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U.S.B.M. PILOT HOLE "X"
HORSE DRAW, RIO BLANCO COUNTY
COLORADO

VOLUME I

SECTION I: GEOLOGY AND GEOPHYSICS

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

by

GOLDER ASSOCIATES, INC.
Kirkland (Seattle), Washington

FINAL REPORT

on

Contract No. S0261060

March 1977

DISCLAIMER NOTICE

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16. Abstract

Pilot Hole "X" was drilled to test the formations through which the ventilation shaft for the proposed U.S.B.M. demonstration oil shale mine would be drilled. The geologic formations encountered in this hole are discussed. Correlation of the geologic horizons encountered in this hole with those encountered in nearby drill holes was accomplished by the use of geophysical logs. Data on the geophysical interpretations are provided. The anticipated geotechnical characteristics of the geologic units encountered in Pilot Hole "X" are described.

17. Originator's Key Words

U.S.B.M. Pilot Hole "X"
Piceance Creek Basin, Colorado
Oil Shale
Geology
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FOREWORD

This report was prepared by Golder Associates, Inc., Kirkland (Seattle), Washington under USBM Contract No. SO261060. The contract was initiated under the Advancing Oil Shale Mining Technology Program. It was administered under the technical direction of the Denver Mining Research Center with Mr. James E. Hawkins acting as Technical Project Officer. Mrs. Darlene Wilson was the contract administrator for the Bureau of Mines.

This report is a summary of the work recently completed as a part of this contract during the period June 1976 to March 1977. This report was submitted by the authors in March 1977.

FOREWORD

This report was prepared by [illegible] Associates, Inc., [illegible], [illegible] under USDA Contract No. [illegible]. The contract was [illegible] and [illegible] Mill [illegible] [illegible] program. It was administered under the technical direction of the [illegible] Research Center with Mr. [illegible] as Technical Project Officer. Mrs. [illegible] was the [illegible] administrator for the [illegible] of [illegible].

This report is a [illegible]; the work [illegible] completed as a part of this contract during the period June 1976 to March 1977. This report was submitted by the authors in March 1977.

SECTION I - GEOLOGY AND GEOPHYSICS

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1.0 INTRODUCTION

Pilot Hole "X" is the third hole drilled in the immediate vicinity of the proposed 96-inch diameter shaft at the site of the U.S. Bureau of Mines experimental oil shale mine. This hole was drilled between October 1 and October 25, 1976. During the drilling of the hole five hydrologic (jet) tests were conducted. In addition to the hydrological tests, a set of geophysical logs were collected prior to plugging the hole. The interpretation of these logs and comparison with the logging of nearby holes provided most of the geologic data in this section of the report. Because of size considerations copies of the geophysical logs are contained in a separately-bound section of this report as Volume I - Section I: Appendix I.

The first section of this volume (Volume I) discusses the geology of Pilot Hole "X" and the general geologic setting of the area. The second section reports on the hydrology (permeability testing) of the hole as determined from the jet test data. Each of the two sections in this volume of the report are presented in a format so that each can stand alone as a separate document.

Volume II of this report is a hole history and provides details of the drilling of Pilot Hole "X". A summary of this hole is presented in Table I.

It must be emphasized strongly that the only basis for geotechnical evaluation of this pilot hole is by the use of the following two indirect processes:

1. Cross-correlation with the geophysical logs from cored holes in the immediate area.

2. Correlation and evaluation of the apparent fracture density using the data available to us from the adjacent cored holes coupled with interpretation of the geophysical logs. The available data did not contain details of the fracture intensity, RQD, or of any physical property tests made on the core. These factors limit the amount of geotechnical data that can be implied by correlation from adjacent holes to Pilot Hole "X".

No laboratory measured mechanical strength data from the adjacent core holes were made available. From work carried out in other parts of the Piceance Creek Basin, there is evidence that some geologic horizons are characterized by lower uniaxial compressive strength. However, due to the depositional environment of the Parachute Creek Member correlation of <u>strength</u> data over substantial distances within, the Basin has proved to be unreliable and possibly dangerous from an engineering design standpoint. The assumption that the <u>oil shale</u> horizons are uniform materials throughout in terms of strength and fracture intensity is proving, as more work is done in the Basin, to be invalid. Over shorter distances, the variation in physical properties is obviously less. However, we feel that it would be misleading and possibly dangerous to attempt a correlation of the strength data for various geological units from the C-a or C-b tract to the area of Pilot Hole "X".

TABLE I

DRILL HOLE SUMMARY

DRILL HOLE DETAILS: Pilot Hole "X"

LOCATION:	Section 29, T1S, R97W	Co-ordinates:	505' FWL/1646' FSL
ELEVATION:	6284.8 ft.	TOTAL DEPTH DRILLED:	2531 ft.
CONTRACTOR:	ESI Drilling	TOTAL VERTICAL DEPTH:	2483 ft.
CORED INTERVAL:	None	INCLINATION:	Vertical at surface, deviating to a maximum of 20.4° at 2400 ft.
BIT SIZE:	6 1/4"		
LITHOLOGY:	Golder Associates (from geophysical logs)	SPUD DATE:	October 1, 1976
		COMPLETION DATE:	October 25, 1976
		DRILLING FLUID:	Saline Mud

HORIZONS (1)	Depth (ft.)(2)	Elevation (ft.)(2)
Base of Uinta	780	5505
Top of 'A' Grove	930	5350
Mahogany Marker	980	5305
Top of Mahogany Bed	1000	5285
Top of 'B' Groove	1130	5150
Base of Leached Zone	1455	4830
Blue Marker	2380	3905
Orange Marker (estimated)	Not Reached (2550)	(3735)

GEOPHYSICAL LOGGING (D)

Densi Log (Gamma Ray, Bulk Density)

Dual Induction (Spontaneous Potential, Resistivity, Conductivity)

Temperature

Caliper

HYDROLOGIC TESTING

		Depth (ft.)(2)
Jetting Test	1	765
	2	1041
	3	1446
	4	1936
	5	2483

WATER LEVELS

Date	Depth (ft.)
Oct. 13, 1976	Initial level 143' below surface

NOTES

(1) Elevations and depths of units derived from geophysical logs and reported to the nearest 5-foot.

(2) Corrected (true) Vertical Depth and Elevation.

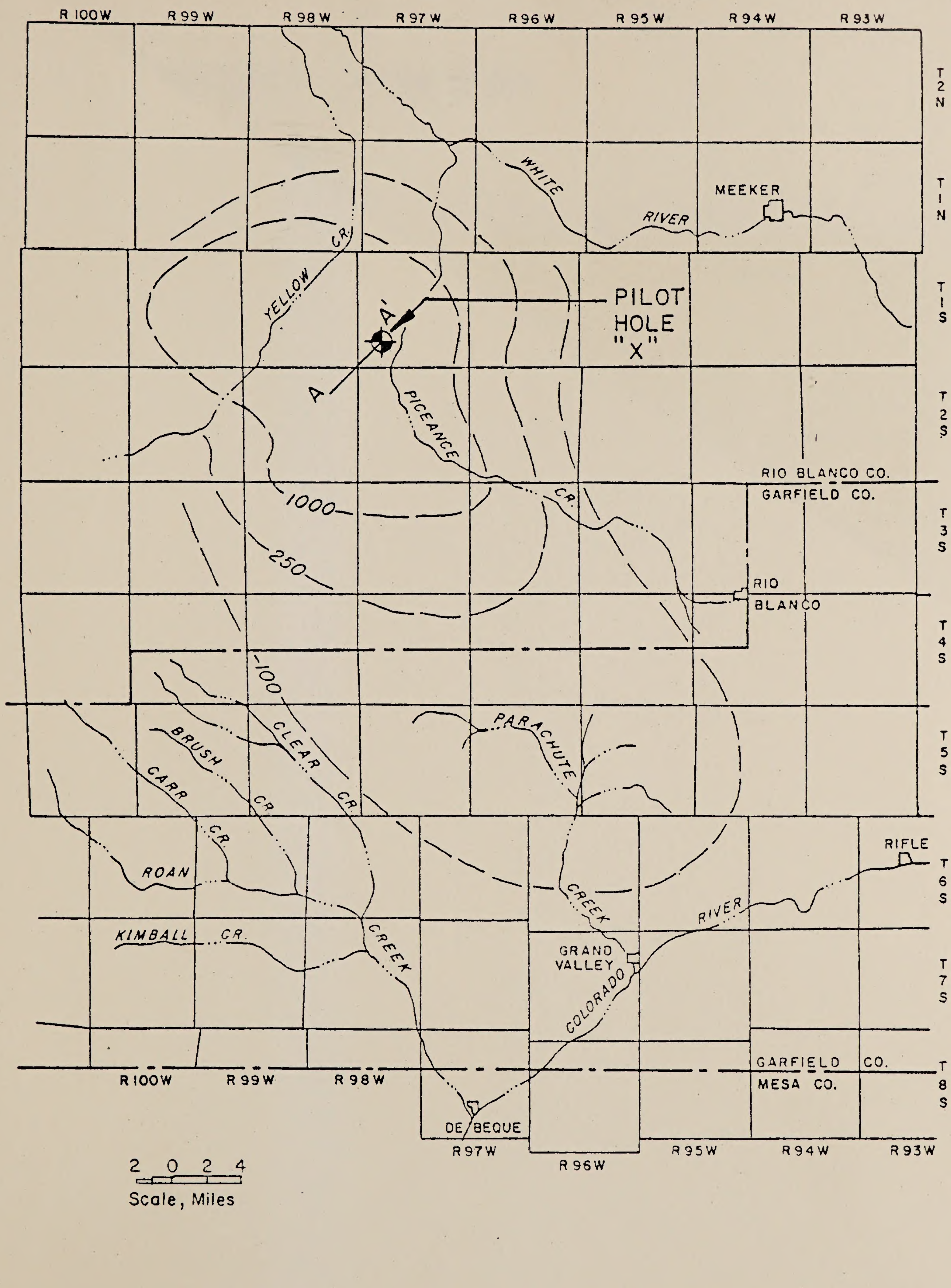
(D) Dresser Atlas

2.0 LOCATION

Pilot Hole "X" is located in Section 29, T1S, R97W, 6th P.M., Rio Blanco County, Colorado. The coordinates of the hole with reference to the southwest corner of Section 29 are 505.5 feet east of the west line and 1,646.05 feet north of the south line. The collar of Pilot Hole "X" is at an elevation of 6,284.8 feet and lies approximately 40 feet to the northeast of the proposed 96-inch diameter shaft. As a result of deviation from the vertical, the bottom of the hole (a total true vertical depth of 2,483 feet) is approximately 360 feet to the north-northwest of the proposed shaft.

The location of the drill hole is shown on Figure 1. The spatial relationship of this hole with respect to drill holes 01A, 02A and the proposed shaft is shown on Figure 2.

MAP OF PICEANCE CREEK BASIN SHOWING LOCATION OF PILOT HOLE "X"

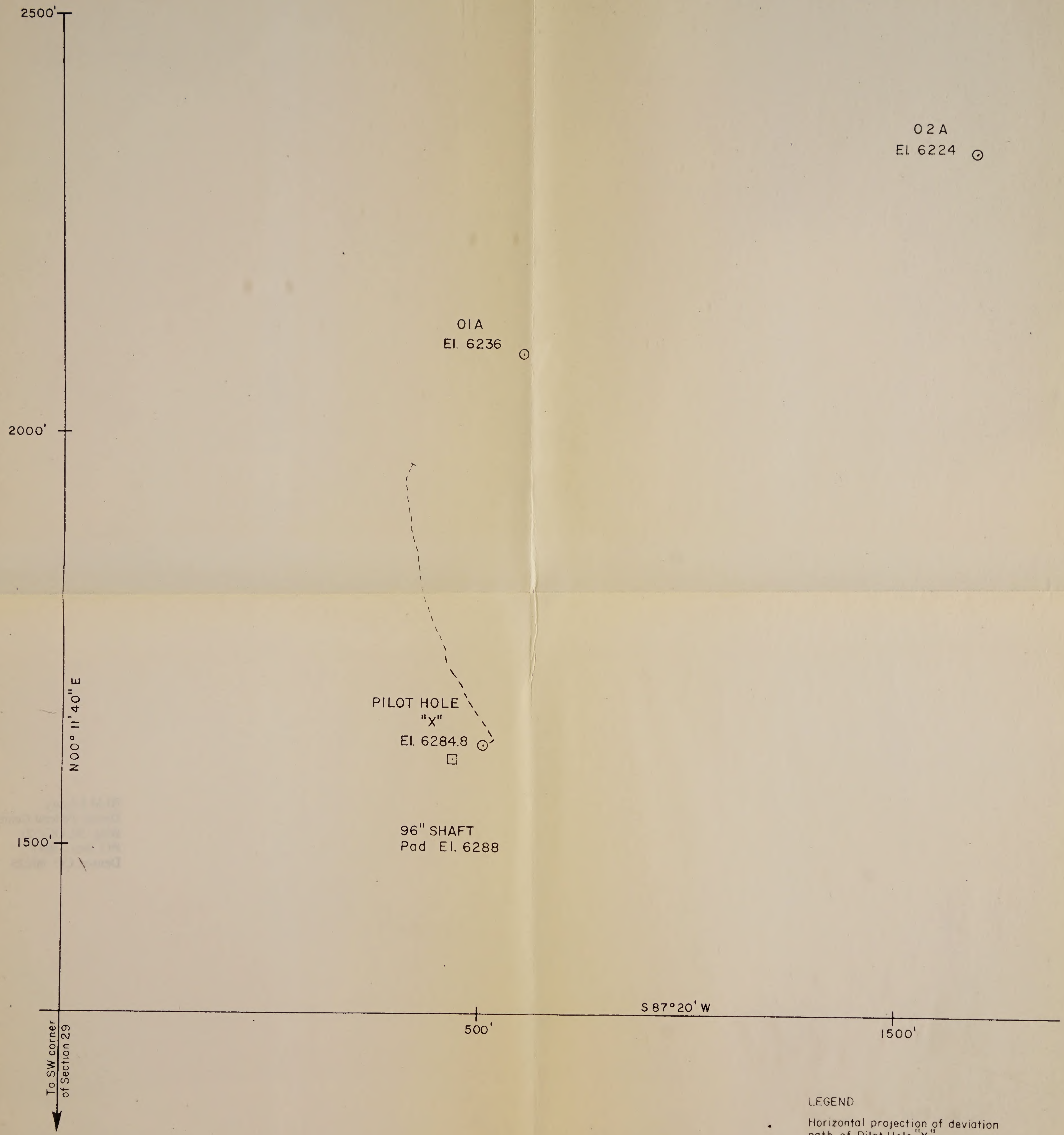


LEGEND

— 1000 — Maximum Thickness, in Feet, of Continuous Oil Shale Section Averaging 25 Gallons of Oil per Ton.

A—A' Cross Section

Figure 2



LOCATION OF DRILL HOLES AND PROPOSED
96" SHAFT IN SECTION 29

SCALE 1"=100'

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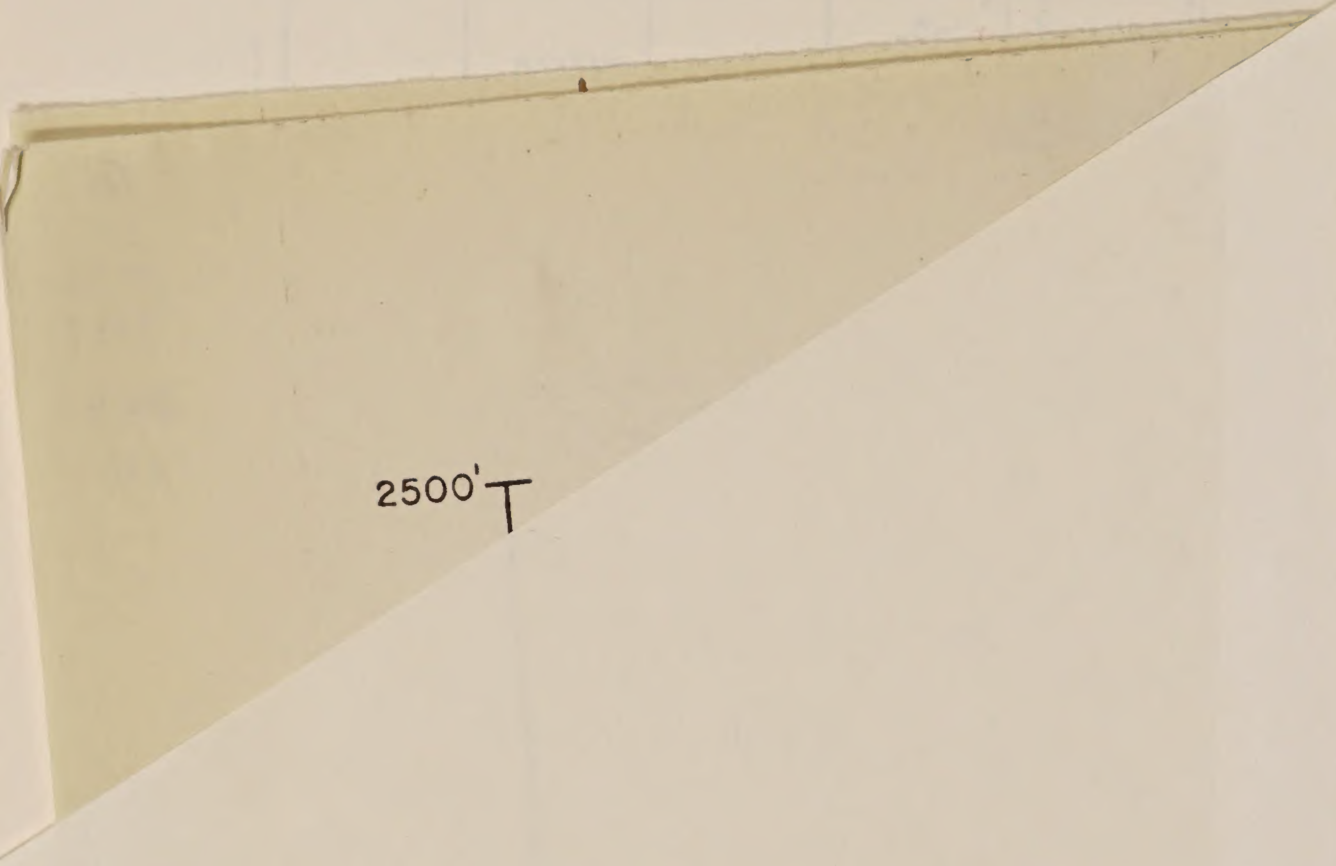

2500'

3.0 GEOLOGICAL SETTING OF THE STUDY

3.1 Introduction

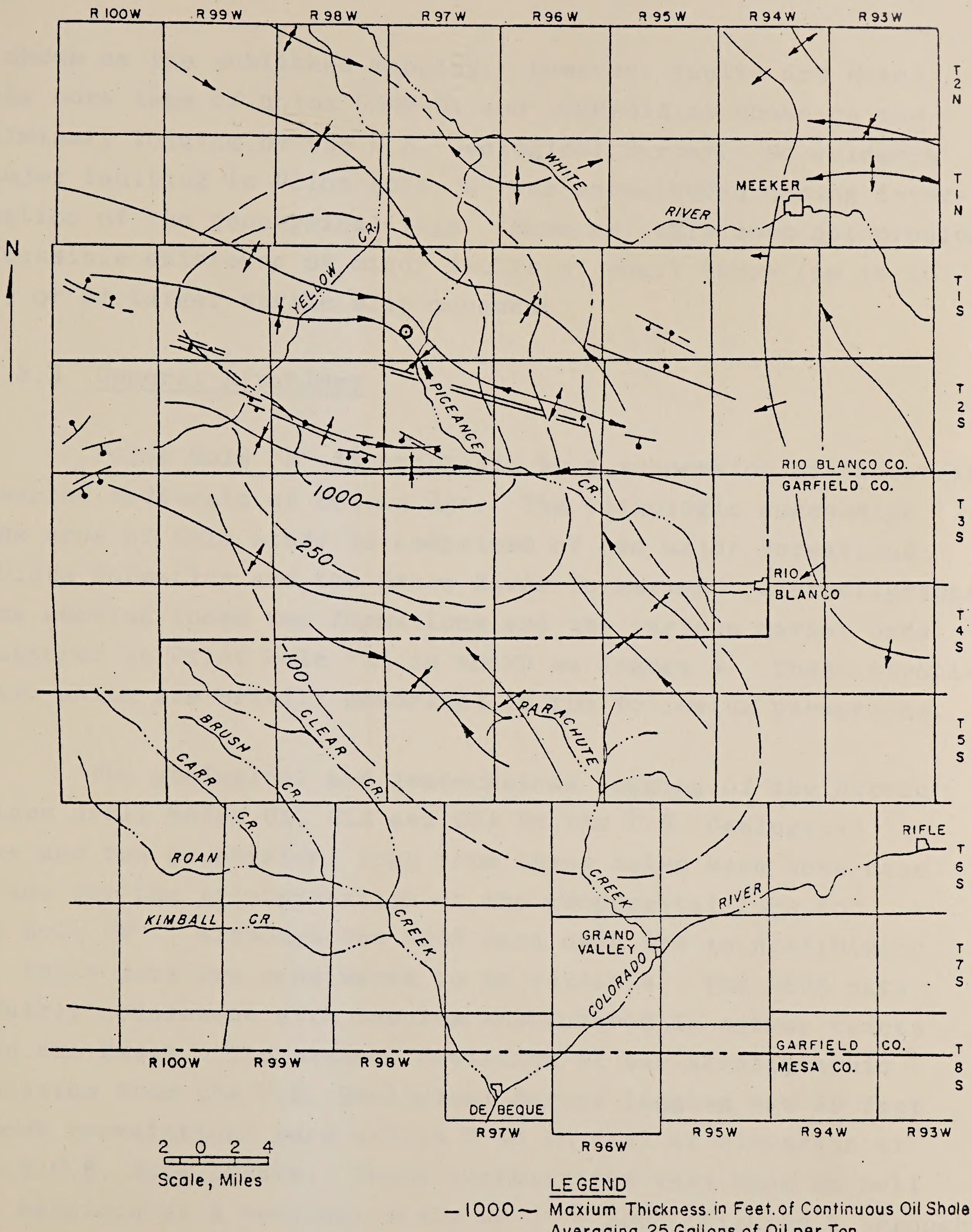
Since Pilot Hole "X" was drilled by the rotary (non-core) method, the geological data presented here is of necessity primarily based upon interpretation of the geophysical logs. The core logging done by the U.S. Geological Survey of three other Bureau of Mines drill holes in the immediate vicinity provided a basis of comparison for the geology of this drill hole.

In the following paragraphs the general geologic setting of the site is described. The major lithologic units encountered in Pilot Hole "X" are discussed and comments are made with respect to their probable geotechnical characteristics.

3.2 Structural Setting

Pilot Hole "X" occurs near the center of the Piceance Creek Basin. This portion of the basin is known to contain over 1000 feet of continuous oil shale section which averages more than 25 gallons of oil per ton. The location of this hole with respect to the published geological structural elements of the region is shown on Figure 3. The hole is located on the northeast limb of a syncline at, or near, a point of flexure of the synclinal axis. To the west of the hole, the syncline is mapped as trending more east-west, while just to the east of the hole the synclinal trend becomes more northwest-southeast. No faults in the immediate vicinity of the hole

STRUCTURAL GEOLOGY OF THE PICEANCE CREEK BASIN.



LEGEND

—1000— Maxium Thickness in Feet of Continuous Oil Shale Averaging 25 Gallons of Oil per Ton.

⊙ Location of Pilot Hole "X"

STRUCTURAL FEATURES

FAULTS

NORMAL FAULT (bar and ball on down dropped side.)

FOLDS

ANTICLINE – SHOWING DIRECTION OF PLUNGE

SYNCLINE – SHOWING DIRECTION OF PLUNGE

MONOCLINE

Structural geology compiled from published data. including Murray and Haun (1974)

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STRUCTURAL GEOLOGY OF THE PICEANCE CREEK BASIN

are shown on the published mapping. However, faults are noted on the core logs of holes USBM-01 and USBM-01A as shown on the preliminary logging by the U.S. Geological Survey. No evidence of major faulting in Pilot Hole "X" was encountered during interpretation of the geophysical logs. However, this does not preclude the possible existence of minor faults of small throw (up to 50 feet) or of larger strike slip movement.

3.3 General Lithology

Pilot Hole "X" is underlain by a succession of lacustrine and marine sediments of Eocene Age. The lithologic succession in the area of this study is comprised of two major formations: The Uinta Formation and the Green River Formation. A stratigraphic column showing these two formations and the various marker beds encountered in Pilot Hole "X" is shown on Figure 4. These stratigraphic units are briefly described in the following paragraphs.

The geological and geotechnical logging of the Bureau of Mines drill holes 01, 01A and 02A by the U.S. Geological Survey and the geophysical logs from these holes have been used as a key for the interpretation of the geophysical logs for Pilot Hole "X". Although the USGS data used are in preliminary form, these data are considered to be reliable. The USGS data are fairly consistent with results encountered in nearby tracts within the Basin. The maximum deviation of our stratigraphic correlation from the U.S. Geological Survey logging was 20 feet and most correlations were within 5 to 10 feet in elevation of the U.S.G.S. data points. These correlations were made on well cross sections at a vertical scale of 1" = 100' (Figures 5 through 10).

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OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : James E. Hawkins, Bureau of Mines
Building 20, Denver Federal Center

DATE: August 20, 1979

FROM : Area Oil Shale Supervisor, Grand Junction, CO

SUBJECT: Return of Pilot Hole "X" Report

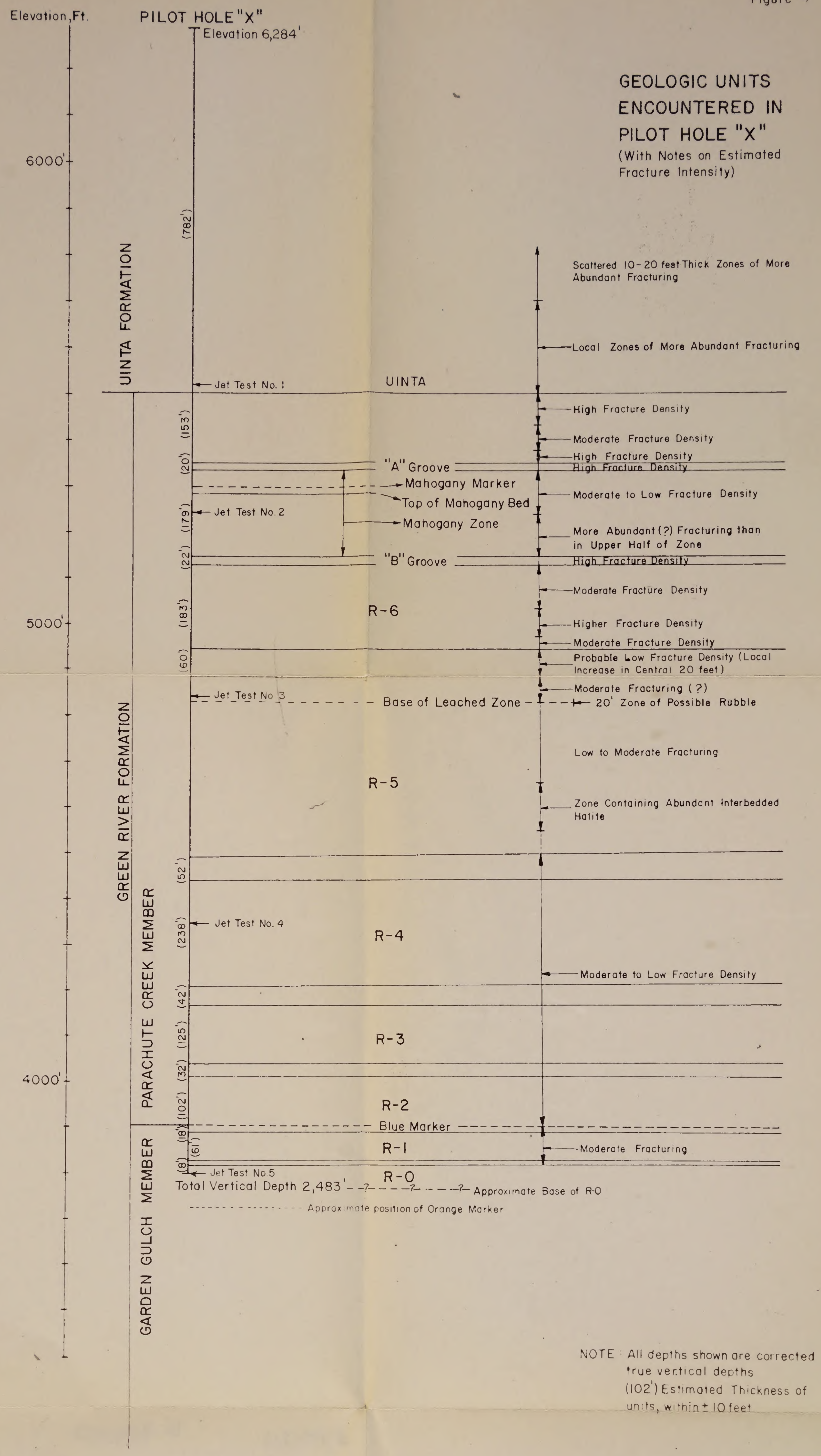
We are returning you file copy and appreciate your promptness.
Thank you.

Barbara Dillard

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

5010-109

Figure 4



GEOLOGIC UNITS ENCOUNTERED IN PILOT HOLE "X"
(With Notes on Estimated Fracture Intensity)

Golder Associates

Dec. 1976
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3.3.1 Uinta Formation

In the study area the Uinta formation is made up of siltstones, fine-grained sandstones and marlstones. Thickness of this formation in the Piceance Creek Basin is typically 500 to 1,000 feet. Interpretation of the geophysical logs indicates that the Uinta is approximately 780 feet thick in Pilot Hole "X". All surface outcrops in the immediate site area are comprised of the Uinta formation. At the surface there exists a highly fractured zone which, from field examination, roughly parallels the topography. This highly fractured surface zone appears to be 15 to 30 feet thick and is most probably weathered.

3.3.2 Green River Formation

The Green River formation is subdivided into a number of members, of which only the Parachute Creek Member and Garden Gulch Member are of relevance to the present study.

3.3.2.1 Parachute Creek Member

The Parachute Creek member contains the major "Oil Shale" deposits. The oil shale is in fact a kerogenous dolomitic marlstone. The Parachute Creek Member is composed of approximately 1,500 feet of near-horizontal layers of oil shale which have a widely varying content of contained kerogen (gallons of oil per ton). Five "rich" zones occur in the Parachute Creek Member below the kerogen rich Mahogany zone. These zones include, and are bounded by, the R-6 at the base of the "B" Groove and the R-2 at the boundary between the Parachute Creek Member and the underlying Garden Gulch Member. Experience in the region has shown that these individual kerogen rich layers and the intervening lean zones have very large lateral

extent. Therefore, the projection and correlation of the oil rich zones from holes 01, 01A and 02A with Pilot Hole "X" using the geophysical logs is considered very reliable. The relative position of these rich and lean zones is shown on the geologic cross section, Figure 5.

Stratigraphic positioning within the Parachute Creek Member is aided by the existence of a number of distinctive marker beds. Five such marker beds are of particular importance in this study:

i. <u>The 'A' Groove</u>

The 'A' Groove is a very useful marker unit. It is an approximately 15- to 20-foot thick band of barren marlstone that occurs approximately 30 feet above the Mahogany Marker. The 'A' Groove is often more easily detectable than the Mahogany Marker on the geophysical logs, particularly on resistivity logs, and provides a useful backup marker.

ii. <u>The Mahogany Marker</u>

The Mahogany Marker is a 6- to 12-inch thick ash bed within the Mahogany Zone. The Mahogany Marker has been used extensively in Piceance Creek Basin as a datum for stratigraphic correlation and information presentation. It lies about 980 feet below the surface in the area of Pilot Hole "X".

iii. <u>The 'B' Groove</u>

The 'B' Groove is an approximately 15- to 20-foot thick band of barren marlstone, the top of which

lies approximately 150 feet below the Mahogany Marker. The 'B' Groove is characterized by a resistivity peak similar to the 'A' Groove mentioned previously.

iv. The Mahogany Zone

The 180 feet of material between the bottom of the 'A' Groove and the top of the 'B' Groove is called the Mahogany Zone. Within the Mahogany Zone, and just below the Mahogany Marker, there occurs a 20- to 40-foot thickness which is extremely rich in contained kerogen. Within the Piceance Creek Basin, this portion of the Mahogany Zone is known as the Mahogany Ledge (or Mahogany Bed) due to its resistance to weathering.

v. The Blue Marker

In addition to the four marker beds briefly described above, one other main marker bed occurs at the base of the Parachute Creek Member. This is the Blue Marker.

The Blue Marker is a distinctive geophysical marker unit with proven large lateral extent within the basin. This marker is taken as the boundary between the Parachute Creek Member and the under-lying Garden Gulch Member.

3.3.2.2 Garden Gulch Member

This member is primarily composed of clayey oil shale. The contained oil in this member is substan-

tially less than that contained in the Mahogany Zone of the overlying Parachute Creek Member where assays have been performed elsewhere in the Basin. The Garden Gulch Member contains two recognized oil shale units. These are the R-0 and R-1 zones. Within the Garden Gulch Member, there is another diagnostic geophysical marker, the Orange Marker. Pilot Hole "X" did not reach the level of this marker unit.

4.0 GEOPHYSICAL LOGGING

4.1 Bulk Density Log

A compensated formation density geophysical log (Densilog) was run in the hole. This log incorporated three basic log types:

1. Bulk Density
2. Natural Gamma Ray, and
3. Caliper

4.1.1 Bulk Density

This tool measures the back-scatter and attenuation of gamma radiation emitted from the probe into the formation. The result is used to define a value for the formation bulk density (including the rock matrix, pore fluid, and formation water). Normally, as in the present case, the result is automatically compensated for borehole rugosity (roughness) during logging. In comparison to the various other parameters measured, the relationship of bulk density with the kerogen content (oil shale grade) has been shown to have a consistent and direct linear relationship in other portions of the Piceance Creek Basin. During the present study, the limits of the RO through R6 rich zones were determined from the bulk density data using the U.S.G.S. logging of 01, 01A and 02A as an interpretative key. The natural gamma data described below was also used to define the rich and intervening lean zones.

4.1.2 Natural Gamma Ray

Natural gamma logs record the amount of gamma radiation that is naturally emitted from the formation adjacent to the geophysical sonde. This log is useful for the identification of different lithologic units within a formation. The

natural gamma ray log proved to be the most useful single log for the regional well log correlations shown on Figures 5 through 10.

Natural gamma logs show a remarkable tract-wide consistency in the Piceance Creek Basin. Comparison of the relative spacing between a number of very well-identified markers confirms that the various stratigraphic units are very consistent along cross section A-A'. Once a particular set of gamma ray markers was identified in holes 01A and 02A, it was possible to correlate these holes with Pilot Hole "X". The gamma ray markers identified for use during this study were identifiable over the entire length of section A-A' (Figure 8). The gamma ray log was of particular importance in correlating the Mahogany Marker from one hole to another in a consistent manner.

4.1.3 Caliper Log

The caliper log provides a measure of the variation of the borehole diameter down the hole. The measurement of the borehole rugosity, or departure from the drill bit diameter, is primarily used to "correct" other forms of geophysical logs but also provides an indication of the in-situ quality of the formation in response to drilling. Large increases in diameter over and above the drill bit size generally indicate "wall collapse" related to fracturing, leached zones, soluble beds, etc., which are often associated with poor rock quality. In the present case, the confidence in the use of the caliper log as an unsupported source of geotechnical information is somewhat diminished. This lower confidence is caused by the prolonged period of drilling, the general absence of a mud cake on the walls

of the hole because of the saline mud used and the effects of the four jet tests that preceeded the geophysical logging. In spite of the possible limitations of the caliper log for Pilot Hole "X", the caliper data shows fairly good correlation with data from caliper logs for other holes in the area (Figure 10). Peaks in the caliper profiles occur at both the "A" and "B" grooves in Pilot Hole "X". This confirms the high fracture density and poor rock quality conditions normally encountered in both of these marlstone beds. Similar caliper peaks that correlate with adjacent drill hole data indicate other zones of rock fracturing. Caliper peaks also occur in the zones of abundant halite.

4.2 Electrical Logs

Electrical logs incorporate measurements of two basic types of information, the resistivity of the formation and its spontaneous potential. Numerous types of electrical surveys to measure resistivity exist. The most successful type of resistivity survey in the Piceance Creek Basin is the older ES (electrical survey) log. Unfortunately the ES log was not specified by the drilling contractor and the logging company (Dresser-Atlas) ran their standard set of logs which did not include the ES log. The log used to measure resistivity in this hole is the Dual Induction Focused Log. Resistivity values were not readable from this log and only the conductivity trace could be used. This was extremely unfortunate in that resistivity is a powerful interpretative tool in the Basin. The conductivity trace from this log is shown on the Resistivity profile, Section A-A'.

4.2.1 Resistivity and Conductivity Logs

In the older (ES) resistivity logs, currents are passed through the formation via electrodes and the corresponding voltage drops are measured. The Dual Induction Focused Log utilizes three transmitting coils to induce a current flow in the formation. The electrical data is collected by a set of receiver coils which should provide resistivity data for three depths of penetration. If the rock is unfractured, the voltage measurements reflect the resistivity (or conductivity) of the rock and contained pore fluids. Conversely, if the rock is fractured, it is likely that the more highly conductive fluid within the fractures will alter the measured voltage. In addition, the resistivity of the formation varies significantly with the organic and kerogen content of the formation. The higher resistivities of the kerogen rich zones would be somewhat diminished by fracturing containing saline formation waters. However, the oil shales would have to be extremely dissected by interconnected fractures to result in greatly reduced resistivities. These factors cannot be definitely uncoupled for rock quality interpretation. In the present case, resistivity data is not available for analysis. The conductivity trace is far less definitive than the resistivity data but could be roughly correlated with the zones of very low resistivity in adjacent drill holes.

4.2.2 Spontaneous Potential

The spontaneous potential (S.P.) log is a recording of the difference between the potential of a moveable electrode in the borehole and the fixed potential of a reference electrode at the surface. The most important source of the S.P. effect arises at the junction of dissimilar materials in the borehole. The log is often used to discriminate between sandstone and shale beds.

4.3 Discussion

Based on the evaluation of the geophysical logs, of all types, the following comments can be made:

1. As discussed previously, the influence of the combination of rock quality properties, lithology, and kerogen content or resistivity cannot be definitively uncoupled. However, certain lithological marker units are identifiable on the electrical logs. Although only the conductivity trace is readable on the Dual Focused Indication Log for Pilot Hole "X", inflections in this log can in some instances be correlated with the resistivity data from adjacent drill holes.

2. The bulk density and natural gamma logs are very useful for detailed correlation of marker beds.

3. The caliper log, within certain limits, provides an indication of the existence of highly fractured zones, pre-existing solutional openings (vugs), and highly soluble zones.

4. Sonic logs, fully compensated, and subsequently digitized, for computer manipulation, have proven useful elsewhere in the Basin for computation of the dynamic elastic properties of the rocks traversed. Sonic logging was not done for Pilot Hole "X" but is recommended for inclusion in any future geotechnical drilling programs.

5.0 INTERPRETATION OF THE GEOPHYSICAL LOGS

5.1 Uinta Formation

In general the resistivity of the Uinta formation gradually increases with depth. The base of the Uinta formation is marked by a well-defined resistivity low followed by an abrupt increase in resistivity in the upper part of the Parachute Creek Member.

The base of the Uinta is coincident with a small inflection in the self potential trace in Pilot Hole "X" but is generally not well-defined on the self potential logs.

The natural gamma character of the Uinta formation is relatively constant. There is a marked decrease in the natural gamma at the base of the Uinta formation.

There is a distinct change in character within the lower 200 feet of the Uinta formation. This lower portion is marked by a combination of several resistivity lows, an inflection in the self potential curve, several zones of greater hole rugosity shown on the caliper log, and lows in the bulk density. These features all indicate a zone of variable, interbedded lithologic character and rock quality. Zones of more abundant fracturing and lower rock quality should be expected within this lower 200 feet of the Uinta formation.

5.2 Green River Formation - Parachute Creek Member

5.2.1 "A" and "B" Grooves

The barren marlstones of the "A" and "B" grooves are identified as consistent low resistivity zones. These zones

also are evidenced by inflections in the self-potential profile and peaks in the caliper logs.

The "A" and "B" Grooves are zones of high fracturing and poor rock quality.

5.2.2 Mahogany Zone

The Mahogany Zone is characterized by moderately high resistivities. The kerogen rich upper half of the Mahogany Zone, the Mahogany Ledge (or Bed), is characterized by higher resistivity, lower natural gamma, more uniform caliper log trace and generally lower bulk density by comparison with the lower portion of the zone. This separation within the Mahogany Zone is also marked by an inflection in the self-potential curve. The upper portion of the Mahogany Zone is expected to have a better rock quality than the lower half.

5.2.3 Base of Leached Zone

The base of the Leached Zone is marked by a change in the character of the resistivity with resistivity decreasing (conductivity increasing) sharply as the base of the leached zone is approached. The base of the Leached Zone is also coincident with a sharp inflection in the self-potential trace and a change in the character of the natural gamma, caliper, and bulk density logs.

Above the base of the Leached Zone nahcolite nodules and beds have been removed by solutional processes. The resulting vugs and local zones of collapse breccia are reflected in the geophysical logs to varying degrees depending upon the relative original amounts of nahcolite present. In Pilot Hole "X" the base of the Leached Zone appears to be marked by a small, up to 20 feet thick, zone of collapse breccia.

5.2.4 Lower Parachute Creek Member

The lower Parachute Creek Member is composed of various zones of alternating rich and lean oil shale. The limits of the R (rich) zones are shown on Figures 4 and 5.

Within the lower part of the R-5 zone, at a depth of approximately 230 feet below the base of the leached zone, there is a 100 to 110-foot thick zone of low resistivity, lower natural gamma and bulk density, and high caliper readings. This zone corresponds to a zone containing beds of halite and is not indicative of abundant fracturing.

5.2.5 Blue Marker

The Blue Marker is marked by an abrupt decrease in resistivity (increase in conductivity), and peaks in both the bulk density trace and the caliper trace, just below an inflection in the self-potential log. This marker was defined in Pilot Hole "X" by correlation with holes 01, 01A and 02A using the natural gamma, bulk density and resistivity (conductivity) logs.

5.3 Garden Gulch Member

The Garden Gulch Member is marked by an abrupt decrease in resistivity and a very smooth and regular caliper trace. The base of the Blue Marker is taken as the top of the Garden Gulch Member.

5.3.1 Orange Marker

The Orange Marker was not reached in Pilot Hole "X". From the interpretative cross sections A-A' (Figures 5 through 10), it appears that this marker lies 60-65 feet below the total true vertical depth reached in Pilot Hole "X".

5.4 Summary of Geophysical Interpretation

The various lithological units have been previously described as have the basics of the different geophysical logs. The lithology and the position of the R0 through R6 rich zones are shown on Figure 4 and the geology cross section A-A' (Figure 5). In spite of the problems caused by the lack of a useable resistivity log for this drill hole, the various units have been adequately defined using the other geophysical logs and the U.S. G.S. logging of core holes 01A and 02A as interpretative keys.

Details regarding the geophysical logs used to prepare the various well log sections A-A' (figures 5 through 10) are given in Table II.

5.4.1 Anticipated Intersection of the Lithologic Units With the 96-Inch Shaft

The intersection of the various units with the proposed 96-inch shaft is shown on Table III. These intersections were determined by the three-point method. The vertical depths as determined from the geophysical logs for holes 01A and 02A and the corrected plan position, and corrected true vertical depth of the various horizons encountered in Pilot Hole "X" were used. Because of the slight variations in accuracy in interpretation of the depth of the various units and the very low dips involved, it was not possible to prepare a consistent set of structural contour maps. A composite variation amounting to as little as five feet markedly changes the determined strike line, sometimes by as much as 90°. However, the depths shown in Table III are considered, in our opinion, to be fairly accurate (i.e. within ± 10 feet).

TABLE II

SUMMARY OF GEOPHYSICAL LOGS

HOLE	SONIC LOG GAMMA RAY	GAMMA RAY BULK DENSITY	DENSI-LOG	FORMATION DENSITY	CALIPER	TEMP.	GAMMA RAY NEUTRON	ELECTRIC LOG	DUAL INDUCTION FOCUSED LOG
SKYLINE #2 (S)	X			X				X (INDUCTION)	
USBM-01 (B)		X			X		X	X	
PAN AMERICAN/SATERDALE #1 (S)	X			X				X (INDUCTION)	
PILOT HOLE "X" (D)			X			X			X
USBM-01A (B)		X			X	X	X	X	
USBM-02A (B)		X			X	X	X	X	
	-NATURAL GAMMA -INTERVAL TRANSIT	-NAUTRAL GAMMA -BULK DENSITY	-NATURAL GAMMA -CALIPER -BULK DENS.	-CALIPER -FORMATION DENSITY	-CALIPER -ORIENTATION	TEMP.	-NATURAL GAMMA -NEUTRON	-RESISTIVITY -SELF POTENTIAL	-SPONTANEOUS POTENTIAL -RESISTIVITY -CONDUCTIVITY

(B) BIRDWELL

(D) DRESSER-ATLAS

(S) SCHLUMBERGER

TABLE III

PROJECTED ELEVATIONS OF GEOLOGIC HORIZONS IN THE 96-INCH SHAFT (1)

	Anticipated Depth from Surface (2)	Elevation (2)
Base of Uinta	785 ft.	5,505 ft.
Top of "A" Groove	935 ft.	5,355 ft.
Top of Mahogany Bed	1,000 ft.	5,285 ft.
Top of "B" Groove	1,140 ft.	5,150 ft.
Base of Leached Zone	1,460 ft.	4,830 ft.
Blue Marker	2,385 ft.	3,905 ft.

(1) Based upon three point solution of beds as identified from geophysical logs of U.S.B.M. holes 01A, 02A, and Pilot Hole "X", and reported to the nearest 5-foot elevation.

(2) Elevations and depths from surface of the geologic horizons shown are expected to be within ± 10 feet of the figures presented in this table. Depths shown are from the pad elevation of 6,288 feet above sea level.

5.5 Anticipated Geotechnical Character[1] of the Units Encountered in Pilot Hole "X"

Pilot Hole "X" was drilled by non-coring methods; therefore, the data presented here are based on interpretation of the geophysical logs and correlation with the preliminary USGS core logging data for nearby holes. The two main geophysical logs used in this portion of the study were the caliper and resistivity (conductivity) logs. Reference was also made to the bulk density data. It must be emphasized that the comments in the following section are qualitative and should be used only as a general guide.

Correlation between the geophysical logs, the core loss zones and the core index (competency) logs for holes 01, 01A and 02A were made. This study confirmed that the zones of high core loss and low core competency encountered during the USGS logging were zones of lower resistivity (higher conductivity), with associated caliper peaks and lower bulk density values. Similar geophysical features in Pilot Hole "X" correlate well with the adjacent holes shown on cross sections A-A'. The zones noted in most cases correspond to stratigraphic sections with more abundant fracturing and a probable higher incidence of groundwater flow. Zones of more abundant fracturing listed in the following sections are based entirely upon these correlations and geophysical interpretation. For any one given horizon one can make comparisons with regard to probable changes in fracture intensity and to some extent such comparisons can be made within any one geologic member. Due to the lack of quantitative data on such features as fracture density in the adjacent holes it is not possible to make more precise engineering parameter judgements.

---

(1) Note this terminology does not include an evaluation of the strength either of the intact or 'rock mass' properties.

5.5.1 <u>Uinta Formation</u>

During the drilling of Pilot Hole "X", a surface zone of very abundant, probably weathered, fracturing, that extends to at least 15 feet and possibly 30 feet in depth, was encountered. Within the upper part of the Uinta formation encountered in Pilot Hole "X", there are several 10- to 20-ft. thick zones that appear to have more abundant fracturing and hence lower rock quality.

In the lower half of the Uinta formation there are several resistivity lows (conductivity highs) and associated peaks in the caliper log. These features indicate a higher incidence of fractured rock units and a higher probability of low rock quality.

5.5.2 <u>Green River Formation - Parachute Creek Member</u>

5.5.2.1 Upper Parachute Creek Member (above the 'A' Groove)

The upper portion of the Upper Parachute Creek Member (above the 'A' Groove) and the zone immediately above the 'A' Groove appears to be highly fractured. The remainder of this zone appears to be less fractured.

5.5.2.2 The 'A' Groove

The 'A' Groove is a zone of brittle marlstones and appears to be as highly fractured in Pilot Hole "X" as it is in other holes in the Basin.

5.5.2.3 Upper Mahogany Zone

The portion of the Mahogany Zone between the top of the Mahogany Bed and the base of the 'A' Groove is marked by coincident caliper peaks and resistivity lows in the adjacent drill holes. The logs for Pilot Hole "X" show only one coincident peak just above the top of the Mahogany Bed. A small caliper peak in the upper part of this zone is probably related to a small ash bed. Fracturing in this zone is considered to be of moderate intensity. Rock quality is expected to be inferior to that of the kerogen rich portion of the Mahogany Zone.

5.2.2 Birds Formation

During the drilling of Pilot Hole "B", a mottled zone of very abundant, strongly fractured [illegible], that extends to at least 15 feet and possibly 30 feet in depth, was encountered. Within the upper part of the Birds formation encountered in Pilot Hole "B", there are several 10- to 20-ft. thick zones that appear to have more abundant fracturing and hence lower rock quality.

In the lower half of the Birds formation there are several resistivity lows (conductivity highs) and associated peaks in the caliper log. These features indicate a higher incidence of fractured rock below and a higher probability of low rock quality.

5.2.3 Green River Formation - Parachute Creek Member

5.2.3.1 Upper Parachute Creek Member (above the "A" Groove)

The upper portion of the Upper Parachute Creek Member (above the "A" Groove) and the zone immediately above the "A" Groove appears to be highly fractured. The remainder of this zone appears to be less fractured.

5.2.3.2 The "A" Groove

The "A" Groove is a zone of brittle materials and appears to be as highly fractured in Pilot Hole "B" as it is in other holes in the Basin.

5.2.3.3 Upper Mahogany Zone

The portion of the Mahogany Zone between the top of the Mahogany bed and the base of the "A" Groove is marked by prominent caliper peaks and resistivity lows in the [illegible] drill holes. The logs for Pilot Hole "B" show only one conspicuous peak just above the top of the Mahogany bed. A small caliper peak in the upper part of this zone is probably related to a small oil bed. Fracturing in this zone is anticipated to be of moderate intensity. Rock quality is expected to be intermediate between that of the sections [illegible] portion of the Mahogany Zone.

5.5.2.4 Mahogany Bed

The kerogen rich Mahogany Bed, or Mahogany Ledge, is considered to be a zone of low fracture density and one of reasonably good rock quality.

5.5.2.5 Lower Mahogany Zone

In the adjacent drill holes the logging all indicates an increase in the degree of fracturing and a decrease in the rock competency below the Mahogany Bed. The geophysical logs in Pilot Hole "X" do not indicate any increase in the fracturing in this zone until just above the "B" groove. However, the lack of recorded conductivity highs in the geophysical log for Pilot Hole "X" does not preclude the existence of small amplitude resistivity lows associated with a slight increase in fracturing below the Mahogany Bed.

5.5.2.6 The 'B' Groove

The 'B' Groove is marked by both caliper peaks and conductivity highs (resistivity lows) indicating a highly fractured character for this marlstone unit.

5.5.2.7 The R6 Zone

The R6 Zone is marked in adjacent holes by a combination of caliper peaks and resistivity lows. Caliper peaks without associated resistivity lows correlate to ash beds in this interval. A correlatable zone of fracturing, indicated by both caliper and electrical logging, occurs between ash zones in the lower half of the R6 zone.

5.5.2.8 Septa Between R6 and R5

The lean zone separating the R6 and R5 rich zone has one conductivity peak in the central portion associated with a slight indication of enlarged hole diameter in the caliper log. This probably represents a 10- to 20-ft. thick central zone of moderate fracturing surrounded by less fractured material.

In some other parts of the Piceance Creek Basin this zone is composed of mudstones which have indicated uniaxial strength of about 1/3 that of the average for the remainder of the stratigraphic column. Thus, this zone should be treated with conservatism from a shaft design standpoint.

5.5.2.9 The R5 Zone

The portion of the R5 zone above the base of the Leached Zone is suspected of being a zone of moderate fracturing. The geophysical data from Pilot Hole "X" is not indicative of a pervasive zone of fracturing in this interval. Only two small conductivity peaks occur in this upper portion of the R5 zone, and these do not have associated caliper peaks. However, logging of the other Bureau of Mines holes in the area are indicative of at least moderate fracturing in this interval.

At the base of the leached zone there are marked coincident peaks in both the caliper and conductivity logs. This is considered to be indicative of a zone of collapse breccia.

Below the base of the leached zone, but within the top half of the R5 zone, there are two small 10- to 20-ft. thick zones of coincident caliper and conductivity peaks associated with halite beds. The basal 100 to 110 feet of this zone is marked by strong, persistent coincident peaks in both the caliper and conductivity logs which are also associated with interbedded halite and oil shale. The smaller caliper peaks in this zone in comparison with the caliper logs for holes 01, 01A and 02A indicate that the saline mud drilling program accomplished the goal of minimizing the solution of the saline section. Fracturing in these portions of the R5 zone is expected to be minimal.

5.5.2.10 Base of R5, R4 through R2

The rich and intervening lean zones between the base of R5 and the base of R2 are of fairly uniform character and are indicative of moderate to fairly low fracture density.

5.5.3 Garden Gulch Member

5.5.3.1 Blue Marker to Top of RO Zone

The interval from the Blue Marker to the top of the RO zone is characterized by a series of conductivity highs without associated caliper peaks. The core competency in the adjacent hole (01A) is low in this shale interval. This zone is possibly one of moderate rock fracturing.

Pilot Hole "X" terminates at the top of the RO zone. Therefore, no direct data exists for lower portions of the Garden Gulch Member. However, based on data from holes 01A and 02A it would appear that the upper portion of the Garden Gulch Member is fairly uniformly fractured. This upper portion of the Garden Gulch Member can be expected to have a higher density of fracturing than exists in the lower portion of the overlying Parachute Creek Member.

5.5.4 Summary

The degree of rock fracturing is highest in the Uinta formation and in the upper portion of the Parachute Creek Member of the Green River formation. The degree of rock fracturing is lower and the general competency of the rock units is possibly higher below the base of the Leached Zone and above the contact with the Garden Gulch Member. The upper portion of the Garden Gulch Member should be anticipated to have fracturing and rock competencies roughly equivalent to those of the Uinta formation. Notes regarding the probable relative degree of fracturing in the various zones are shown on Figure 4.

As stated previously, although the interpretations presented here are both reasonable and correlatable with the data from adjacent core holes, they should be applied with caution.

No evidence indicative of major faulting or fault offset of the stratigraphy was encountered during the interpretation of the geophysical logs of Pilot Hole "X". If any faults are present they are minor structural features with little, if any, stratigraphic offset (i.e. less than 50 feet).

Respectfully submitted,

GOLDER ASSOCIATES, INC.

D. L. Pentz

Leigh A. Readdy

LAR:hd

REFERENCES

Murray, D.K. (ed), 1974, Energy Resources of the Piceance Creek Basin, Colorado: Twenty-fifth Field Conference, Rocky Mountain Association of Geologists, 301 p.

Murray, D.K., and Haun, J.D., 1974, Introduction to the Geology of the Piceance Creek Basin and Vicinity, Northwestern Colorado; *in* Murray, D.K. (ed), Energy Resources of the Piceance Creek Basin, Colorado: Twenty-fifth Field Conference, Rocky Mountain Association of Geologists, p. 29-39.

ID: 88011050

igure 5

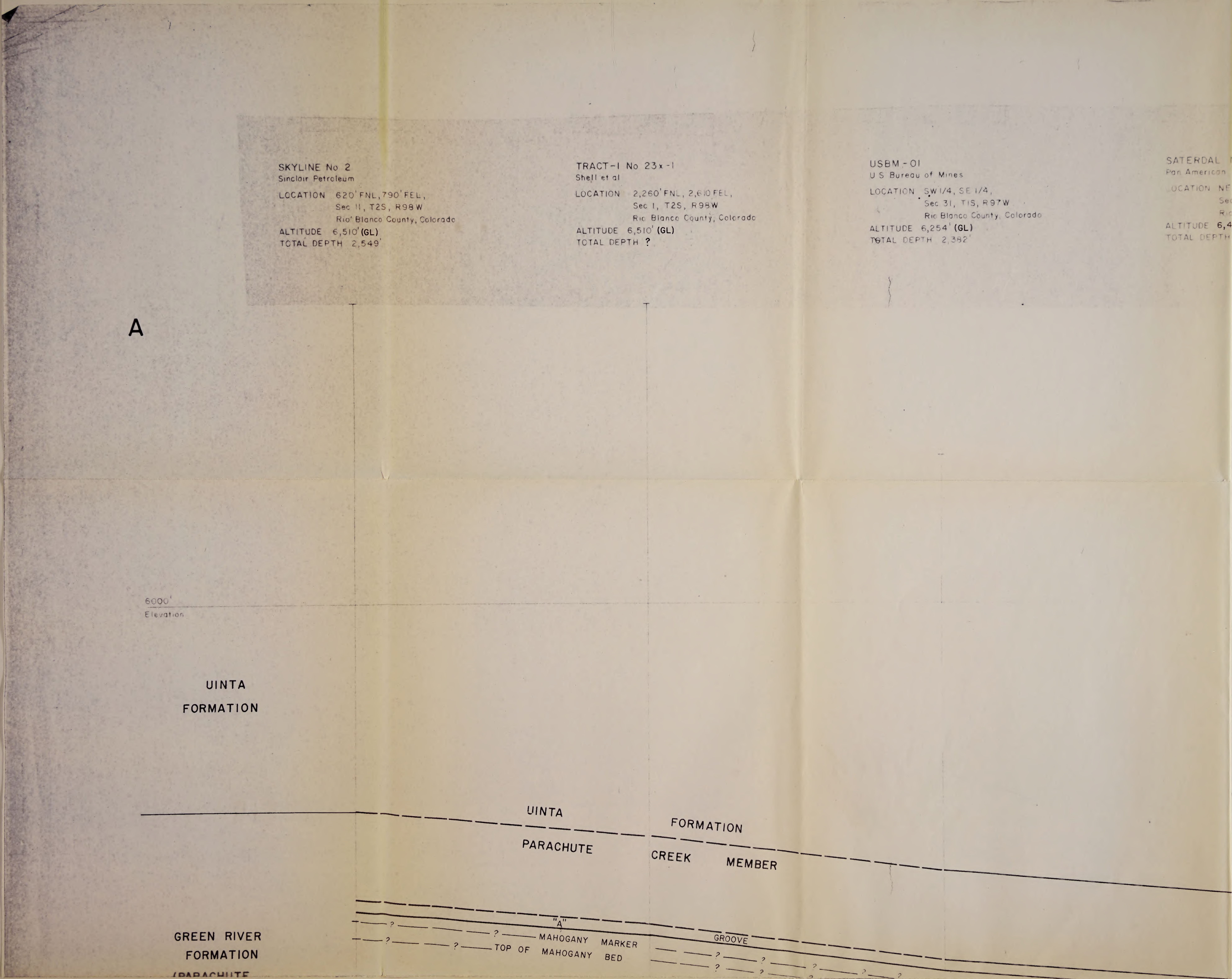

A
SKYLINE No 2
Sinclair Petroleum
LOCATION 620' FNL, 790' FEL,
Sec 11, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH 2,549'
TRACT-1 No 23x-1
Shell et al
LOCATION 2,260' FNL, 2,610 FEL,
Sec 1, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH ?
USBM-01
U S Bureau of Mines
LOCATION SW 1/4, SE 1/4,
Sec 31, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,254' (GL)
TOTAL DEPTH 2,382'
SATERDAL
Pan American
ALTITUDE 6,4
TOTAL DEPTH
6000'
Elevation
UINTA
FORMATION
UINTA
FORMATION
PARACHUTE
CREEK
MEMBER
"A"
MAHOGANY MARKER
TOP OF MAHOGANY BED
GROOVE
GREEN RIVER
FORMATION

Figure 5

GEOLOGY

SECTION A-A'

o l
etroleum
/4, NW1/4, SE1/4,
31, T1S, R97W
Blanco County, Colorado
50' (GL)
2,745'

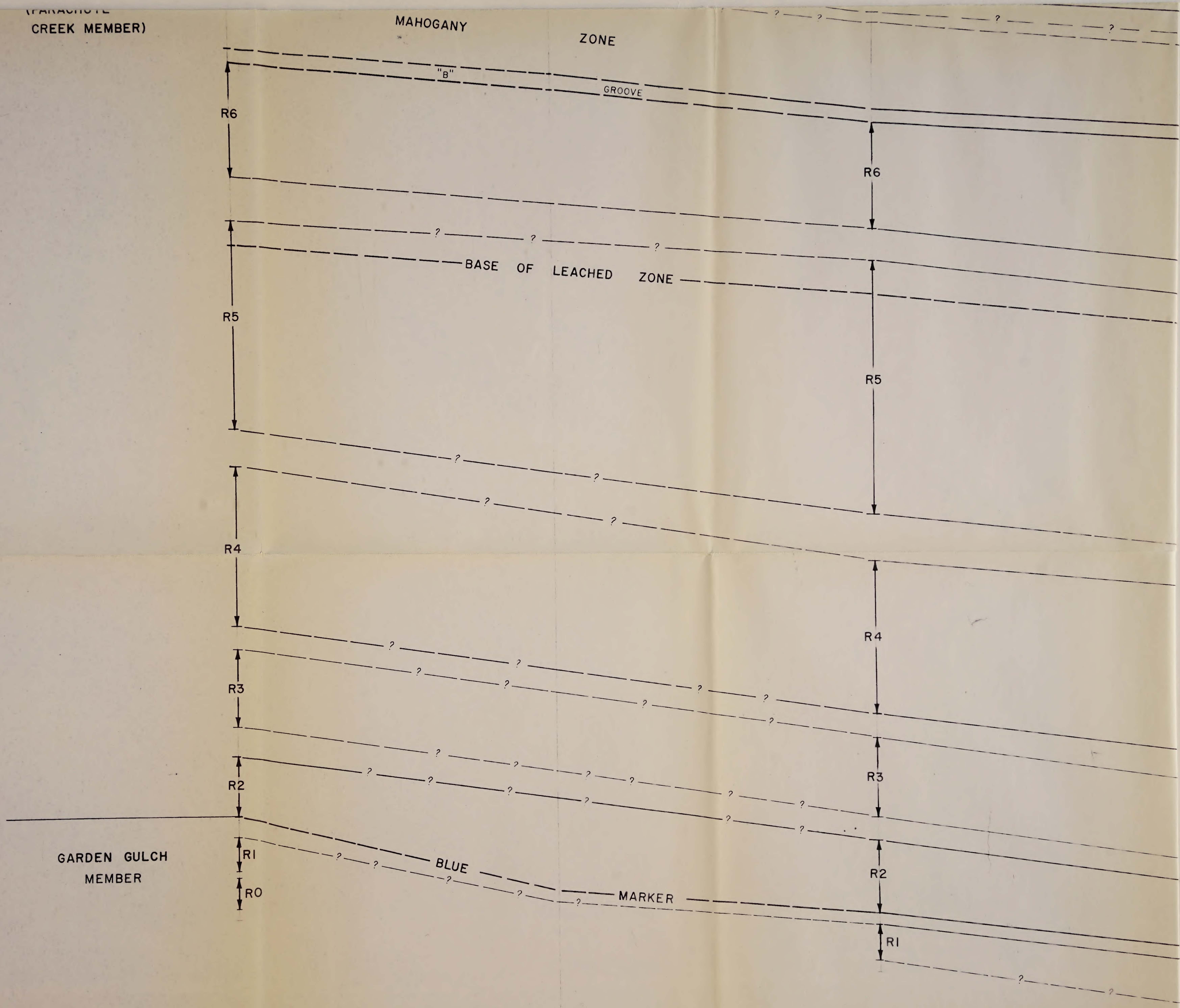
PILOT HOLE "X"
U.S. Bureau of Mines
LOCATION 505' FWL, 1,646' FSL,
Sec 29, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,284' (GL)
TOTAL DEPTH 2,531'
(Vertical depth = 2,483')

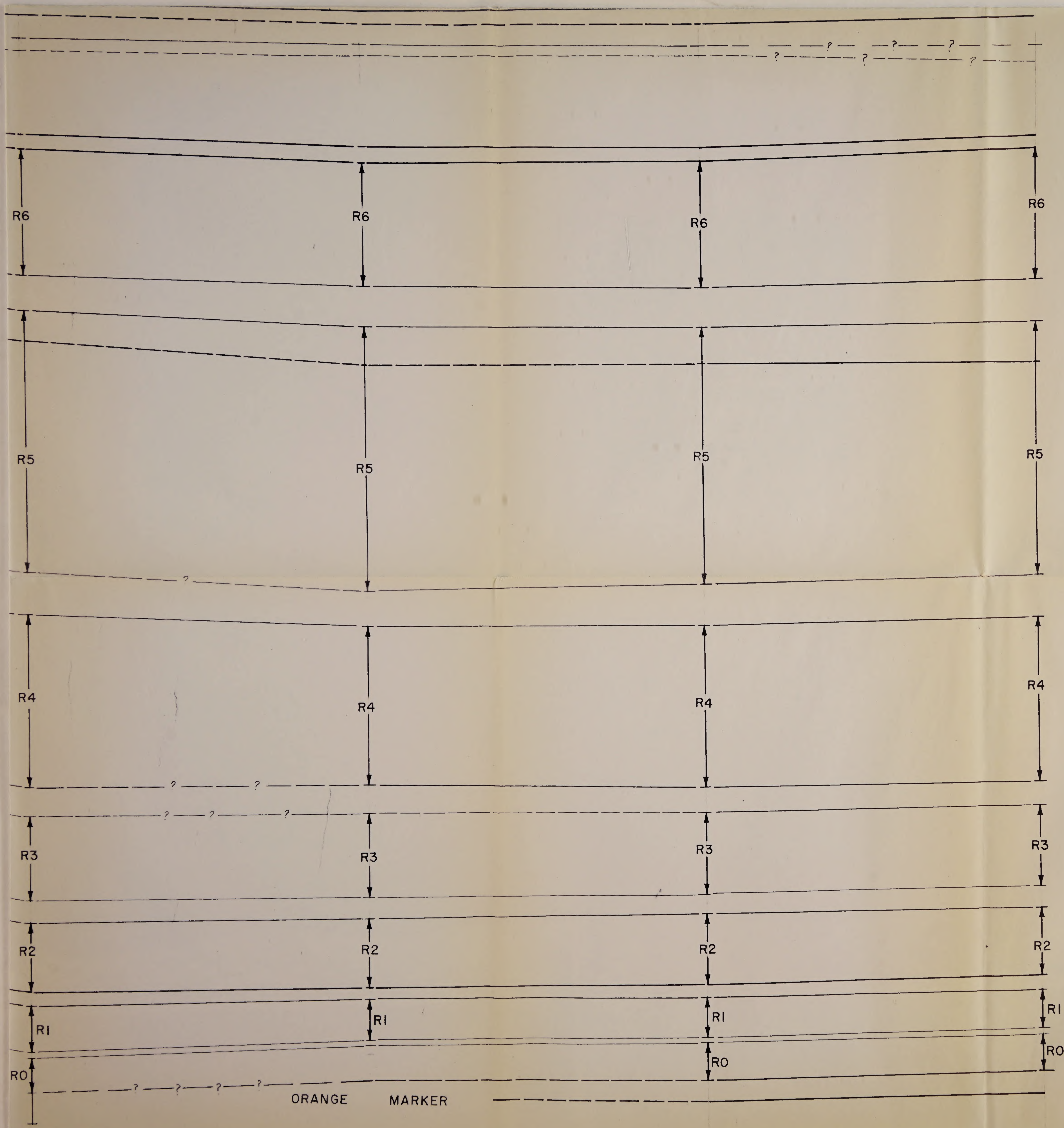
USBM - 01A
U.S. Bureau of Mines
LOCATION 549' FWL, 2,124' FSL,
Sec 29, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,236' (GL)
TOTAL DEPTH 2,610'

USBM - 02A
U.S. Bureau of Mines
LOCATION 1,088' FLW, 2,393' FSL,
Sec 29, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,224' (GL)
TOTAL DEPTH 2,664'

A'

6000
Elevation


(PARACHUTE
CREEK MEMBER)
MAHOGANY
ZONE
"B"
GROOVE
R6
R6
BASE OF LEACHED ZONE
R5
R5
R4
R4
R3
R3
R2
R2
GARDEN GULCH
MEMBER
BLUE
MARKER
R1
R0
R1


R6
R6
R6
R6
R5
R5
R5
R5
R4
R4
R4
R4
R3
R3
R3
R3
R2
R2
R2
R2
R1
R1
R1
R1
R0
R0
R0
ORANGE MARKER

EXPLANATION

RO —— Kerogen Rich Zones

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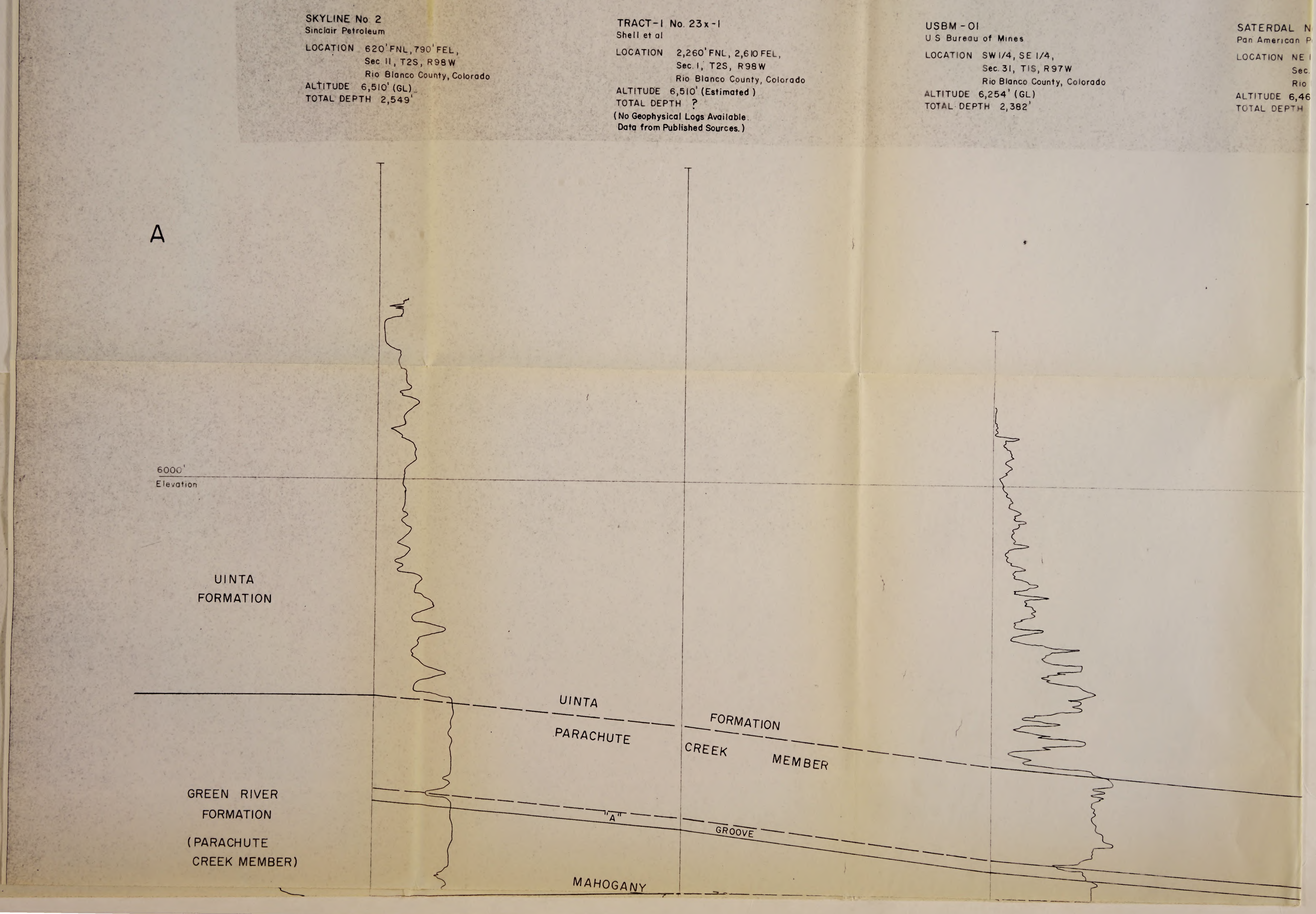
December 1976

Figure 6



SKYLINE No. 2
Sinclair Petroleum
LOCATION 620' FNL, 790' FEL, Sec 11, T2S, R98W Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH 2,549'
TRACT-I No. 23x-1
Shell et al
LOCATION 2,260' FNL, 2,610 FEL, Sec. 1, T2S, R98W Rio Blanco County, Colorado
ALTITUDE 6,510' (Estimated)
TOTAL DEPTH ?
(No Geophysical Logs Available. Data from Published Sources.)
USBM-01
U S Bureau of Mines
LOCATION SW 1/4, SE 1/4, Sec. 31, T1S, R97W Rio Blanco County, Colorado
ALTITUDE 6,254' (GL)
TOTAL DEPTH 2,382'
SATERDAL N
Pan American P
LOCATION NE
ALTITUDE 6,46
TOTAL DEPTH
A
6000' Elevation
UINTA FORMATION
UINTA FORMATION
PARACHUTE CREEK MEMBER
GREEN RIVER FORMATION (PARACHUTE CREEK MEMBER)
"A" GROOVE
MAHOGANY

RESISTIVITY

Figure 6

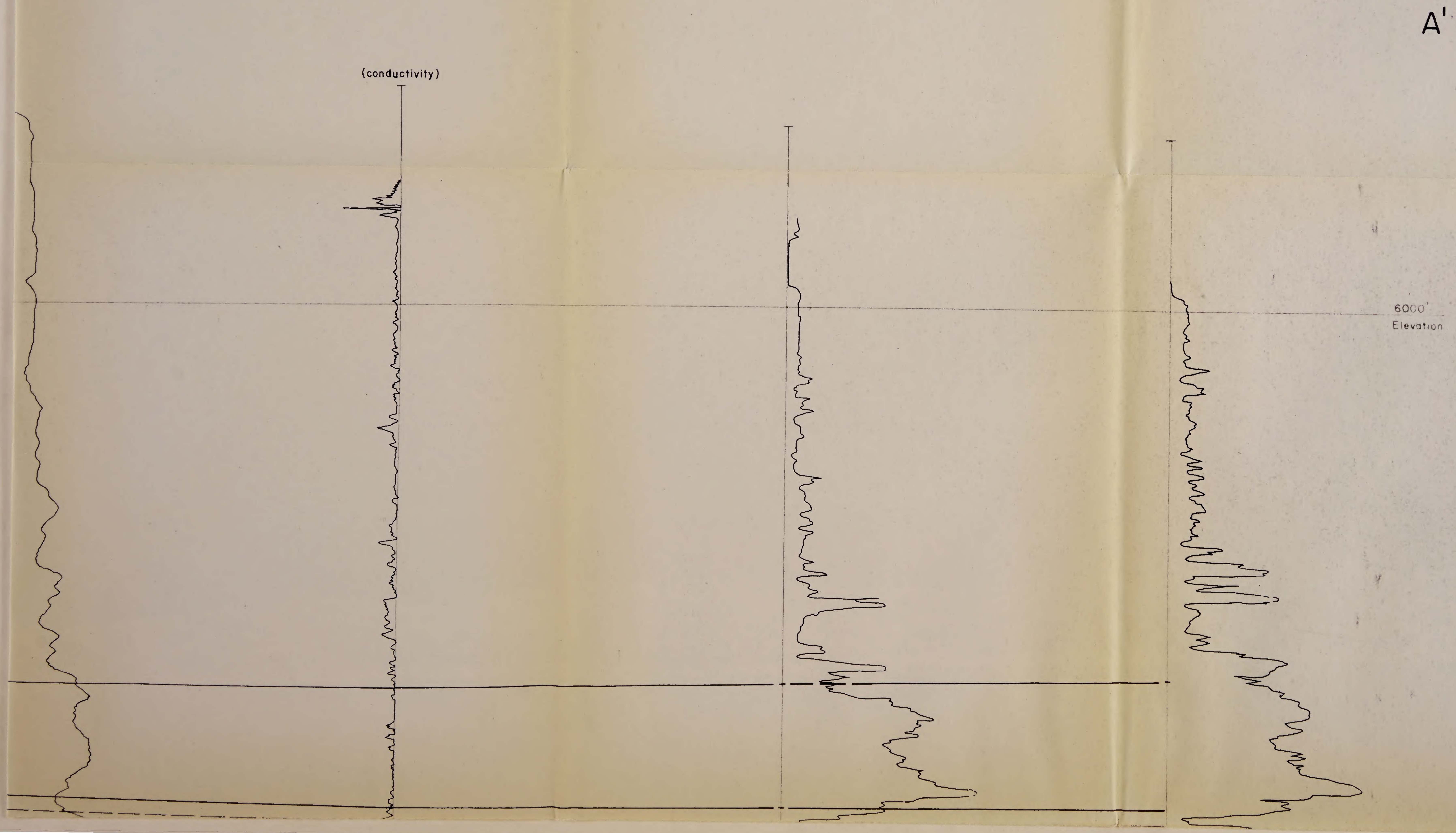
SECTION A-A'
THROUGH PILOT HOLE "X"

. I
troleum
/4, NW1/4, SE1/4,
31, T1S, R97W
lanco County, Colorado
)" (GL)
2,745'

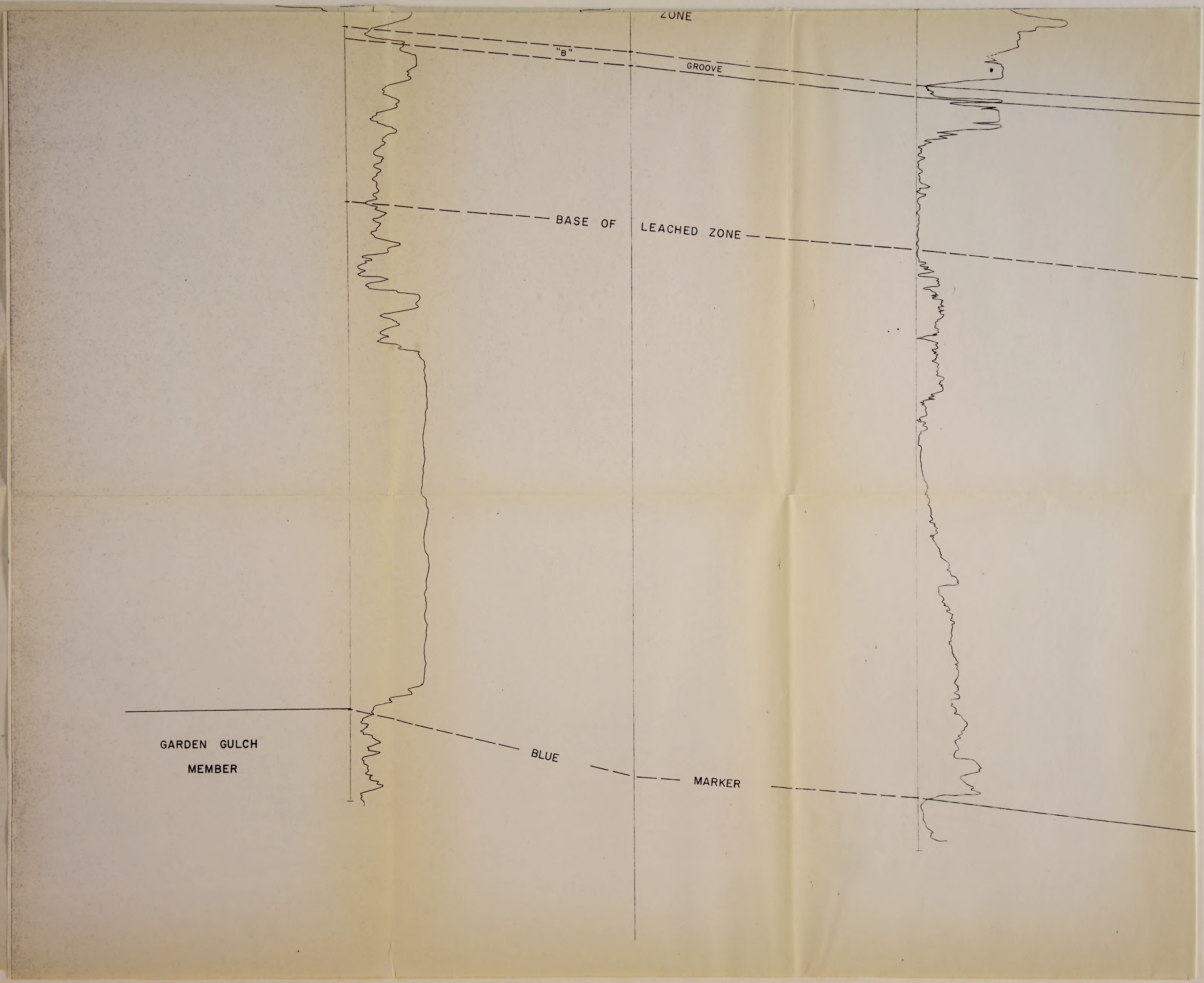
PILOT HOLE "X"
U.S. Bureau of Mines
LOCATION 505' FWL, 1,646' FSL,
Sec.29, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,284' (GL)
TOTAL DEPTH 2,531'
(Vertical depth = 2,483')

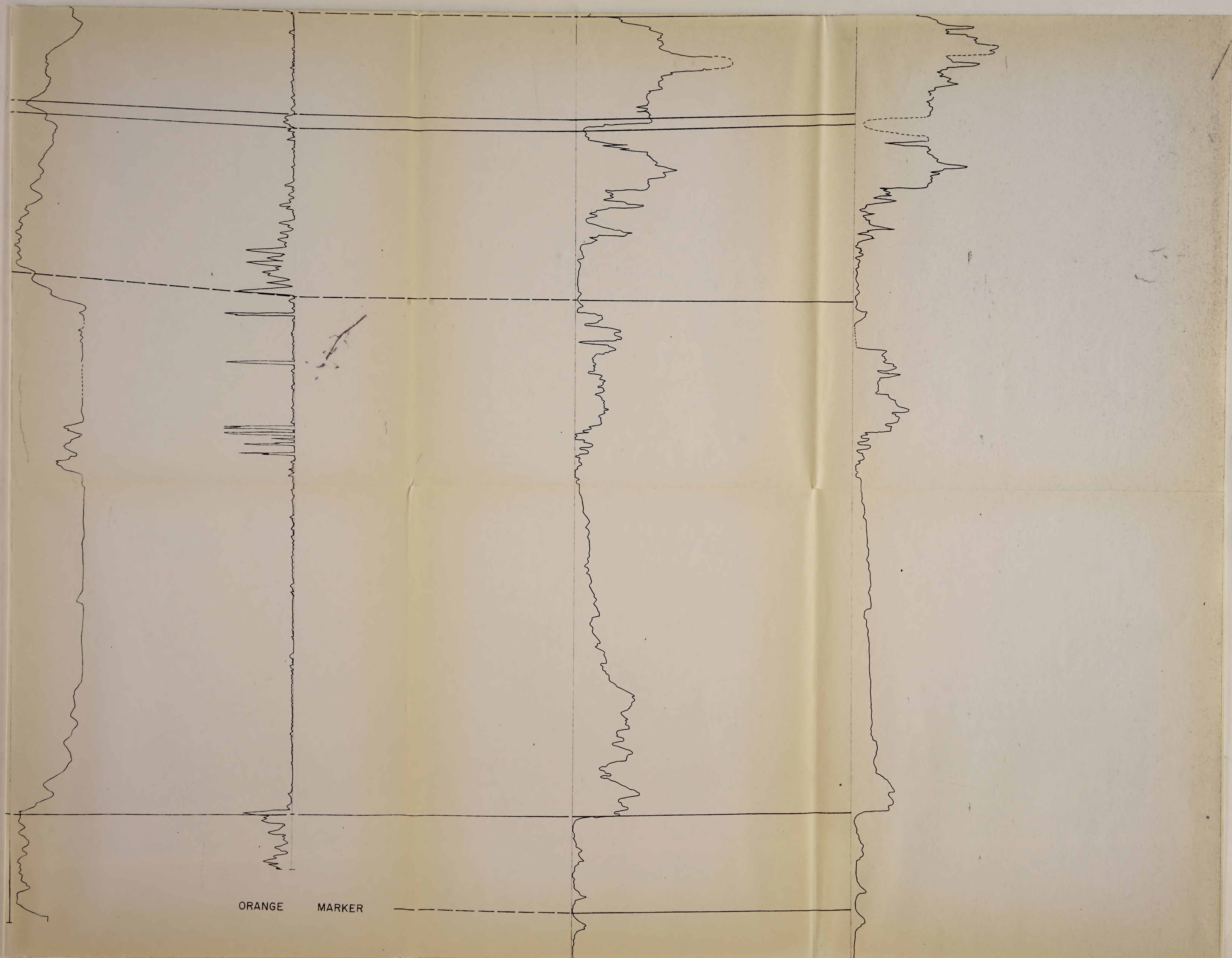
USBM-01A
U.S. Bureau of Mines
LOCATION 549' FWL, 2,124' FSL,
Sec 29, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,236' (GL)
TOTAL DEPTH 2,610'

USBM-02A
U.S. Bureau of Mines
LOCATION 1,088' FLW, 2,393 FSL,
Sec 29, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,224' (GL)
TOTAL DEPTH 2,664'



BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

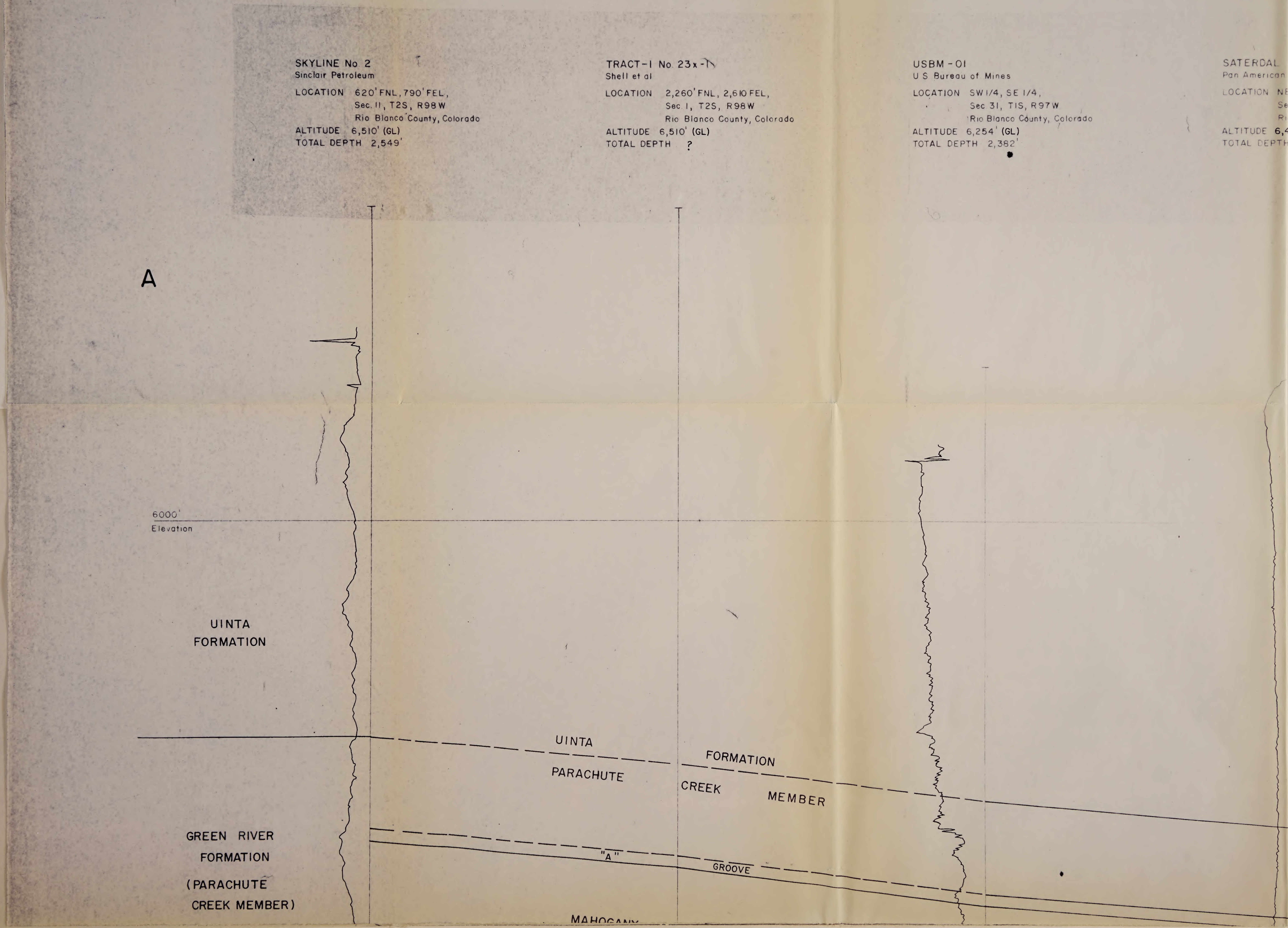

ZONE
"B"
GROOVE
BASE OF LEACHED ZONE
GARDEN GULCH
MEMBER
BLUE
MARKER


ORANGE MARKER

Golder Associates

December 1976

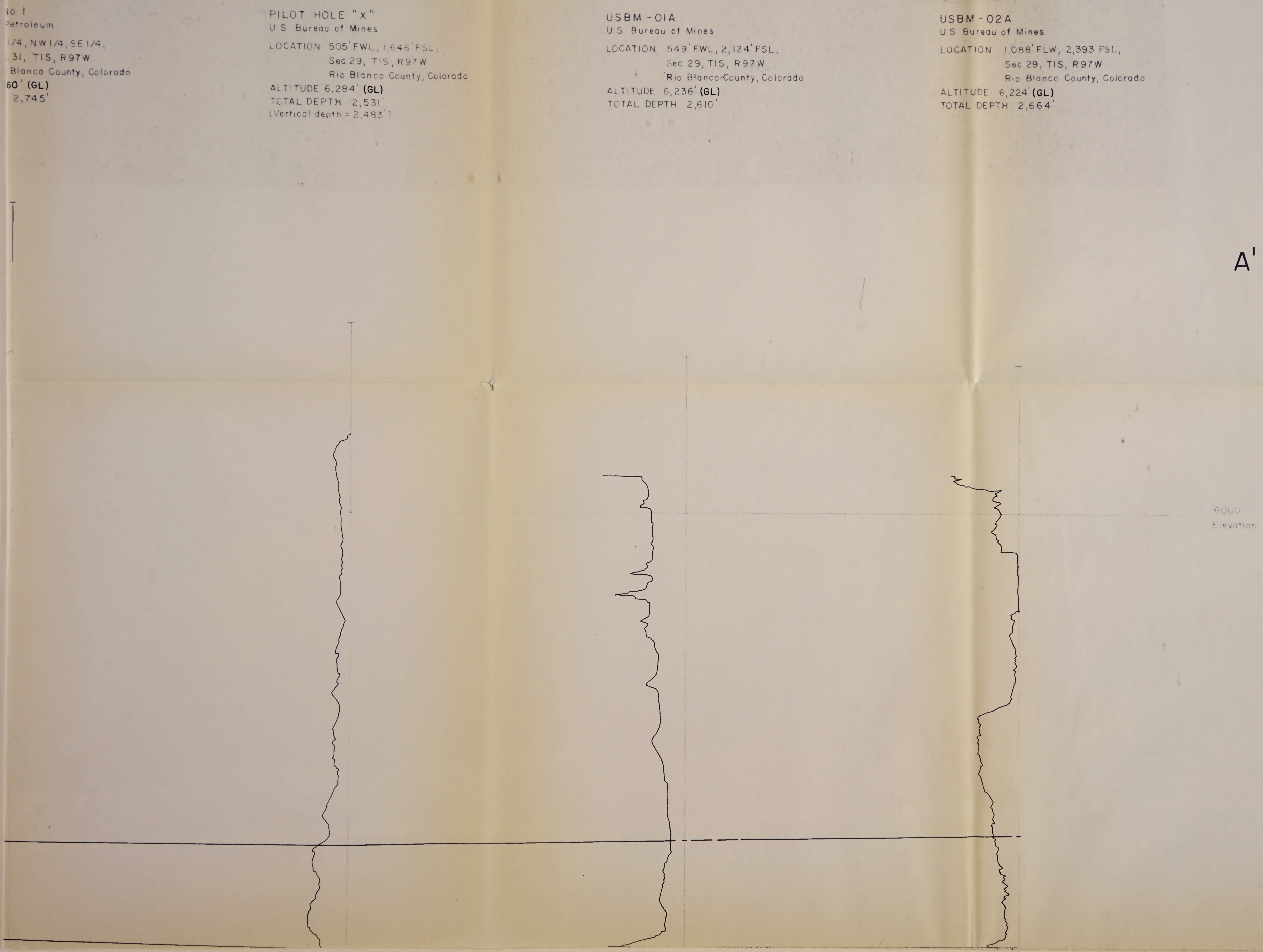
Figure 7

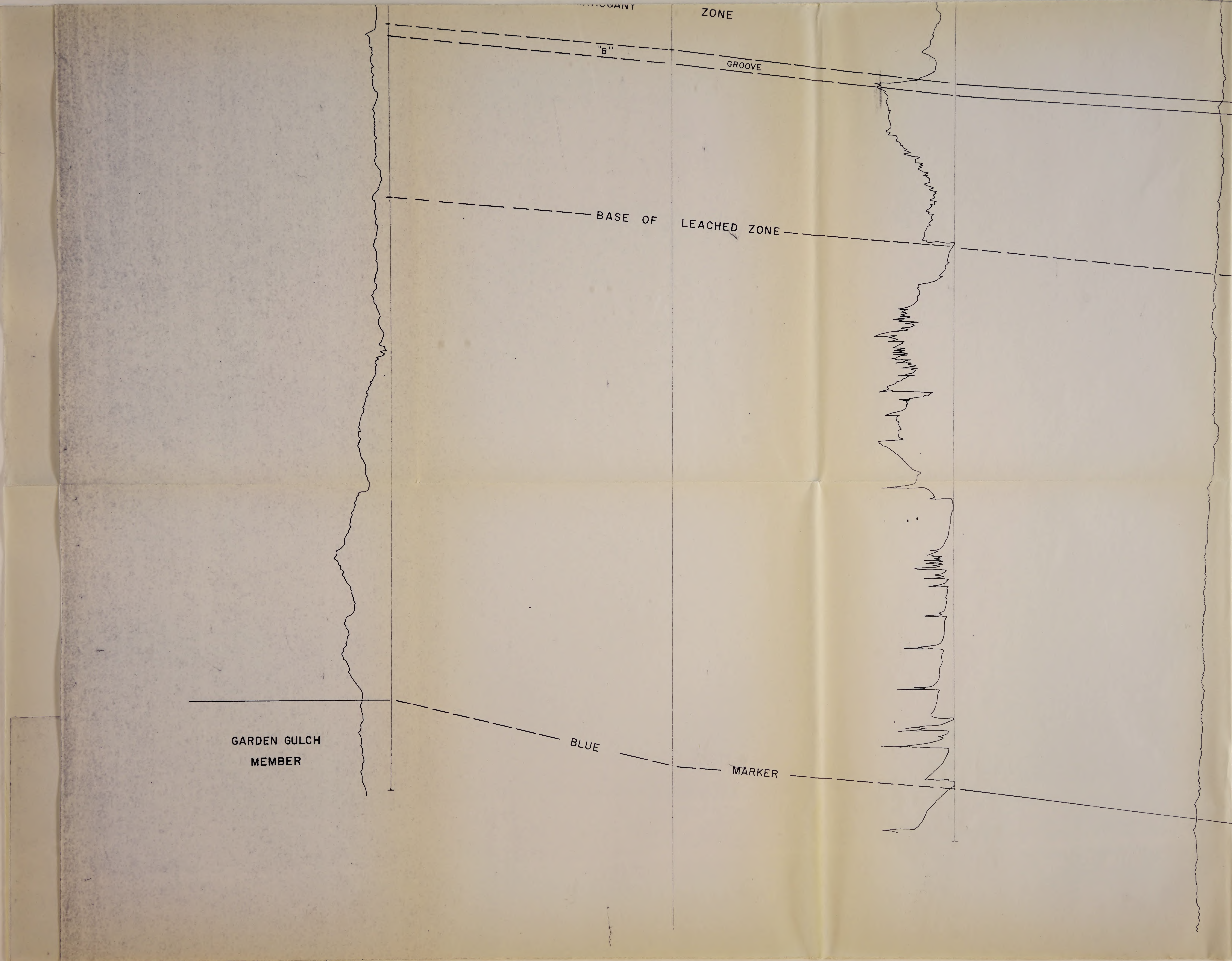

SKYLINE No 2
Sinclair Petroleum
LOCATION 620' FNL, 790' FEL,
Sec. 11, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH 2,549'
TRACT-I No. 23x-1
Shell et al
LOCATION 2,260' FNL, 2,610 FEL,
Sec 1, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH ?
USBM-01
U S Bureau of Mines
LOCATION SW 1/4, SE 1/4,
Sec 31, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,254' (GL)
TOTAL DEPTH 2,382'
SATERDAL
Pan American
LOCATION
ALTITUDE
TOTAL DEPTH
A
6000'
Elevation
UINTA
FORMATION
UINTA FORMATION
PARACHUTE CREEK MEMBER
GREEN RIVER
FORMATION
(PARACHUTE
CREEK MEMBER)
"A" GROOVE

SELF POTENTIAL

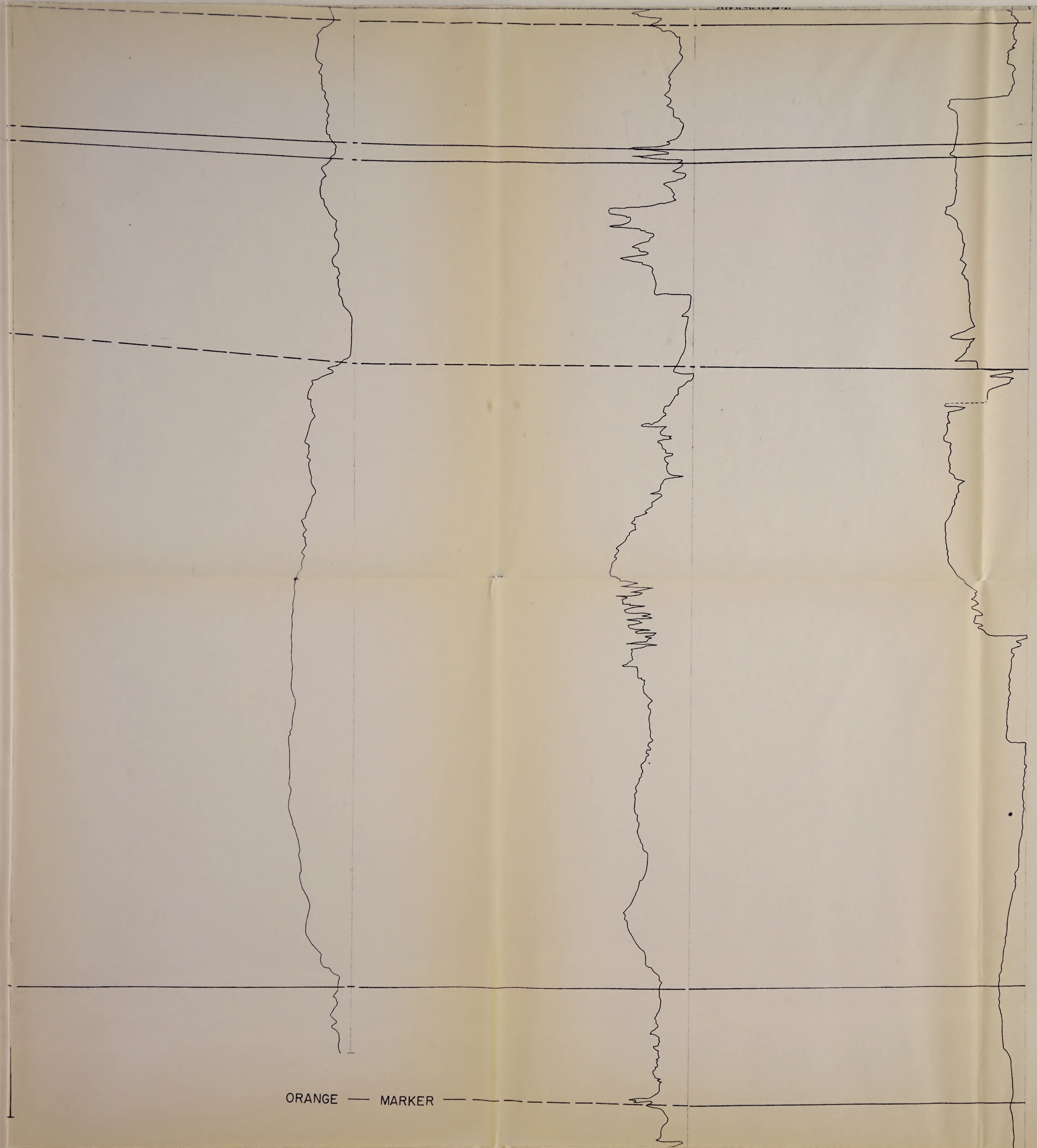
SECTION A–A'
THROUGH PILOT HOLE "X"

Figure 7





ZONE
"B"
GROOVE
BASE OF LEACHED ZONE
GARDEN GULCH
MEMBER
BLUE
MARKER


ORANGE — MARKER


S 76029

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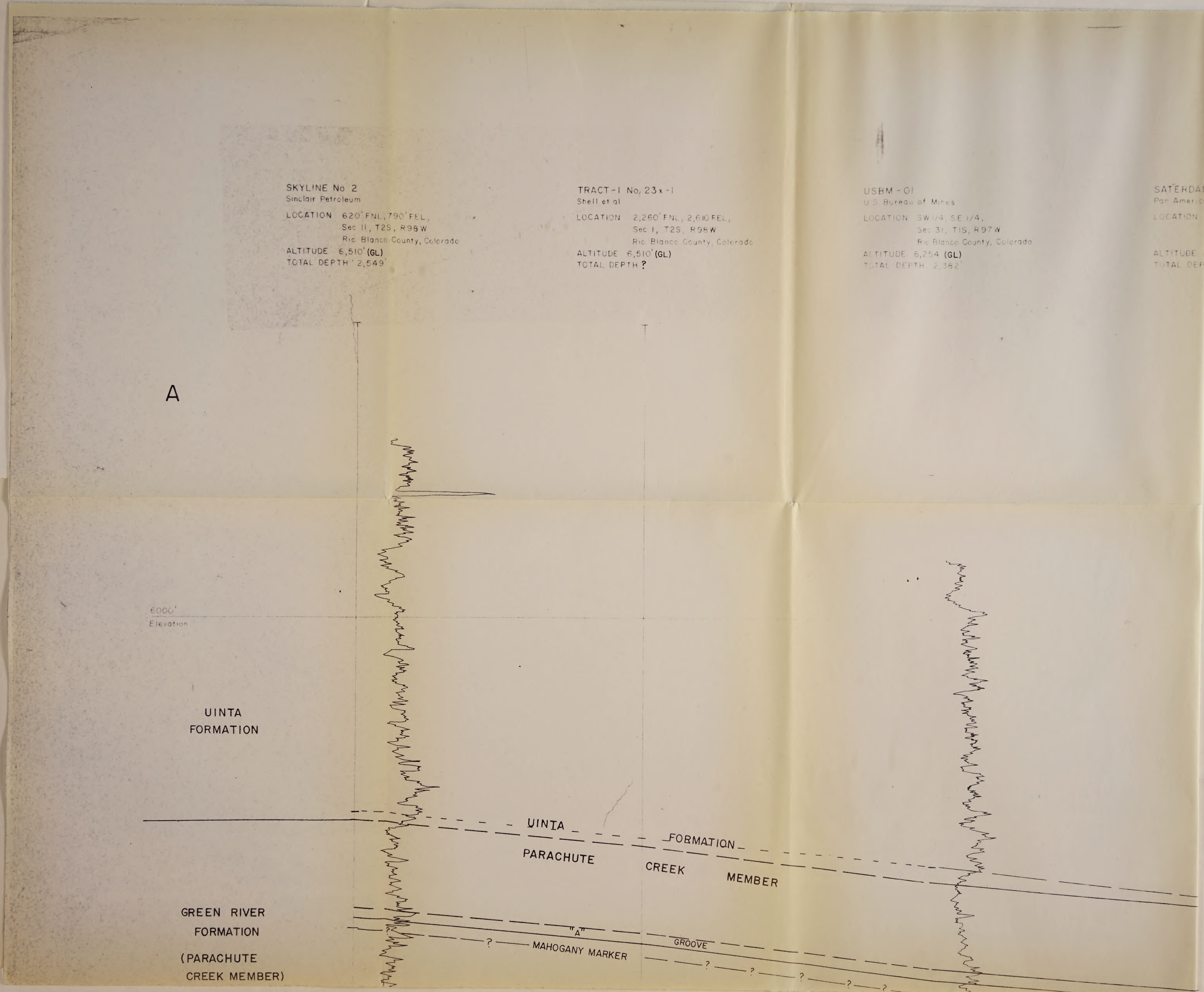
December 1976

Figure 8

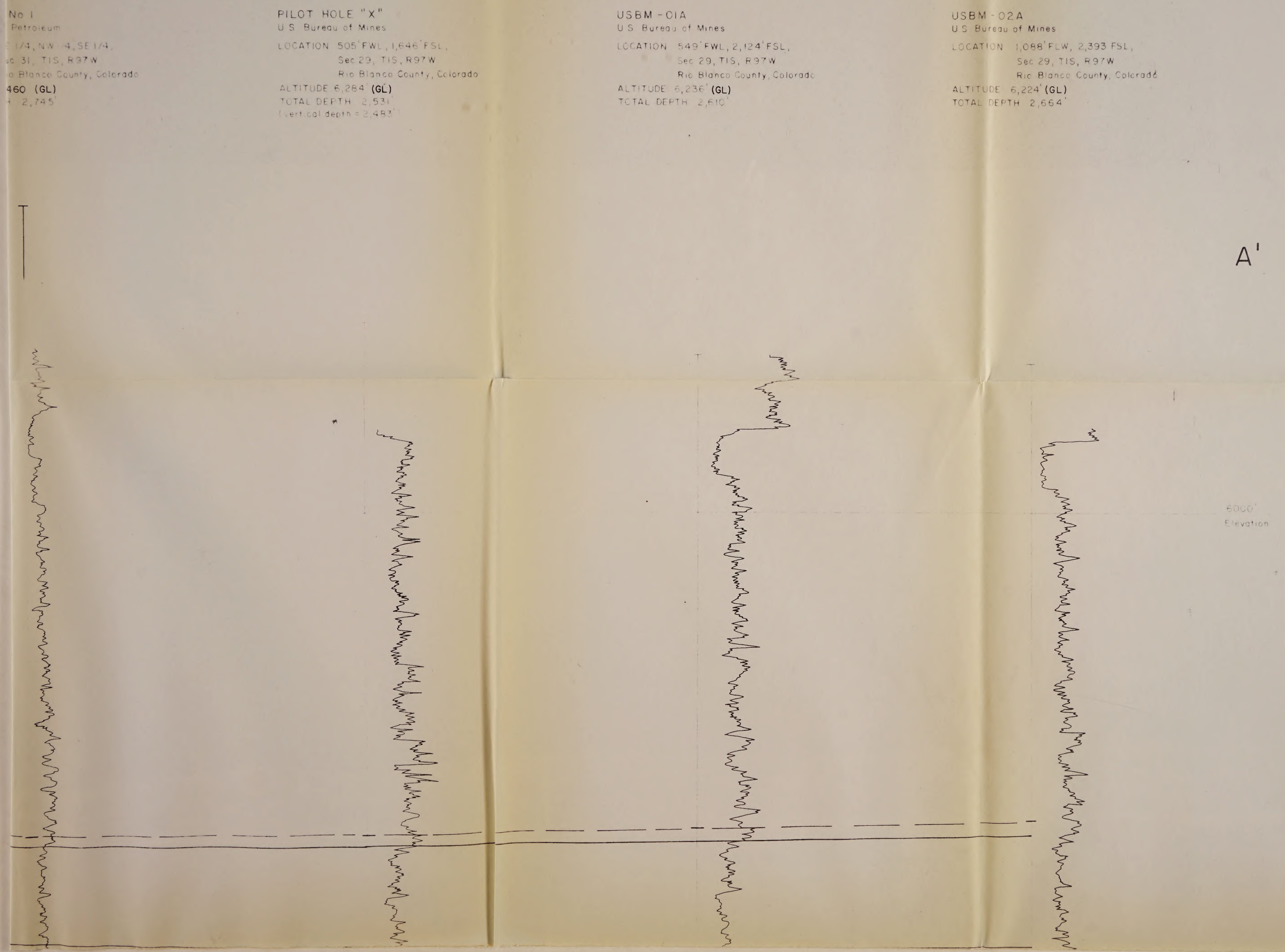


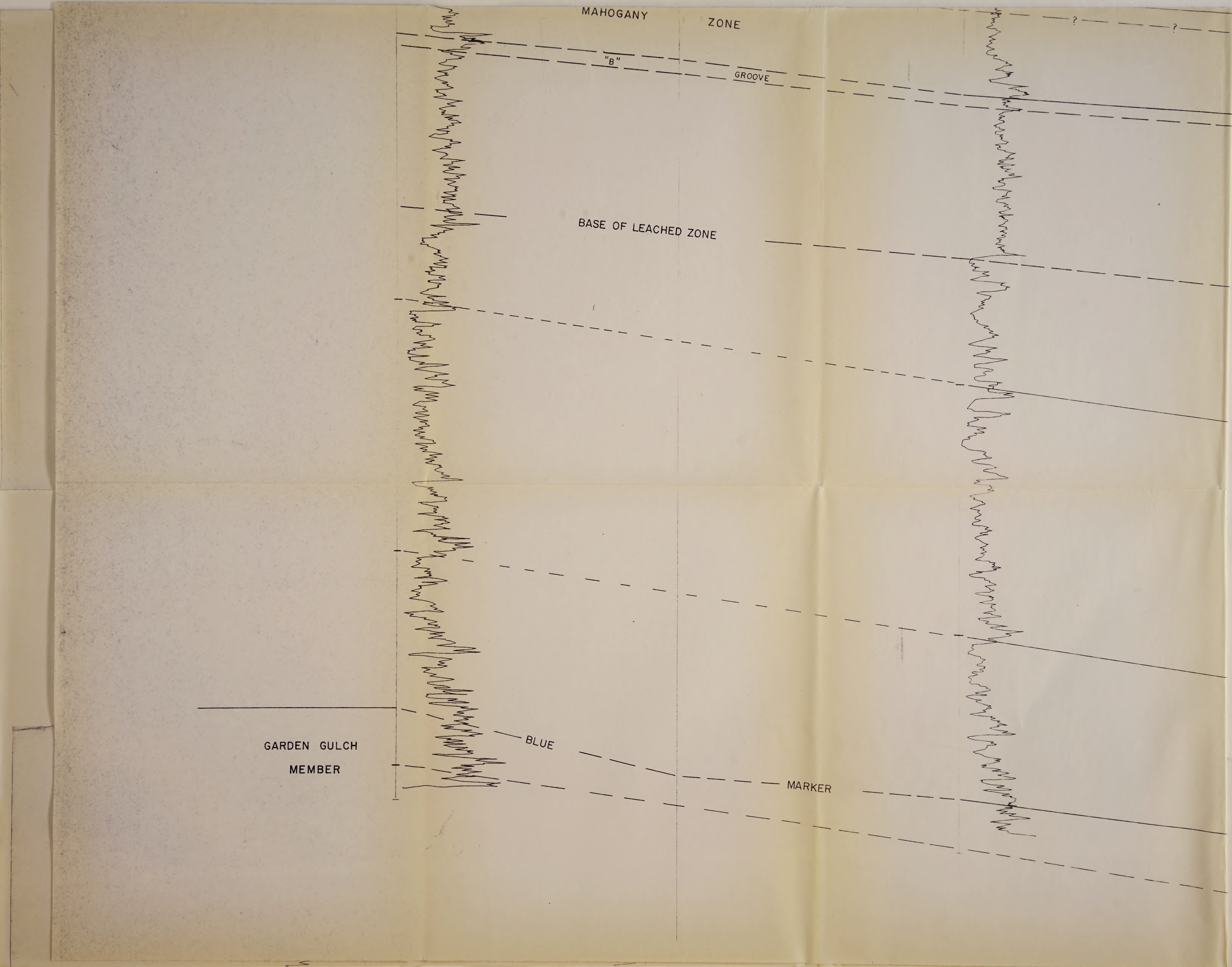
SKYLINE No 2
Sinclair Petroleum
LOCATION 620' FNL, 790' FEL,
Sec 11, T2S, R98 W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH 2,549'
TRACT-1 No. 23x-1
Shell et al
LOCATION 2,260' FNL, 2,610 FEL,
Sec 1, T2S, R98 W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH ?
USBM-01
U.S. Bureau of Mines
LOCATION SW 1/4, SE 1/4,
Sec 31, T1S, R97 W
Rio Blanco County, Colorado
ALTITUDE 6,254 (GL)
TOTAL DEPTH 2,382'
SATERDAL
Pan America
LOCATION
ALTITUDE 6
TOTAL DEPT
A
6000'
Elevation
UINTA
FORMATION
UINTA FORMATION
PARACHUTE CREEK MEMBER
GREEN RIVER
FORMATION
(PARACHUTE
CREEK MEMBER)
"A"
GROOVE
MAHOGANY MARKER

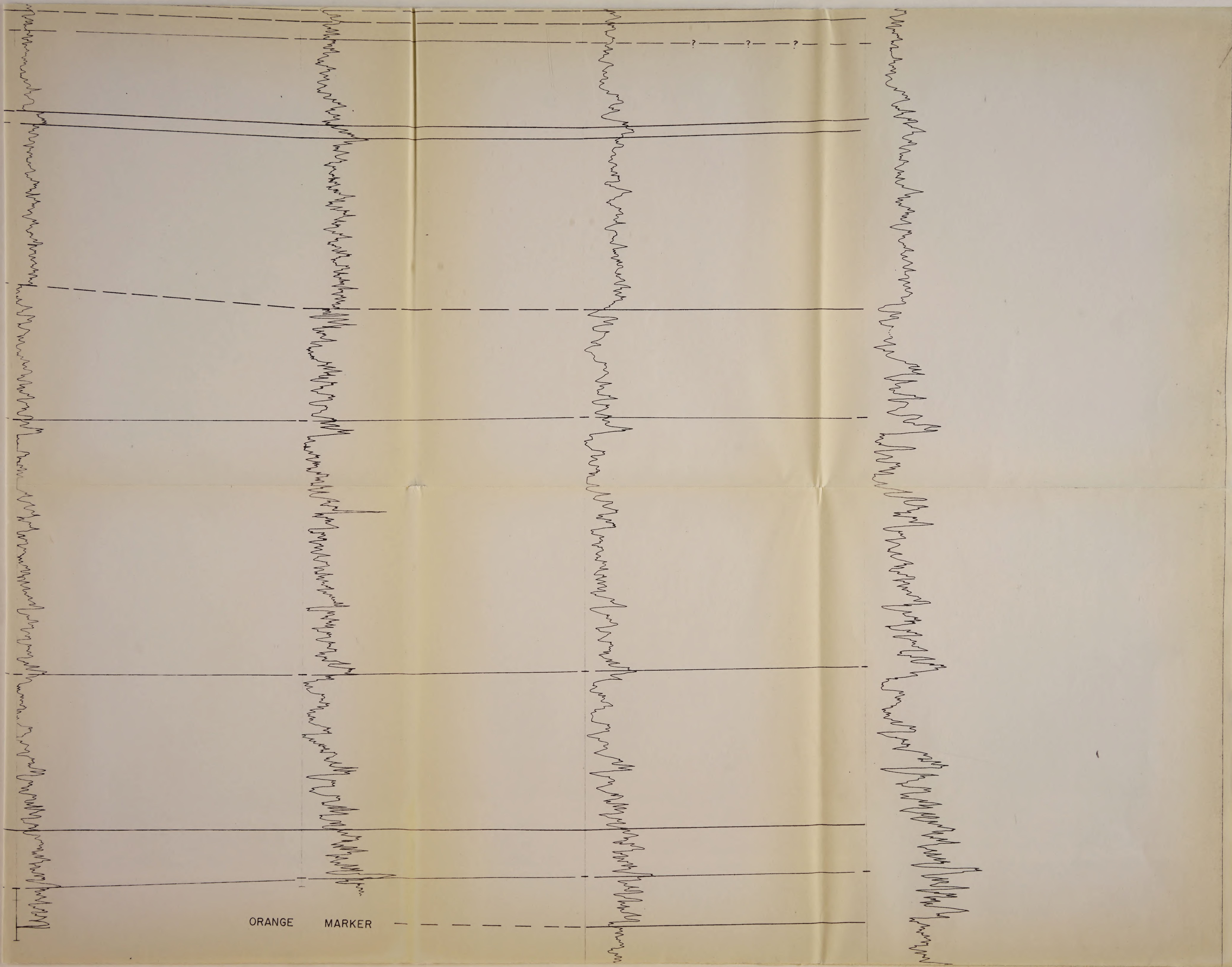
Figure 8

NATURAL GAMMA

SECTION A-A' THROUGH PILOT HOLE "X"




MAHOGANY ZONE
"B" GROOVE
BASE OF LEACHED ZONE
GARDEN GULCH MEMBER
BLUE MARKER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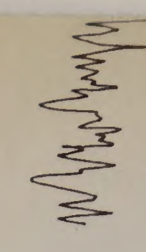

EXPLANATION

— ———— — — Natural Gamma Marker

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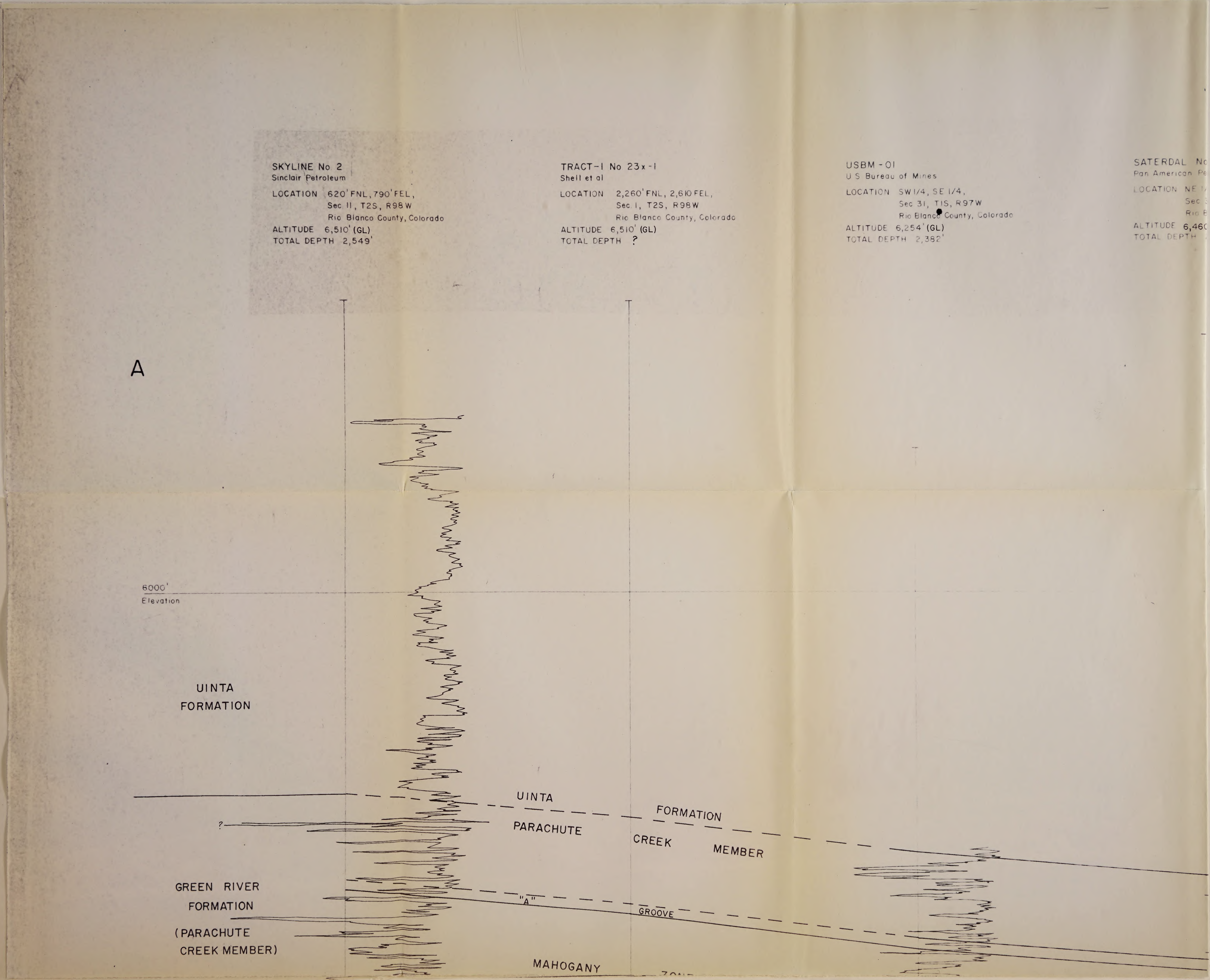
December 1976

Figure 9

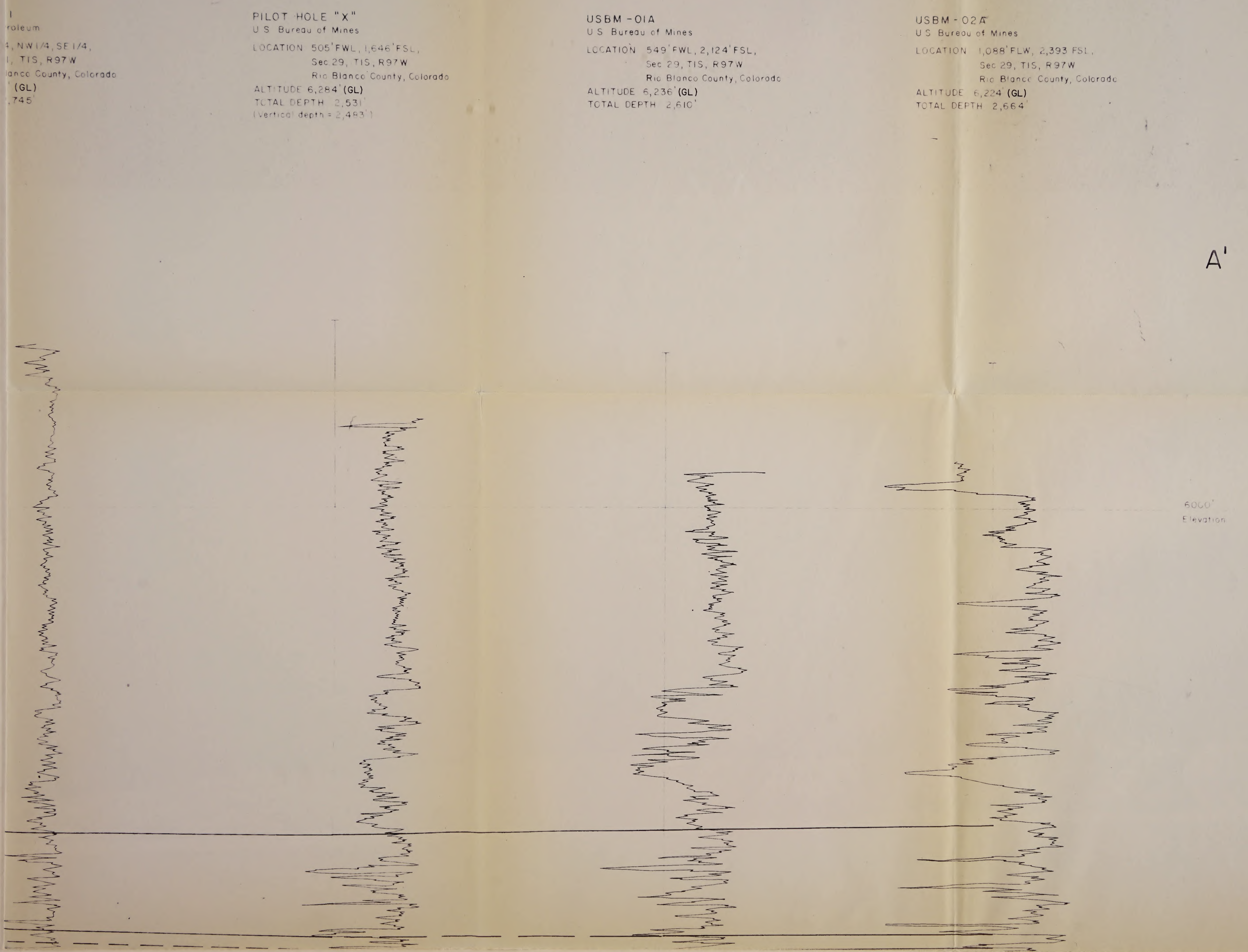


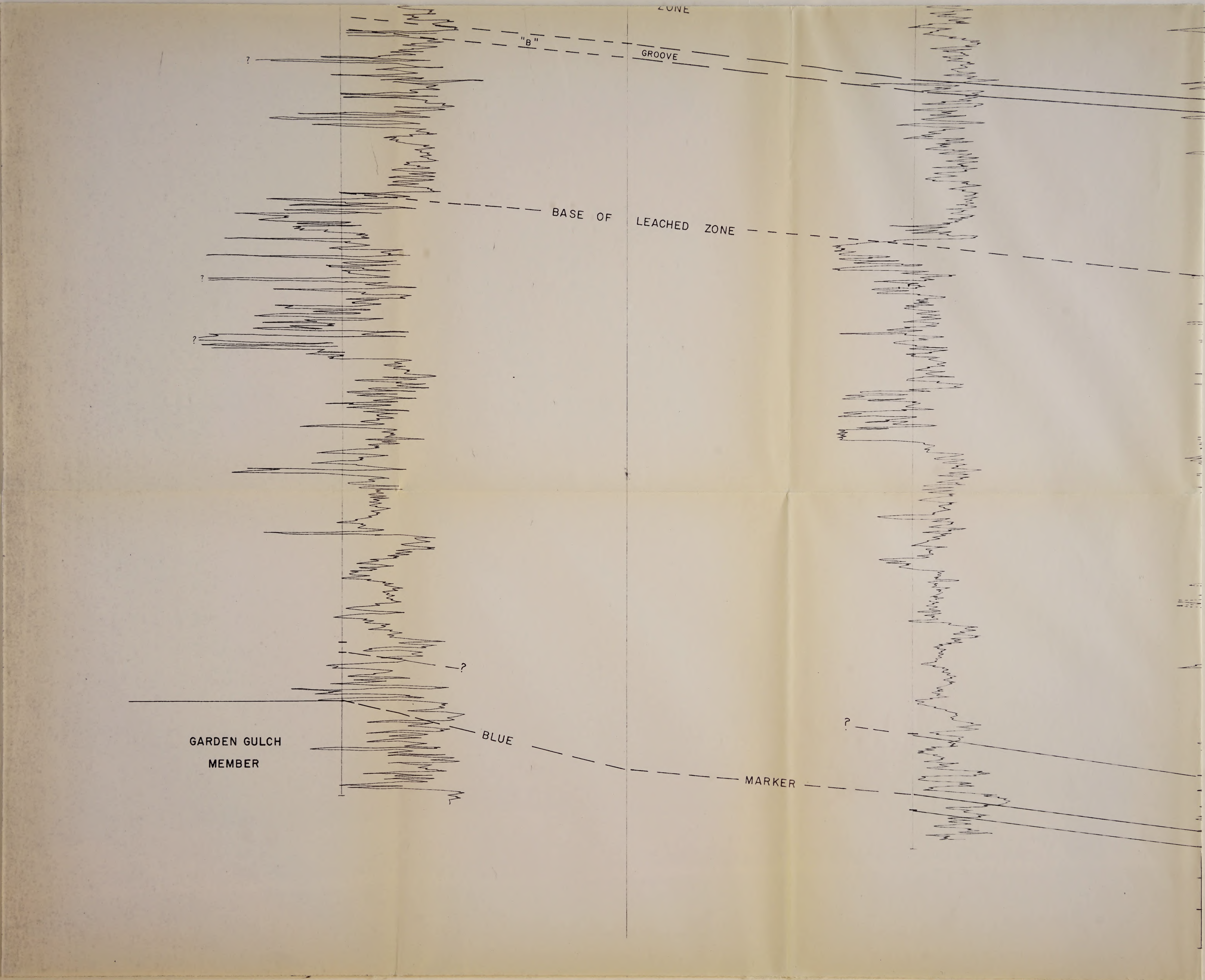
A
SKYLINE No 2
Sinclair Petroleum
LOCATION 620' FNL, 790' FEL,
Sec 11, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH 2,549'
TRACT-I No 23x-1
Shell et al
LOCATION 2,260' FNL, 2,610 FEL,
Sec 1, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH ?
USBM - 01
U S Bureau of Mines
LOCATION SW 1/4, SE 1/4,
Sec 31, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,254' (GL)
TOTAL DEPTH 2,382'
SATERDAL
Pan American
LOCATION
ALTITUDE
TOTAL DEPTH
6000'
Elevation
UINTA
FORMATION
UINTA
FORMATION
PARACHUTE
CREEK
MEMBER
GREEN RIVER
FORMATION
(PARACHUTE
CREEK MEMBER)
"A"
GROOVE
MAHOGANY

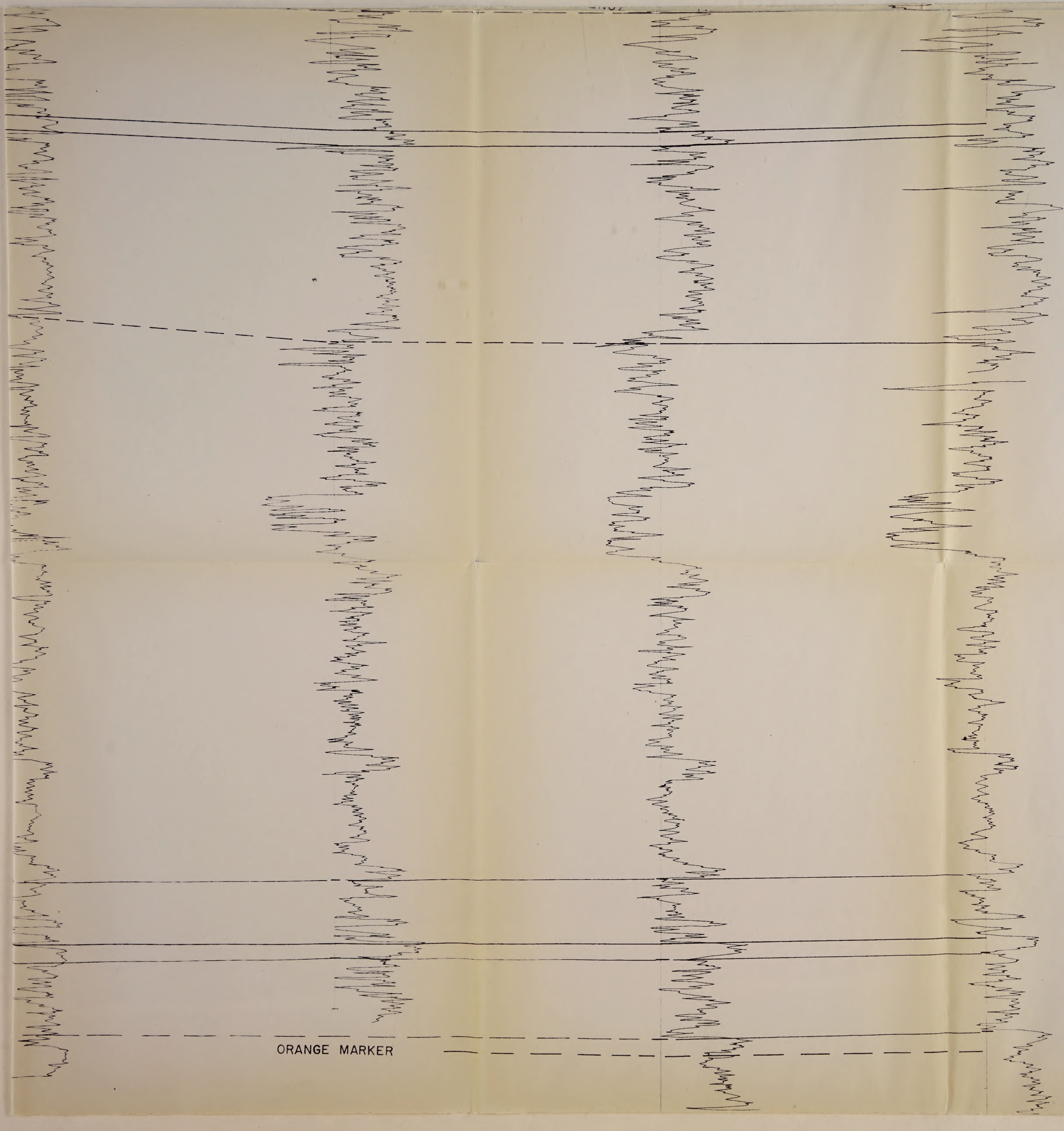
Figure 9

BULK DENSITY

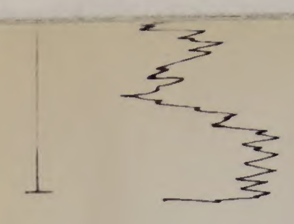
SECTION A-A'
THROUGH PILOT HOLE "X"




ZONE
"B"
GROOVE
BASE OF LEACHED ZONE
BLUE
MARKER
GARDEN GULCH
MEMBER


ORANGE MARKER

S-75029



EXPLANATION

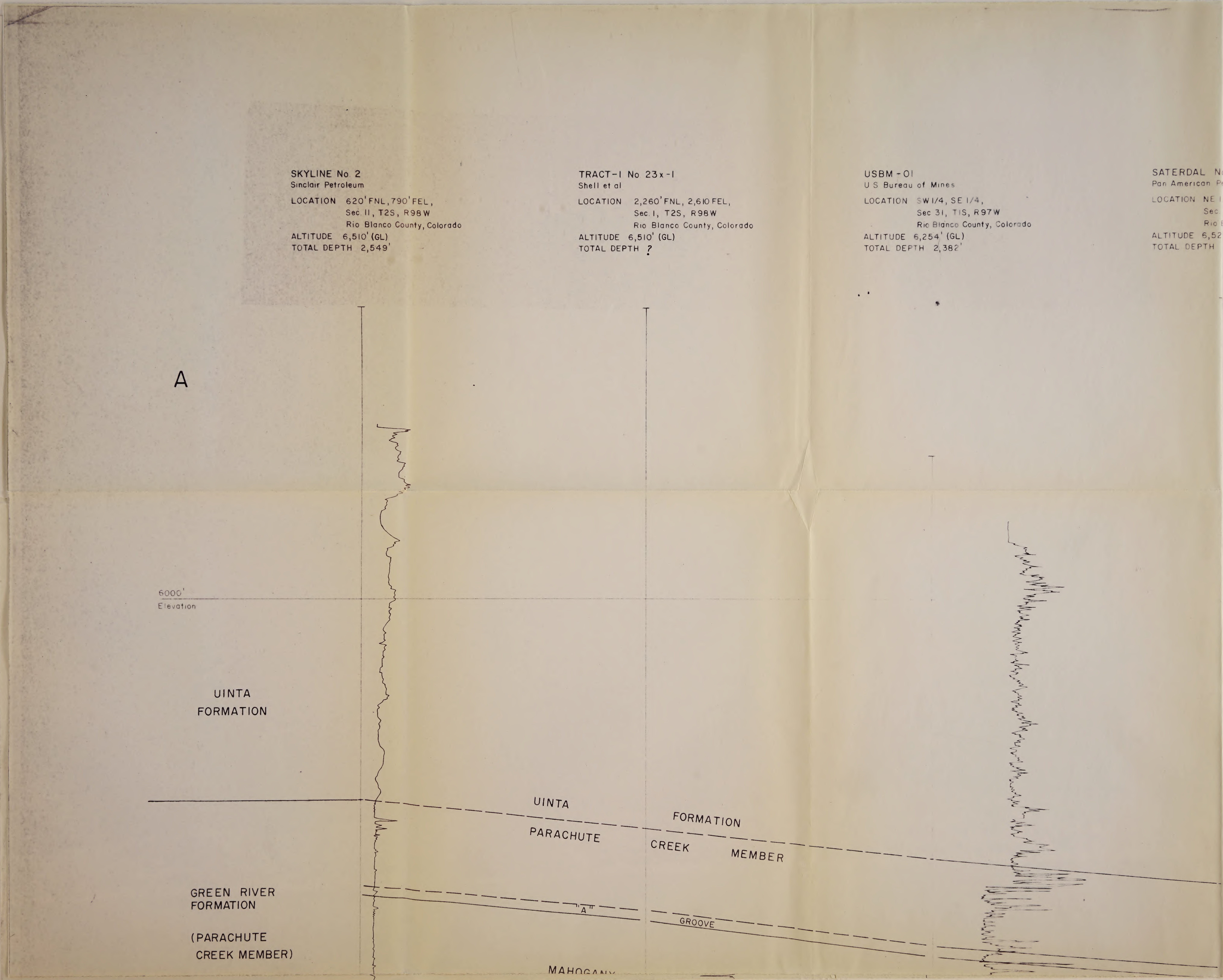
——— — — Bulk Density Marker

Golder Associates

December 1976

50

Figure 10



SKYLINE No. 2
Sinclair Petroleum
LOCATION 620' FNL, 790' FEL,
Sec. 11, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH 2,549'
TRACT-1 No 23x-1
Shell et al
LOCATION 2,260' FNL, 2,610 FEL,
Sec. 1, T2S, R98W
Rio Blanco County, Colorado
ALTITUDE 6,510' (GL)
TOTAL DEPTH ?
USBM-01
U S Bureau of Mines
LOCATION SW 1/4, SE 1/4,
Sec 31, T1S, R97W
Rio Blanco County, Colorado
ALTITUDE 6,254' (GL)
TOTAL DEPTH 2,382'
SATERDAL N
Pan American P
LOCATION NE
Sec
Rio
ALTITUDE 6,52
TOTAL DEPTH
A
6000'
Elevation
UINTA
FORMATION
UINTA
FORMATION
PARACHUTE
CREEK
MEMBER
GREEN RIVER
FORMATION
(PARACHUTE
CREEK MEMBER)
"A"
GROOVE

Figure 10

CALIPER

SECTION A-A' THROUGH PILOT HOLE "X"

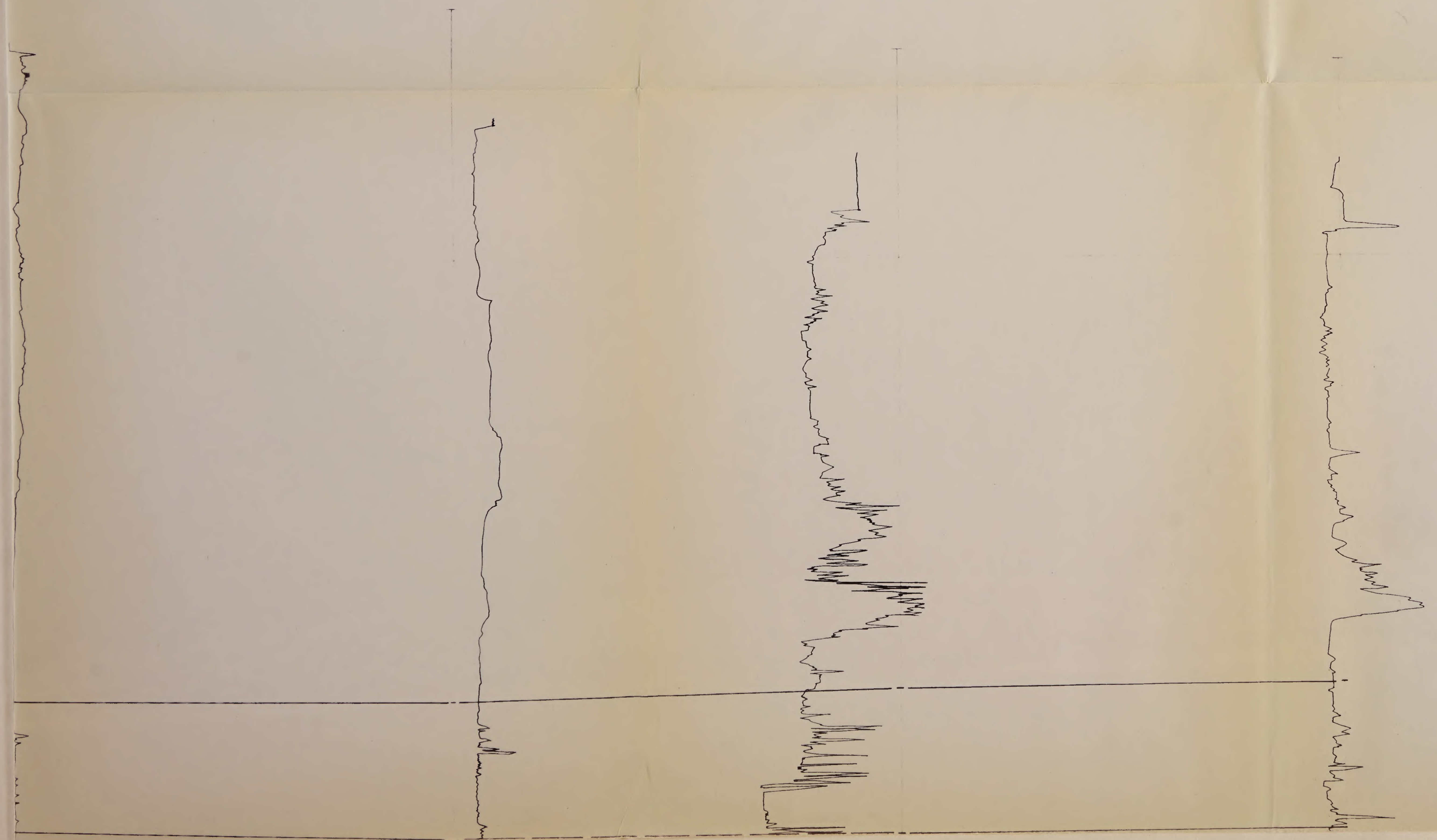
I
troleum
4, NW1/4, SE1/4,
31, TIS, R97W
lanco County, Colorado
5' (GL)
2,745'

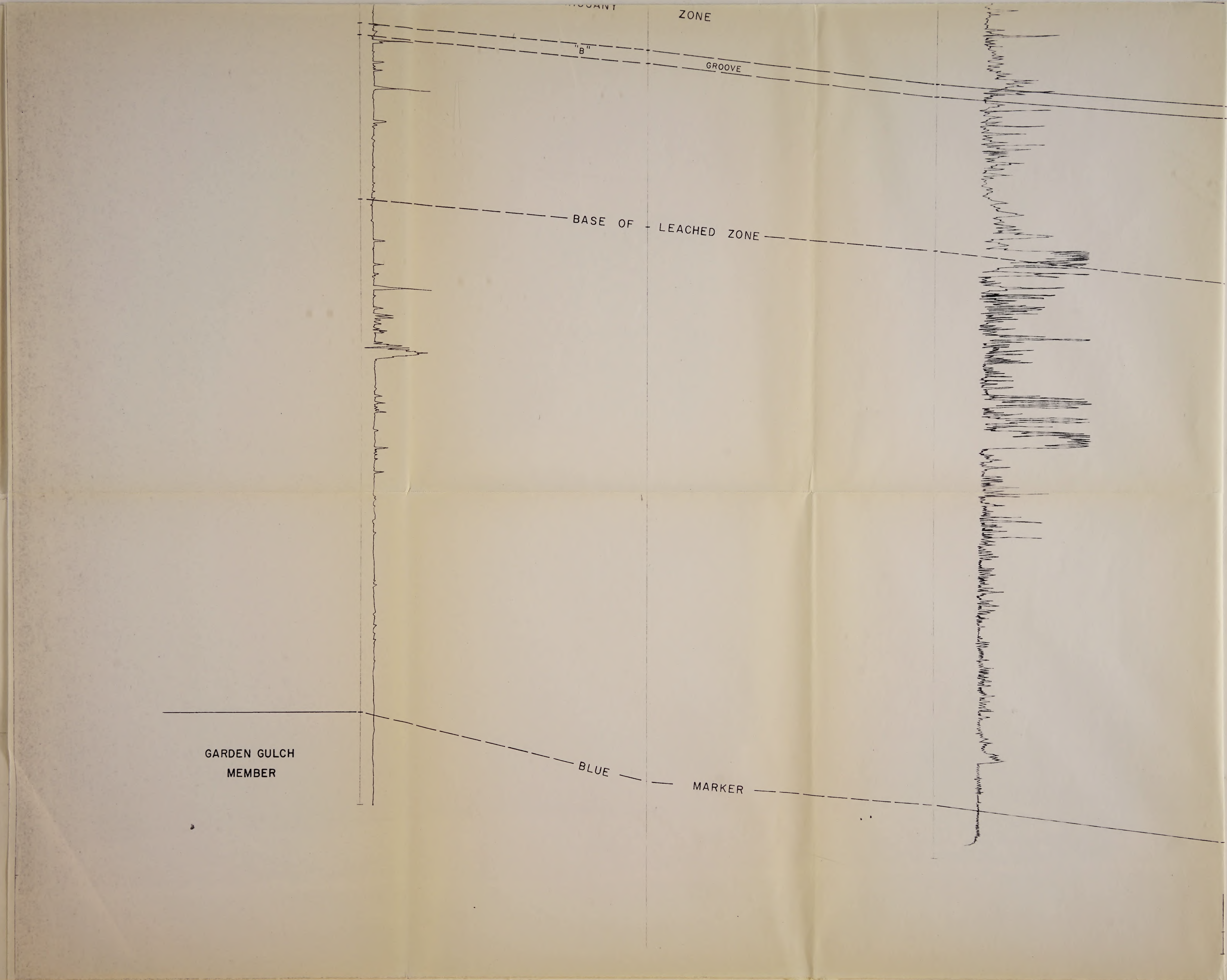
PILOT HOLE "X"
U S Bureau of Mines
LOCATION 505' FWL, 1,646' FSL,
Sec 29, TIS, R97W
Rio Blanco County, Colorado
ALTITUDE 6,284' (GL)
TOTAL DEPTH 2,531'
(Vertical depth = 2,483')

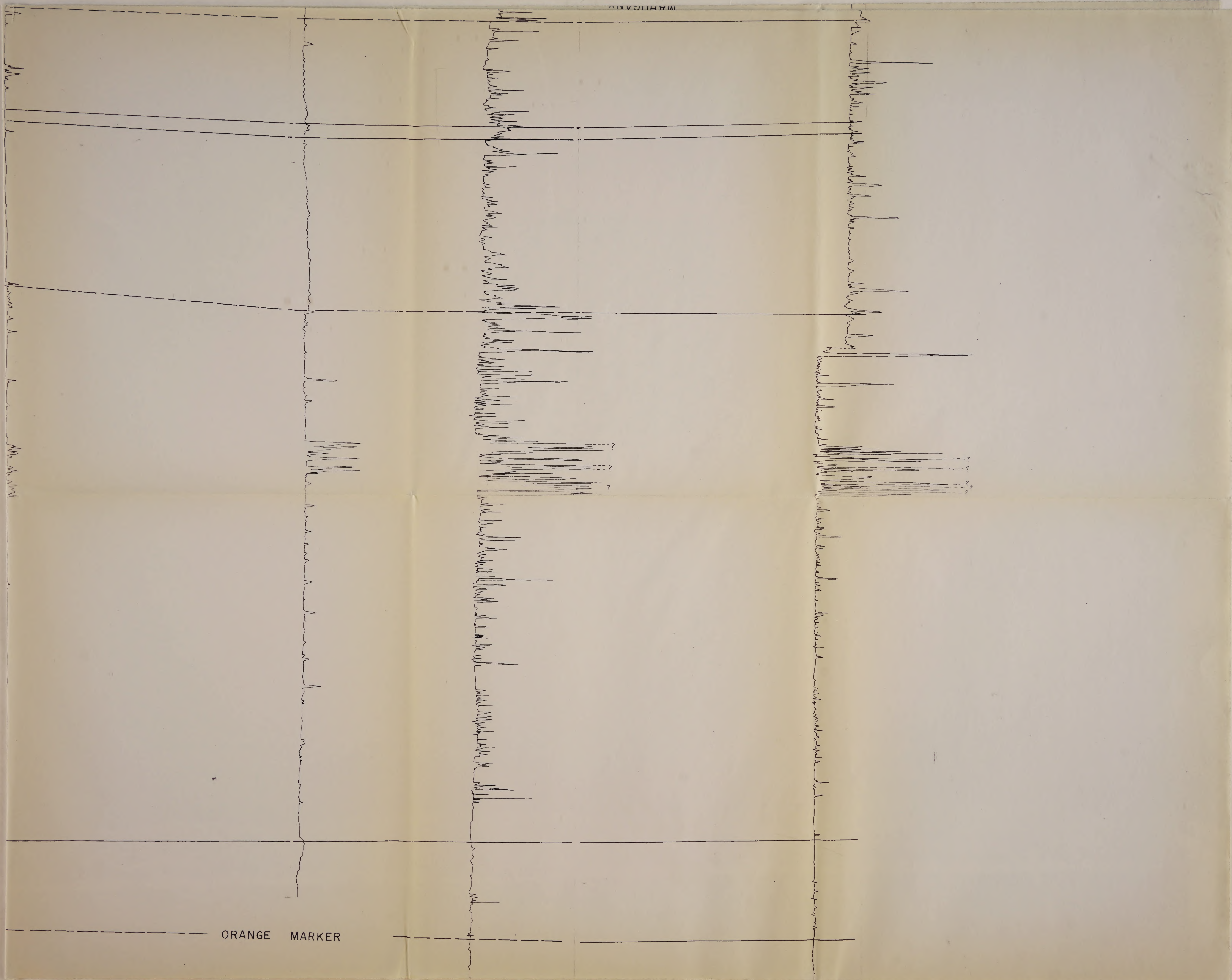
USBM-01A
U S Bureau of Mines
LOCATION 549' FWL, 2,124' FSL,
Sec 29, TIS, R97W
Rio Blanco County, Colorado
ALTITUDE 6,236' (GL)
TOTAL DEPTH 2,610'

USBM-02A
U S Bureau of Mines
LOCATION 1,088' FLW, 2,393 FSL,
Sec 29, TIS, R97W
Rio Blanco County, Colorado
ALTITUDE 6,224' (GL)
TOTAL DEPTH 2,664'

A'




ZONE
"B"
GROOVE
BASE OF LEACHED ZONE
GARDEN GULCH
MEMBER
BLUE MARKER


ORANGE MARKER

Golder Associates

December 1976