SAN JUAN COUNTY, UTAH

INTRODUCTION:

This report was undertaken at the request of Mr. C. C. Miller, Chief Geologist of the Renwar Oil Corporation of Corpus Christi, Texas.

The acreage evaluated is located in San Juan County, Utah ans is described as follows:

Township 39 South, Range 22 East, SLM.

Section 36: SW¼

Township 40 South, Range 22 East, SLM.

Section 1: All
" 12: All
" 13: All
" 14: E½
" 23: N½

Containing 2720 acres, more or less.

The block is presently under lease to the Three States Natural Gas Company and is known as the South Bluff Unit. The unit is located about 20 miles south of the town of Blanding, Utah. A well maintained black top and gravel road leads from Blanding to within one mile of the north edge of the block.

PURPOSE OF INVESTIGATION:

Renwar Oil Corporation is considering a farmout proposal

from the Three States Natural Gas Company on the acreage. The purpose of this study is to evaluate as thoroughly as possible the oil and gas potential of the South Bluff Unit.

METHOD OF INVESTIGATION:

A detailed subsurface study was made using all possible available data. Emphasis was placed on the two main productive zones of the Paradox, namely the "B" and "C" zones. A resume of the formations penetrated and the other oil horizons with limited potential will also be briefly described.

The subsurface structure map was constructed using the top of the "B" zone of the Paradox as the datum plane. A surface study done previously by the writer was incorporated into the map in regions of sparce control, particularly to the west of the South Bluff Acreage.

Radioactivity logs and related lithologic studies were used in correlation because of its superior ability in the Paradox Basin to record lithologic changes in the carbonate sections, thus giving sharper and more certain formation boundaries. Porosity determination was made by a combination of sample and core analyses where available, micrologs and the Neutron curves. Drill stem tests and production perforation intervals were used as the main indication of the formation productive ability.

GEOLOGY AND STRUCTURE:

The following description and tops of the formations

found in the South Bluff area should be similiar to the Pan American #1 Featherstone well in Section 24-40S-22E. The depths to the formation tops will vary depending upon the position of the well location in the section. The Morrison formation crops out over most of the area and the well location would probably be in the lower half of the Morrison section.

PAN AMERICAN #1 FEATHERSTONE - 24-40S-22E
SAN JUAN CO., UTAH

FORMATION RECORD

From	To	Thickness/feet	Formation
			JURASSIC
0	393	393	Morrison, Bluff and Summerville undifferientiated.
393	450	57	Entrada - white to reddish brown, fine grained, calcareous sandstone with thin interbedded red brown shale.
450	500	50	Carmel - Bright red to gray variegated shale, silty in part, with minor white to reddish brown sandstone beds.
500	900	400	Navajo - White to buff, fine grained sandstone with medium grained porous streaks. A water producing formation.
900	965	65	Kayenta - Red and brown silty shale and fine grained sandstone beds.
965	1367	402	Wingate - light to dark red, calcareous medium grained to conglomeratic sandstone. Porous.
			TRIASSIC
1367	2100	733	Chinle - Variegated dark red, brown and gray shales, siltstones and sandstones. The shale is calcareous. Thin limestone beds may be present locally.

Continued*

From	To	Thickness/feet	Formation
2100	2172	72	Shinarump - Medium grained to conglomeratic, white to buff sandstone with interbedded dark red shale.
2172	2387	215	Moenkopi - Dark red shale and mudstone in upper part grading downward into variegated shales and mudstones in the lower half. Thin pink to purple limestone beds locally.
			PERMIAN
2387	3671	1284	Cutler - Dark red shales interbedded with red siltstone and coarse grained sandstone in upper third. Lower third is dark red shale with thin interbeds of siltstone and sandstone.
			PERMO-PENNSYLVANIAN
3671	4470	799	Rico - Red and variegated shales with numerous thin interbeds of gray limestone and thin sandstones. This top is hard to pick and the upper part may be Cutler in part.
			PENNSYLVANIAN
4470	5100	670	Upper Hermosa - Dark gray fossiliferous limestone with variegated and gray shale interbedded. Thin light gray sandstone beds.
5100	5670	570	Upper Paradox - Dark gray limestone and dolomite interbedded with black carbonaceous shales and anhydrite. Salt at base.
			Top "B" zone 5298' - main objective. Top "C" zone 5517' - second objective. Top of Salt 5670'

From the foregoing tabulation, it can be seen that the "B" and "C" zones are the two lowermost zones of the upper Paradox.

These zones are separated by a 40-foot bed of black carbonaceous shale.

The main producing pay at the Aneth field proper and on the Three States Arrowhead lease, directly east of the South Bluff Unit, is from the "C" zone of the upper Paradox. There, the "C" zone is a highly developed dolomite and limestone section, whereas, the wells in the South Bluff area have become thinner and anhydritic. This change is from marine to shallow lagoonal type deposition. The change can be very rapid, occuring in less than a quarter mile. It is very possible to have the "C" zone developedand oil productive in the postulated high area shown on the enclosed map even though it is flanked by wells showing a poor and thinly developed section.

The primary objective in the South Bluff Unit is the "B" zone of the Upper Paradox. This zone is productive at the Pan American #1 Featherstone (31' total microlog porosity); and the Shell #1 Recapture Creek (30' total microlog porosity); Carter #1 Hickman (22' total microlog porosity),and the Shell #3 Bluff (20' total porosity). The Gulf #1 & 2 Desert Creek wells to the south of the South Bluff Unit had 46 feet and 40 feet respectively of effective microlog porosity with oil saturation in the "B" zone. These wells are presently completed in the Paradox "C" zone however.

The Three States #1 South Bluff well in Section 12-40s-22E showed streaked porosity in a shaley dolomite in the lower "B" zone.

From this discussion it can be seen that the South Bluff Unit is flanked by an indicated belt of porosity on the south and east. The Carter #1 Bluff Bench well in section 29-39S-22E, to the northwest of the Unit had excellent porosity in the "B" zone but it was heavily loaded with salt water. It then appears that any test, with geological merit, would have to be located within an indicated belt of porosity and on a structural high.

The sturctural high which centers in the northeast corner of section 19-40S-23E, and extends westward into the south partof the South Bluff Unit (see enclosed map) and lies within the indicated porosity belt.

The best location for a test well on the Unit which would satisfy porosity and structural conditions would be in the southeast corner of section 13-40S-22E. This location would be situated within the closed -700 foot contour. Net effective porosity of 25 to 30 feet could be reasonably expected in the "B" zone.

Shell Oil Company and Pan American Production Company have the offset acreage to the east and south respectively and could be approached for an acreage or money contribution.

CONCLUSIONS AND RECOMMENDATIONS:

Part of the South Bluff acreage is located in a favorable geological position for production from the Paradox "B" zone and possible limestone porosity development in the Paradox "C" zone.

Based upon the above, the southeast part of the Unit justifies a test and it is recommended that the test be located 660 feet

from South and East lines of Section 13-40S-22E., San Juan County, Utah.

PRE-PENNSYLVANIAN POSSIBILITIES:

The Mississippian, Devonian and Cambrian series are considered secondary objectives in the area. Surface structures reflect subsruface structures downward to the top of the Molas formation of lower Pennsylvanian age. A seismograph survey would be necessary to outline the pre-Pennsylvanian structure.

Respectfully submitted,

Silas C. Brown

Silas C. Brown
Geological consultant
Durango, Colorado

GEOLOGICAL REPORT

OF THE

DEVILS CANYON AREA

EMERY COUNTY, UTAH

PREPARED FOR

REYNOLDS MINING CORPORATION

OIL AND GAS DIVISION

HOUSTON, TEXAS

By: Silas C. Brown
Consulting Geologist
Durango, Colorado
July 21, 1956

GEOLOGICAL REPORT

of the

DEVILS CANYON AREA

Emery County, Utah

INTRODUCTION:

This report is made to evaluate the oil and gas possibilities of the Devils Canyon area. The main part of the lease block is situated about 43 miles southwest of Green River and 23 miles southeast of the town of Ferron, Utah. The Devils Canyon block, under a lease option to Reynolds Mining Corporation, contains about 27,520 acres. All available well data and measured sections throughout the San Rafael Swell area have been studied and integrated in parts of the report. Structural studies on a regional and local level were also made to help in the evaluation of the acreage.

The surface structure map was constructed using the base of the Shinarump conglomerate or Mossback sandstone as a datum. Across the area where younger beds crop out, a mappable horizon was used and all elevations were corrected to the base of the Shinarump. Data for the structure map was obtained from field inspection and photogeologic maps.

LOCATION AND ACCESSIBILITY:

The Devils Canyon block, containing about 27,520 acres, is situated in Townships 22, 23, 24, and 25 South, Ranges 8, 9, and 10 East,

Emery County, Utah. Access to the block is rather complicated due to rough terrain. A good graveled road extends from the community of Moore, Utah, eastward to the Copper-Globe Mine in Section 11, Township 23 South, Range 9 East (unsurveyed). Jeep roads lead to the edge of the main west block, but no roads extend across the block. About two miles of cut and fill road would have to be built to the proposed location. Water is a major problem but is available from the Muddy River about 15 miles southwest of the location.

STRATIGRAPHY:

Formational units are listed below from the Jurassic downward to include the Cambrian. Lithologic descriptions and thicknesses are taken from well data and measured sections.

JURASSIC

Carmel

The thickness of the Carmel ranges from zero to 100 feet. Its lithology changes rapidly due to its rapid thickening toward the west. The section exposed on the main western block consists of thin limestones, sandstones, and variegated red and green shale. Some siltstones and minor gypsum streaks were noted.

Navajo

The Navajo sandstone has a thickness ranging between 450 to 475 feet. It consists of fine to medium grained, pink, massive, and cross-bedded sandstone with minor streaks of variegated shale and anhydrite.

Kayenta

The Kayenta averages between 150 and 250 feet thick. Sand-

stones predominate and are varicolored, fine grained, and silty with streaks of variegated red and green, calcareous shales.

Wingate

The Wingate sandstone averages about 400 feet thick in the Devils Canyon area. It is a massive, fine to medium grained, light orange to red, calcareous sandstone. Minor lenses of coarse grained sandstone and shale are present in the section.

TRIASSIC

Chinle

The Chinle formation has thinned to the northwest to average only about 250 to 275 feet thick in the area. It consists predominantly of variegated red and purple, silty sandstone. Minor streaks of shaly limestones are also present.

Shinarump (Mossback)

The Shinarump unit is present in small lenses and patches which represents an unconformity at this horizon. In many places the Shinarump is missing, and a lower Chinle sand development is present. This lower Chinle sandstone is referred to as the Mossback unit. Both the Shinarump and the Mossback units are absent locally.

The base of these units or the top of the Moenkopi was used as the datum plane on the structural maps.

Some oil staining was reported in this unit at Huntington Dome in the Phillips well.

Moenkopi

The Moenkopi, including the Marine Sinbad member, attains a thickness of 850 to 900 feet in the Devils Canyon area. Its chief

constituent is reddish-brown micaceous siltstone. The Sinbad member is about 200 feet above the base of the Moenkopi and averages 75 to 100 feet in thickness. It consists of light to dark gray and brown dolomites and limestones with some limy sandstone and shale near its top. A Sinbad section was measured in T21S-R11E, and it showed about 50 feet of good vugglar porosity with some oil staining. At Huntington Dome the marine Moenkopi section was saturated with oil in fractures. Cores, bleeding oil, and gas were reported. At South Last Chance, about 20 miles to the southwest, a well was completed in 1924 for a reported 21,000 MCF of 840 B.T.U. gas per day. The well was shut-in for lack of market. The Equity #1 Mounds well about 45 miles north of the Devils Canyon area, produced a small amount of gas from the marine section. Good shows of oil and gas were reported in other wells in the general area.

Shows could be expected in the Devils Canyon area, but their magnitude is questionable.

PERMIAN

Kaibab

The Kaibab varies rapidly in thickness throughout the area, but an estimated thickness of 200 feet may be expected in the area. It consists of dolomitic limestones and dolomites with minor chert and silty bands. The rocks are white to light gray in color. Geodal porosity is characteristic with some vuggular and intercrystalline porosity present. Oil staining is common in Straight Wash Canyon on the east flank of the San Rafael Swell.

Pennsylvanian

The Pennsylvanian Series includes the Hermosa and Molas

formations. The Molas is probably present but not as distinct a formation as farther east. The Pennsylvanian is characterized by light brown to buff and white dolomites and limestones. The dolomites are quite sandy with thin shale beds near the top of the section. The lower 500 feet of the section contains considerable chert. Minor oil shows have been reported in the Hermosa equivalent. The Paradox facies is absent in the Devils Canyon area. The Pennsylvanian as a whole is considered a poor prospect in the area.

Mississippian

An estimated thickness of 800 to 900 feet of Mississippian exists in the Devils Canyon area. It consists mainly of white to buff colored dolomite with chert bands and nodules. Fair to very good porosity is present, but no oil or gas shows have been reported in near-by wells. Because of the shifting of structure with depth, it is not known if any of the wells have been drilled on Mississippian highs.

Devonian

The Devonian section is represented by about 400 to 450 feet of light to dark gray dolomites and dolomitic limestones, variegated, red, green, and maroon shales and glauconitic, fine to coarse grained sandstone. Dolomites predominate. No shows have been reported in any of the wells drilled in the general area.

Cambrian

The Cambrian series is estimated to be between 1400 and 1500 feet thick. The Cambrian includes the Lynch, Bowman-Hartman, Ophir, and Tintic formations. With further paleontological studies,

the Lynch may prove to be Ordovician in age. A breakdown of these formations will not be attempted in this report. Descriptions of all formations except the Bowman-Hartman are included in the Red Knoll report.

In general, the Cambrian series consists of dolomites in the upper third of the section, oolitic and crystalline limestones and minor dolomites in the middle third, and limestone, shale, sandy shale, and quartzite in the lower part.

No shows were reported in nearby wells. It is possible that none of the wells were drilled on Cambrian highs. Lithologic studies indicate poor source beds in the general area. Better source beds exist in southwest Utah and southeast Nevada; however, some migration eastward might be possible.

STRUCTURE, LOCAL AND REGIONAL:

The Devils Canyon lease is situated on the northwest flank of the San Rafael Swell. The dominent structural feature is in the main west block which consists of a faulted anticline. The fault structure has about 600 to 650 feet of closure and an area of closure of approximately 4100 acres. The fault forming the structure has a throw of 200 to 300 feet and is a normal fault. Two major fault trends and several minor trends were noted in the area. Prominent northwest-southeast trending faults are believed to be the oldest as they parallel the older structural trends which are related to the Uncompahgre Uplift. The northeast-southwest fault trend parallels the San Rafael Swell and is probably of Laramide age. The minor fault trends are Laramide or younger in age.

Very detailed surface work in conjunction with a detailed

seismograph survey would be necessary to outline the older lines of folding. The younger folds are not expected to produce oil or gas in commercial quantities.

RECOMMENDATIONS AND CONCLUSIONS

The Paradox facies, which is the major producing section in the Paradox Basin proper, wedges out before it reaches the Devils Canyon area. The Ferron sandstone member of the Mancos formation, which produces in the Wasatch Plateau to the west, crops out above the section on the structure and is, therefore, missing in the block. Since these major objectives are missing in the area, the rest of the Pennsylvanian and younger formations show little promise for commercial production. The Sinbad, Kaibab, and Coconino have all had shows, but none have proved commercial.

The Mississippian, Devonian, and Cambrian rocks have questionable potentials since it is not known if these horizons have been tested on structure. These older structural trends are not generally reflected on the surface; therefore, a seismograph survey is necessary to help evaluate these horizons. Source beds are not abundant in the pre-Pennsylvanian rocks.

Without a seismograph survey to depict the older structure; the main objective in the Pennsylvanian and younger formations being absent, and the presence of low B. T. U. gas and carbon dioxide in the area, the Devils Canyon lease is considered a poor prospect. For these reasons it is recommended that the block be farmed-out or the leases allowed to expire.

A test well is not recommended; however, if one is necessary

to fulfill an obligation, it is recommended that the location be 1320 feet from the north and west lines of Section 17, Township 23 South, Range 9 East, Emery County, Utah.

Respectfully submitted,

Silas C. Brown

Silas C. Brown

Report on the

THOMPSON-ALDRIDGE URANIUM PROJECT

Sections 4 and 9, T 36 N - R 9 W

La Plata County, Colorado

for

Col. D. Harold Byrd

Byrd Oil Corporation

1110 Tower Petroleum Bldg.

Dallas 1, Texas

Osterhoudt and Brown, Consultants
Geology and Geophysics
Durango, Colorado

by Silas C. Brown
Silas C. Brown
Geologist

THOMPSON-ALDRIDGE URANIUM PROJECT

Introduction

S. C. Brown, Consulting Geologist, of Durango, Colorado was contracted by Col. D. Harold Byrd of Dallas, Texas to supervise the exploratory field work on the Thompson-Aldridge Project on September 2, 1954. Three drill holes had been completed. The writer surveyed the locations of these three holes and made new drill hole locations. The mineralized zones of the outcrop localities were mapped and a total of 16 holes were drilled and subsequently surveyed to complete the exploratory work in order to evaluate the prospect.

The object of the drilling program was to outline possible ore bodies and to determine whether mining operations were feasible. Representative cores were assayed to obtain a comparative value for evaluating the geophysical probes.

Considerable bulldozer work was done to build access roads to the drilling locations and to make discovery cuts on the claims.

Field work pertaining to the drilling, geophysical logging and other geological field studies extended from September 2 to September 22, 1954. Compilation of maps, logs, other data and the report extended the project to September 30, 1954. The writer was assisted by W. J. Osterhoudt, Geophysicist, in making the geophysical logs and interpretations.

Drilling and Bulldozer Work:

A total of 16 holes were drilled, several of which were cored to obtain geological, geophysical and sample data. A 17th hole was abandoned because the drill could not penetrate the glacial gravel boulders. The depth of the holes ranged from 101 feet to 142.5 feet with the exception of Hole No. 11 which was drilled to 250 feet.

The object was to drill to a point near the estimated top of the enriched zone, and to core through that zone. The location of each new hole was determined from the results of the preceding hole or holes. Possibly valuable core information was lost due to occasional fouling and crushing of the cores within the core barrel.

A total of 96½ hours of bulldozer work was done in making locations for the core drill and making discovery cuts on the uranium claims. Discovery cuts were dug on all but 5 claims -- one of which could not be dug due to very rough terrain. When it became apparent that the uranium ore was low grade with a high lime content, i.e. not a profitable mining operation, the bulldozer work was terminated.

Geology and Structure:

The mineralized zone occurs in a stratum composed of hard, micaceous, sandy and shaley limestone in various gradations. The ore bed lies about 40 feet below the top of the Rico formation of Permo-Pennsylvanian Age. Red-beds of the Cutler Group of Permian Age overlie the Rico formation. The regional strike of the beds is N 80° W with southerly dips decreasing from 14° at the north to 5° a few miles south. Minor structural undulation causes local variations in the strikes and dips.

Uranium ore enrichment appears to be present along joints and fracture planes trending from N 25° E to N 35° E. The major joints observed are about 150 feet apart.

A small fault is indicated between drill holes No. 12 and No. 15. This fault apparently is on the southern extension of a strong joint observed in the canyon wall. The continuance of the fault toward the south and its magnitude in that direction remain unknown. The displacement of the fault noted between holes Nos. 12 and 15 is about 10 to 15 feet with the downthrown side to the east. The higher grade ore is located on the eastern side of the joints and faults.

Geophysical Logs and Interpretation:

The drill holes were probed with a Precision Drill Hole Counter Model 120 with the following results:

Hole No.	Measured T.D.	Max. Reading Units	Thickness of Ore Zone	Est. Ore Grade
1	122.5'	.635	2 '	.11
2	141.7'	.15	---	---
3	115.6'	.65	2 '	.11
4	124.0'	1.20	2 '	.13 +
5	107.3'	.43	1 '	.08
6	119.0'	.30	---	---
7	121.3'	.22	---	---
8	101.0'	.29	---	---
9	110.0'	.22	---	---
10	111.3'	.525 upper zone .62 lower zone	1½' 1½'	.10 .11
11	250.0'	.30	---	---

Hole No.	Measured T.D.	Max. Reading Units	Thickness of Ore Zone	Est. Ore Grade
12	137.5'	.85	2 '	.12
13	135.0'	.67	2½'	.11
14	142.5'	.19	---	---
15	138.7'	.62	1 - 1½'	.11
16	132.0'	.12	---	---
17	15 '	Abandoned		

These data were checked at least twice, and found to be consistent and satisfactory. (Data by Osterhoudt and Brown.)

Most of the drill holes were probed also by a contractor using an A.E.C. type gamma ray (Brown) prober to check and compare the results with the data obtained by the Model 120 counter. The gamma ray logging equipment was new and numerous "bugs" developed in the probe and cable, consequently the original logs were useless. After repair work was completed several of the holes were re-run with better results, but the depths recorded were too long by 4% error. The correct depths were estimated from the apparent error. Some of the holes had caved while the equipment was being repaired and, therefore, only certain holes produced results.

An interpretation of the gamma ray logs follows:

Hole No.	Thickness of Ore Body	Grade of Ore
1	Probe not working	
2	Probe not working	
3	Probe not working	
4	2 '	.12
5	Non-commercial	
6	½'	.10

Hole No.		Thickness of Ore Body	Grade of Ore
7		Non-commercial	
8		Caved to 87'	
9		Not probed	
10	(upper zone)	1½'	.11
	(lower zone)	1 '	.10
11		½'	.10
12		2½'	.11
13		3 '	.11
14		Non-commercial	
15		Caved	
16		Non-commercial	

(Interpretation by D. F. Coolbaugh of Moab, Utah.)

These readings are an average for the thicknesses stated and it is recognized that from one to three inches of much richer ore is present within the section outlined. It is doubtful that the richest zones would exceed .20 to .25% grade. Due to the high $CaCO_3$ content even these higher grades are considered non-commercial.

The percentages of uranium ore estimated on the gamma ray data are based upon curves developed from the probing of several thousand drill holes and are assumed to be practical approximations. These results check fairly well with geiger counts and with the assays of certain cores made by chemists at the Vanadium Corporation of America mill at Durango.

Worthy of mention is the show of low grade ore at about 225 feet in hole No. 11.

Chemical Analyses:

Five chemical analyses were made on 4 holes by the Vanadium Corporation of America. The results are as follows:

Hole No.		% V_2O_5	% U_3O_8	% $CaCO_3$
10		Nil.	(.07 Geiger (.08 Chem. Analysis	Not run
11		Nil.	.04 Geiger	Not run
12	123 -124.5'	Nil.	.04 Geiger	20.4
12	124.5-126.5'	Nil.	.08 Geiger	21.3
15		Nil.	.09 Geiger	29.5

The cores from holes Nos. 10 and 11 were not complete as the shalier portions of the cores were ground-up and blown out during drilling. The core recovery on the remainder of the holes was 100% and the assays are assumed to be correct within .01 - .02%. A core sample usually included from six inches to two feet of section showing fair count and the value of that section is representative of minable ore. In most instances a two to three inch zone of the core assayed showed .20 MR/hr. or greater count. When the enrichment was spread out over a greater thickness the average count was considerably lower. A three inch zone is not economically minable even for ore of much higher value.

Lime content analyses were run on cores from three holes and are assumed to be representative for the ore in this formation. Ore with a lime content of 6% or less is acceptable by the mills. There is a penalty of $1.00 for the first 1.0% over 6% and $0.30 per ton penalty for each succeeding per cent.

Chart Showing Penalty for $CaCO_3$ Content

$CaCO_3$ Percentage	Penalty
6% or less	No penalty
7%	$1.00
8%	1.30
9%	1.60
10%	1.90
15%	3.40
20%	4.90
29%	7.60
29.5%	7.75

The Vanadium Corporation of America reports that they will not accept ore having a lime content in excess of 15%. However, if the ore were in large enough quantity and of a higher grade it is believed that the 15% limit would be reconsidered.

The Kerr-McGee Uranium plant at Shiprock, New Mexico would take ore with high lime content but would prefer ore having 15% or less lime. It is a matter of economics rather than refusal to buy the high lime ore. The standard penalty for 6% or more lime is deducted by Kerr-McGee

The uranium mill at Grants, New Mexico does not penalize the seller for lime content in excess of 6%. They do not process or pay for ore having vanadium or other allied ores except uranium. The haulage in this case would even exceed the lime penalty.

Conclusions and Recommendations:

The uranium ore body as outlined by the drilling, coring and logging program has proven to be low grade and of limited size. Deposition of the ore is apparently controlled by parallel joint planes and small faults.

The high lime content of the ore is a major problem due to the penalty applied on ore containing over 6% lime.

Many local zones may be found by more drilling and by bulldozer work in areas of thin overburden. Some of the ore bodies may be larger and richer, but any ore, in order to be commercial, must be considerably higher in grade to offset the penalty for lime.

I recommend that the option not be exercised because of the low grade and limited amount of ore, the penalty for lime, the high costs of hard rock mining and the high cash payment required to complete the deal.

Respectfully submitted,

Silas C. Brown

Silas C. Brown

Box 1143
Durango, Colorado
September 30, 1954

ENCLOSURES

Exhibit I - Map showing contours of the Ore Datum.

Exhibit II - Map showing Iso-Unit contour lines.

Exhibit III - Index map showing location of Cross-sections.

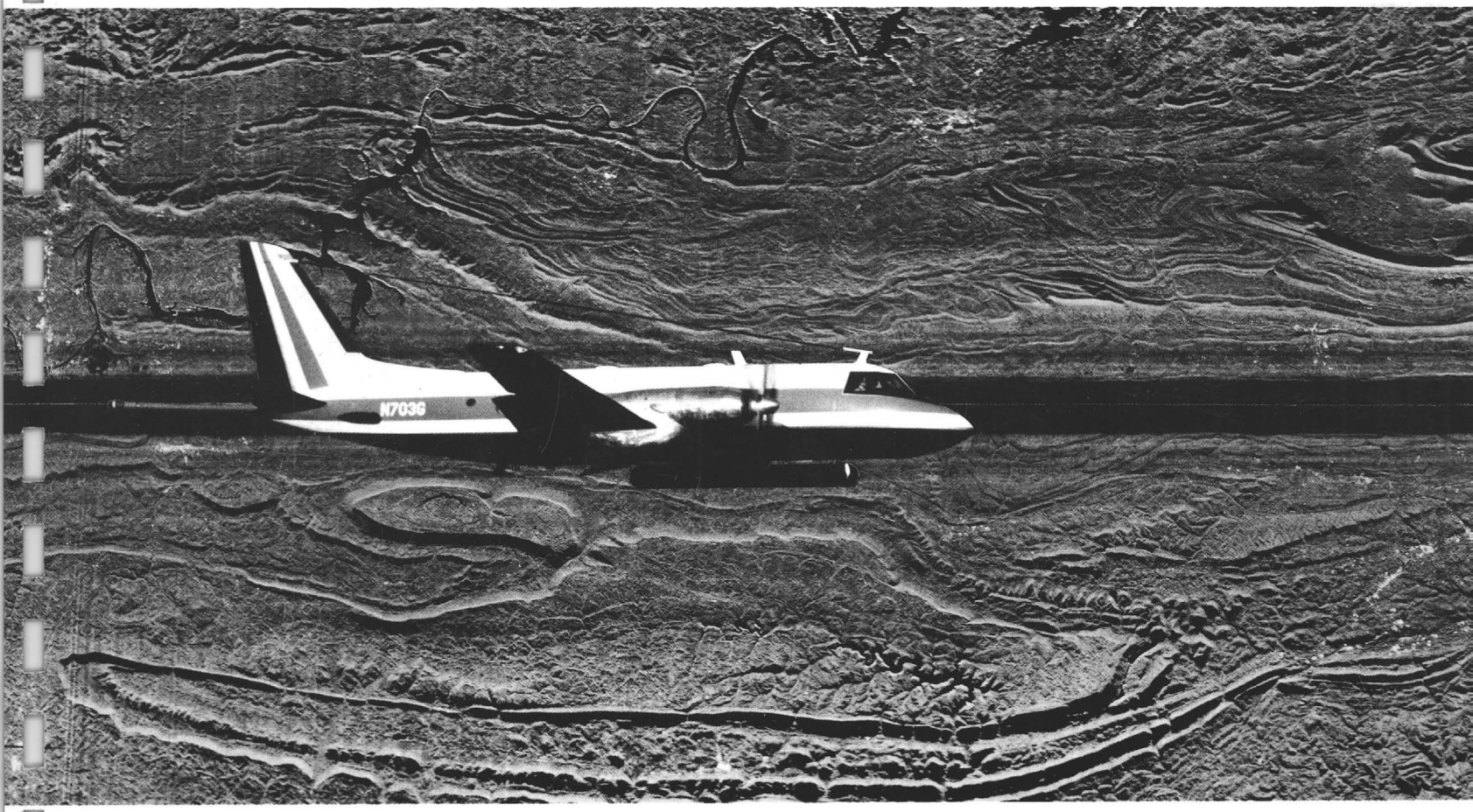
Exhibit IV - Cross-section A - A' - From Northwest to Southeast.

Exhibit V - Cross-section B - B' - From North to South.

Exhibit VI - Cross-section C- C' - From West to East.

Exhibit VII - Gamma Ray logs by the Empire Logging Service. (IN FOLDER)

AN APPLICATION OF SIDE-LOOKING AIRBORNE RADAR FOR SURVEYING GEOLOGY AND NATURAL RESOURCES POTENTIAL



Presented by

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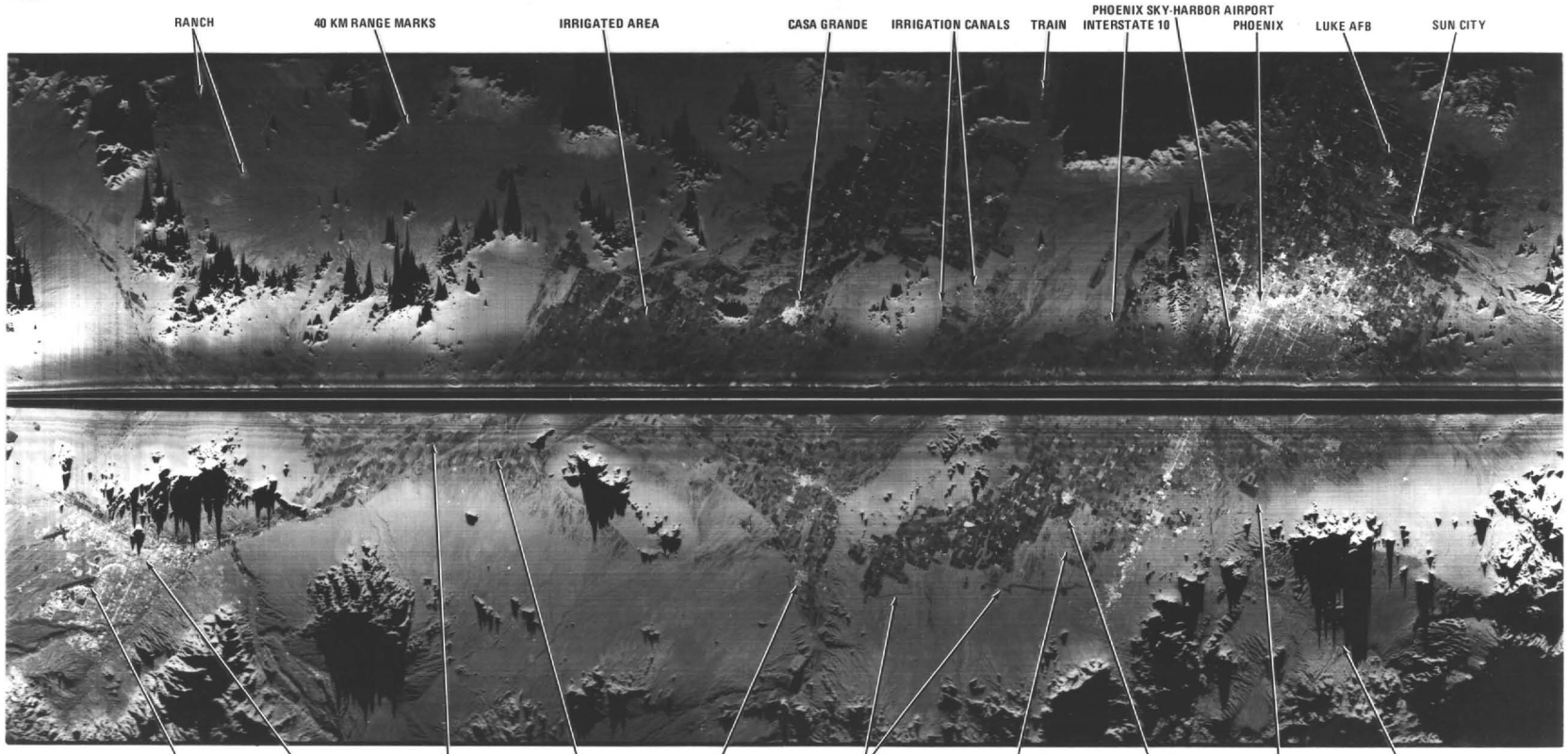
AUGUST, 1976

AN/APS-94D FIXED TARGET IMAGERY
CENTRAL ARIZONA



MOTOROLA INC.

AN APPLICATION OF SIDE-LOOKING AIRBORNE RADAR FOR SURVEYING GEOLOGY AND NATURAL RESOURCES POTENTIAL

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AUGUST, 1976

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I. SUMMARY

Motorola Aerial Remote Sensing, Inc. (MARS) is pleased to introduce to you, through this brochure, the application of side-looking airborne radar (SLAR) in aerial surveying of resources inventory, land utilization and geologic studies of any size project area of interest. The resulting survey data will substantially improve all levels of the user's knowledge of the resources and physical features of the project area.

MARS, with its staff of highly experienced and specialized geologists using the company-owned aircraft and sensors, works with the prospective user's staff to plan the survey to obtain optimum data, accepts all acquired imagery and then works with the user to understand and interpret the imagery — or can supply the total interpretive services.

A SLAR survey can be accomplished in a short time span for a relatively low expenditure considering the large area of coverage and the resulting vast data bank. The survey can provide extremely valuable regional and local information — as in the case of a country, the government will be able to formulate in-depth policies regarding natural resources, land utilization, construction siting and other critical matters. This area information will have a favorable impact on the political, human and economic affairs.

Each survey has its own characteristic specifications and constraints. Therefore, a standard survey price is nonexistent. However, with a known statement of work, survey pricing can be easily generated and Motorola Aerial Remote Sensing, Inc. would be pleased to respond with a firm proposal to meet your requirements. All proposals are submitted as a proprietary document to protect both you and MARS.

II. INTRODUCTION

This brochure specifically outlines the application of side-looking airborne radar in resources inventory, land utilization and geologic studies. The equipment and techniques explained have recently become available commercially for resource surveys and related work through Motorola Aerial Remote Sensing, Inc.

The survey involves three basic operational phases as follows:

1) Data Gathering — A side-looking airborne radar survey of the total geographic area of interest;
2) Data Processing — Preparation of radar imagery strips and radar mosaics covering standard 1:250,000 topographic map sheets; and
3) Data Interpretation — Maps providing an initial geological interpretation of the survey data to the extent needed to provide basic geologic and resource classification.

These phases are more thoroughly discussed and illustrated in following sections of this brochure.

III. PURPOSES OF SURVEY

The purposes of a survey are many and relate to resource, construction, environmental, municipal, agricultural, land use, and other geologic aspects. The survey is not intended to be a final, definitive answer to exploration and other area problems. No such all-encompassing method currently exists or is likely to be developed. However, both military and industrial experience with side-looking airborne radar has shown that the method has added materially to and improved significantly upon existent knowledge of resource, engineering and other problems directly and indirectly related to earth characteristics and configurations.

Specific uses of the survey data and its interpretation include, but are not limited to, the following:

1) Improvement of the existing knowledge of the regional geology of the project area and therefore of the understanding of the occurrence and distribution of natural resources, particularly hydrocarbons (oil and natural gas) and metallic and non-metallic minerals.

2) Additions to the present level of knowledge of engineering geology; e.g., the location of faults, fracture systems, potential landslide areas and other features which may seriously affect construction of dams and reservoirs, nuclear power plants, highways, power lines, pipelines and other such structures.

3) Providing, through a consistent and detailed form of data presentation, complete coverage of the project area for later use by land-use planners, forest inventories and other important public purposes.

IV. TECHNOLOGY

A. INTRODUCTION

The Motorola side-looking airborne radar operates upon the following basic principles:

1) All materials reflect a portion of the microwave energy transmitted as a pulse from the radar antenna; and

2) Microwave energy travels in straight lines at the speed of light.

The specialized antenna employed in the radar system is fixed with respect to the aircraft and transmits an extremely narrow beam of energy directed perpendicular to the line of flight. As the aircraft moves forward, the beam scans over the survey area in a series of rapid sequential pulses. Energy reflected from the ground to the receiving antenna is transformed into optical energy and is exposed on photographic film. The film records at a rate proportional to the ground speed of the aircraft to produce desired strip imagery at selectable map scales.

The strip imagery is comprised of thousands of data lines per inch, each line recording discrete variations in high and low returns differentiated as various shades of gray and dark shades for low reflected radar energy from the earth's surface. The magnitude of the reflected energy is primarily a function of:

1) Topography;

2) Angle of incidence between the radiated beam and reflecting surface;

3) Surface roughness (angular vs specular);

4) Moisture content; and

5) Dielectric constant of the material.

Radar is particularly useful and highly advantageous in mapping such geological and related features as:

1) Gross differences in lithology;

2) Discrete lithologic units; i.e., igneous stocks, sills, etc.;

3) Sedimentary rock trends;

4) Geologic structures such as domes, anticlines and carbonate reefs; and

5) Faults, shear and fracture zones which normally cannot be seen on conventional types of imagery, particularly in areas covered by dense forest or jungle.

Range is particularly effective in areas of heavy forest cover because the reflected radar energy integrates the individual trees into a homogeneous mass which thus accentuates drainage, fracture and topographic detail from which valid geologic deductions may be made. Past surveys have shown how these geologic features are clearly delineated in an area covered by a thick jungle canopy.

B. HISTORY OF SIDE-LOOKING AIR-BORNE RADAR

Motorola Inc.'s association with the research and development of the side-looking airborne radar dates from the mid-1950's. Initial work leading to its refinement was carried out by the Corporation in conjunction with the U.S. Armed Forces. Its primary role for the Armed Forces was the detection and surveillance of military targets. The MARS radar is of contemporary design and specially modified for industrial applications.

C. ADVANTAGES OF RADAR

1) Introduction

Radar is unique from all other methods of airborne sensing because it is an active system; i.e., it generates its own energy to illuminate the earth's surface with invisible microwave rays. All other systems are passive. The advantages of an active system are that it can penetrate cloud cover and, if necessary, it can be flown at night. Figures 2c and 3 were obtained through total cloud cover. Figure 2c was obtained at night. (Note: all the figures in this brochure, unfortunately, are fourth- to sixth-generation copies. Thus, the quality is degraded considerably.)

2) Aerial Photography

Although aerial photos have higher resolution, the most obvious difference between aerial photography and radar is that aerial photography is dependent upon weather and the reflections of the sun's energy from the target. A second major difference is one of scale. Most geological targets, such as faults or stocks of significant economic size, occupy an area which normal large-scale aerial photography cannot encompass. Radar enables the interpreter to have an overall synoptic view which allows such features to be seen in their entirety and thus are more easily recognized for what they are.

Photography is normally flown during the four hours of maximum sun ascendency. Thus, shadows caused by the sun are uncontrolled. They not only vary during the day, but on an extended project, vary month by month and from season to season. Radar illumination angles on the other hand are constant and are controlled by the altitude of the aircraft. Unlike aerial photography, changes in aircraft altitude do not alter mapping scales because radar is a time-distance function of the electronically recorded pulsed energy. With Motorola's unique two-look system, what is in shadow in one look is illuminated in the other providing a marked advantage in the interpretation process. (Figures 4a and b demonstrate this capability.) Other advantages of radar are: rapid data acquisition; penetration of smoke or haze; and real-time in-flight display of the developed film for on-the-spot examination of the imagery for quality.

3) ERTS Satellite Imagery (Earth Resources Technology Satellite)

While satellite imagery displays gross regional views of the earth's surface in four different wavelengths, or bands, at a scale of 1:1,000,000, it has comparatively poor resolution and it is not possible to detect or delineate geologic detail that is routinely identified on radar. Like air photos it is also dependent upon solar lighting and weather conditions, and is of little geologic value in areas covered by dense forests or jungles. Radar, on the other hand, has considerably higher resolution than satellite imagery and is particularly useful in areas covered by dense vegetation because of its low oblique illumination angle.

Figures 2a, 2b and 2c show a comparison of satellite imagery, air photo, and side-looking radar of the San Francisco Peninsula, California. It is important to note how vividly the topographic and geologic detail are accentuated in the forested area on the radar compared to the satellite image or air photo.

D. GEOLOGICAL APPLICATIONS

1) Introduction

One of the principal values of a SLAR survey is to improve upon the current knowledge of the geology and natural resources potential of the project area both in mapped and unmapped areas. The resultant information will have broad applications in:

a) The identification of the mineral and hydrocarbon provinces indicating natural resources potential;

b) Providing resource information to the user and, as in the case of a government, it may direct the efforts of governmental departments such as the Bureau of Mines, Natural Resources, Energy Sources, Corp of Engineers, and others concerned with natural resources exploration and development;

c) Focusing the attention of those concerned with geological factors and features that affect the planning and construction of major civil works projects.

2) Mapped Areas

Experience has shown that in many parts of the world radar has been successful in defining geologic features which were not previously detected by conventional airborne imaging methods or through surface mapping.

It is assumed that parts of the project area have been mapped in varying degrees of detail and at different scales. Perhaps in many instances, the character of the mapping has been at the reconnaissance level only in the sense that field crews have been forced to restrict their observations to valley bottoms, ridge tops and stream courses. This method requires interpolation and extrapolation and thus allows the possibility of missing something of geologic and economic significance. By way of contrast, radar provides complete and detailed coverage of all segments of the area surveyed although it does not eliminate the need for groundtruth surveys. Consequently, the radar system, with proper interpretation, can be applied to improve substantially upon the geologic knowledge of large areas, even in areas which have been previously mapped.

3) Unmapped Areas

Possibly, there are areas of interest that have not been mapped geologically. To a large extent this deficiency results from the physical and economic problems of entry into and mobility within these areas. The radar method will provide geologic coverage of the unmapped portions at a much lower cost than that involved in surface field work. Thus, the geological data provided from a radar survey could lead to the discovery of important new natural resources assets.

E. MINERAL RESOURCE APPLICATIONS

A number of mineral producing areas and metallogenic provinces have been flown and mapped using the Motorola radar system. Favorable results in terms of the definition of mineral trends, known productive areas and potential new ore deposits have been obtained. Unfortunately, the data is confidential client information and examples cannot be shown here. However, it can be said without qualification that the radar technique has proven to be successful in mineral exploration and development in the following situations:

1) The extrapolation or extension of known mineral trends on the basis of fracture analysis and related anomalies;

2) The determination of controls of known mineral occurrences and the definition of low-risk unexplored areas which exhibit similar control features;

3) The delineation of mineralized contact metamorphic trends surrounding or contained within batholiths, stocks and other intrusives.

This type of information could be of great value in the appraisal of the mineral potential over large areas of varying geology that exist. The information will serve two primary purposes: (1) the focusing of attention on areas of lowest exploration risk and therefore maximum potential return; and (2) the establishment of mineral resource royalty schedules and other policies to reflect compensation on the basis of the probability of resource occurrence.

F. HYDROCARBON RESOURCE APPLICATIONS

Side-looking airborne radar has been and is being successfully applied in known and potential oil and gas producing areas. Radar has been directly responsible for important discoveries in Indonesia, Malaysia, and South America. Radar and its proper interpretation is particularly useful in hydrocarbon exploration and development in the definition of:

1) Fracture and fault trends, patterns and densities which lead to the detection of fracture porosity and permeability in shaly or other low permeability sands;

2) Known producing and the discovery of new potentially productive geologic structures, and the extrapolation of geologic control factors into unexplored but potentially productive areas for the purpose of defining low-risk areas and features of interest; and

3) Known producing reefs and, on the basis of the definitive parameters involved, the location of potentially productive but yet undiscovered reefs.

As in the case of mineral deposits, this information is of significant value in the determination of the hydrocarbon resource potential that will be of great assistance in long-range exploration, production and marketing planning.

G. ENGINEERING APPLICATIONS

1) Introduction

The engineering applications of radar are numerous and among the most immediately rewarding. Radar has been successfully used by both government agencies and private firms in the investigation and siting of dams and reservoirs, nuclear power plants, tunnels, pipelines, roads and railroads, and regional seismic studies. It has been used advantageously for flood mapping and assessment, location of sources of construction materials and in hydrology.

2) Dam Sites and Reservoirs

Geologic consideration such as the physical properties and characteristics of the formations in the abutments, foundations, spillway areas, reservoir wall rocks and construction materials weigh heavily in the design of such structures. Of considerable importance are the location of faults and fracture patterns. Radar with its synoptic views and low angles of illumination has the remarkable ability to enhance geological and topographic features even in areas of low relief and where subdued by erosion or masked by dense vegetation. Faults, shear zones and fracture patterns are clearly distinguishable on radar that are frequently overlooked in the field or on aerial photographs. Numerous examples can be cited where these features were missed in the field and where they would have had a material affect on the design of the project. Two such examples are annotated in Figures 5 and 1c and 1d. Figures 1a through 1e demonstrate a series of comparisons of satellite imagery, air photo, radar imagery, radar mosaic, and regional geologic map of the project area. Although the radar mosaic is a 4x reduction and sixth-generation print, it clearly reveals numerous geologic features that were previously unknown and unmapped.

3) Linear Utility Installations

Geologic and topographic features are as important in the location and design of linear utility installation structures as they are in dam and reservoir projects. Highways and railroads, more than transmission lines and pipelines, usually have the added engineering stability problems of cut-slopes and fills. Landslides and slope failures are a particular headache and sometimes very costly. The geometry and attitude of bedding planes, joints, fractures and faults are important contributing factors in these types of failures. Normally it is economically infeasible to drill every cut slope or fill area, and geologic reconnaissance in dense forest regions are inadequate at best. From radar, however, the major and controlling fracture patterns can be identified in the planning phases. In the case of pipelines in seismic regions such as the trans-Alaska pipeline, radar was extremely valuable in identifying previously unmapped faults and fracture patterns. An annotated example is shown in Figure 6.

4) Local Installations

Structures requiring the safety and welfare of people in seismic regions are challenging to design engineers. In the case of a nuclear power plant for example, laws and regulations may require the most thorough and rigorous type of geologic investigations. Because of their expense, economics dictates that the exploration, design and construction phases be completed in a timely manner. Again, Motorola side-looking airborne radar has been, and is being, used to great advantage because of the wealth of geologic data that can quickly be obtained.

Engineers and geologists alike, state that radar was essential in their studies of nuclear power plant sites in California, Oregon and Washington states where dense forests blanket the countryside. The most recent application of radar imagery for a nuclear power plant siting study was in the vicinity of Bagac, Bataan Peninsula, Philippines by Motorola under contract to Ebasco and NPC.

H. OTHER APPLICATIONS

Radar has also been used and is gaining favor as a viable tool in land-use planning, agriculture and forestry, sea-ice reconnaissance, flood mapping and assessment, and beach erosion studies. Regional planning relating to the zoning of lands for agriculture, cattle grazing, forestry, recreation, green-belting, etc. can be very effectively augmented with radar.

V. SURVEY PROCEDURE

A. INTRODUCTION

Side-looking airborne radar surveys of the magnitude described herein require comprehensive mission planning, a moderately large and stable high-performance aircraft equipped with precision navigational aids, reliable sensor systems, and competent professional personnel. Close and positive client coordination is essential in a logistically complex survey of this nature, particularly during ingress and egress to the project area, and data acquisition phases of the project. Below is a brief summary of the equipment, personnel and operational aspects of the proposed survey.

B. EQUIPMENT AND PERSONNEL

1) Equipment

The major survey equipment is the aircraft and the radar system which are described below:

a) Aircraft specification

(1) Grumman Gulfstream Type G-159 (N703G) twin-engine turboprop, pressurized (Figs. 7, 8, & 9);

(2) Fuel, Jet Al or equivalent;

(3) Range, 1800 nm (excluding reserves);

(4) Total weight (loaded), 36,000 lbs.;

(5) Cruising speed, 120 to 280 nm per hour;

(6) Maximum rated altitude, 30,000 feet msl;

b) Radar specifications

(1) Modified Motorola AN/APS-94D real-aperture system;

(2) X-band (3 cm) wavelength;

(3) Real-time in-flight display, wet processing 9.5" x 40' film (Fig. 10);

(4) Mapping scales, 1:250,000, 1:500,000, 1:1,-000,000;

(5) Area mapped; left side, right side or both sides simultaneously;

(6) Swath width capability, 25, 50 and 100 km;

(7) Stabilized antenna;

(8) Swath overlap, approximately 60 percent (allowing for steroscopic viewing).

2) Motorola Personnel

The Motorola crew consists of two highly qualified, licensed pilots with extensive international and domestic experience, a crew chief, and a radar engineer. Three of the crew members are FAA certified Airframe and Power Plant (A/P) mechanics. The fifth member of the party is a project manager/remote sensing specialist who supervises the survey, data acquisition, and acceptance of the film at the base of operations. A corporate officer and geologist may also make visits to the base of operations to oversee the entire project.

3) Mobilization and Demobilization

Mobilization and demobilization consists of all costs related to project planning and the transport of the aircraft, crew and equipment to the survey area from Phoenix, Arizona, USA, and return. The cost of mobilization and demobilization is separate from that of flying the data acquisition portion of the project.

4) Airfield Requirements

In compliance with Corporate regulations and safety requirements, and to protect the radar antenna beneath the aircraft, paved runways of 5,000 feet or greater are satisfactory airfields from which to operate under full-load conditions. Commercially available jet A-1 or equivalent fuel with over-the-wing refueling accomodations and ground power units are also requirements of acceptable airfields from which to operate.

5) Navigational Control

Radar surveys, more than any other type of airborne survey, require near-perfect straight

flight lines in order to maintain parallelism and the desired overlap of adjoining flight strips for mosaic construction. In addition to the sophisticated radio communications equipment, distance measuring equipment (DME) and Singer-Kearfott doppler navigation systems (Fig. 9), additional navigation equipment is utilized by MARS depending upon the complexity and size of the project area and upon the user's specifications. This is in the form of either inertial or VLF navigation equipment.

C. FIELD OPERATIONS

1) Flight Line Patterns and Coverage

Topographic configuration of the terrain, relief, slope angles, and general geologic structural grain of the region, govern aircraft flight-path headings and altitudes. Line spacings will be adjusted in order to optimize the geology and radar imagery presentation. These requirements are carefully considered in the mission planning stage of a survey. If the area is characterized by rugged mountains with steep slopes and high relief, adjustments will be required in flight-line spacing and altitudes in order to maintain desired depression angles (radar shadowing).

The structural grain will be considered in determining the optimum flight line direction. A 10-kilometer flight-line spacing (6.2 miles) will provide 60 percent overlap between adjacent imagery strips and afford stereo viewing during interpretation. Imagery acquisition will be at a scale of 1:250,000. In order to divide the area into standard conventional map sheet sizes (1:250,000 scale, one-degree by one and one-half degree sheets) and to maintain control of this scale for mosaic construction, individual flight line lengths will be chosen for maximizing data miles and minimizing the total flight time.

The natural fracture pattern and geologic structural trends in the project area must be studied to determine the optimum flight line direction. Actual flight line heading and other survey parameters will be closely coordinated with user representatives prior to a survey.

2) Recording of Data

The ability to gather imagery out of both sides of the radar antenna simultaneously with the Motorola system is unique in the industry. Double radar coverage of the entire area will be obtained producing two mosaics of any given area which will be illuminated from opposite directions — in other words, a feature which is in shadow on one mosaic will be illuminated on the other. This method insures that all surfaces will be illuminated on the other. This method insures that all surfaces will be illuminated for more thorough interpretation. Motorola provides this special two-look direction radar imagery at no additional cost.

The imagery is recorded and developed on-board while in flight in a recorder-processor unit, which produces developed film negatives for real-time viewing and examination and is the permanent data record. See Figure 10. The film is 9.5 inches wide and 40 feet long, and is of a special, rapid-developing type manufactured by Kodak. Standard developer is used.

3) Processing of Data

Special portable equipment is used to wash, fix and dry the film immediately after each flight. Each image strip is then numbered and checked on a variable-intensity light table for scale and quality by the project manager. Strips containing excessive flaws or inadequate sidelap are identified and reflown at Motorola's expense. Upon completion of individual blocks of data, contact prints of each imagery strip will be made and delivered to the client. Film negatives will be returned to Phoenix, Arizona, USA, for printing, scale and tone matching, and construction of the mosaics. Full-size negatives for each mosaic sheet will be made showing appropriate title blocks, index maps, and coordinates. The final deliverable products will include but are not limited to:

a) Original negatives of imagery strips;

b) Contact prints of imagery strips;

c) Full-size negatives of mosaic sheets;

d) Contact prints of mosaic sheets;

e) Detailed survey flight logs;

f) Flight index map.

4) Scheduling

Typically, a three-month scheduling window is desired, particularly for a survey performed outside the USA. Obtaining permits from all governments concerned as well as the logistics of planning is time consuming. This also allows for mobilization to the project area. In climate zones that have extreme conditions such as very heavy rains or extreme cold, longer schedule times may be necessary so that the optimum climatological time may be used. Although SLAR is an all-weather sensor, extreme conditions can effect the imagery quality.

In those cases where a survey is needed immediately, the first available idle time of the aircraft and crew will be utilized.

5) Data Delivery

Normally, good data can be delivered to the

MARS home office for contact printing and mosaic construction seven days after the aircraft and crew arrive at the project area providing no external interference is experienced. Usable, high quality SLAR imagery can be acquired at a very high rate; for example 10,000 square miles was recently obtained in three, six-hour flights.

The acquisition rate is a function of many parameters: distance to and from project area and base area, extreme weather conditions, aircraft and sensor maintenance as an example.

Contact prints of the strip imagery can be delivered two weeks after imagery acquisition and mosaics can be delivered six weeks after imagery acquisition. In the case of very large areas, the data deliveries can start six weeks after the first imagery is acquired and will be delivered on an as-finished basis.

Interpretation can start as soon as imagery is available. However, overlays, lineament analysis and final data normally is delivered three to six months after completion of all data acquisition and mosaic construction.

VI. DATA INTERPRETATION

A. INTRODUCTION

Experienced and qualified geologists in engineering and exploration geology — and recognized experts in radar interpretation — are on the MARS' staff. Other technical personnel, if required, are available to MARS on a consulting basis. It is these geologists whose expertise is in remote sensing who will provide the interpretation of the radar imagery obtained from a survey. As previously noted, the data presentation is provided in two basic forms:

1) Individual flight-line radar imagery for each line flown;
2) Mosaics on the scale of 1:250,000 which generally correspond in geographic coverage and size to existent topographic and geological sheets of the project area. Two opposite look radar imagery mosaics will be provided for each map sheet.

B. INTERPRETATION

Using the flight line and mosaic presentations referred to above, along with other available information, MARS will prepare interpretive maps which will define:

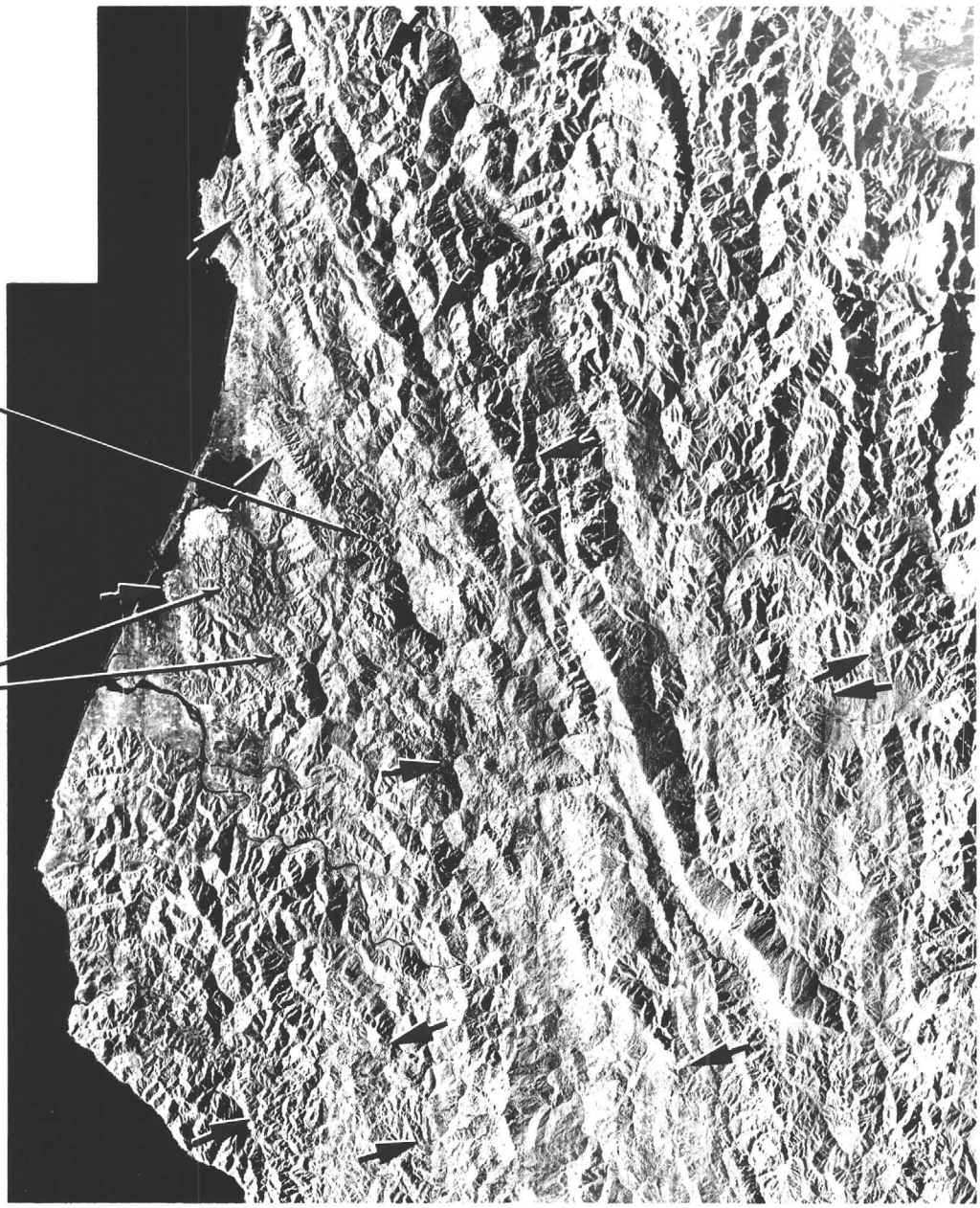
1) Gross lithologic boundaries;
2) Major geologic structural features such as folds and faults;
3) Major geomorphic features;
4) Significant surface drainage and tonal anomalies;
5) Lineament map showing all significant fault and fracture patterns; and if desired a
6) Lineament analysis including histograms, fracture deviations and fracture density contour maps.

The above interpretation is primarily geological in nature related to natural resources exploration and development. It is not intended in any way to be final or a complete analysis — nor is it intended to include all the types of data that can be extracted from the imagery. For example, foresters or land-use planners would be interested in an entirely different type of interpretation — nevertheless that kind of data are available from the radar imagery.

The interpretive data will, however, provide a comprehensive initial presentation of major geologic features which will focus attention upon high-priority areas of interest that may be of economic significance. These selected areas or features would, of course, warrant further, more meticulous and detailed interpretation and ultimately ground field studies for verification.

Large number of northeasterly trending lineaments, some of which are indicated between small arrows. Not previously mapped, see geological map (Figure 1e).

Subsequent field check indicated many are faults. Northwesterly trending lineaments previously known.

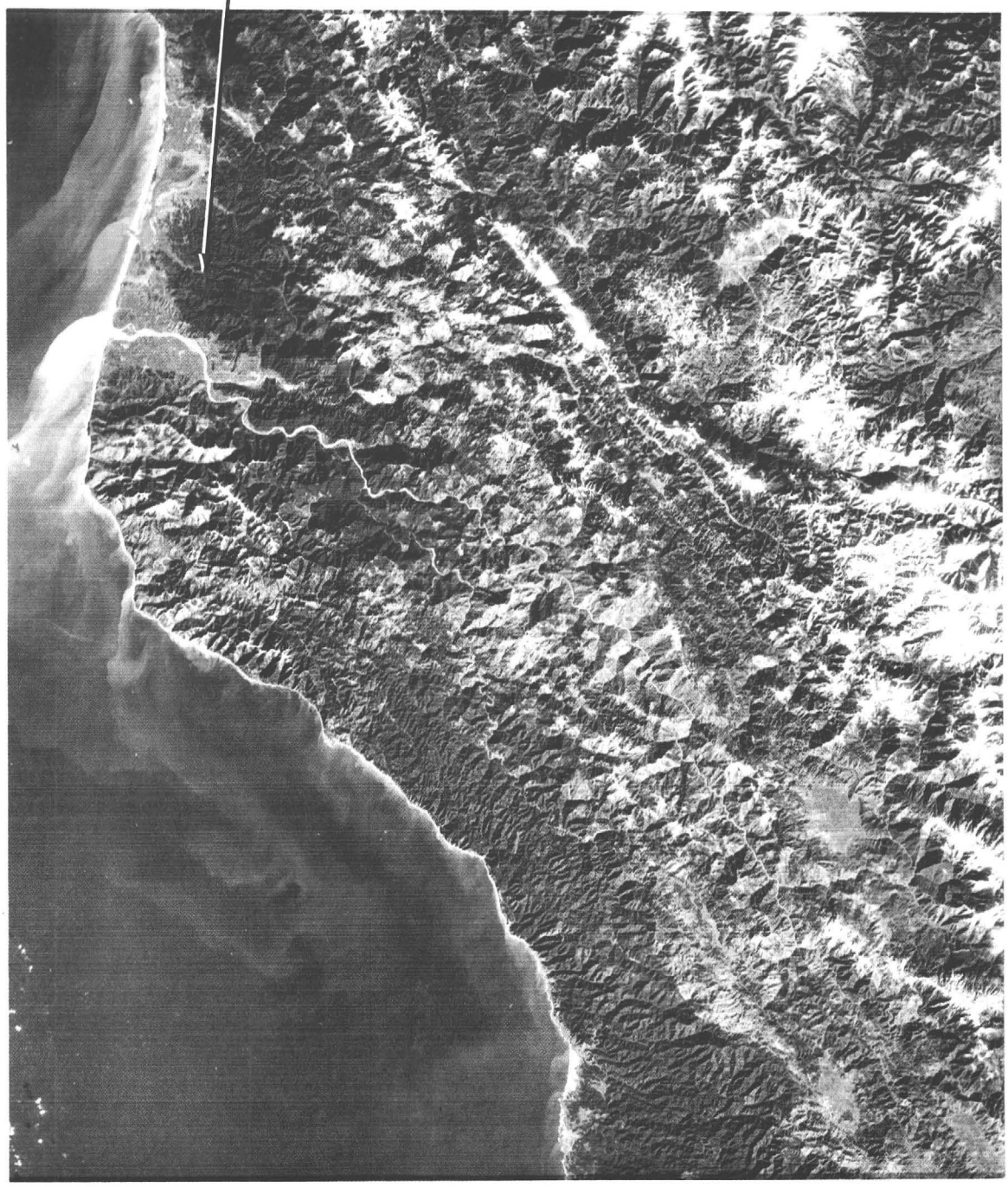


Compare this radar mosaic with ERTS image of same area (Figure 1b) for detail

APPROX SCALE 1:1,000,000
REDUCED FROM ORIGINAL SCALE OF 1:25,000
AREA FLOWN WITH APPROX 55% CLOUD COVER

Figure 1a. Motorola Radar Mosaic, Cape Mendocino Area, California

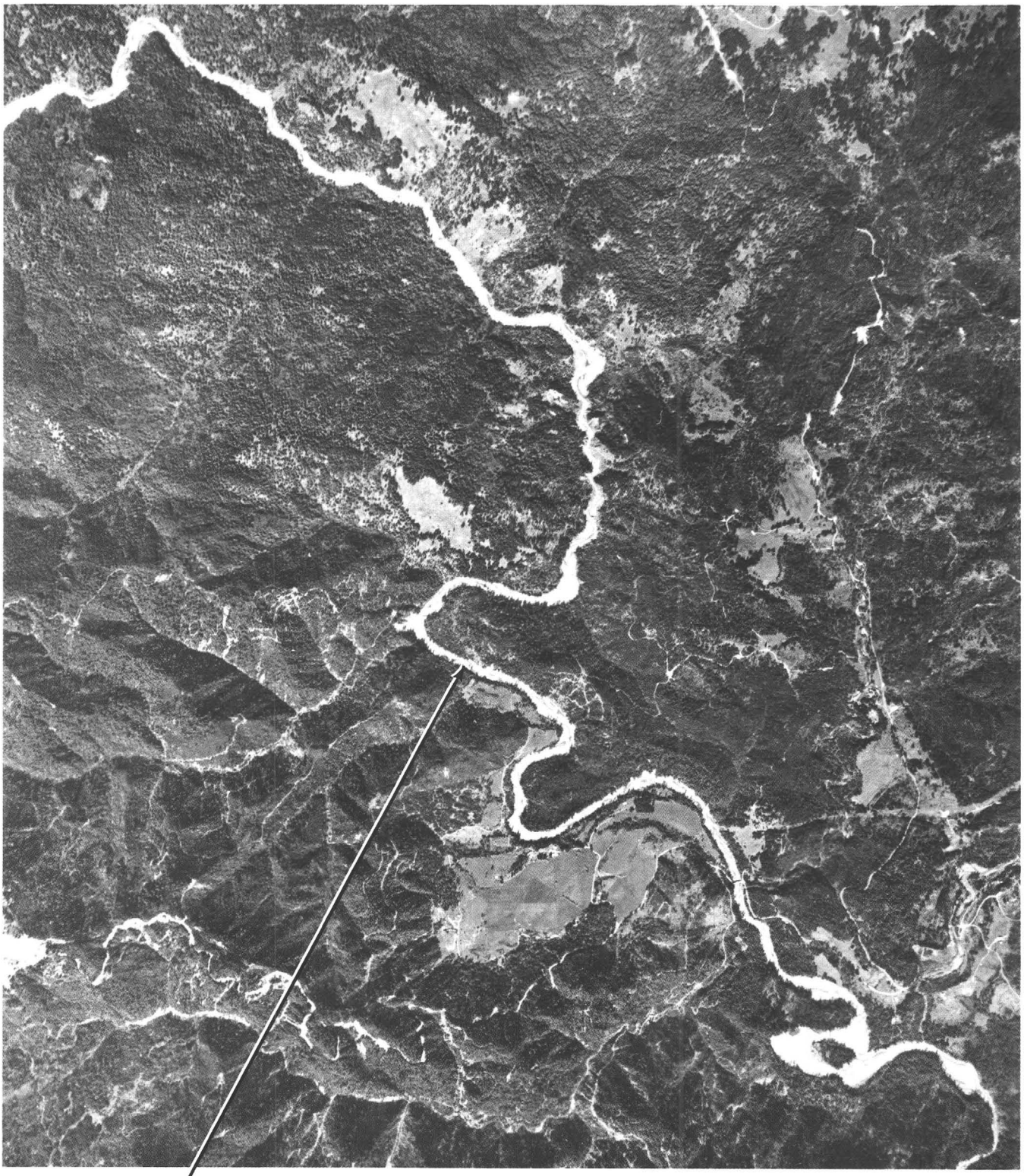
EGG SHAPED AREA AND SURROUNDING AREA
NOT DIVISIBLE AS ON RADAR MOSAIC



Compare with radar mosaic (Figure 1a) for detail

Approx Scale 1:1,000,000

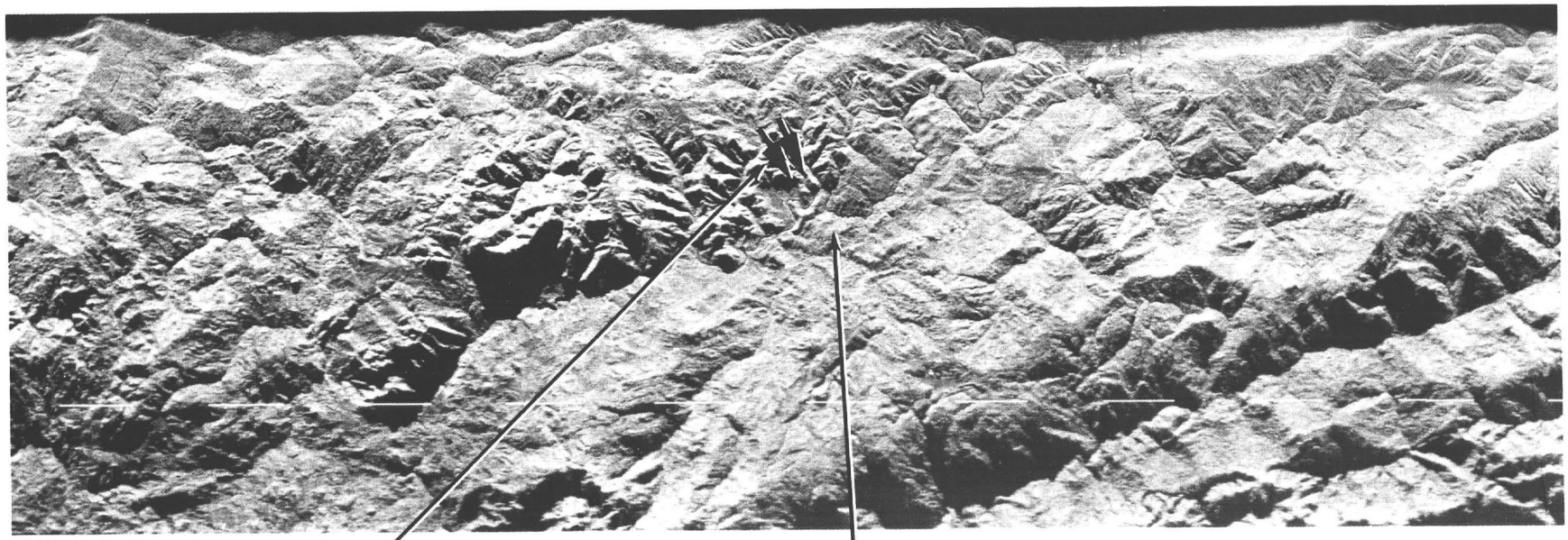
Figure 1b. ERTS Band 5 Image, Cape Mendocino Area, California



BUTLER VALLEY DAM SITE
NOTE LINEAMENT ON RADAR STRIP (Figure 1d)
CANNOT BE SEEN ON THIS PHOTOGRAPH

Scale 1:33,600

Figure 1c. Aerial Photograph of Butler Valley, Cape Mendocino Area, California

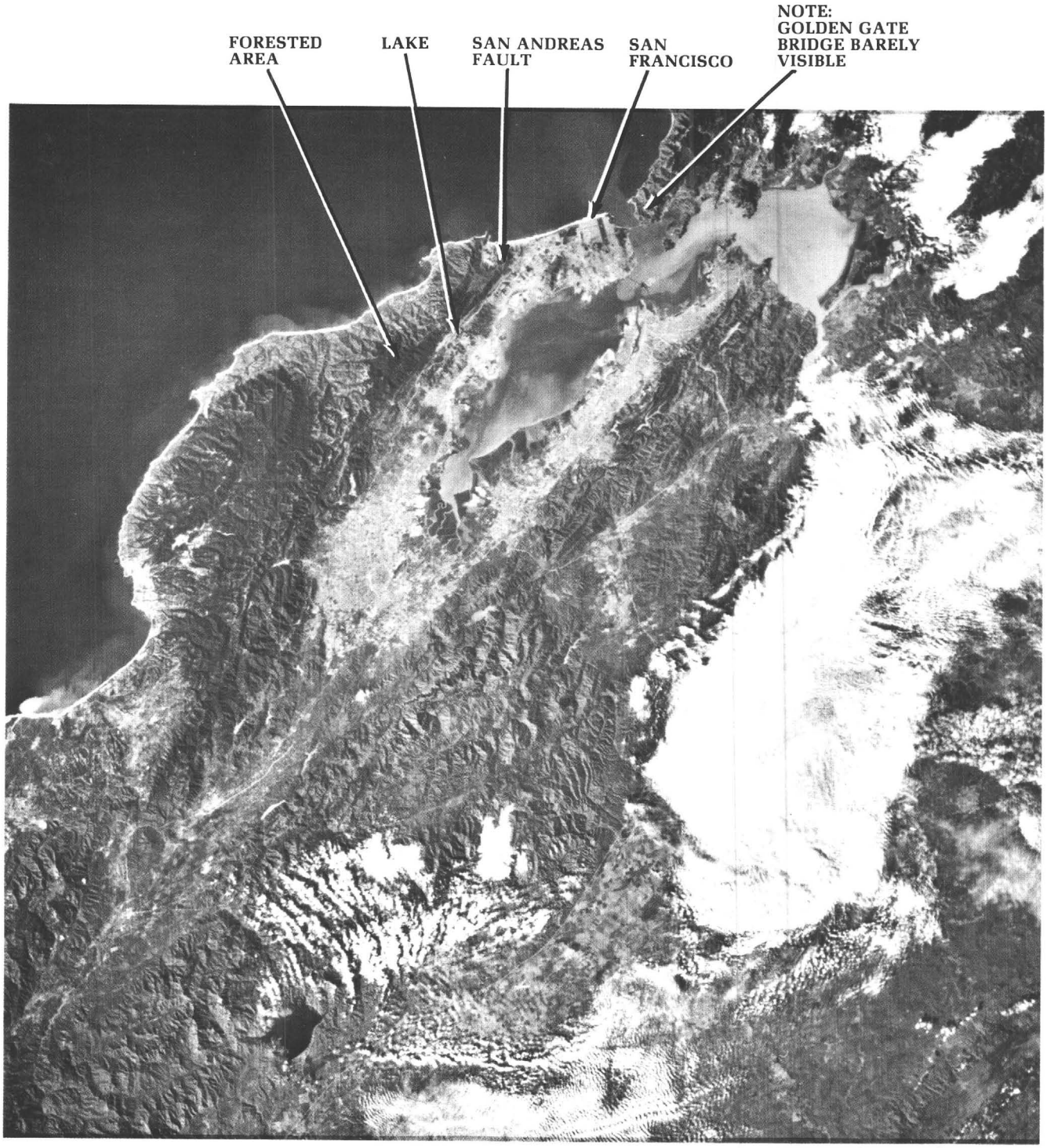


Scale 1:250,000

TWO STRONG LINEAMENTS TRENDING NORTHEASTERLY DIRECTLY THROUGH DAM SITE. SUBSEQUENT FIELD CHECK PROVED THEM TO BE FAULTS.

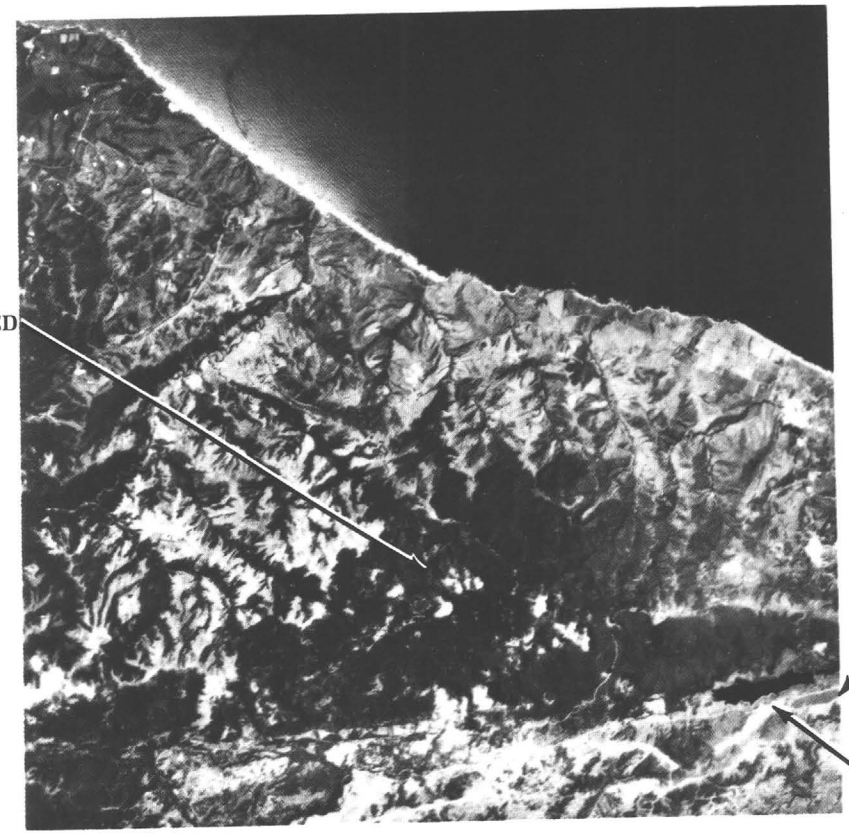
BUTLER VALLEY DAM SITE

Figure 1d. Radar Strip, Butler Valley, Cape Mendocino Area, California



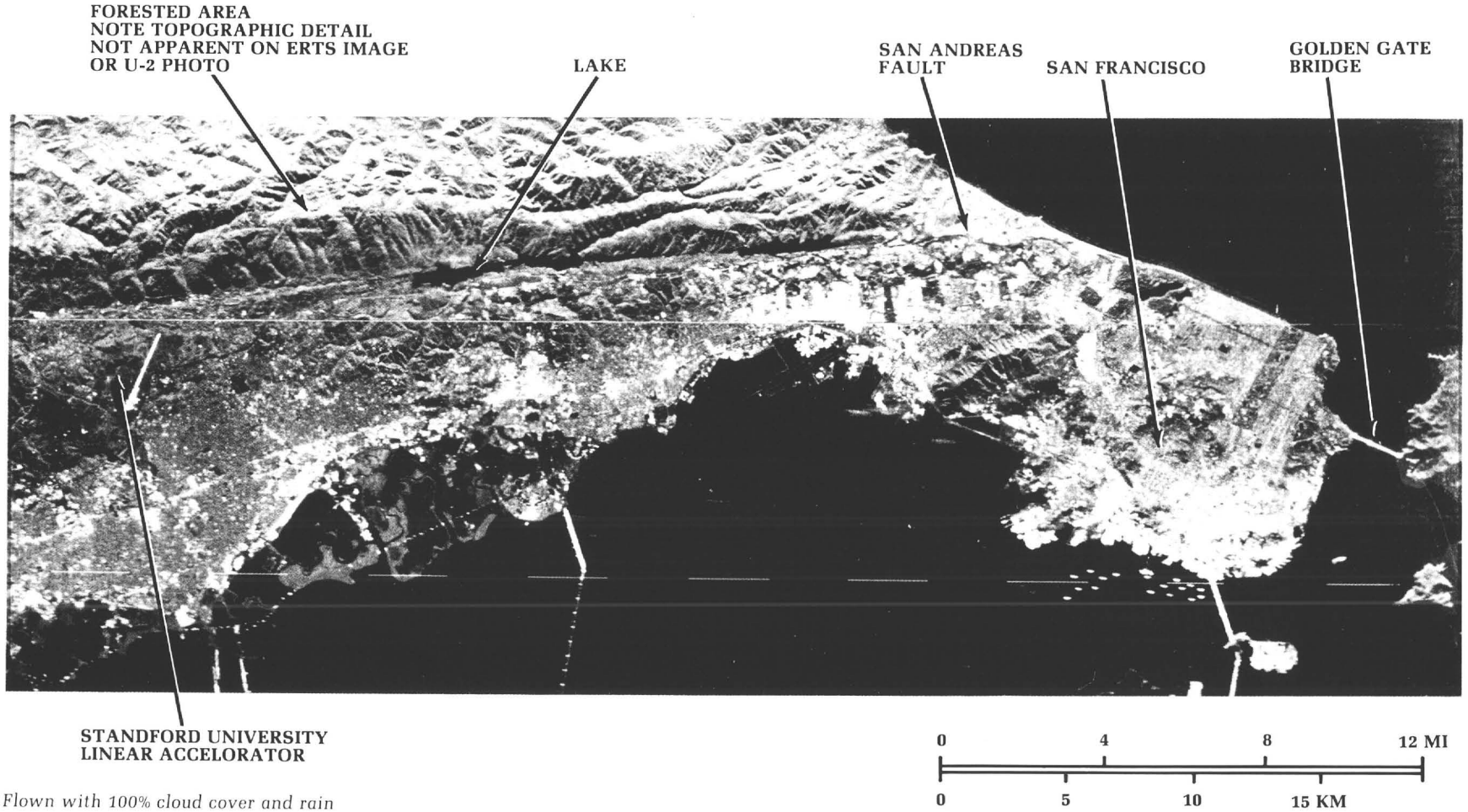
Approx Scle 1:1,000,000

Figure 2a. ERTS Band 5 Image, San Francisco Bay Area, California



Scale 1:250,000

Figure 2b. Photograph Taken from High Flying U-2 Aircraft, San Francisco Bay Area, California



Flown with 100% cloud cover and rain

Figure 2c. Radar Image, San Francisco Bay Area, California

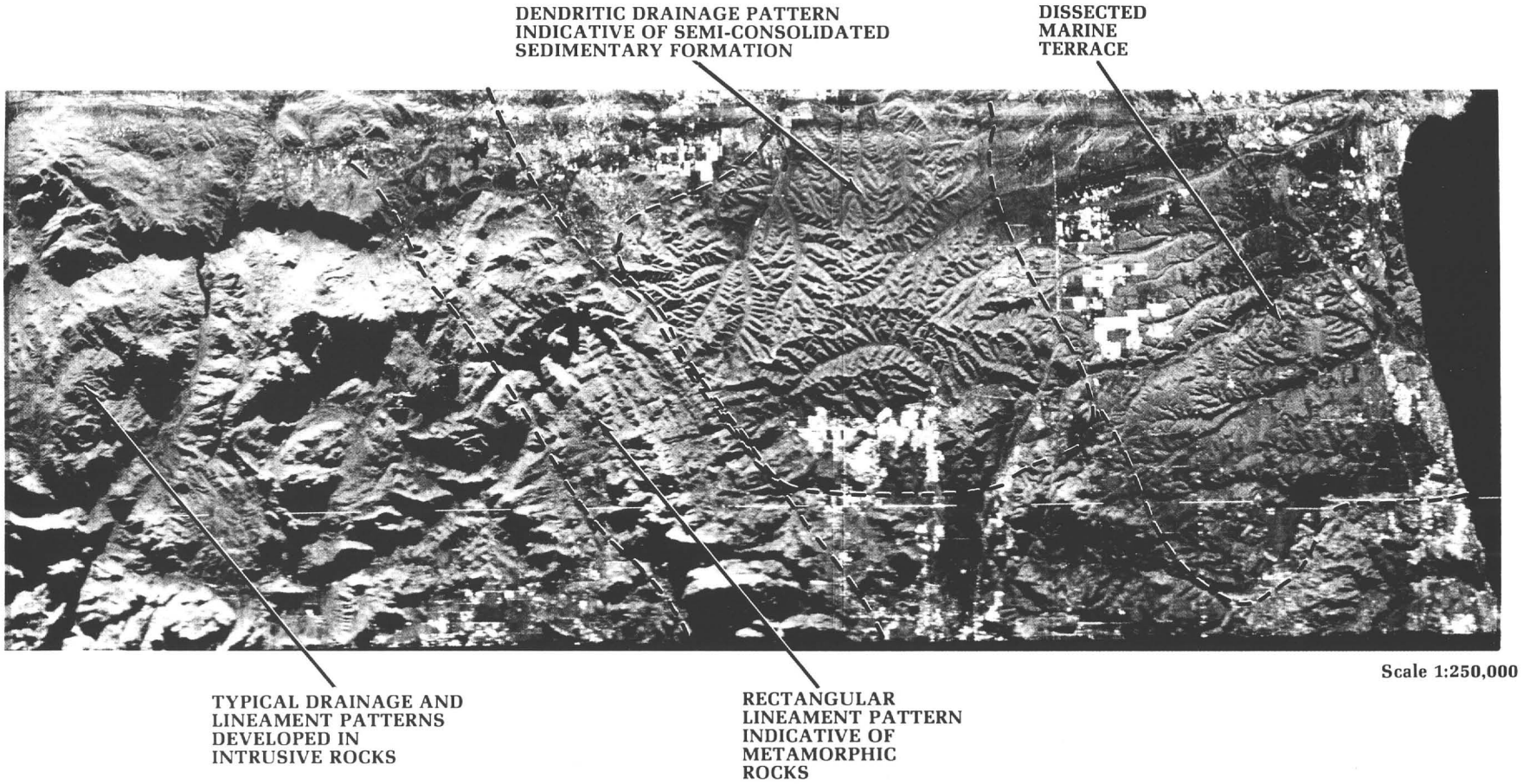


Figure 3. Radar Strip, La Jolla Area, California

BLUFF ILLUMINATED
FROM EAST

Scale 1:250,000

N

Figure 4a. Radar Image, North Texas Area, West Look

BLUFF ILLUMINATED
FROM WEST

Scale 1:250,000

N

Figure 4b. Radar Image, North Texas Area, East Look

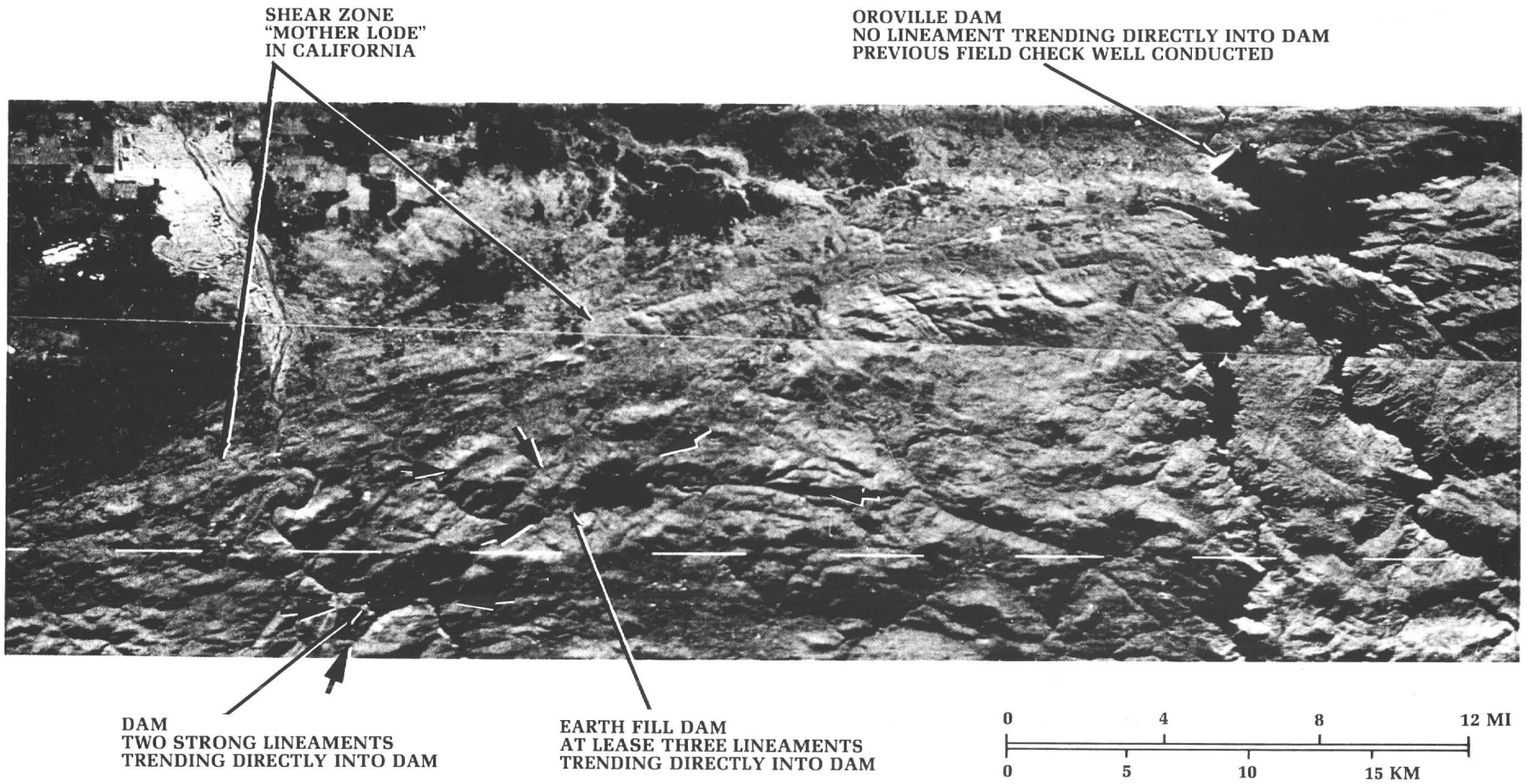


Figure 5. Radar Strip, East Sacremento Valley Area, California

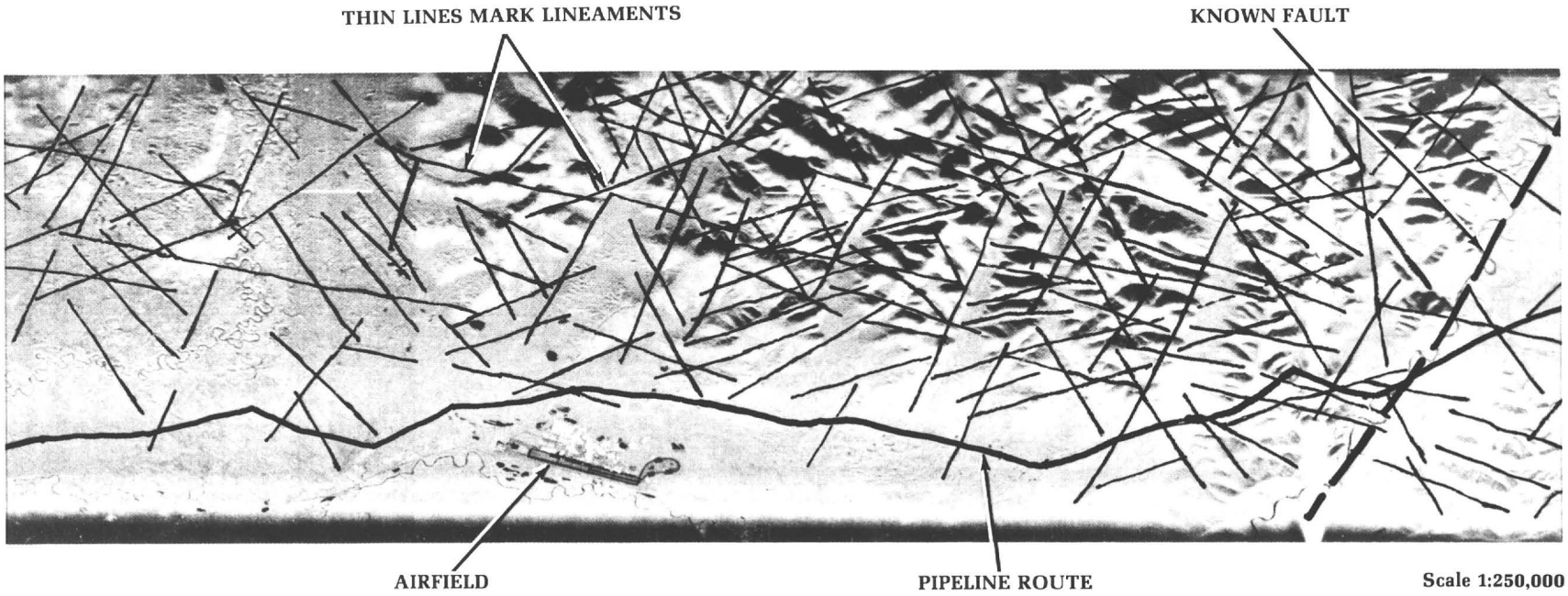


Figure 6. Radar Strip, Alaskan Pipeline Route

Figure 7. Aircraft in flight

Figure 8. Cockpit and controls

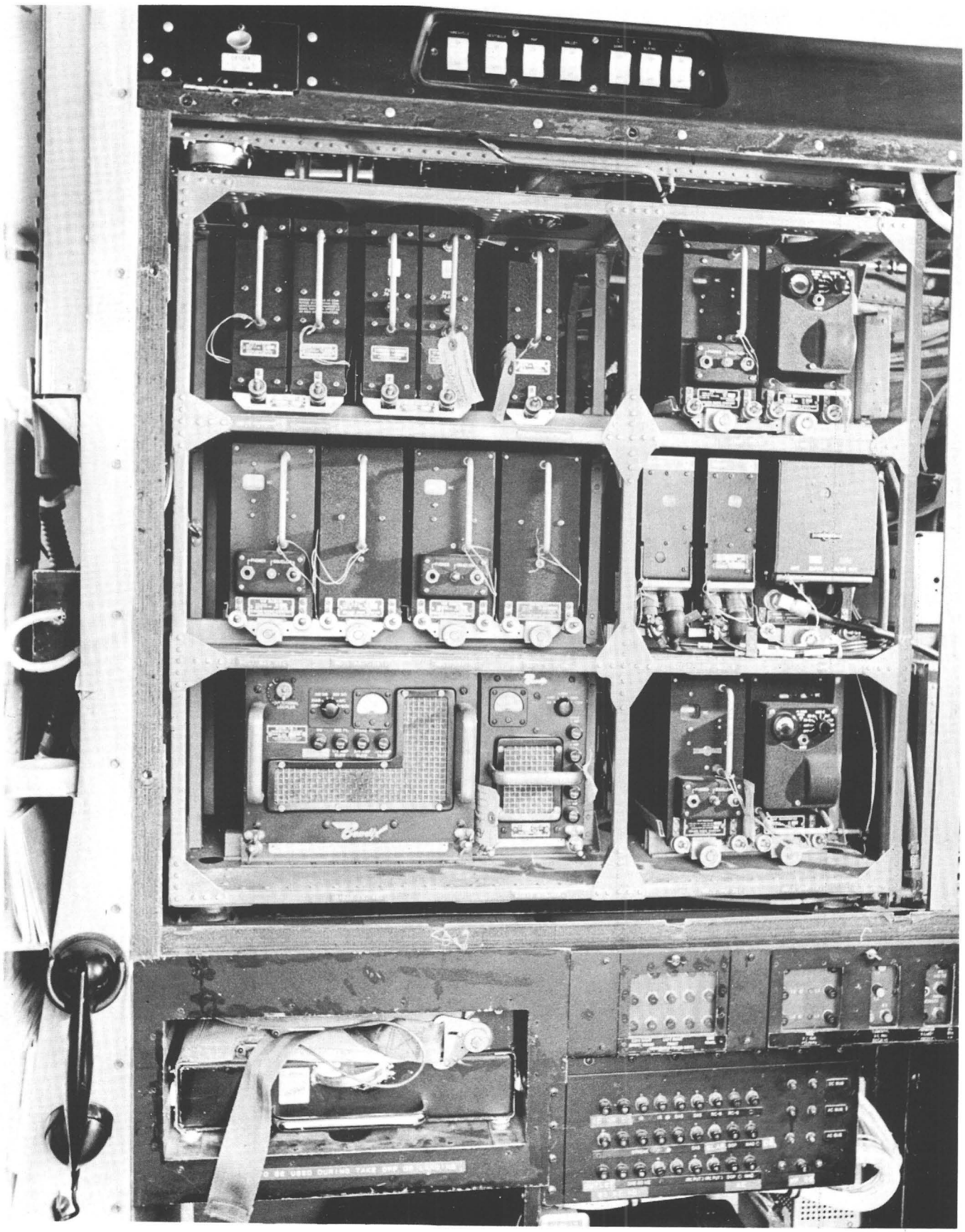


Figure 9. Navigational Equipment

Figure 10. Radar

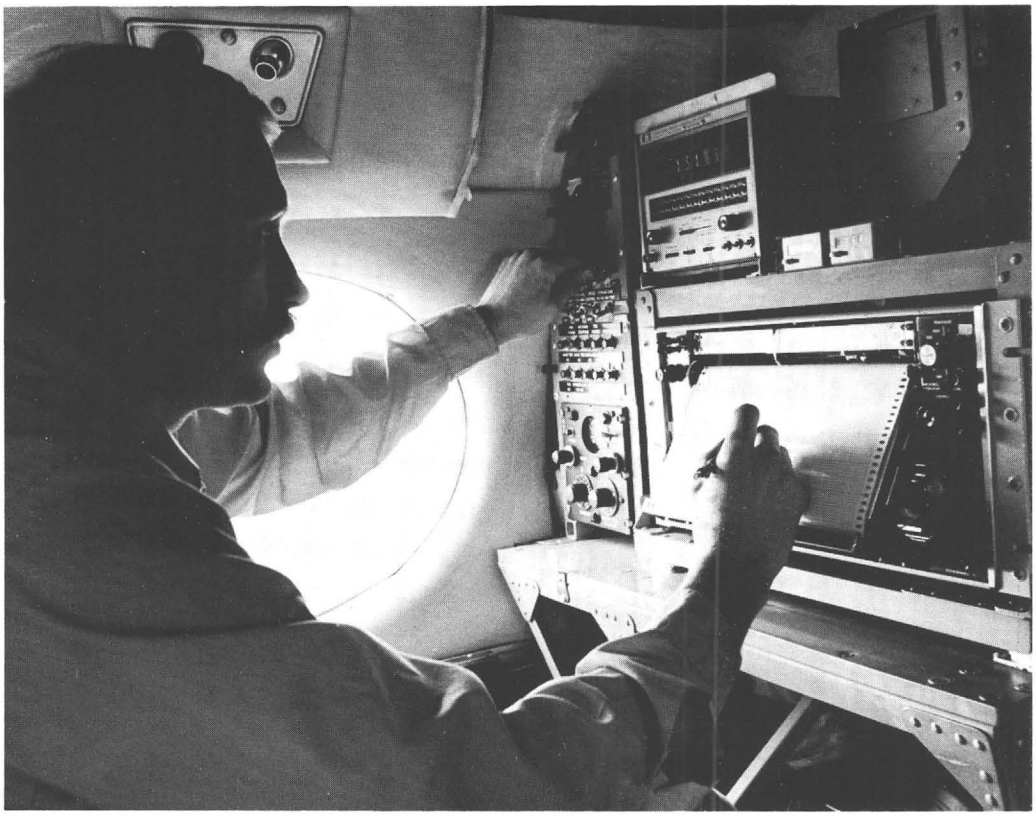


Figure 11. Magnetometer

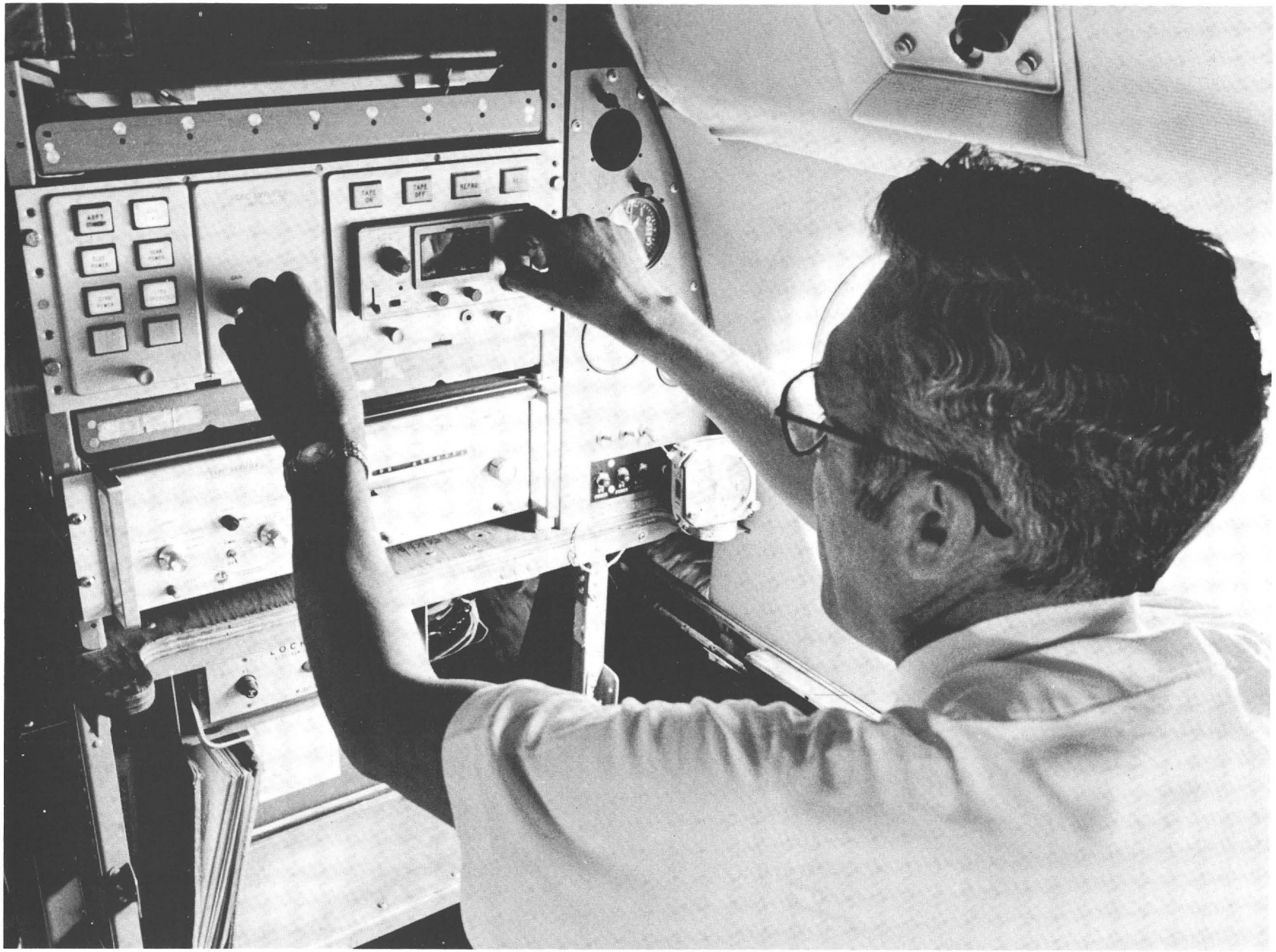


Figure 12. Data recording bank

MOTOROLA Aerial Remote Sensing, Inc.
4350 EAST CAMELBACK ROAD, PHOENIX, ARIZONA 85018 • (602) 244-5751 • TELEX 667490

8556 8/76

Designed and produced by
INFORMATION SERVICES

Eastern Petroleum Co.

Navajo Springs Structure

Shooting Elevations on "A" Bed
of Chinle Fm. between
Kerr-McGee well in 32 & Eastern Sante Fe #B
in Sec 31.
Phone Instructions from Jim Dean
9:30 PM Sept 9, 1963

Sept. 10, 1963
SLB & CAM Jr.

Sta	Dist	Beam	Rod	Diff	HT
⊙1					
⊼1	970	48 -2	13.7	+33.1	5751.1
⊙2	770	49 -1	13.7	-21.4	
⊙3	330	level	13.4	-13.4	
⊙4	380	47-3	14.4	-25.8	
⊙5	1490	47-3	1.7	-45.4	
⊙6 TP	960	49-1	14.0	-23.6	
⊼6	700	49-1	14.0	+21.0	5748.5
⊙7	350	48-2	12.3	-19.3	
⊙8	410	46-4	12.0	-28.4	
⊙9	440	level	9.2	-9.2	
⊙10	850	level	TH 5.5 1.2 LN 11.4	-1.2	
⊙11	1210	level	12.4	-17.4	
⊙12	750	46-4	14.8	-48.8	
⊙13 TP	1270	49-1	14.9	-27.6	
⊙14	1470	46-4	1.3	-60.1	
⊼13	355	level	12.3	+12.3	5733.2
⊙15	450	47-3	13.9	-27.4	
⊙16 TP	895	level	3.4	-3.4	
⊼16	930	48-2	5.8	+24.4	5754.2
⊙17	490	49-1	14.5	-19.4	

Sept. 10, 1963
clear-calm

Elev	Remarks	
5718	Kerr McGee well El 5718 Gr 1650 S + W/L Sec 32	
5729.7	Top "A" Bed of Chinle	
5737.7 (5733)	5' above Top "A" (At Bed)	
5725.3	Top "A"	
5705.7	Top "A"	Top Toadstool Rock
5727.5	Top "A"	
5729.2	Top "A"	
5720.1	Top "A"	
5739.3	Top "A"	
5747.3	Top "A"	
5731.1	Top "A"	
5699.7	Top "A"	in Wash (slump)
5720.9 TP	Top "B"?	
5688.4	Top "A"	±20' above "A" 20' B A
(5720.9)	4' above "B"	
5705.8	Top A	
5729.8 TP		
	5740 Gr #13	
5735.8	Eastern #13 Sante Fe	

J C Brown
C A Martin Jr

Eastern #13 Santa Fe Sec 31-20-27
5786? 5740
1650 S/L 2630 E L
#14 Santa Fe 5-19-27
1650 E+N/L Gd+he
(He)
5801 Gr

Kansas Pacific 32-20-27
1650 S+W/L
(He) 5718 Gr

Crest #2 Santa Fe 33-20-27
1980 S+W/L
5759 Gr
(He) Pc 4697
G-W +4689 8' He

Crest #9 S Fe 34-20-27
1650 S+W/L
5779 Gr Pc +4489 (He?)

Eastern #18 SFe ~~18~~ 13-20-27
1650 W/L 2640 N/L (He?)
5833 Gr Perforated 9-10-63

Eastern #12 SFe 11-20-27 1650 S+W/L
5892 G Pc +4604 (Wy)

J. G. Brown #1 Santa Fe 34-20-27
1650 N+E/L
5845 Gr
Pc +4636
Gw +4640 est
Dry

Crest #6 Santa Fe 35-20-27
1650 N+E/L
5798 Gr
Pc +4575
Dry

Crest #5 Santa Fe 26-20-27
1650 S+W/L
5754 Gr
Pc +4616
Dry

Crest #11 SFe 26-20-27
1650 N+E/L
5764 Gr Pc +4384
Dry

Crest #8 SFe 25-20-27
1980 N/L 1650 W/L
5789 Gr Pc +4438 Gw -4432 Hole
He

Eishen #15 SFe 16-20-27
2600 N/L 1650 E/L
5743 Gr Pc +4721
Dry

Eaton #4 SFe 19-20-28
2640 N/L 1650 W/L
~~5823~~ Gr 5808 Gr.
Pc + 4345

Loc Eaton #21 SFe 31-19N-28
1000' N+W/L

Crest #3 SFe 4-19-27
1980 E+N/L
5893 Gr Pc+4629 Dry

Eaton #17 SFe 3-19-27
2640 N/L 990 W/L
Loc

Eaton #14 SFe 5-19-27
1650 N+W/L
5801 Gr
No Well

#7 Crest SFe 1-19-27
1650 N+E/L
Pc

Cactus #1 Reese 1-19-26
1650 N/L 660 W/L
5725 G Pc 4698 Dry

Dry

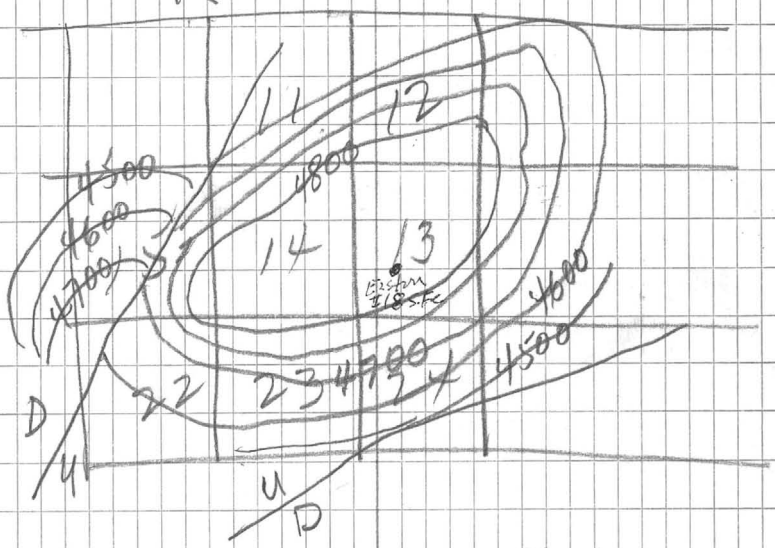
Oxy #1 Sk 19-20-27
~~1680~~ 2868 W/L 1980 S/L
5652 G Pc 4464
Shut in Dry

LOC Eastern #29 S.Fe
1300 N/L 1350 E/L 8-19N-27E
1300' Coco Test

Franklin, Astor + Fair #1 Bernstein-Sktc
1650 E+S/L 36-18N-23E 300' Test

21	11	12
15	14	13
22	23	24

KIVA STRUC.



20-27

Mary Lake Structure

Coconino Co. Ariz

7-1-64

SCM

CAM

Scale 1" = 2000'

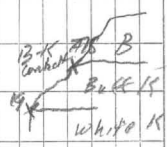
Sta	Dist	Beam	Rod	Diff	H.I
☐ TBM 9	Assume Elev.		6900'		
A1	175		TH 04 -0.5	-0.5	6899.5
02	100	55+5	0.5	+4.5	
03	290	level	0.9	-0.9	
04	540	level	2.8	-2.8	
05	600	level	3.2	-3.2	
06 TBM	1380	level	8.5	-8.5	
07	810	level	3.7	-3.7	
08 TP	640	53+3	6.3	+12.9	
A8	325	46-4	3.6	+16.6	69290
09 TP	325	55+5	3.2	+13.1	
A9	400	46-4	6.2	+9.8	69519
010	290	20+2	1.7	+56.3	
A10	170	36-16	10.7	+37.9	7046.1
011	220	60-10	4.9	+17.1	
A11	310	53+3	3.9	-5.4	7057.8
012 Cont	110	45-5	14.2	-19.7	
013 TP	230	37-13	10.6	-40.5	
A13	170	69+19	1.4	-30.9	6986.4
014 ☐ Sag Cr	150	53+3	1.7	+2.8	
A14	200	55+5	1.9	-8.1	6981.1
015	260	67+17	0.5	+33.7	
A14	345	40-10	14.8	+49.3	7038.5
016	190	64+14	8.8	+7.8	
A16	225	40-10	3.45	+25.9	7072.2

7-2-64

Elev.	Remarks
	Post on E side of wash Flagged
6904.0	K - White Ls Manvil
6898.6	K - " " M
6896.7	K " " "
6896.3	K " " "
6891.0	K " " " Fl. TBM.
6895.8	K " " "
6912.4	TP Going S.W.
6942.1	
7008.2	Contact Basalt - K sebab - Buff SS.
7063.2 TP	Basalt
7038.1	contact Basalt K - Buff SS
7017.3	K
6989.2	Sec Cor 6/5 7/8 19N 8E
7014.8	Contact Basalt - Buff K.
(6989.2)	Contact B+K Going S. from Sec Cor.
7046.3 TP	Basalt
	Basalt Sinkhole in Basalt 100' E of M 10

Sta	Dist	Beam	Rod	Diff	HI
017	340	level	7.7	-7.7	
~~A17~~	260	54+4	21	-8.3	7056.2
018	270	45-5	26	-10.9	
~~A18~~	130	+4 54	1.0	-4.2	7052.0
~~A8~~	275	47-3	8.2	+16.4	6928.8
019	420	60+10	4.5	+37.5	
~~A1 W~~	750	48-2	8.5	+23.5	6923.5
020 TP	190	54+4	1.5	+6.1	
~~A20~~	430	44-6	6.5	+32.3	6961.9
021	210	48-2	13.5	-17.7	
022	320	65+15	4.5	+43.5	
023	240	level	10.9	-10.9	
~~A23~~	245	56+6	0.5	-14.2	6936.8
024	300	60+10	1.6	+28.4	
~~A5~~	890	47-3	5.8	+32.5	6928.8
025	1050x2 2100	49-1	LH 52 15.7	-36.7	
~~A25~~	880	48-2	8.7	+26.3	6918.4
026	830x2 1660	level	2.4	-2.4	
~~A26~~	920	level	LH 12.5 17.1	+57.1	6933.1
027	150	64+14	1.7	+19.3	
028	1200	52+2	4.0	+20.0	
~~A28~~	600	level	11.8	+11.8	6964.9

Elev.	Remarks
7064.5 TD	>Bicort
	B
7045.3	
	4' above contact B+K = 7048
(6912.4)	
6966.3	Contact Buff + wh K
(6900)	
6929.6	K
6944.2	Buff-white K contact
70054	Contact B + Buff K
6951.0	~~above~~ contact Buff + white K
6965.2	contact B + Buff K. on W side / fault?
(6896.3)	Going South from 05
6892.1	~~contact~~ Buff + white K ? + NO
6916.0 TD	
6952.4	Try lower massive limestone
6953.1 TD	



Sta	Dist	Beam	Rod	Diff	HI
029	620	54+4	1.7	+23.1	
030 TP	580	51+1	4.5	+1.3	
π30	800	49-1	11.7	+19.7	6985.9
031 TP	620	53+3	2.7	+15.9	
π31	210	level	14.2	+14.2	70160
032	500	51+1	1.9	+31	
π32	80	level	4.8	+4.8	7023.9
033	240	69+19	1.9	+43.7	
034 Sucx	170	52+2	0.3	+3.1	
π25	420×4 1680	level	TH 65 -1.9	-1.9	6894.0
035	640	52+2	3.9	+8.9	
036	1050	level	2.0	-2.0	
037	1200×2 2400	level	2.5	-2.5	
038	950×4 3400	level	7.8	-7.8	
039	1480	level	5.6	-5.6	
π38	1030×2 2060	51+1	8.7	-11.9	6874.3
040	1020	51+1	TH 47 -.4	+10.5	
041 TP	770	55+5	TH 32 -0.2	+38.7	
π41	275	49-2	13.8	+19.3	6932.3
042	430	level	2.7	-2.7	
π42	500	level	5.7	+5.7	6935.2
043	350	level	2.5	-2.5	
π43	500	level	7.7	+7.7	6940.4

Elev	Remarks
6988.0	5' below lower Massive Ls 6993
6966.2 TP	
7001.8 TP	Near [illegible] Ls.
7019.1 TP	
7077.6	(7097.6) Contact is 75' W. + 20' high in [illegible]
7027.0	Sec Cor 7 | 8 / 18 | 17 14N-85
(6892.1)	Going NE
6902.9	Top Massive Ls
6892.0	" " "
6891.5	" " "
6886.2	" " " Flagged
6888.4	
	8-9-04 Cloudy
6885.5	Top Massive Ls (6972)
6913.0 TP	
6929.5	In Butt SS
6932.7 TP	

Sta	Dist	Beam	Rod	Diff	HT
0 44	470	level	9.6	-9.6	
A 44	260	52+2	2.5	-2.7	69281
0 45	590	level	2.6	-2.6	
A 45	220	level	6.4	+6.4	69319
0 46	560	level	9.3	-9.3	
A 46	570	52+2	7.2	-4.2	69184
0 47	340	level	LH 14.8 16.5	-16.5	
A 47	780	level	2.4	+2.4	69043
0 48	600	52+2	5.0	+7.0	
A 48	530	level	6.0	+6.0	69173
0 49	870	level	8.7	-8.7	
A 49	500	52+2	4.5	-5.5	69031
0 50	1400	level	5.7	-5.7	
A 50	700	level	7.3	+7.3	69047
0 51	450	51+1	2.1	-2.5	
A 51	1140	48-2	10.4	+33.2	69404
0 52	260	52+2	0.7	+4.5	
A 52	200	level	13.4	+13.4	69583
0 53	520	52+2	4.5	+5.9	
A 53	310	52+2	1.8	-4.4	69598
0 54	350	level	7.2	-7.2	
A 54	225	61+11	5.0	-19.8	69328
0 55	670	44-6	10.2	-30.0	
A 55	1300	level	6.8	+6.8	69096
0 56	200	52+2	0.5	+3.5	

Elev		Remarks
6930.8	TP.	Basalt
6925.5		
6922.6		
	Basalt	
6901.9	TP.	Basalt
6911.3	TP	B.
		B.
6908.6	TP	B
		B.
6897.4	TP.	B
6907.2		
6944.9		
6964.2		
6952.6		
		100' S. of Bike flagging Above Basalt-Bull ss contact
6902.8	TP	Vallen
6913.1	Top Mamm	SS 6999

Sta	Dist	Beam	Rod	Diff	HI
057	970	level	1.5	-1.5	(6909.6)
058TP	730+4 2920	level	T# 8.0 -6.6	+6.6	
#58	1250	level	5.6	+5.6	6921.8
059	1200	level	T#04 -5.6	+5.6	
060	125	54+9	1.0	+10.2	
061	66082 1320	level	T#64 -0.2	+0.2	
#61	900	level	8.3	+8.3	69303
062	450	54+4	4.0	+14.0	
063TP	680	level	1.2	-1.2	
064	300' from 062				

Elev

6908.1	Spring		
6916.2			
6927.4		Massive SS	7023
6932.0		" "	7028
6922.0	TP Gate		
6944.3		Massive SS	7040
6929.1	TP F1		
6945.0	15 ~~25~~ below	Massive SS	

SILAS C. "BUZZ" BROWN

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

PHONES:
OFFICE WH 6-2701
RES. WH 6-2603

22 SHOEMAN LANE
P. O. BOX 1266
SCOTTSDALE, ARIZONA

Hope Claims - Moon Anchor
Sec 31, T4N R 7W
Maricopa Co

Lead
Zinc
Copper
Gold
Silver
} Assay

Fluoride - 1 or 2 Assays

2 or 3 Semi Quantity Spectrol

Nov- 30 -

Tonopah Interprises

Drilling Program

Plane Table Survey
of Drill Holes w/Elev.

①

Sta	Dist	Beam		Rod	Diff	HI
⊙ 1	Elev 2500					
⊼ 1	140	44	-6	12.7	+21.1	2521.1
⊙ 2	130	55	+5	2.10	+4.4	
⊙ 3	40	52	+2	0.9	+0.1	
⊙ 4	210	46	-4	14.7	-23.1	
⊙ 5	105	level		4.7	-4.7	
⊙ 6	240	67	+17	2.8	+38.0	
⊙ 7	400	67	+17	4.6	+63.4	
⊙ 8 TP	325	67	+17	3.0	+52.3	
⊼ 8	65	52	+2	0.7	+0.6	2574.0
⊙ 9 CH	40	level		0.5	-0.5	
⊙ 10	180	60	+10	1.3	+16.7	
⊙ 11	320	67	+17	2.0	+52.4	

21.1	21.1
63.4	52.3
84.5	73.4
	73.5
74.0	16.7
16.7	90.2
7	73.5

2574.0
52.4
2626.4

Fri NOV 30 1979
Scm + Frank Clark

Elev.	Remarks
	OIL Core Hole #1 2500 Est
2525.5	CH
2521.2	CH
2544.2	CH
2516 .4	CH
2559.1	CH
2584.5	CH
2573.4	TD Concrete Column Sh. Ft
2573.5	CH
2590.7	2x2 Post
2626.4	Ceiling Corner 2x2

Bob Smith

John Fisher – Chief Eng & Planning Coordinator

1238# absolute bottom hole press

	Seams	
Earl #13	1/2 – 706	= 138 md.
Barbert	78 – 1855	= 246 md
Crest #2		= 31.5 md.
Unit #7	2.3 – 685	= 167 md
#14	05 – 756	= 186.3 md
#17	1.3 – 198	= 65.5 md
		139 md for field

Kenmow Barbert 23,904 Ac Ft
24.26% of field

FILE COPY

Report
SHALLOW DRILLING AND LOGGING

THE SPRECHER URANIUM PROSPECT

McKinley Co., New Mexico

6-16-54

by: S.C. Brown
W.J. Osterhoudt

Delegated

Shallow Drilling and Logging Report on

The Sprecher Uranium Prospect

McKinley County, New Mexico

Introduction

This report on the shallow test holes and the Gamma Ray Logging on the Sprecher Uranium Prospect supplements the report of March 6, 1954 by Silas G. Brown, Consulting Geologist, Durango, Colorado.

Following Brown's recommendations on Page 3 of the above dated report, 14 holes were drilled at certain locations to test the lower Dakota and/or the upper Morrison formations. The lower strata of the Dakota were examined and detailed by surface geology. Two Geiger counters, a Geiger probe and a Precision Scintillator were used to check the formations in situ, and as exposed by the bulldozer work for radio-active emanations. The shallow hole Geiger-counter probe was used in Hole 5 and in Holes 7 and 9, but it was too erratic to be dependable in Holes 7 and 9, largely due to poor cable insulation and water leaks into the probe and into the cable.

Finally, in order to evaluate the possible commercial value of the uranium-bearing formations, Brown and Osterhoudt recommended that all holes be logged by an Atomic Energy Commission unit, which should provide permanent records of the data.

Geology and Discussion

Detailed examination of the lower Dakota and upper Morrison formations, as commonly called and accepted by local geologists, disclosed two zones in the lower Dakota (or perhaps in the Morrison-to-Dakota transition zone) which contained gray or dark colored shales and siltstones sometimes bearing enough carbonaceous material to be called "coal". The local uranium enrichments on the Sprecher Prospect were associated with these dark shales and siltstones. True coal did not possess much radio-active material. The upper shale zone contained more pseudo "coal" or carbonaceous constituents, and was more consistent in appearance than the lower shale. The lower shale zone was subject to variable lensing, pinchouts and subdivision by sandstone strata. A cross-section is included with this report to illustrate these local characteristics.

Field Operations

Mr. Ben Case of Aztec, New Mexico superintended the bulldozer and drilling operations. A heavy duty Allis-Chalmers bulldozer was run by "Kelley" Noland of Aztec to score cuts across the Dakota formations, to prepare roads for the drill and to place the drill and air compressor trucks on locations. These operations were well planned and capably managed.

The drilling was done by a Mayhew shot-hole drill equipped with dual air compressors. The drilling equipment was presumably owned by a contractor, Coffee, from Gallup, New Mexico. Rotary drills with air to blow out cuttings are used effectively in dry rock country provided no ground water is encountered. If necessary, Coffee's drilling unit could be serviced by a water truck and fluid mud pump. Although water was encountered in three shallow holes, Nos. 6, 7 and 8, the results of the testing of the other holes did not seem at the time to warrant deeper drilling by fluids.

W. J. Osterhoudt, Consulting Geophysicist, used a "Precision Scintillator", an "Explorer Model" Geiger counter, a "Detectron Model DG-7" Geiger counter supplied by Mr. Case, a Geiger counter probe supplied by Mr. Sprecher, and also made two checks with a "Grand Junction" type Geiger counter owned by the drilling contractor. All instruments were checked frequently against known ore samples and with a calibration disc on the scintillator. The small Geiger counters seemed to be the most sensitive, but also were the most erratic. The most dependable and conservative instrument was the scintillator. One Geiger counter was extremely sensitive to wind-borne dusts (and perhaps radon gases ?) released by the bulldozer's fresh cuts across the lower Dakota strata.

Brown surveyed the locations of the test holes and tied them to the recognized southeast corner of Section 36, T16N-R18W. Assumed elevations were used to refer the results of test holes to a common datum. No search was made to locate a bench mark, nor was it considered feasible to carry elevations from Gallup or the highway to the prospect.

Field operations were begun by Osterhoudt on May 21, 1954. Prior to this date Mr. Case had done considerable bulldozer work and had drilled Holes 1, 2, 3 and 4. Brown and Osterhoudt worked together on May 22. Brown returned to the field on May 24 to witness the Atomic Energy Commission's logging by A.E.C. Engineer Harvey Ward. Copies of the gamma ray logs were submitted by the A.E.C. to Mr. Sprecher and forwarded to Brown and Osterhoudt for analysis and interpretation.

Interpretation of Results

We were somewhat skeptical of the qualities of the Geiger counter and scintillator equipment, consequently we tried to check several instruments against each other, and to examine the local and known uranium bearing samples frequently. We are fairly certain that the readings finally accepted are conservative and generally dependable. The A.E.C. logs are standard sets of recorded data. However, we do not know the conversion factor of the instrument to reduce the values on the logs to counts per hour, or to possible percentages of uranium ore.

The average background counts on or near the lower Dakota formations ranged from a minimum count of 150 milliroentgen units per hour to a maximum of 300 MR per hour.

Fresh outcrop exposures of the dark shales indicated counts up to 650 MR per hour. Some shale cuttings from the test holes gave counts up to 500 MR per hour. The highest count recorded by the Geiger counter probe in Hole No. 5 was 700 MR per hour at 72.5 feet. Subtracting an average background count of 200 MR per hour, it seems probable that net counts of sample cuttings and outcrop are ranged conservatively 300 to 500 MR per hour.

Outcrop examination and samples of commercial uranium ore mined at the Hyde open pit mines south of the Sprecher Prospect yielded total counts of 900 to 1700 MR per hour, with no subtraction for background counts which were probably high. We were informed that the Hyde mine had been opened following the discovery of very low counts on the surface. The ore became richer as mining operations progressed deeper into the unweathered formations.

The highest gamma ray units recorded by the A.E.C. logging unit were 10+. Without application of a correction factor, the background and peak counts were in general agreement with sample cuttings and Geiger probe measurements made at Hole No. 5. We would be inclined to convert 10 units to 1000 MR per hour, but Brown reported that the A.E.C. engineer used a correction curve to reduce these unit values to approximately one third, or 323 MR per hour. On this basis, the A.E.C. engineer advised Mr. Brown the ore deposits would be considered non-commercial.

However, after we received the A.E.C. logs and compared them with our field data, we are inclined to revise our earlier conclusions which were condemnatory and to report with reserved optimism that the prospect has some merits which may yet be below borderline commercially. We are not qualified to report quantitatively on the prospect. We believe that satisfactory, solid cores at recommended locations might enhance the prospect. If the history of the Hyde Mine is substantially correct as reported, the Sprecher Prospect may yield similar ore.

Recommendations

In our opinion, the Sprecher Prospect should be reserved as a possible source of low-to-medium-grade uranium ore. If determined by A.E.C. to be non-commercial at this time, any change in the critical international conditions could alter the demand for uranium ore, thereby elevating present border-line ores to commercial grades. The Sprecher Prospect is accessible by good roads, and the haul to processing plants is relatively short. As mentioned above, the recorded data furnished by A.E.C., correlated with our field data and combined with geological information present enough facts to keep this prospect open for more quantitative tests.

It is questionable that the border-line quality of the ore found to date justifies unlimited expenditures toward further drilling at this time. If ores of definite commercial values were found, more core holes would be recommended as outlined in this report. It is recognized that mining operations would be expensive due to the high angle dips of the formations involved .

We therefore recommend that no more evaluation work be done at this time. The area apparently contains a fair sized deposit of low-to-medium grade ore which may later be considered commercial by the A.E.C., in the event of a national emergency. If this be the case then a series of 5 or 6 core holes are recommended offsetting Holes 9 to 14 inclusive. Medium to large cores should be taken so that samples can be assayed for proper percentage values. These core analyses in conjunction with gamma ray logs and geological interpretation should provide enough information to properly evaluate the quality and quantity of the ores in the area.

Contrary to original opinions, many of the test holes were not drilled deep enough to evaluate all of the uranium possibilities. Hole No. 14 showed three zones of enrichment even though they were not considered commercial by the A.E.C. engineer.

Silas C. Brown
Silas C. Brown
Geologist

Walter J. Osterhoudt
Walter J. Osterhoudt
Geophysicist

Durango, Colorado.
June 16, 1954

Enclosures:

1 Map showing test hole locations with elevations.

1 Sketch Cross-Section.

13 A.E.C. Gamma Ray logs.

1 Table of test hole data.

1 Copy of the original geological report by S. C. Brown.

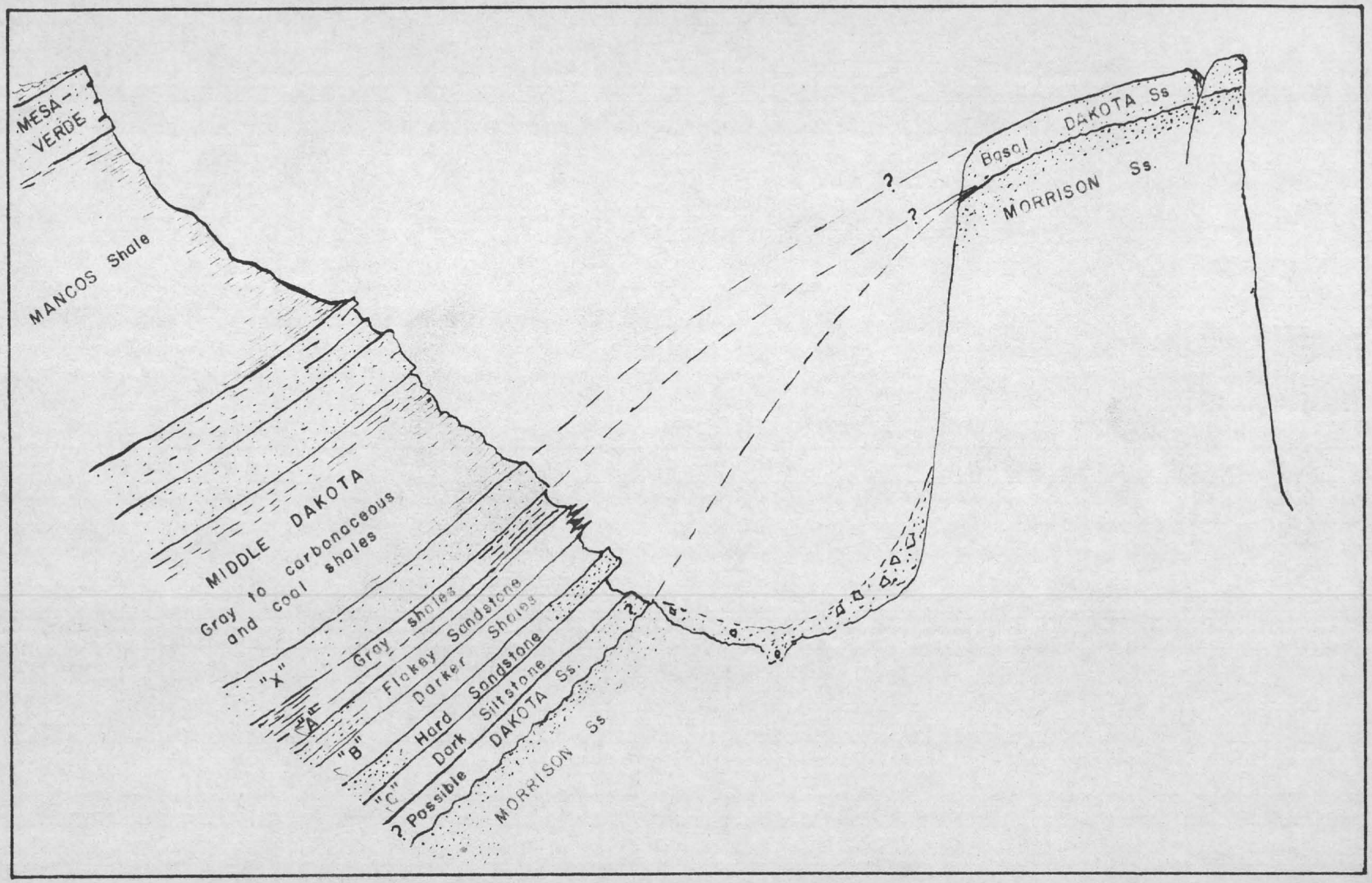
Table of Hole Data

A total of 14 core holes were drilled to investigate the possibilities of increased uranium enrichment with depth. Thirteen of these holes were logged by a Gamma Ray unit operated by an Atomic Energy Commission engineer. Hole No. 4 was not logged because it had caved within 11 feet of the surface.

Record of Holes Logged

Hole Number	Elevation	Logged to	Formation Spudded	Formation Completed	Uranium Shows, A.E.C. Units
1	6737.0	199'	Valley fill	Morrison	None
2	6715.5	74'	Valley fill	Morrison	None
3	6729.3	23'	Valley fill	Morrison ?	None
4	6721.3		Valley fill		----
		Caved -- Did not run Gamma Ray log.			
5	6750.0	98'	Dakota	Morrison	.05+ at 78-80'
6	6738.1	24'	Weathered Dakota	Dakota	None logged
7	6736.5	28'	Weathered Dakota	Dakota	None logged
8	6734.0	22'	Weathered Dakota	Dakota	None logged
9	6802.3	119'	Dakota	Dakota	.10+ at 105-107.5'
10	6816.8	138'	Dakota	Dakota	.05 to .09 at 129-134'
11	6782.4	89'	Dakota	Dakota	.05 to .10 at 80-89'
12	6782.4	72'	Dakota	Dakota	Doubtful
13	6793.2	178'	Dakota	Morrison	(.10 at 106-108' (.10 at 105-106'
14	6792.8	80'	Dakota	Dakota	.10 at 79'

NOTE: A surface elevation, 6750 feet, was assumed at Hole No. 5. This elevation was not tied to a bench mark.



SKETCH CROSS-SECTION

In the vicinity of
Drill Hole #5

Durango, Colorado
June 16, 1954

W. J. Osterhoudt
S. C. Brown

THE SPRECHER URANIUM PROSPECT

McKinley County, New Mexico

Introduction

The field reconnaissance work of the Sprecher, et al. properties, which consists of Section 36, Township 16 North, Range 18 West, N.M.P.M., McKinley County, New Mexico, was conducted on October 30 and 31, 1953. Since the survey was of a reconnaissance nature a detailed map of the area was not made and apparently is not available.

Evidence of Uranium ore enrichment was noted in the Dakota coal horizon and in probable Morrison sandstones immediately below the Dakota formation. None of the shows within the area outlined was of commercial quantity or quality, but more exploration work with the bulldozer or core drill may outline commercial ore bodies.

Geology and Discussion

The Morrison formation (Jurassic) is exposed in the southeastern part of Section 36, Township 16 North, Range 18 West. Going toward the northwestern part of the same section, the Dakota, Mancos and Mesaverde formations (Cretaceous) are exposed.

The Morrison formation is considered an objective exploratory horizon based upon enrichment found in "Gragg Rock", a boulder which had fallen from the Dakota-Morrison cliffs. The boulder is either of Morrison age or is from a transition zone between the Morrison and the overlying Dakota formation. More exploration work should be conducted along the Dakota-Morrison contact zone.

The main zone of enrichment in the area studied is in the "Coal horizon" of the Dakota formation (see sketch section). Commercial ore has been mined from this zone at the Hyde Mine in Section 12, Township 15 North, Range 18 West, about one and one-quarter miles south of Section 36. Extending along the same Dakota outcrop northward from the Hyde Mine are two spots which gave a higher gamma count than the normal background count, but neither appeared to be of commercial intensities. These "hot" spots are, however, places where more exploration work should be conducted.

Any sand development in the Mancos formation should be checked with the scintillator but very little sand development was observed in the Mancos in Section 36.

The Mesaverde sands which occur in the extreme northwestern part of Section 36 should also be checked with the scintillator; especially those area where the sandstone beds thicken rapidly, indicating channeling.

Many geological features occur in the area which are favorable for the occurrence of Uranium ores in commercial quantities and quality. First, the steep hogback is a zone of weakness along which Uranium ores may have migrated upward from deeper sources. There is no evidence of faulting at the surface, however, the steeply dipping beds may be faulted with depth. Primary and secondary Uranium ores are generally found near these zones of weakness and the secondary ores are found in diminishing quantities away from the source.

Second, sand development in the Morrison, Dakota and the Mesaverde formations, especially where channeling is present, is favorable for deposition of Uranium ores.

Third, and probably the most important fact, is the presence of some enrichment in the area even though that at the surface is not of marketable value. The surface indications at the Hyde mine to the south were not commercial at the surface either, but the ore value increased to commercial percentages with depth. Therefore, these enriched areas are the obvious places to start exploration work for possible richer ore bodies with depth.

Recommendations and Conclusions

To summarize: The presence of a zone of weakness, the apparent channeling of the sandstone beds and the presence of some local enrichment indicate that the area should be further explored.

It is recommended that the Dakota "coal" horizon be thoroughly explored with the scintillator and the enriched zones be bulldozed to check the possibilities of richer ores with depth. Because of the high angle dip of the beds, especially in the southern part of Section 36, only a limited number of core holes are recommended near the outcrop area. If the bulldozer work opens up richer ore than that at the surface then core holes may be planned to test the horizon at depths below the limits of the dozer.

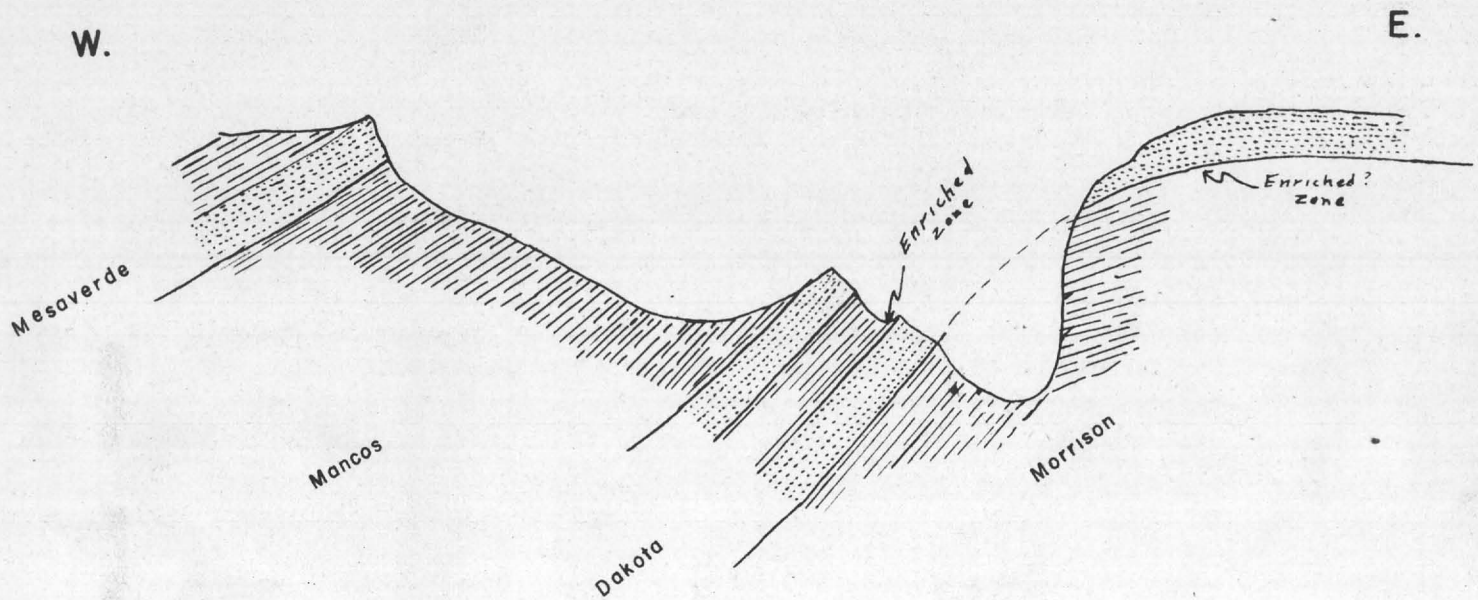
Going eastward in Section 36 where the Dakota beds cap the mesa, spot core drilling should be attempted. This coring campaign should test the Dakota and about the upper 25 feet of the Morrison for the possibility of enrichment in that horizon.

If enrichment is found in any of the exploratory holes then offset holes within a radius of 100 feet should be drilled to outline the limits of the ore body. The cores and cuttings should be checked with the scintillator as the hole is being drilled. Good representative samples of the "hot" cores and/or cuttings should be collected and an analysis be made of each. The thickness and richness of an ore body must be outlined for proper evaluation.

Respectfully submitted

Silas C. Brown

Durango, Colorado
March 6, 1954



SKETCH CROSS-SECTION

IN GENERAL AREA OF

Sec. 36-16N-18W

McKINLEY COUNTY, NEW MEXICO

Shallow Drilling and Logging Report on

The Sprecher Uranium Prospect

McKinley County, New Mexico

Introduction

This report on the shallow test holes and the Gamma Ray Logging on the Sprecher Uranium Prospect supplements the report of March 6, 1954 by Silas C. Brown, Consulting Geologist, Durango, Colorado.

Following Brown's recommendations on Page 3 of the above dated report, 14 holes were drilled at certain locations to test the lower Dakota and/or the upper Morrison formations. The lower strata of the Dakota were examined and detailed by surface geology. Two Geiger counters, a Geiger probe and a Precision Scintillator were used to check the formations in situ, and as exposed by the bulldozer work for radio-active emanations. The shallow hole Geiger-counter probe was used in Hole 5 and in Holes 7 and 9, but it was too erratic to be dependable in Holes 7 and 9, largely due to poor cable insulation and water leaks into the probe and into the cable.

Finally, in order to evaluate the possible commercial value of the uranium-bearing formations, Brown and Osterhoudt recommended that all holes be logged by an Atomic Energy Commission unit, which should provide permanent records of the data.

Geology and Discussion

Detailed examination of the lower Dakota and upper Morrison formations, as commonly called and accepted by local geologists, disclosed two zones in the lower Dakota (or perhaps in the Morrison-to-Dakota transition zone) which contained gray or dark colored shales and siltstones sometimes bearing enough carbonaceous material to be called "coal". The local uranium enrichments on the Sprecher Prospect were associated with these dark shales and siltstones. True coal did not possess much radio-active material. The upper shale zone contained more pseudo "coal" or carbonaceous constituents, and was more consistent in appearance than the lower shale. The lower shale zone was subject to variable lensing, pinchouts and subdivision by sandstone strata. A cross-section is included with this report to illustrate these local characteristics.

Field Operations

Mr. Ben Case of Aztec, New Mexico superintended the bulldozer and drilling operations. A heavy duty Allis-Chalmers bulldozer was run by "Kelley" Noland of Aztec to score cuts across the Dakota formations, to prepare roads for the drill and to place the drill and air compressor trucks on locations. These operations were well planned and capably managed.

The drilling was done by a Mayhew shot-hole drill equipped with dual air compressors. The drilling equipment was presumably owned by a contractor, Coffee, from Gallup, New Mexico. Rotary drills with air to blow out cuttings are used effectively in dry rock country provided no ground water is encountered. If necessary, Coffee's drilling unit could be serviced by a water truck and fluid mud pump. Although water was encountered in three shallow holes, Nos. 6, 7 and 8, the results of the testing of the other holes did not seem at the time to warrant deeper drilling by fluids.