

MULTIELEMENT GEOCHEMICAL EXPLORATION DATA FOR THE
COVE FORT-SULPHURDALE KNOWN GEOTHERMAL RESOURCE AREA
BEAVER AND MILLARD COUNTIES, UTAH

by

Robert W. Bamford

and

Odin D. Christensen

Date Released - September, 1979

Earth Science Laboratory
University of Utah Research Institute
420 Chipeta Way, Suite 120
Salt Lake City, Utah 84108

Prepared for
THE DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY
UNDER CONTRACT NO. DE-AC07-78ET28392

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PCY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

CONTENTS

	<u>Page</u>
ABSTRACT	1
INTRODUCTION	2
METHODS	3
Sample Preparation	5
Chemical Analyses	5
Data Presentation	6
Data Interpretation	8
DISCUSSION OF RESULTS	9
Paleohydrothermal Events	9
Geothermal Targets	10
Comparison with Temperature Gradient and Earthquake Data	14
CONCLUSIONS AND RECOMMENDATIONS	15
ACKNOWLEDGEMENTS	16
REFERENCES	17
Distribution List	

ILLUSTRATIONS

Figure

- 1 Generalized geology, alteration, and drill hole locations, Cove Fort-Sulphurdale KGRA, Beaver and Millard Counties, Utah
- 2A Arsenic in +3.3 less magnetics, 0-100 ft. sample depth
- 2B Arsenic in +3.3 less magnetics, 100-200 ft. sample depth
- 3A Arsenic in whole rock sample, 0-100 ft. sample depth
- 3B Arsenic in whole rock sample, 100-200 ft. sample depth
- 4A Mercury in whole rock sample, 0-100 ft. sample depth
- 4B Mercury in whole rock sample, 100-200 ft. sample depth
- 5A Lead in +3.3 less magnetics, 0-100 ft. sample depth
- 5B Lead in +3.3 less magnetics, 100-200 ft. sample depth
- 6A Lead in whole rock sample, 0-100 ft. sample depth
- 6B Lead in whole rock sample, 100-200 ft. sample depth
- 7A Zinc in +3.3 less magnetics, 0-100 ft. sample depth
- 7B Zinc in +3.3 less magnetics, 100-200 ft. sample depth
- 8A Zinc in whole rock sample, 0-100 ft. sample depth
- 8B Zinc in whole rock sample, 100-200 ft. sample depth
- 9A $1000 \text{ As}/(\text{Pb}+\text{Zn})$ in +3.3 less magnetics, 0-100 ft. sample depth
- 9B $1000 \text{ As}/(\text{Pb}+\text{Zn})$ in +3.3 less magnetics, 100-200 ft. sample depth
- 10A $1000 \text{ As}/(\text{Pb}+\text{Zn})$ in whole rock sample, 0-100 ft. sample depth
- 10B $1000 \text{ As}/(\text{Pb}+\text{Zn})$ in whole rock sample, 100-200 ft. sample depth
- 11A $1000 (\text{As}+.1 \text{ Hg})/(\text{Pb}+\text{Zn})$ in whole rock sample, 0-100 ft. sample depth
- 11B $1000 (\text{As}+.1 \text{ Hg})/(\text{Pb}+\text{Zn})$ in whole rock sample, 100-200 ft. sample depth

Figure

- 12A Wt. % +3.3 less magnetics in rock, 0-100 ft. sample depth
- 12B Wt. % +3.3 less magnetics in rock, 100-200 ft. sample depth
- 13A Wt. % magnetite in rock, 0-100 ft. sample depth
- 13B Wt. % magnetite in rock, 100-200 ft. sample depth
- 14 Temperature gradient map: Cove Fort-Sulphurdale KGRA,
Beaver and Millard Counties, Utah

TABLES

Table

- 1 Estimated threshold values for Cove Fort-Sulphurdale geochemical data
- 2 Summary of pertinent drill hole sample data
- 3 Surface sample whole rock geochemical data

ABSTRACT

Multielement geochemical exploration data have been acquired for the Cove Fort-Sulphurdale Known Geothermal Resource Area (KGRA). This was accomplished by analysis of both whole rock and +3.3 specific gravity concentrate samples from cuttings composites collected from shallow rotary drill holes. Areal distributions are reported for arsenic, mercury, lead and zinc. These are elements indicated by previous studies to be broadly zoned around thermal centers in geothermal systems and thus to be useful for selecting and prioritizing drilling targets.

Results from this work suggest that reservoir temperature and/or reservoir to surface permeability, and thus possibly overall potential for a geothermal resource, increase northward beneath the approximately 18 square mile area containing shallow drill holes, possibly to beyond the northern limits of the area. The data provide a basis for development of three principal target models for the geothermal system but do not permit prioritization of these models. It is recommended that geochemical, geological, and temperature gradient surveys be expanded northward from the present survey area to more fully define the area which appears to have the best resource potential and to aid prioritization of the target models.

INTRODUCTION

A multielement geochemical survey has been completed for the Cove Fort-Sulphurdale Known Geothermal Resource Area (KGRA) (Fig. 1) to aid ongoing geothermal exploration which is partially funded by the Department of Energy, Division of Geothermal Energy, through its Industry Coupled Program. The work constitutes an initial exploration application of geothermal system geochemical zoning models based on extensive three-dimensional data for the Roosevelt Hot Springs, Utah, hot-water system and less extensive well data for the Geysers, California, vapor-dominated system (for example, Bamford, 1978).

The geologic configuration of the Cove Fort-Sulphurdale area contrasts with settings of the previously studied Roosevelt and Geysers systems. Over much of the Cove Fort-Sulphurdale area, the water table is depressed to approximately 400 meters (Union Oil Co, 1978a) and, consequently, principal surface manifestations reflect the effects of degassing and boiling at depth. Hydrogen sulfide gas is presently evolving from some of the altered areas near Cove Fort and from the central portions of the Sulphurdale deposit. Release of hydrogen sulfide from the geothermal fluids followed by oxidation, formation of sulfuric acid, and downward leaching has been considered as an explanation for the intensely leached alteration assemblages observed near the surface (Moore and Samberg, 1979). The geologic structure of the central part of the Cove Fort-Sulphurdale area is characterized by low-angle faults and gravitational glide blocks which form an impermeable cap over the geothermal system. These faults separate a nearly isothermal lower portion of the reservoir from an upper zone characterized by a steep thermal gradient. This steep thermal gradient may in part reflect influx of cold meteoric waters into

the upper block (Moore and Samberg, 1979). Although existence of a hot-water system has been confirmed by deep drilling, surficial features common to such systems, such as hot springs and deposits of siliceous and calcareous sinter, are not present. Near-surface characteristics of the Cove Fort-Sulphurdale field are thus similar to a vapor-dominated system, necessitating that interpretation of geochemical survey results be based on models for both hot-water and vapor-dominated geothermal systems.

Geochemical data were acquired mainly through the expediency of analyzing available cuttings samples from shallow temperature gradient holes drilled by Union Oil Co. (Union Oil Co., 1978b). This approach, though limited somewhat by a lack of specific survey and sampling design, has been previously shown to be a reasonable means of quickly obtaining useful initial geochemical information for a large area within a limited time frame and at an acceptable cost (Bamford, 1978). Spatial distribution of sampled gradient holes was adequate within the Cove Fort area for purposes of the survey, and sampling of most of the holes had been done with sufficient frequency that sample bias, if any, could be corrected by compositing. Both conventional whole rock and enhanced geochemical data were acquired for the drill cuttings samples. A few surface rock chip samples were also collected and analyzed in this work to complement drill hole sample results.

METHODS

Enhancement of hydrothermal geochemical signatures relative to those of original rock has been accomplished through separation and analysis of a nonmagnetic +3.3 specific gravity heavy liquid concentrate fraction from

original whole rock drill chip composite samples. In this manner rock-forming and alteration silicates, largely barren of hydrothermally derived trace elements, are mostly removed to leave samples which contain a large proportion of hydrothermal oxides and sulfides and thus are relatively and systematically enriched in the trace elements of interest. The +3.3 sample fraction has additional qualities of being readily reproduced and relatively inexpensive (Bamford, 1978). It thus constitutes a practical sample type for routine exploration use.

In this survey, two sample types from a maximum of three depth intervals in each drill hole have been utilized (Table 2). Whole rock samples were analyzed as well as the +3.3 specific gravity concentrates to confirm the validity of the concentrate analyses and corroborate the location of geochemically anomalous areas. Both sample types were derived from 100-foot cuttings composites for the depth intervals 0-100, 100-200, or 200-300 feet, depending on total hole depth. Investigations to date have not indicated that any one shallow depth interval is invariably preferable to another; indeed, it is expected that differences probably exist between geothermal areas depending upon differences in the nature and depth extent of post-depositional element redistribution. Analysis of samples from more than one depth interval also provides useful corroboration of the existence of specific kinds of geochemical anomalies when, as in this survey, distance between discrete sample locations (drill holes) is relatively large. In this particular application, geochemical data from two depth intervals, 0-100 feet and 100-200 feet, are emphasized primarily because sample suites are most complete for these intervals.

As mentioned earlier, a few surface rock chip composite samples were also collected and analyzed in this work to provide a partial check on the drill hole sample results. Only whole rock material was analyzed for these samples (Table 3).

Sample Preparation

Drill cutting grab samples are washed (to remove drilling mud and exotic fines), crushed to -4 mesh, cleaned of iron drill bit and drill rod shavings with a hand magnet, and pulverized to -80 mesh. Composite samples are prepared, each containing 3 to 10 original samples and representing 100' of drilling interval. The practice of analyzing composite samples helps smooth potential random sampling variation of individual original grab samples and decreases the number of samples which must be prepared and analyzed to a practical total.

Twenty to eighty grams of each -80 mesh composite sample are used to prepare the +3.3 specific gravity heavy liquid (methylene iodide) fraction. The -3.3 specific gravity fraction is discarded. A magnetic fraction, consisting mostly of magnetite with minor residual iron shavings, is separated from the +3.3 specific gravity fraction using a hand magnet. All sample fractions are weighed and then examined under a binocular microscope to determine their approximate mineralogic composition.

Chemical Analysis

The original whole rock sample and the +3.3 specific gravity less magnetics fraction from each composite have been routinely analyzed for 38 and 37 major, minor, and trace elements, respectively. Na, K, Ca, Mg, Fe, Al, Si,

Ti, P, Sr, Ba, V, Cr, Mn, Co, Ni, Cu, Mo, Pb, Zn, Cd, Ag, Au, As, Sb, Bi, Se, Te, Sn, W, Li, Be, B, Zr, La, Ce, and Th were determined by means of the ESL Inductively Coupled Argon Plasma Spectrometer (ICPQ). The ICPQ is an Applied Research Laboratories Model 137 with a 1080 line/mm grating and dedicated computer operating system. Quadratic calibration and matrix interference corrections and background subtraction of digestion blanks are performed automatically by the computer software system.

Arsenic in whole rock samples and in selected +3.3 check samples was determined using a colorimetric method. Mercury was determined on whole rock samples only using a Model 301 Gold Film Mercury Detector (Jerome Instrument Corp., Jerome, Arizona).

Data Presentation

Limits of quantitative detection (LQD), representing lowest meaningful analytical values for the elements presented, are: arsenic (+3.3, ICPQ) 16 ppm, arsenic (+3.3 colorimetric) 5 ppm, arsenic (whole rock, colorimetric) 1 ppm, lead (+3.3) 20 ppm, lead (whole rock) 10 ppm, zinc (+3.3) 2 ppm, zinc (whole rock) 1 ppm, and mercury (whole rock) 1 ppb. Analytical precision (95% confidence level) at the LQD is approximately $\pm 100\%$ and at five times the LQD is approximately $\pm 10\%$.

Data for the Cove Fort-Sulphurdale area are presented on computer-generated plan plots. The plots facilitate rapid evaluation of the inter-relationships between geochemical data, geological data, and geothermal phenomena. Because the data are limited to a maximum of 19 locations distributed irregularly over the area, plots have only been roughly hand-

contoured to show approximate data trends. Minimum contour values are lowest meaningful values determined by inspection. Each higher contour value is double that of the preceding lower value, thus helping assure that data variations delineated are real rather than the product of random sampling and analytical biases.

Interpretations presented in this report are based primarily on the data graphics. Only large consistent changes in geochemistry for both of the sample depth intervals evaluated and/or in both whole rock and +3.3 concentrate samples are interpreted as significant. No attempt is made to calculate mean background values or population statistics since the data are limited and do not necessarily incorporate a single background population. Threshold values have been conservatively estimated and are presented (Table 1) only to qualify the term "anomalous" as used later in the text. These values approximate arithmetic means of trace element data presented in Table 2. Their conservative nature as threshold values results from their estimation from the total data set which incorporates both a background population and at least one anomalous population of about equal size.

Concentrations of 38 elements were determined for each sample, although data presented in this report are limited to a few of these for reasons described below. The complete multielement data package and related information are available for open-file inspection at the Earth Science Laboratory of the University of Utah Research Institute in Salt Lake City, Utah.

Data Interpretation

The exploration significance of the multielement geochemical distributions is adequately established by geochemical models developed at Roosevelt Hot Springs, Utah, and The Geysers, California (Bamford, 1978; Bamford et al., in preparation). These models indicate that multielement geochemical zoning is developed at both a relatively small scale over hundreds of feet about individual fluid entries in geothermal wells and at a larger scale over thousands of feet both vertically and laterally about prominent thermal centers in geothermal systems. The consistent relationships that the models reveal between geothermal phenomena and multielement distributions suggest that this type of geochemistry may be one of the more reliable and cost-effective methods for defining geothermal drilling targets.

Elements and multielement parameters selected for presentation are limited to those which most clearly delineate geothermal resources at Roosevelt and The Geysers. The most important of these for *both* hot-water and vapor-dominated systems are arsenic and mercury. These elements tend to develop broad-scale surface anomalies, hereinafter referred to as central-zone anomalies, in permeable zones over the hottest or shallowest and sometimes most readily exploited parts of reservoirs, and also to form small-scale anomalies at or close to individual thermal fluid entries in geothermal wells (Bamford, 1978, and Bamford et al., in preparation). Depending on the nature and orientation of permeable zones connecting the surface and a reservoir and on the nature and amount of fluid flux, however, a finite amount of displacement of central-zone anomalies laterally away from a position directly over the hot spot can be expected. In hot-water systems, lead and zinc tend to

form anomalous concentrations peripheral to the hottest or shallowest parts of reservoirs and their associated central-zone mercury-arsenic anomalies (and to fluid entries in wells). This is similar to their zoning behavior in hydrothermal ore deposits and helps to further delimit prime target areas while increasing overall target size. Lead and zinc distributions in vapor-dominated systems are just beginning to be understood and may reflect both deposition from a precursor hot-water system as well as deposition (for lead only?) related to vapor transport. As a result, the multielement parameters $1000 \text{ As}/(\text{Pb}+\text{Zn})$ for +3.3 fraction samples and $1000 (\text{As}+0.1 \text{ Hg})/(\text{Pb}+\text{Zn})$ for whole rock samples are most specifically applicable to the mapping of central-zone anomalies over hot-water systems but are also likely to be similarly useful, although not optimum, for vapor-dominated systems. (Concentration units used in calculating these parameters are ppm for arsenic, lead, and zinc and ppb for Hg.)

DISCUSSION OF RESULTS

Paleohydrothermal Events

Two hydrothermal events are thought to have affected portions of the Cove Fort-Sulphurdale KGRA prior to the beginning of geothermal activity (Moore and Samberg, 1978), but do not appear to have produced geochemical signatures strong enough to confuse interpretation of the geothermal geochemistry. During the mid-Tertiary, propylitic alteration of volcanic rocks and limited development of pyrite and base metal mineralization accompanied intrusion of quartz monzonite and latite porphyry dikes and stocks. Subsequently, fluorite mineralization developed during a separate hydrothermal event which may also

significantly predate acid alteration and sulfur deposition in the currently active geothermal environment.

Although the possibility of contributions from these events to the hydrothermal geochemistry defined in this survey cannot be conclusively eliminated, several lines of evidence suggest that such contributions, if any, are small and that the critical geochemical patterns defined are related primarily to the geothermal activity. The evidence includes: 1) geochemical anomalies in diagnostic elements such as arsenic and mercury are equally well developed in both allogenic postmineral alluvium and premineral, mostly tuffaceous, country rock (Tables 2 and 3); 2) little or no geologic evidence of the base metal mineralizing event is observed at the surface in the survey area or in the drill cuttings from the temperature gradient holes; 3) geochemical patterns are internally consistent whether or not samples are from readily identifiable areas of geothermal activity (characterized by sulfur deposition and acid alteration) or from other adjacent sample sites (cf., Figure 1 and Figures 2A, B thru 11A, B); and 4) central-zone anomalies indicated by the geochemical data correspond approximately to apparent temperature gradient anomalies (see below).

Geothermal Targets

The most clearly defined central-zone geochemical anomaly lies in the north end of the sample area around drill holes 74-2, 74-3, and 74-4 and appears to be open to the north (cf., Figures 1; 9A, B; 10A, B; and 11A, B and Table 2). Prominent anomalies in arsenic and/or mercury are developed in both concentrate and whole rock samples from these holes (Figures 1; 2A, B thru 4A,

B and Table 2). As stated earlier (page 8), these elements are known to provide a direct or indirect indication of proximity to a thermal reservoir in both hot-water and vapor-dominated geothermal systems. Concentrations of lead and, to a lesser extent, zinc are low in these holes relative to peripheral areas (Figures 1; and 5A, B thru 8A, B and Table 2). Plots of the multi-element parameters $1000 \text{ As}/(\text{Pb}+\text{Zn})$ for +3.3 concentrate samples and $1000 (\text{As}+0.1 \text{ Hg})/(\text{Pb}+\text{Zn})$ for whole rock samples (Figures 9A, B; 10A, B; and 11A, B) which clearly define the main geothermal resource area in the Roosevelt Hot Springs KGRA (Bamford et al., in preparation) consistently delineate this northern target. Although lead and zinc anomalies display less systematic zoning with respect to arsenic and mercury than at Roosevelt (possibly due to combined effects of vapor phase geochemical overprinting, partial nongeothermal origin, and secondary dispersion), little if any ambiguity is introduced into interpretation of the data by inclusion of lead and zinc in the multielement parameter. Such ambiguity might be expected if the origins of the lead and zinc distributions were entirely nongeothermal and thus random with respect to the geothermal system. Data for surface whole rock chip composite samples (Table 3) are consistent with the drill hole results and thus further verify the anomaly patterns described.

A second, less well defined, central-zone geochemical anomaly is developed at the south end of the survey area, around drill holes 74-1, 74-13, 74-22, 77-3, and 77-4, and may extend beyond this area (cf., Figures 1; 9A, B; 10A, B; and 11A, B). Anomalies in arsenic or mercury occur in one or more samples from each of these holes, but are much less consistently developed and have less correspondence to one another than in the northern target area (Figures

2A, B thru 4A, B, and Table 2). Mercury anomalies are particularly less prominent in samples from this southern area (Figures 4A and B, and Table 2), possibly indicating less widespread present-day escape of thermal gases here compared to the northern anomalous area.

These results, interpreted in the context of geologic and exploration well data for the area (Moore and Samberg, 1979 and Union Oil Company, 1978a, b, c, and d), tentatively suggest three principal target models for the geothermal system. The targets are the inferred locations of the reservoir center(s) in the system. No one of the target models is clearly unique or superior to the others based on presently available information, and additional exploration data will be required to permit their prioritization.

Models 1 and 2 are closely related to one another and place the location of a single reservoir center near or beyond the north end of the survey area north and northeast of Cove Fort (Model 1) or one to two miles southeast of Cove Fort near or beneath the low permeability gravity glide blocks (Model 2). Both models derive from the recognition of central-zone geochemical anomalies both north and south of the relatively impermeable gravity glide blocks which cap the intervening part of the geothermal system and apparently prevent development of central-zone geochemical anomalies at the surface in that area. An assumption of reservoir continuity beneath the gravity glide blocks is implicit in these models and is to some extent supported by drilling results for Utah State Well 42-7, which encountered hot (+340°F) water and high fracture permeability under the glide blocks at about 400 meters depth. Placement of the single reservoir center towards the north end of the system

near Cove Fort is based on the development of a larger, stronger, and more coherent central-zone geochemical anomaly and of more wide-spread geothermal alteration in that area compared to the southern area around Sulphurdale. This configuration of the geochemistry and alteration suggests that the northern sector of the reservoir is probably larger and characterized by higher temperatures and/or more pervasively developed permeability which connects to the surface. Selection between models 1 and 2 is not possible without access to or acquisition of additional exploration data. Determination of the magnitude and dimensions of northern extensions of the central-zone geochemical anomaly beyond the northern limits of the present survey would be particularly helpful in this regard. Significant extension would tend to support Model 1, rapid closure of the anomaly would tend to support Model 2.

Model 3 places one of two separate reservoir centers at the north end of the survey area near Cove Fort and the second center in the south near Sulphurdale. It assumes that permeability beneath the gravity glide blocks is not continuous from south to north and therefore that the centers are isolated from one another. The greater areal extent and magnitude of the central-zone geochemical anomaly near Cove Fort may again be taken to suggest greater resource potential in the northern area, although this remains somewhat indeterminate due to lack of information on the northward extent of the northern central-zone anomaly. Determination of the relative validity of model 3 versus models 1 and 2, if warranted, would require that the existence of hydrologic and thermal continuity between the Cove Fort and Sulphurdale anomalies be established.

Comparison with Temperature Gradient and Earthquake Data

Available temperature gradient data for the Cove Fort-Sulphurdale KGRA are summarized in Figure 14. These data show that generally higher temperature gradients have been measured over a broad area at the north end of the area. Assuming that thermal conductivities are roughly similar throughout the area, these results might indicate that the most prominent heat flux anomaly detected occurs in the northern part of the survey area and that this anomaly is open to the north. If this interpretation is correct, the geochemical results and the temperature gradient data are essentially in agreement, with both methods suggesting that subsurface permeability and/or temperature, and thus possibly overall potential for a geothermal resource, are greatest at the northern end of the system near Cove Fort.

The most prominent characteristic of earthquake activity in the Cove Fort area is a large cluster of epicenters located approximately 3 km northeast of Cove Fort in a zone of high earthquake activity which extends northward a distance of about 10 km (Olsen and Smith, 1976). The authors of the earthquake study suggest that the earthquake cluster could be related to an active volcanic center. If so, this center may be the principal heat source for the geothermal system and its location supports the concept of greater geothermal resource potential in the north near Cove Fort.

CONCLUSIONS AND RECOMMENDATIONS

1. The geochemical results suggest that reservoir temperature and/or reservoir to surface permeability, and thus possibly overall potential for a geothermal resource, increase northward beneath the Cove Fort-Sulphurdale survey area, possibly to beyond the northern limits of the area. The data provide a basis for development of three principal target models for the geothermal system but do not permit prioritization of these models.
2. Geochemical, geological, and temperature gradient data coverage should be expanded to the north to more fully define the area which appears to have the best resource potential and to aid prioritization of the principal target models. Target definition can be usefully expanded at low cost, if necessary, based on grid soil geochemistry and additional geologic mapping alone.

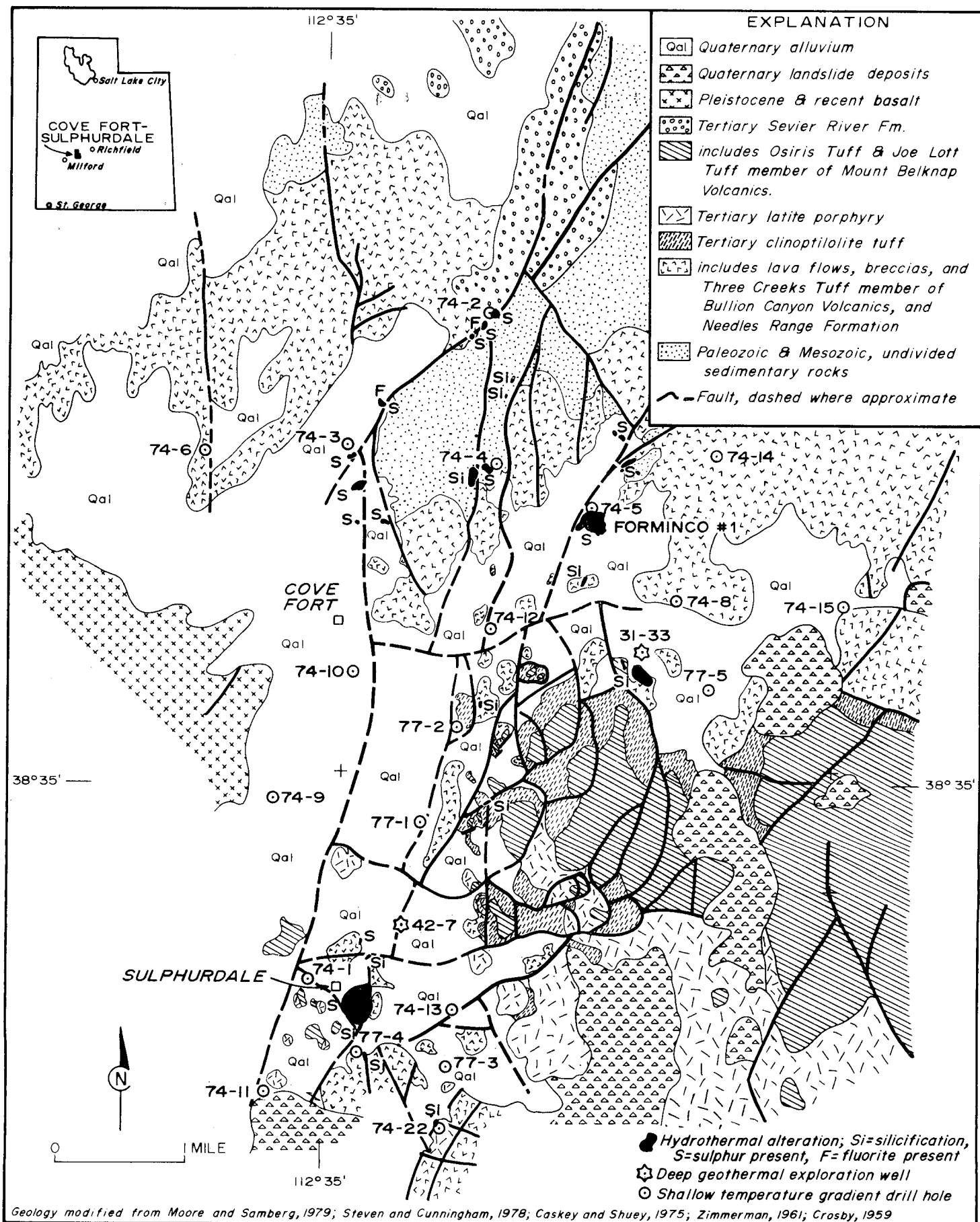
ACKNOWLEDGEMENTS

Other ESL staff contributing to this work included Ruth Kroneman who performed most of the chemical analytical work, Regina Capuano who provided the mercury analyses, and Jeff Hulen who carried out the mineralogical studies. Computer programming support was provided by Carol Withrow and drafting was done by Connie Pixton. Joe Moore provided useful insights into the geology of the Cove Fort area and, along with Mike Wright and Regina Capuano, reviewed the report.

Funding for the work was provided by the Division of Geothermal Energy, DOE, under contract DE-AC07-78ET28392.

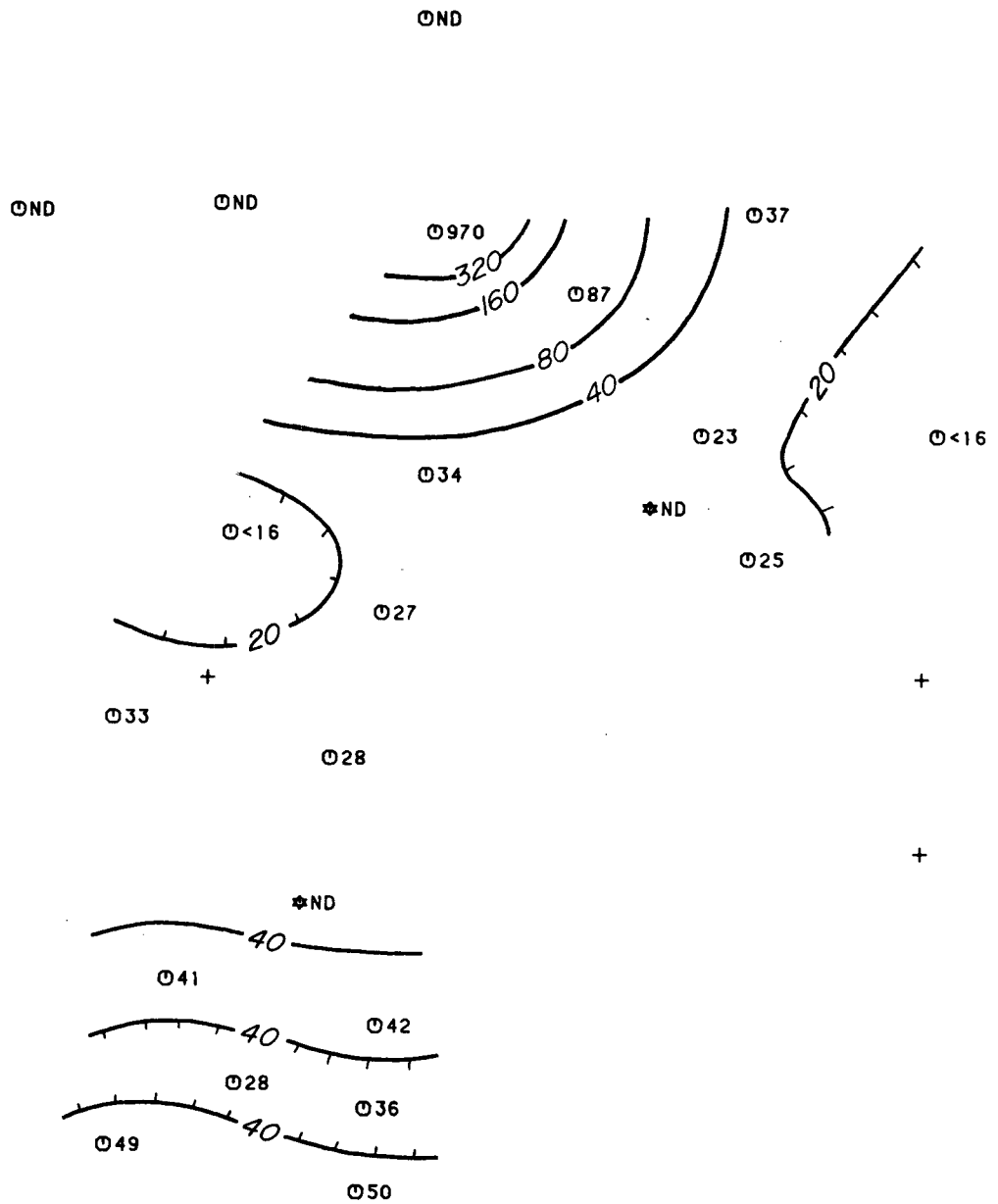
REFERENCES

- Bamford, R.W., 1978, Geochemistry of solid materials from two U.S. geothermal systems and its application to exploration: University of Utah Research Institute, Earth Science Laboratory Report no. 6, DOE contract no. EY-76-S-07-1601, 196 p.
- Caskey, D.F., and Shuey, R.T., 1975, Mid-Tertiary volcanic stratigraphy, Sevier-Cove Fort area, central Utah: Utah Geology, v. 2, p. 17-25.
- Crosby, G.W., 1959, Geology of the South Pavant Range, Millard and Sevier Counties, Utah: Brigham Young University, unpub. M.S. Thesis.
- Moore, J.N., and Samberg, S.M., 1979, Geology of the Cove Fort-Sulphurdale KGRA: University of Utah Research Institute, Earth Science Laboratory Report no. 18, DOE contract no. EG-78-C-07-1701, 44 p.
- Olson, T. L., and Smith, R. B., 1976, Earthquake surveys of the Roosevelt Hot Springs and the Cove Fort areas, Utah: Univ. Utah Dept. Geol. and Geophysics Report v. 4, Grant no. GI-43741, 83 p.
- Steven, T.A., and Cunningham, C.G., 1979, Clinoptilolite resources in the Tushar Mountains, west-central Utah: U.S. Geol. Survey Open-File Report 79-535, 20 p.
- Union Oil Company, 1978a, Cove Fort-Sulphurdale Geothermal Unit Area, Millard and Beaver Co., Utah, Geologic Report.
- Union Oil Company, 1978b, Temperature gradient investigation, Cove Fort-Sulphurdale area, Beaver and Millard Counties, Utah: Data in open file, University of Utah Research Institute, Earth Science Laboratory through DOE/DGE Industry Coupled Case Study program, contract no. EG-78-C-07-1701.
- Union Oil Company, 1978c, Cove Fort-Sulphurdale Unit Well #42-7, Beaver Co., Utah, technical report.
- Union Oil Company, 1978d, Cove Fort-Sulphurdale Unit Well #31-33, Millard Co., Utah, technical report.
- Zimmerman, J.T., 1961, Geology of the Cove Creek area, Millard and Beaver Counties, Utah: University of Utah, unpub. M.S. Thesis, 91 p.



**FIGURE 1 - GENERALIZED GEOLOGY, ALTERATION AND DRILL HOLE LOCATIONS
COVE FORT-SULPHURDALE KGRA
BEAVER AND MILLARD COUNTIES, UTAH**

+

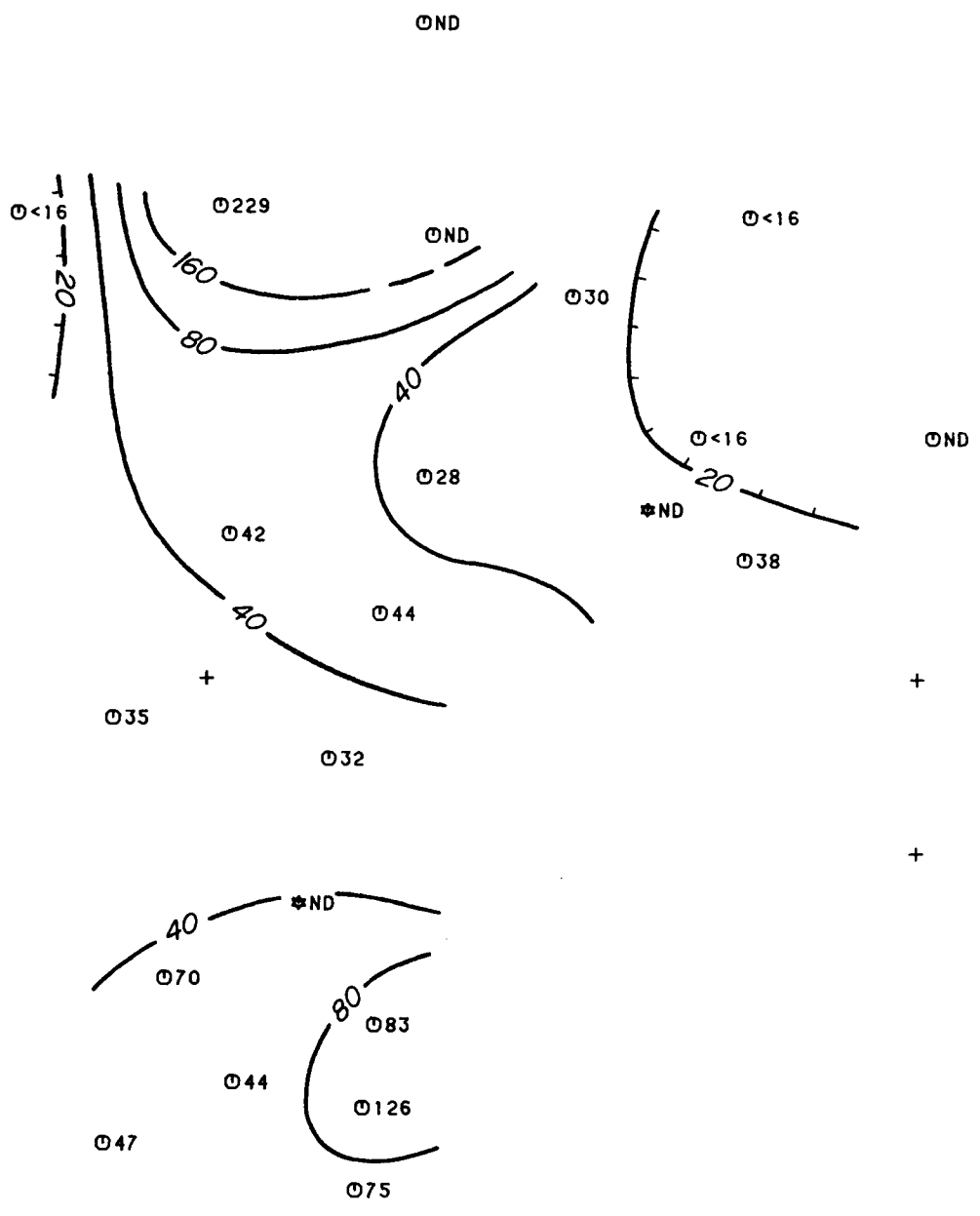


4000 FEET

FIGURE: 2A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

ARSENIC (PPM) 0-100 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD: ICPQ



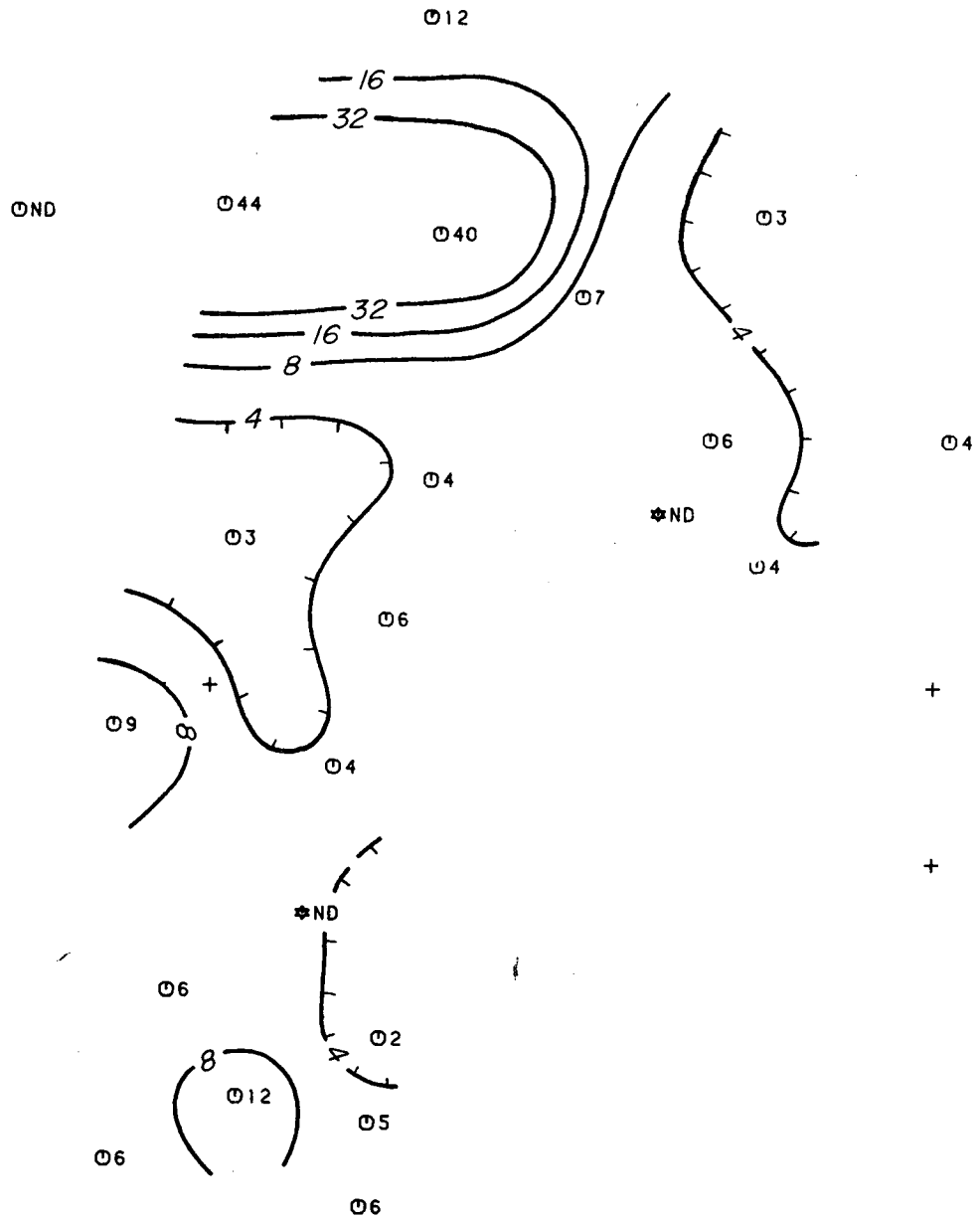
4000 FEET

FIGURE: 2B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

ARSENIC (PPM) 100-200 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD: ICPQ

+

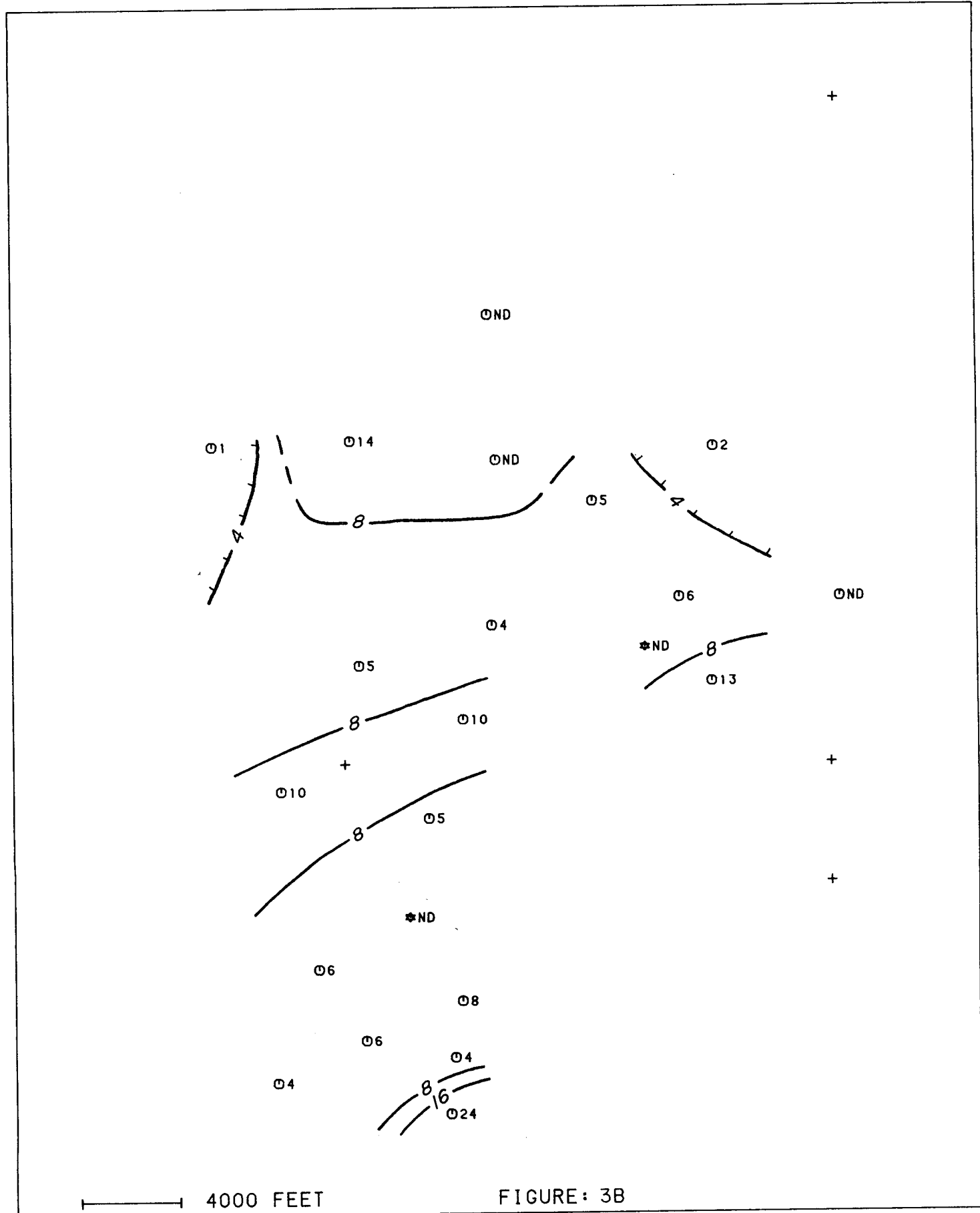


4000 FEET

FIGURE: 3A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

ARSENIC (PPM) 0-100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD: COLOR

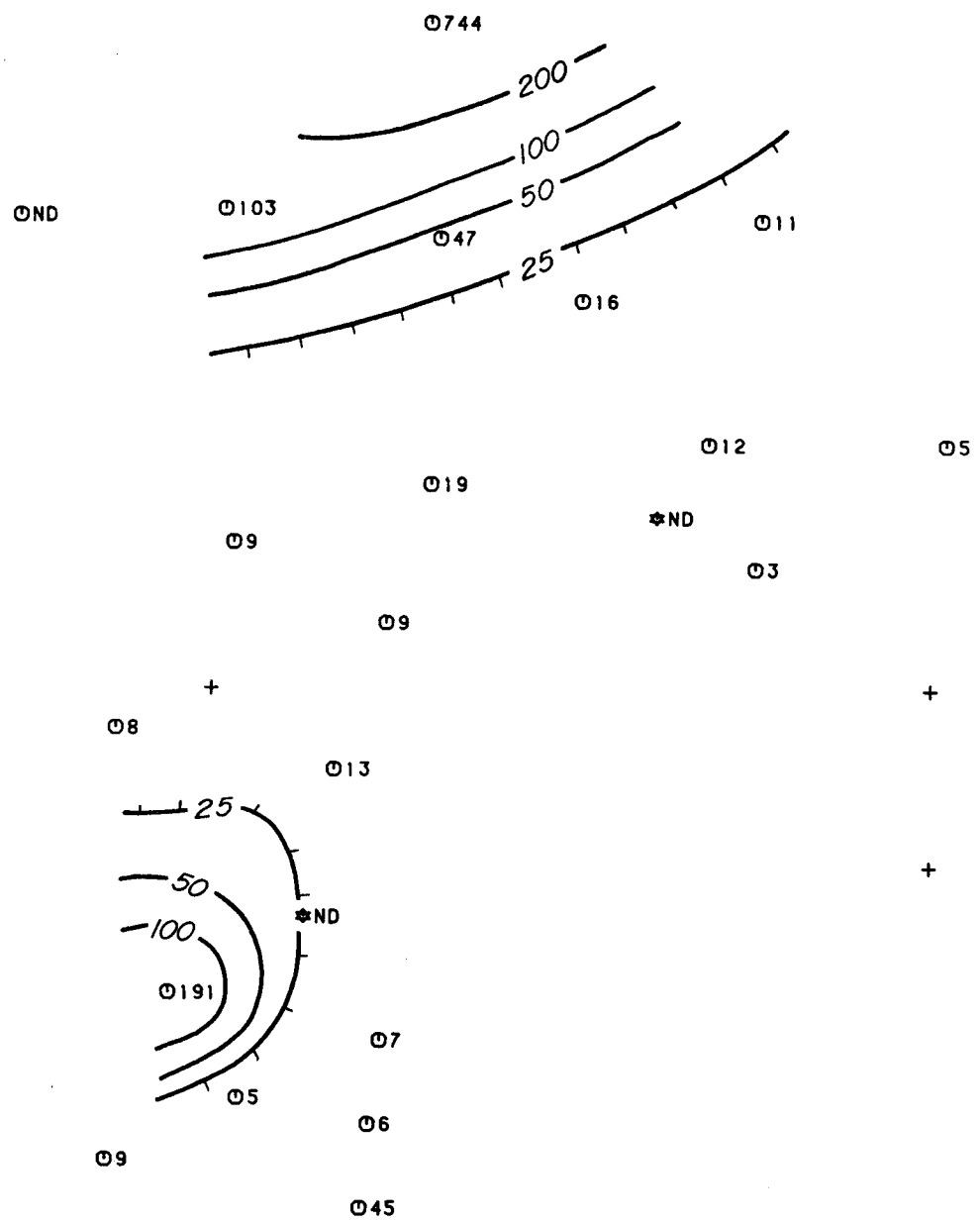


4000 FEET
 COVE FORT-SULPHURDALE KGRA
 MILLARD & BEAVER COS., UTAH

FIGURE: 3B

ARSENIC (PPM) 100-200 FT.
 SAMPLE TYPE: WHOLE ROCK
 ANALYTICAL METHOD: COLOR

+

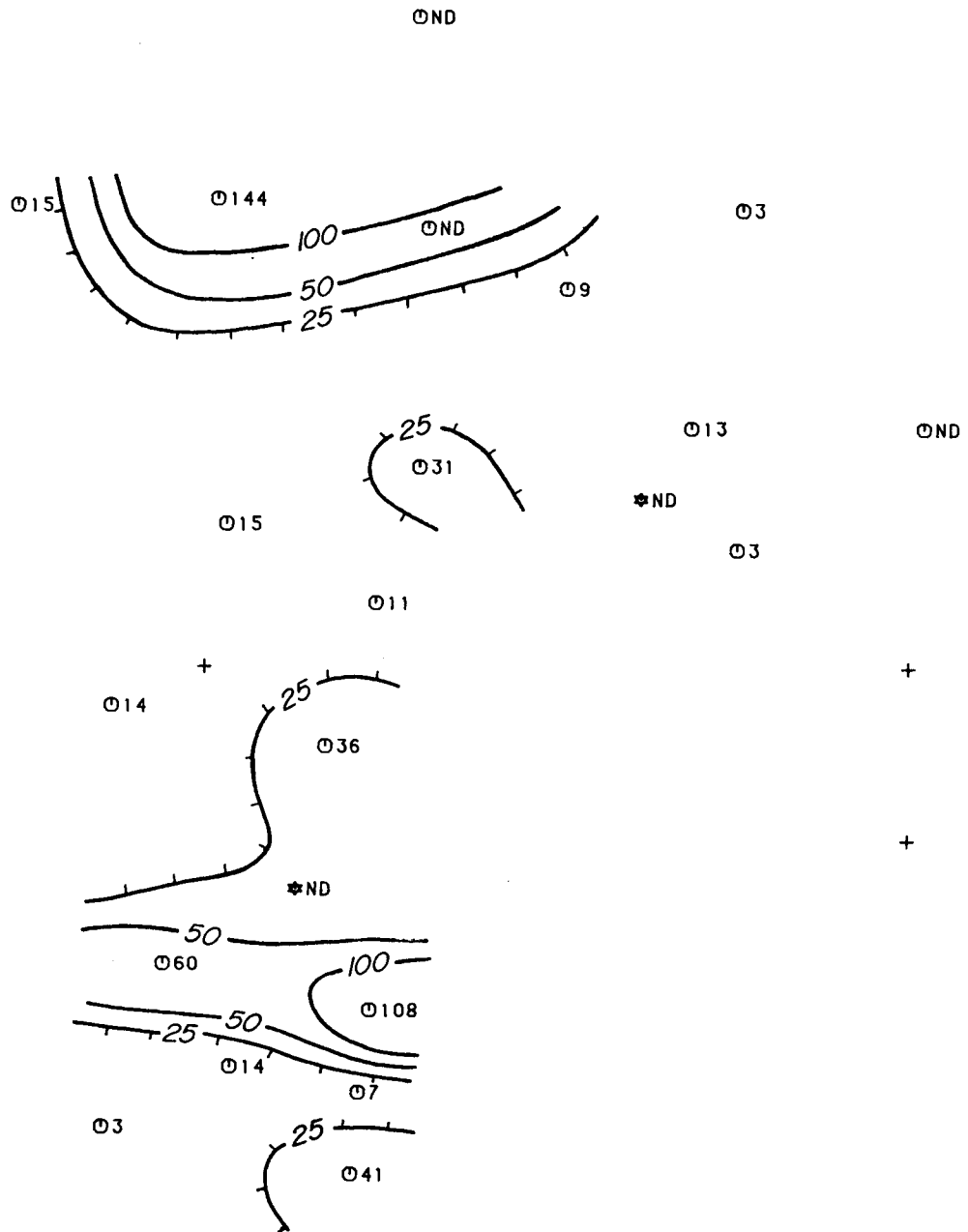


4000 FEET

FIGURE: 4A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

MERCURY (PPB) 0-100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD: GOLD FILM



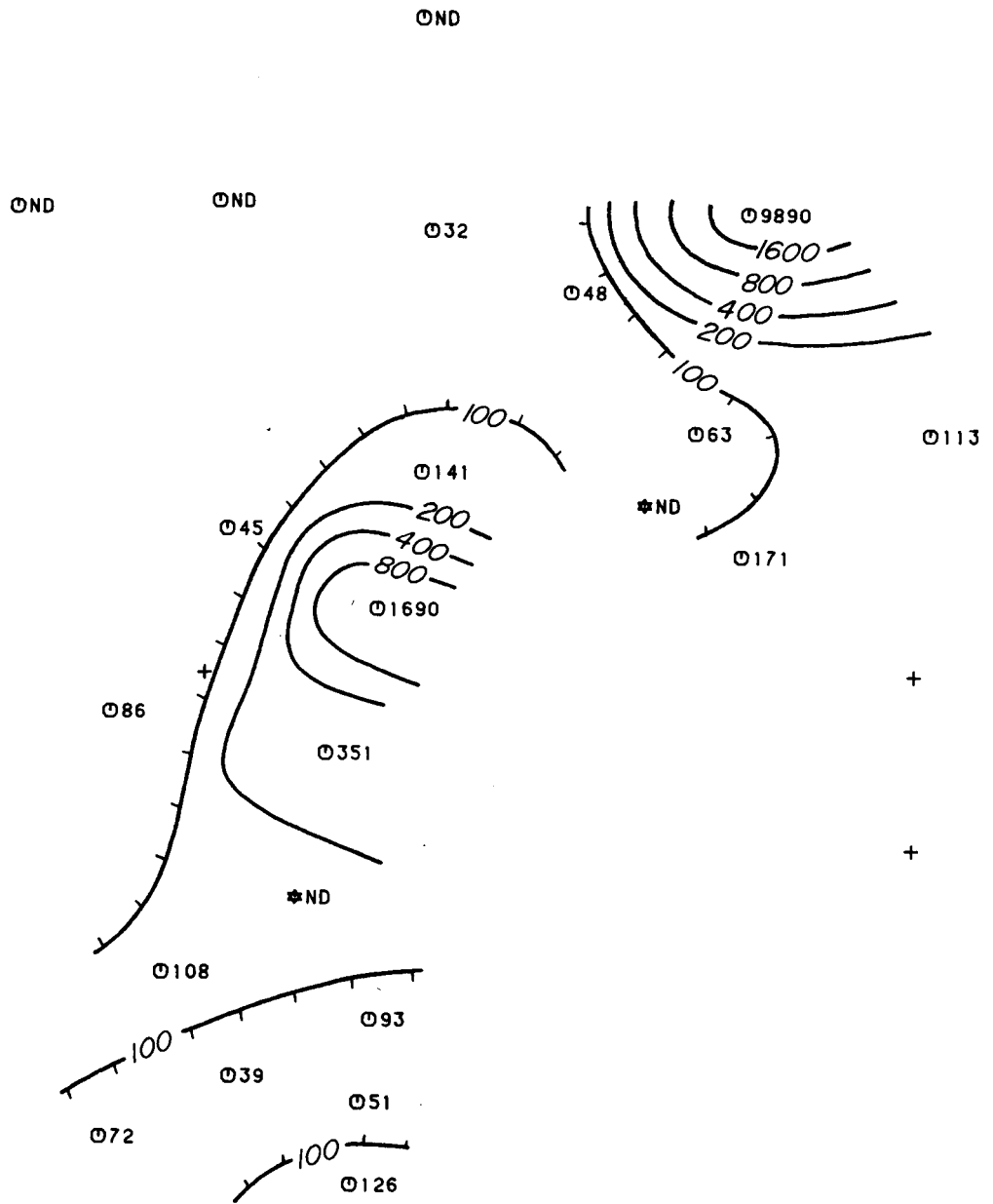
4000 FEET

FIGURE: 4B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

MERCURY (PPB) 100-200 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD: GOLD FILM

+

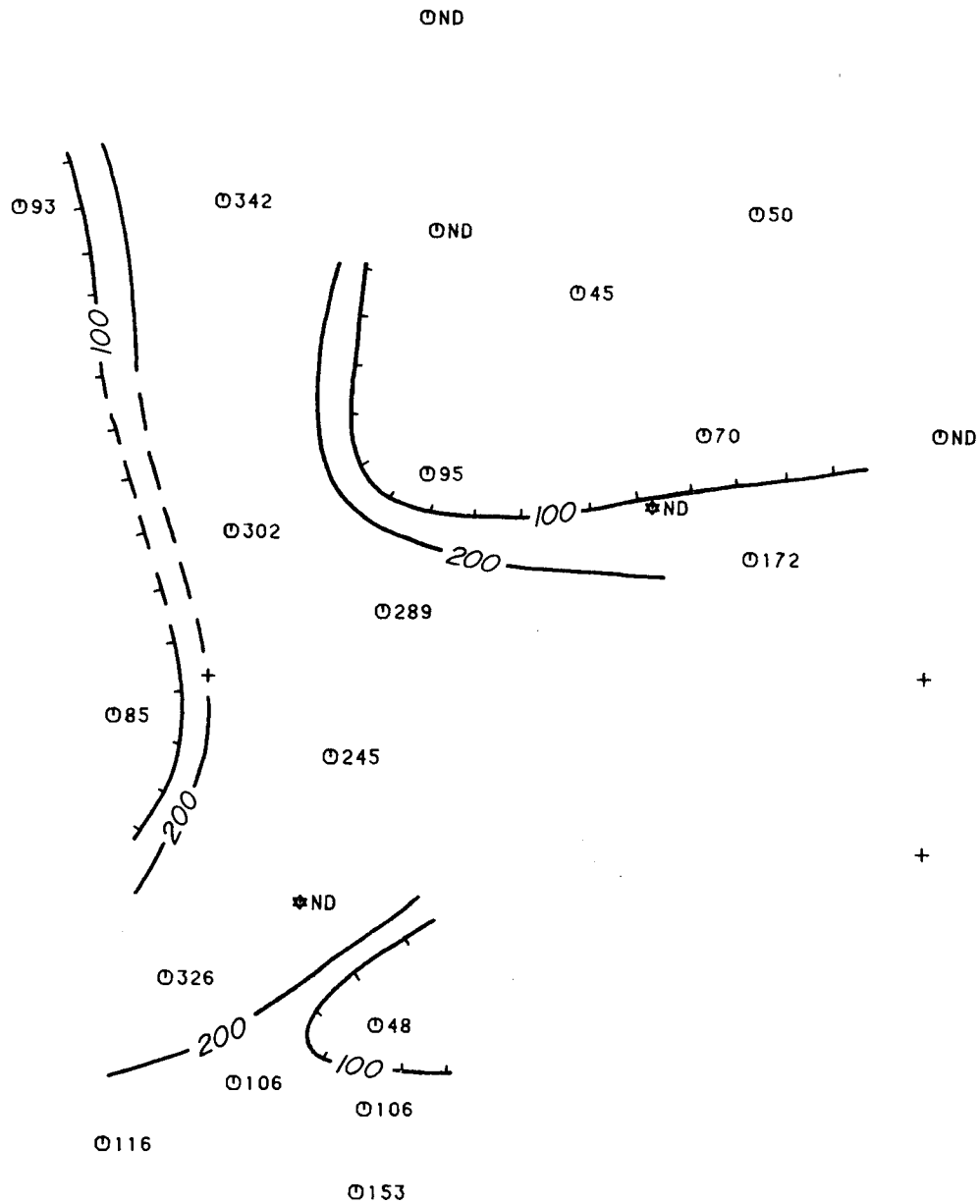


4000 FEET

FIGURE: 5A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

LEAD (PPM) 0-100 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD: ICPQ



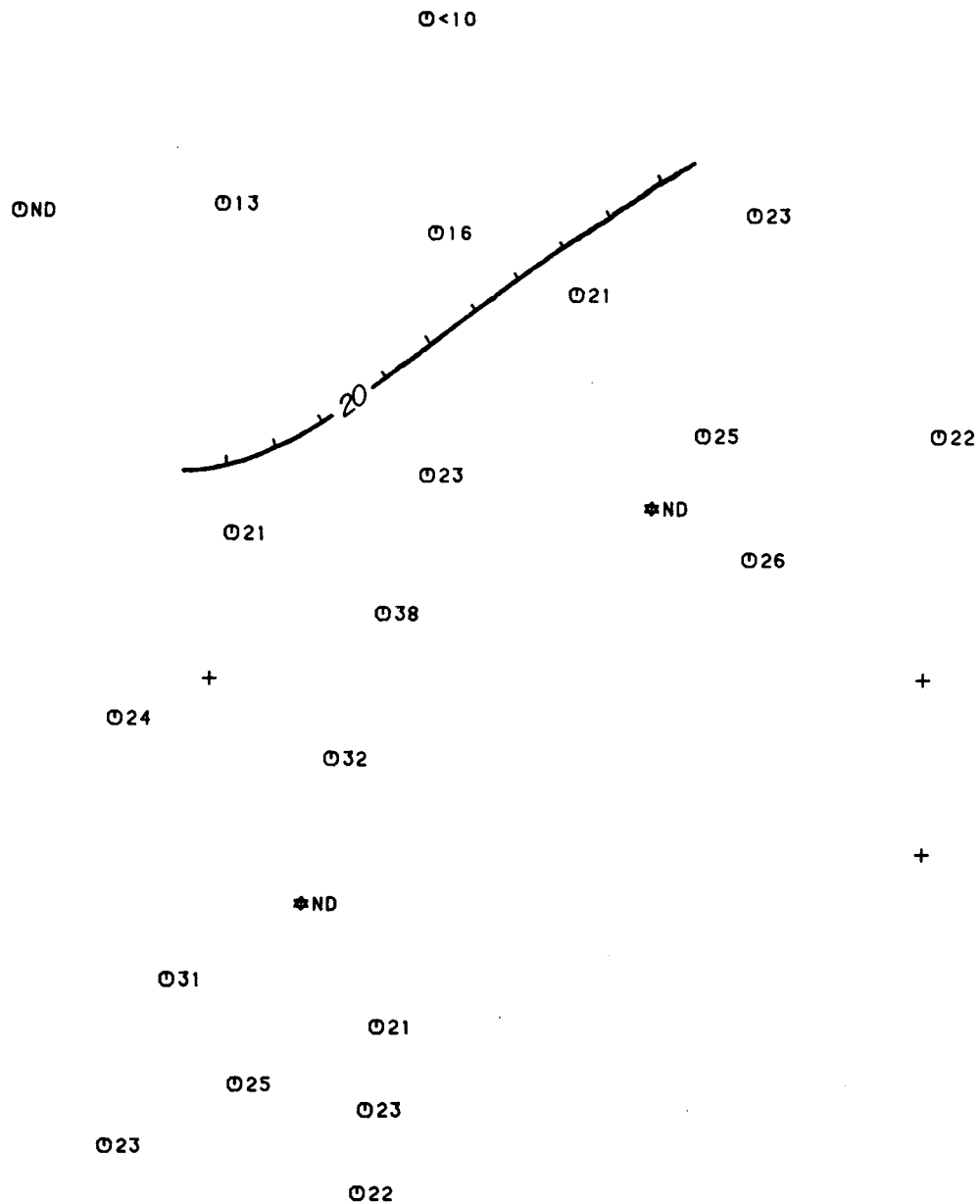
4000 FEET

FIGURE: 5B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

LEAD (PPM) 100-200 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD: ICPQ

+

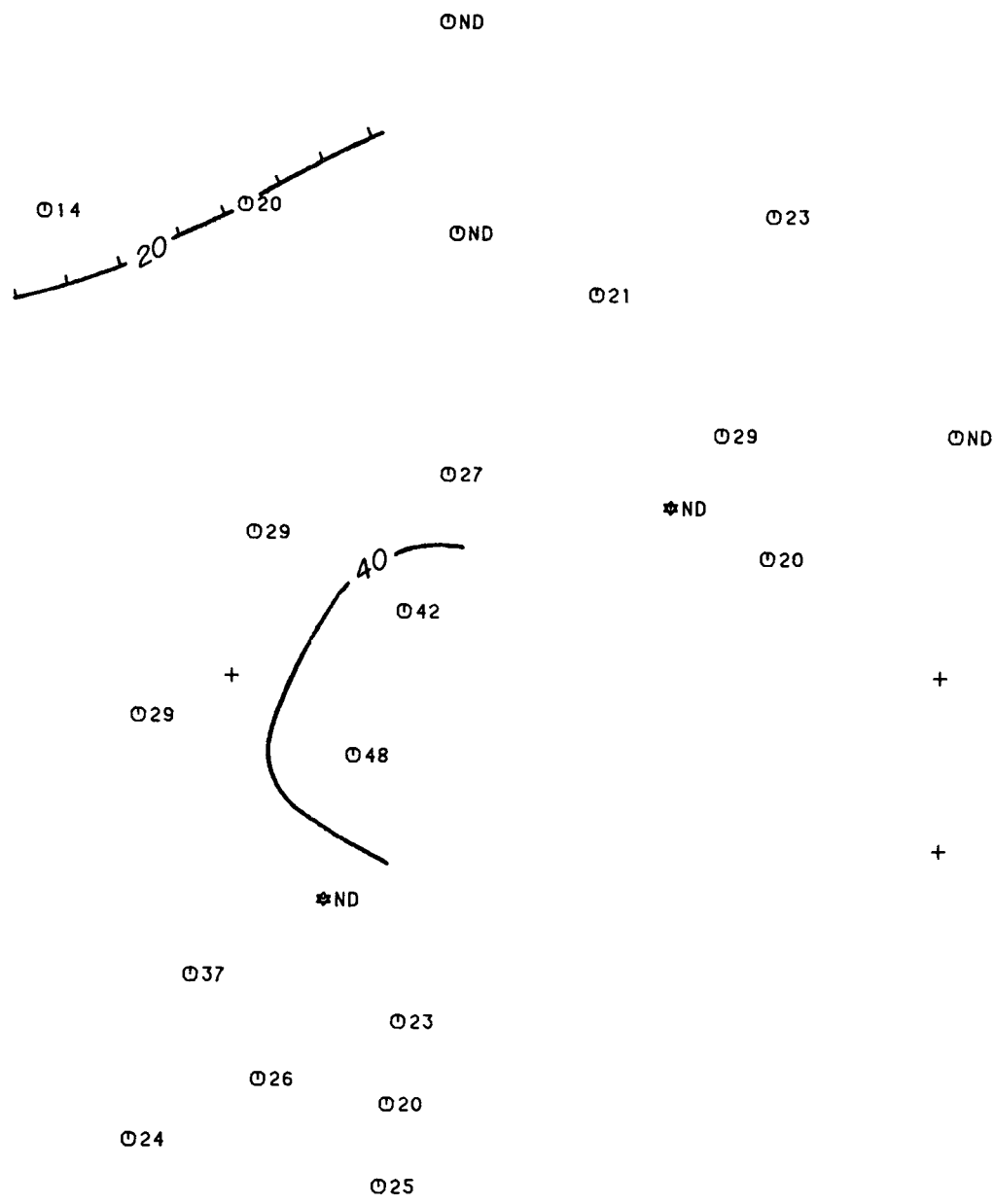


4000 FEET

FIGURE: 6A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

LEAD (PPM) 0-100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD: ICPQ



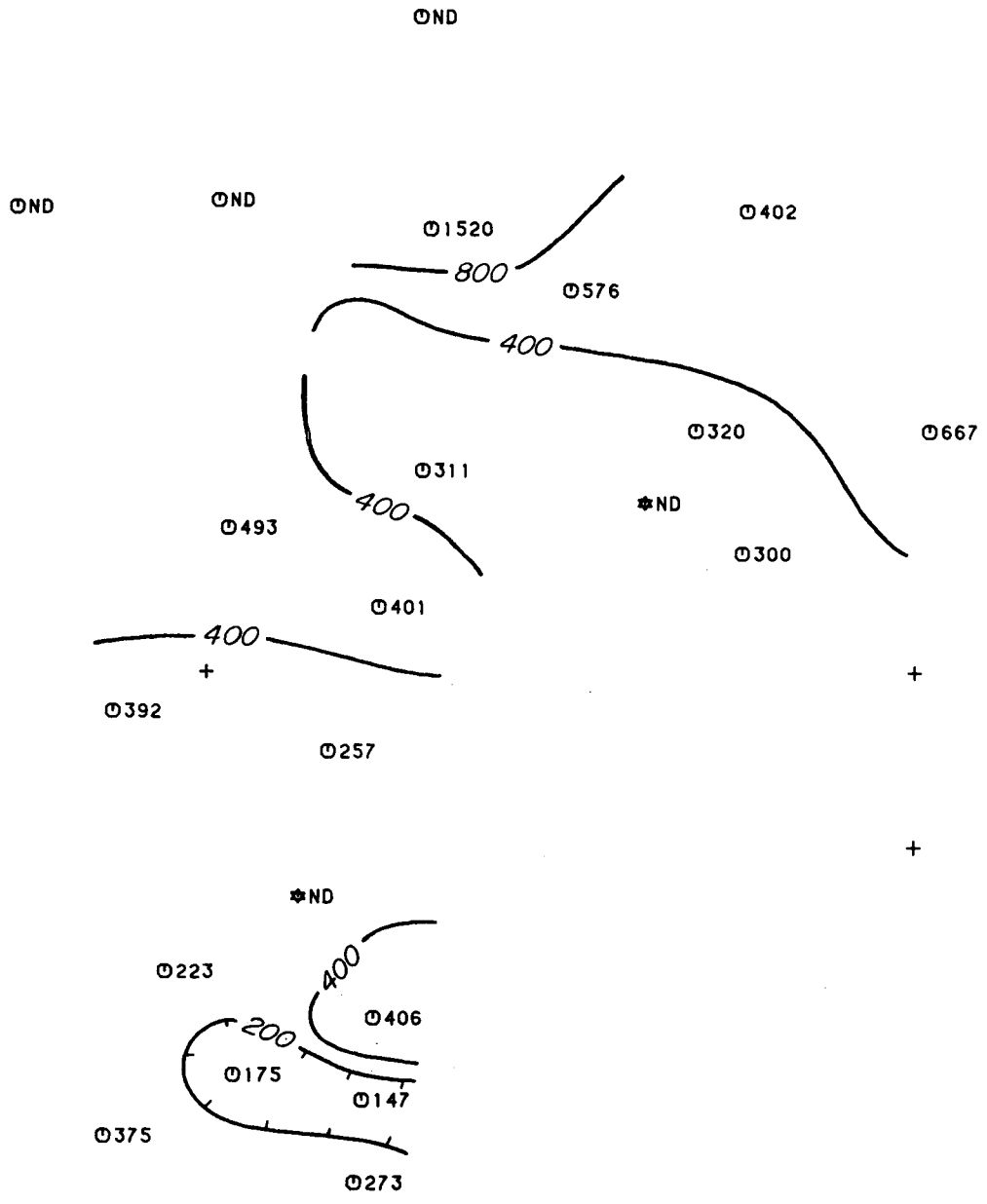
4000 FEET

FIGURE: 6B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

LEAD (PPM) 100-200 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD: ICPQ

+

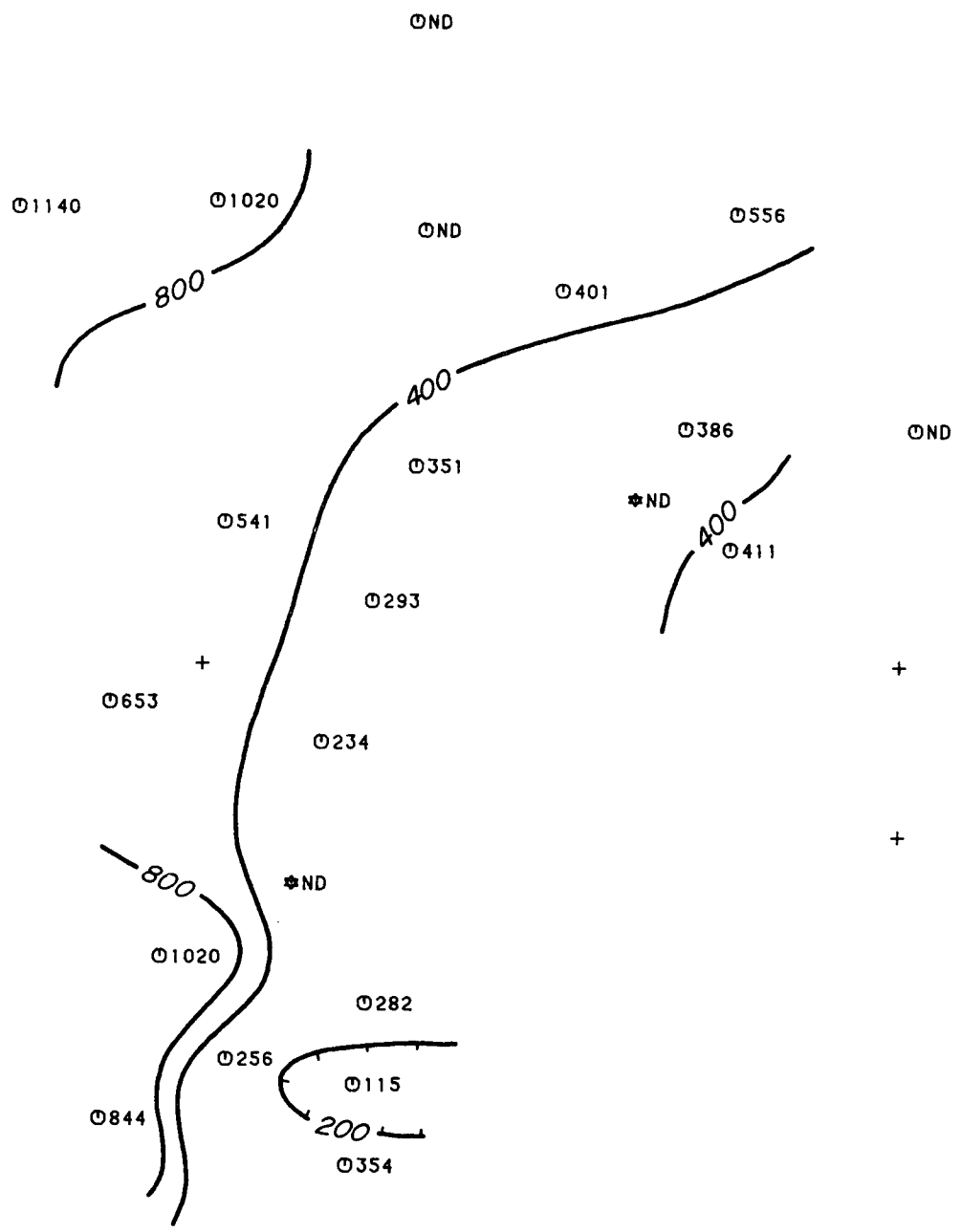


4000 FEET

FIGURE: 7A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

ZINC (PPM) 0-100 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD: ICPQ



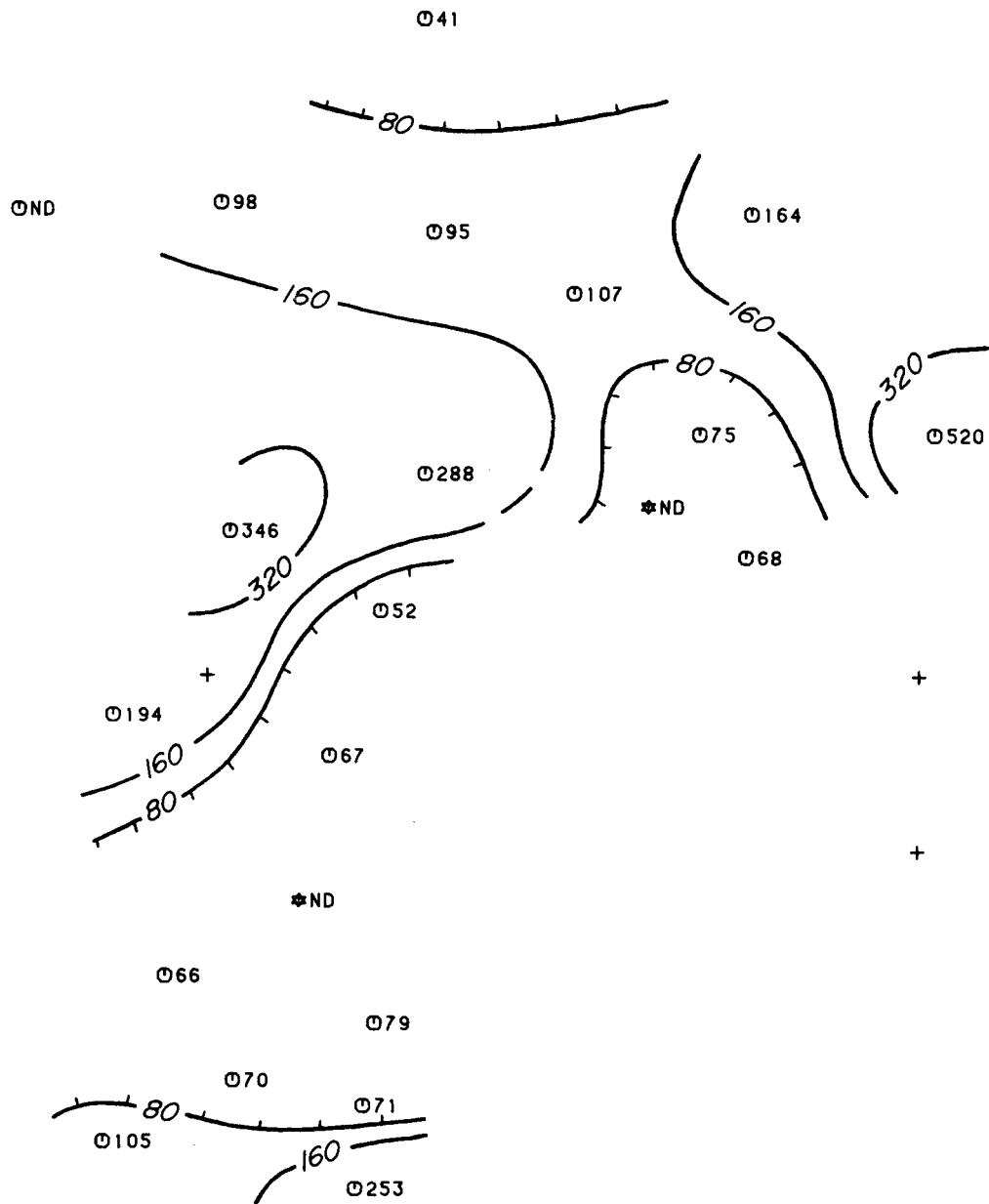
4000 FEET

FIGURE: 7B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

ZINC (PPM) 100-200 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD: ICPQ

+

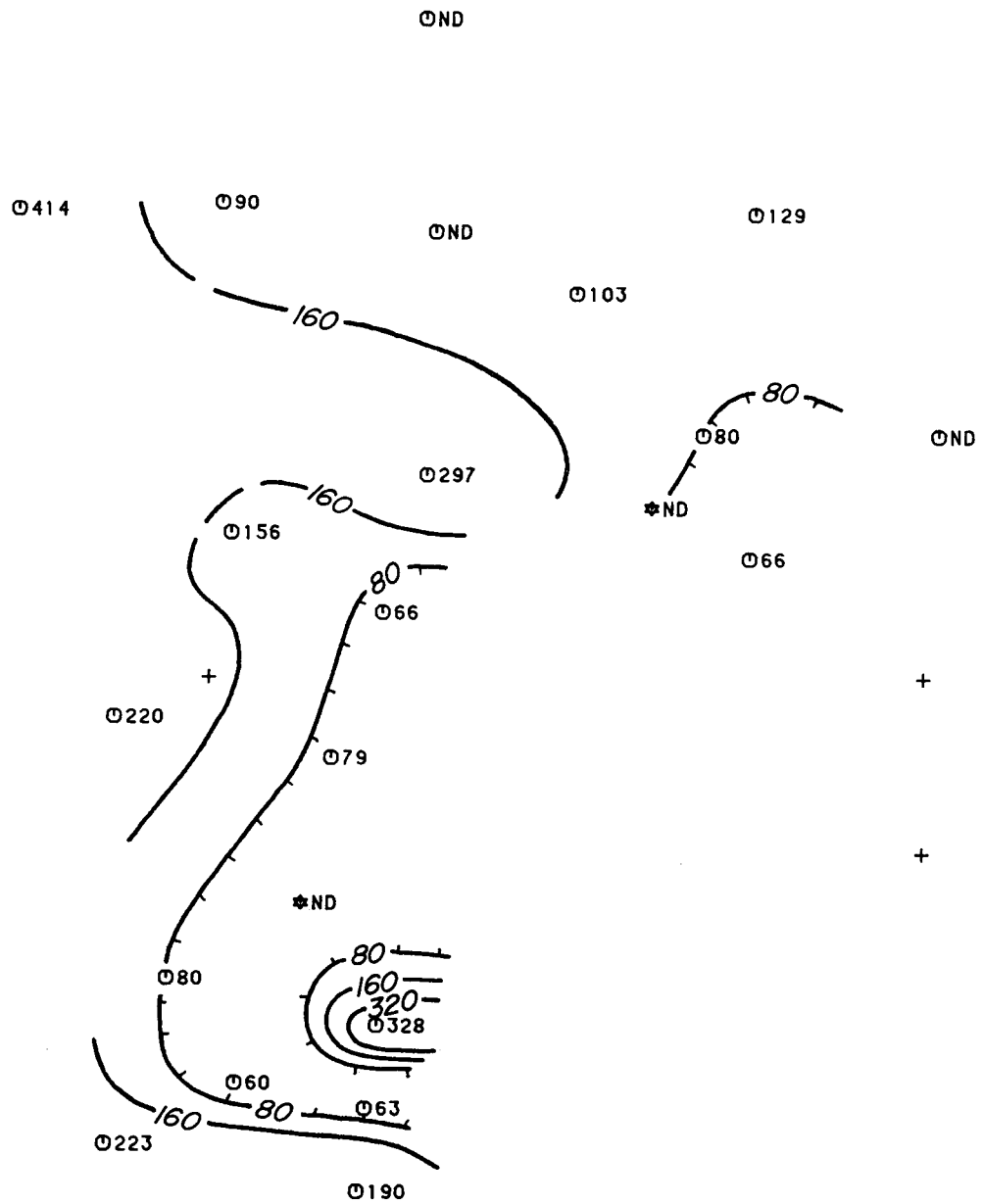


4000 FEET

FIGURE: 8A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

ZINC (PPM) 0-100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD: ICPQ



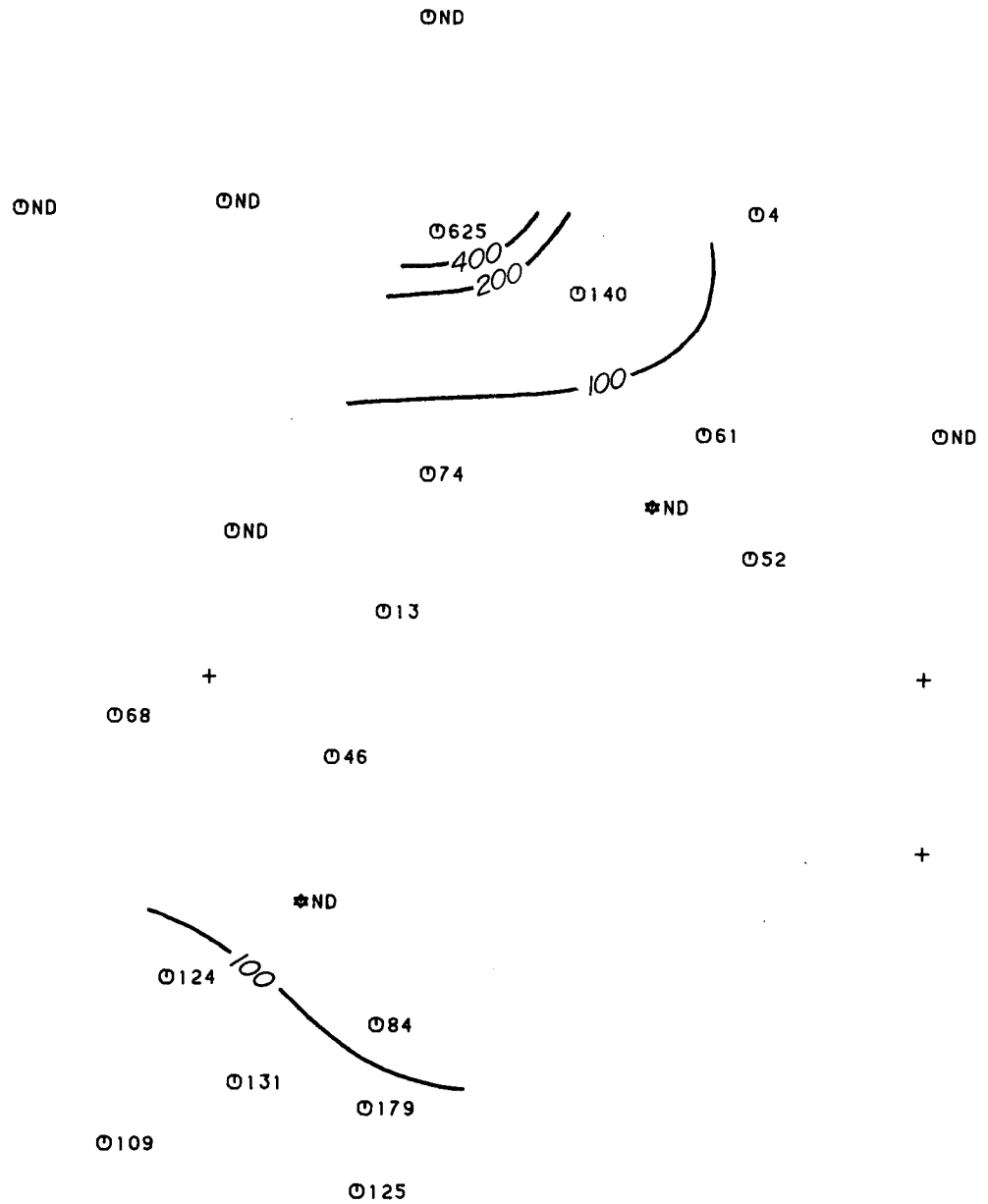
4000 FEET

FIGURE: 8B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

ZINC (PPM) 100-200 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD: ICPQ

+

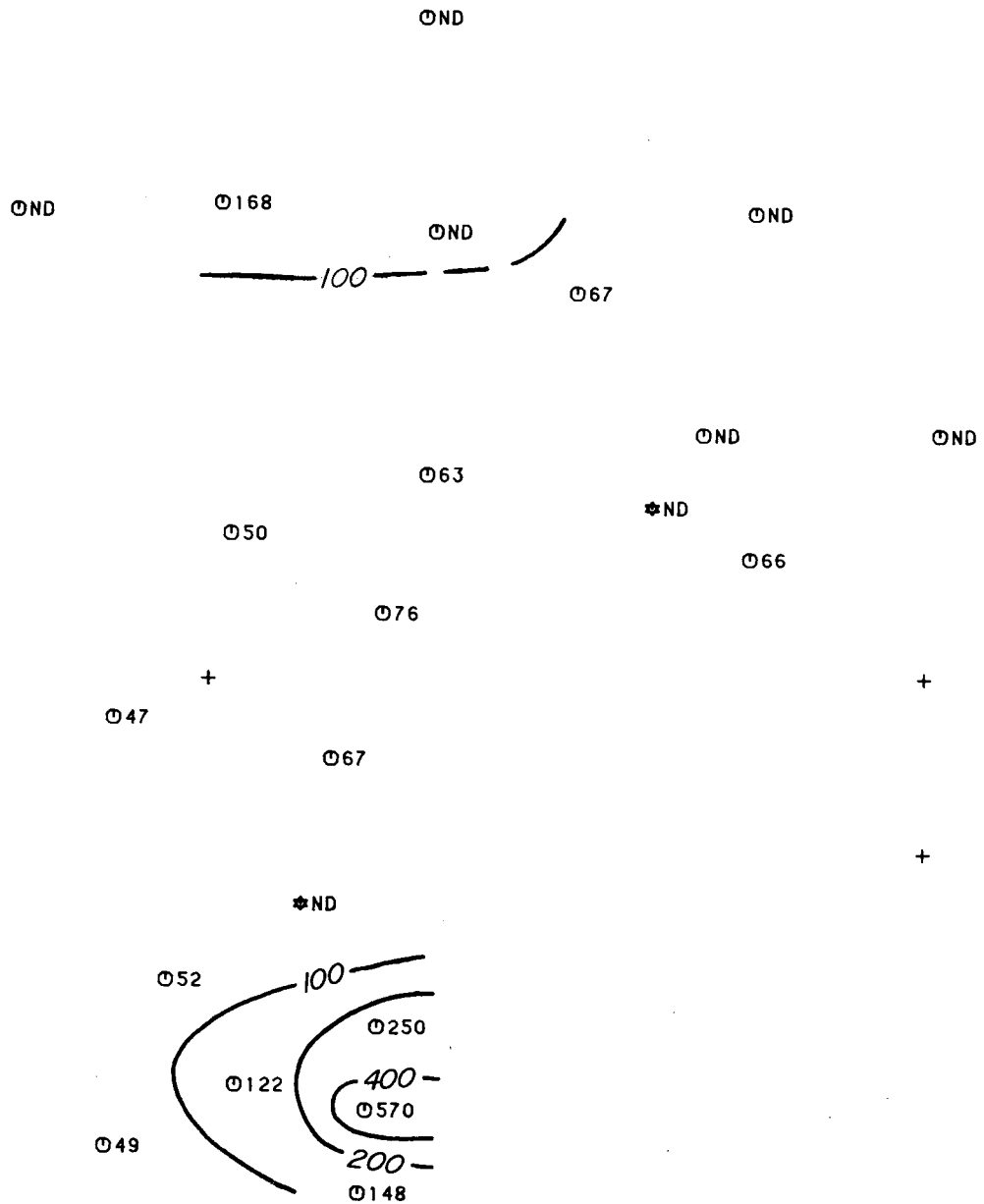


4000 FEET

FIGURE: 9A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

1000 AS/(PB+ZN), 0-100 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD:



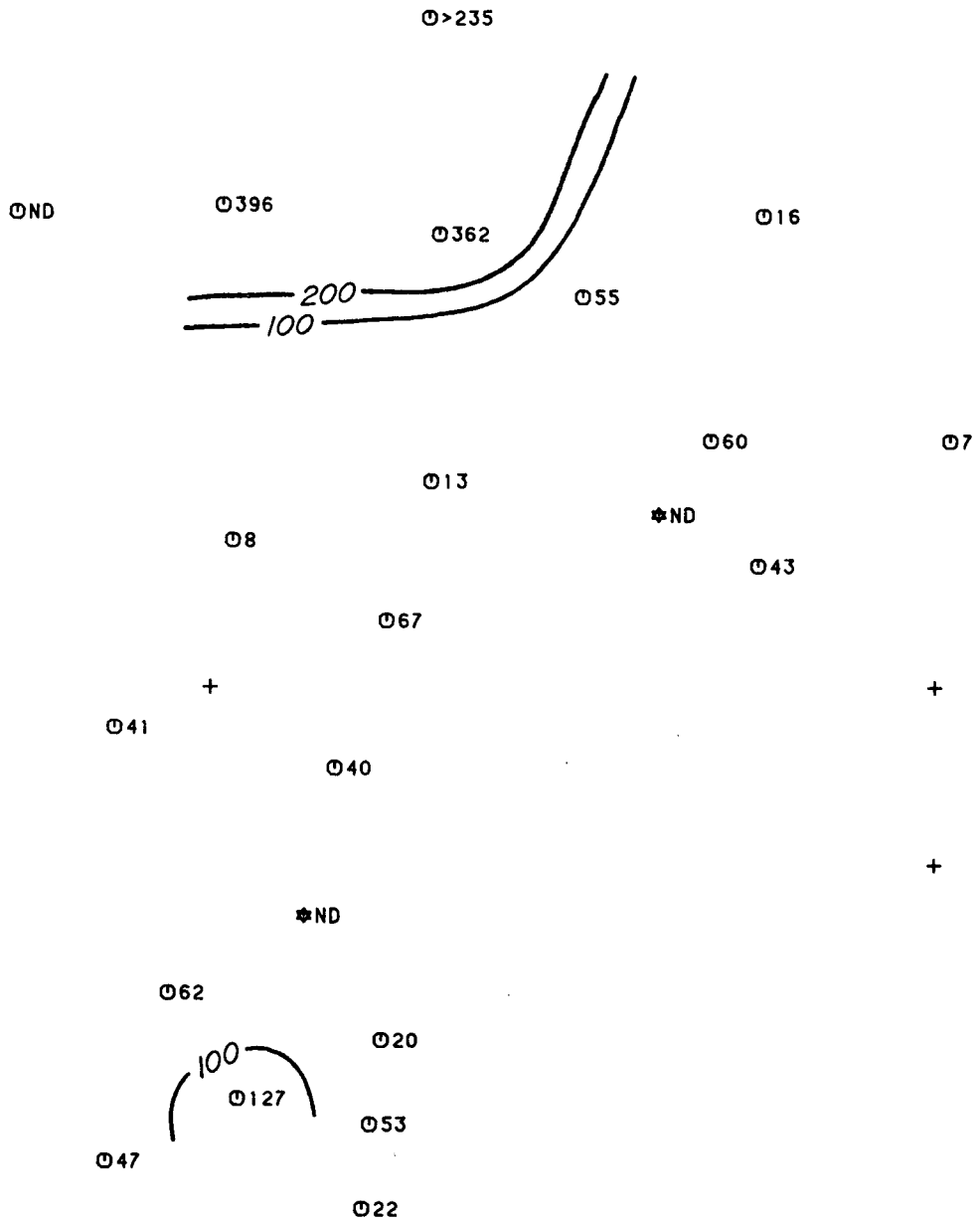
4000 FEET

FIGURE: 9B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

1000 AS/(PB+ZN), 100-200 FT.
SAMPLE TYPE: +3.3 LESS MAG.
ANALYTICAL METHOD:

+

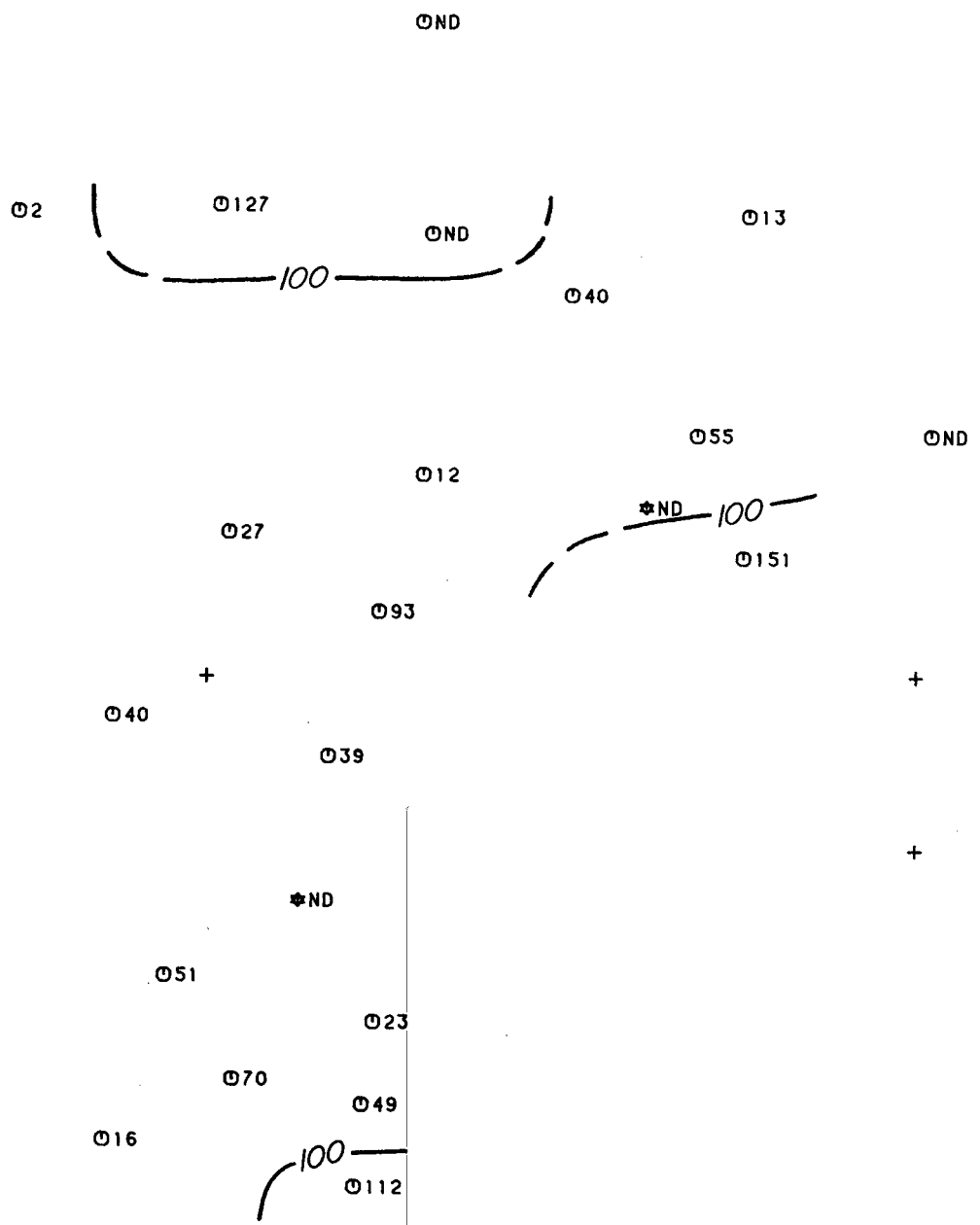


4000 FEET

FIGURE: 10A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

1000 AS/(PB+ZN), 0-100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD:



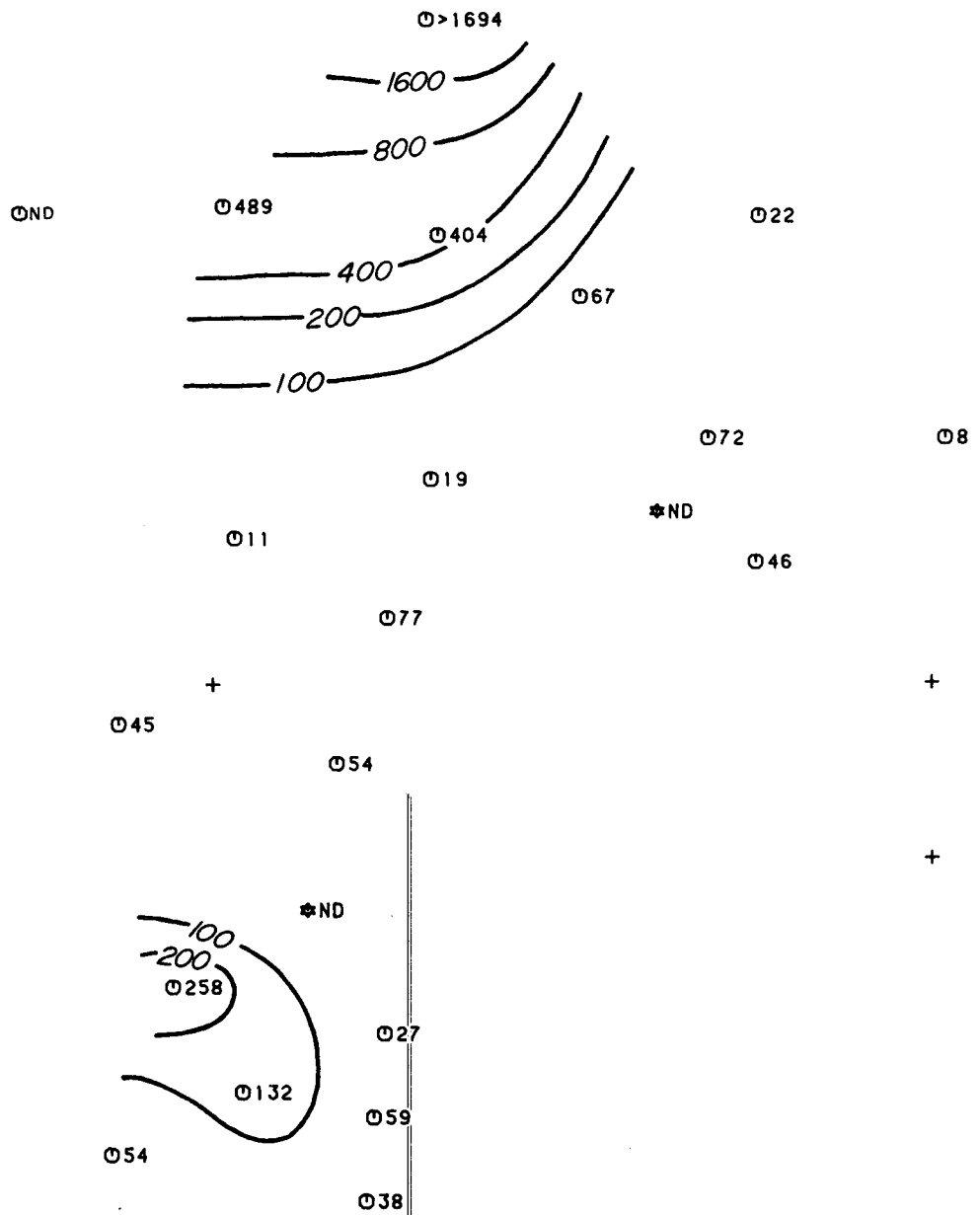
4000 FEET

FIGURE: 10B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

1000 AS/(PB+ZN), 100-200 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD:

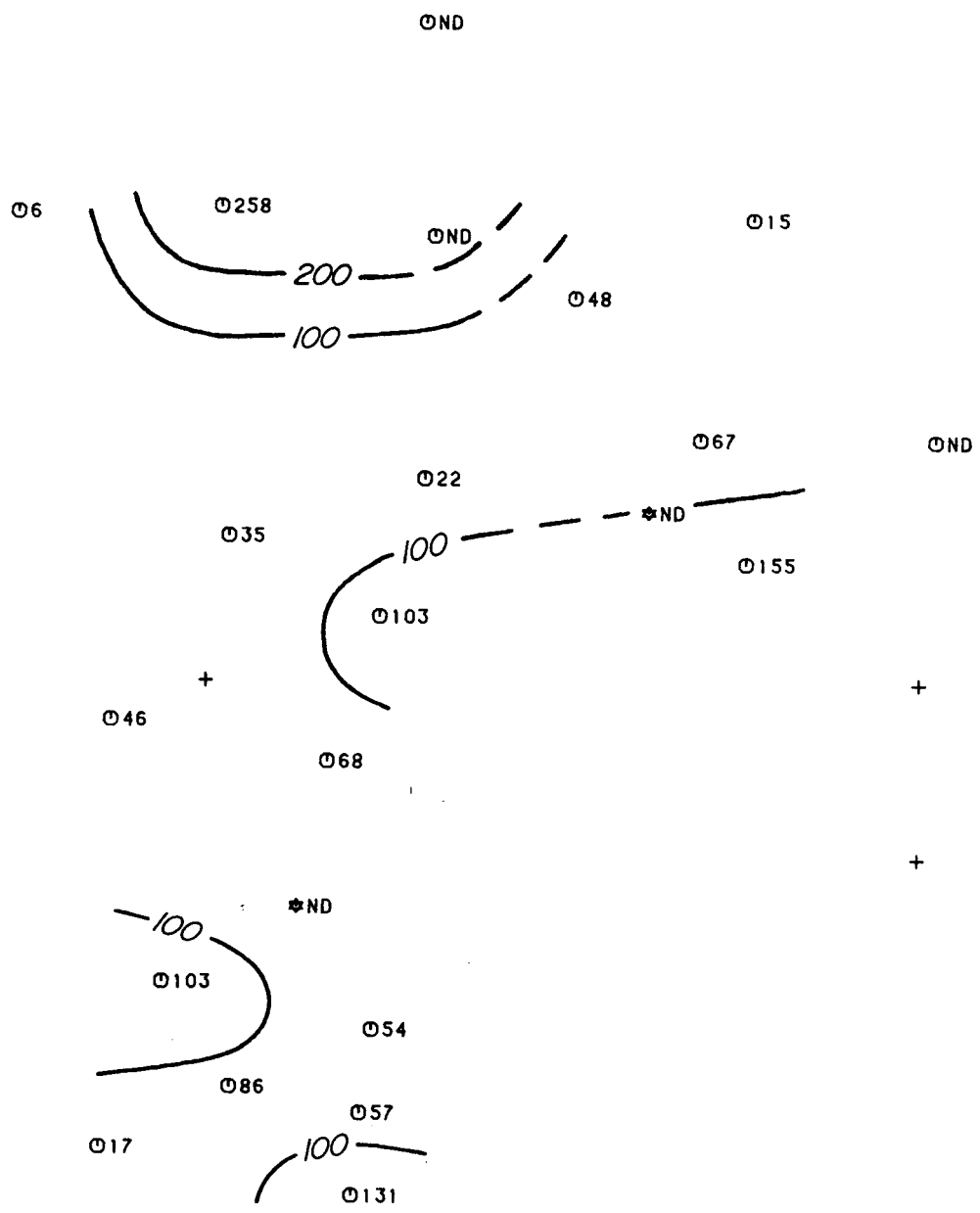
+



COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

FIGURE: IIA

$1000 (AS + .1HG) / (PB + ZN)$, 100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD:



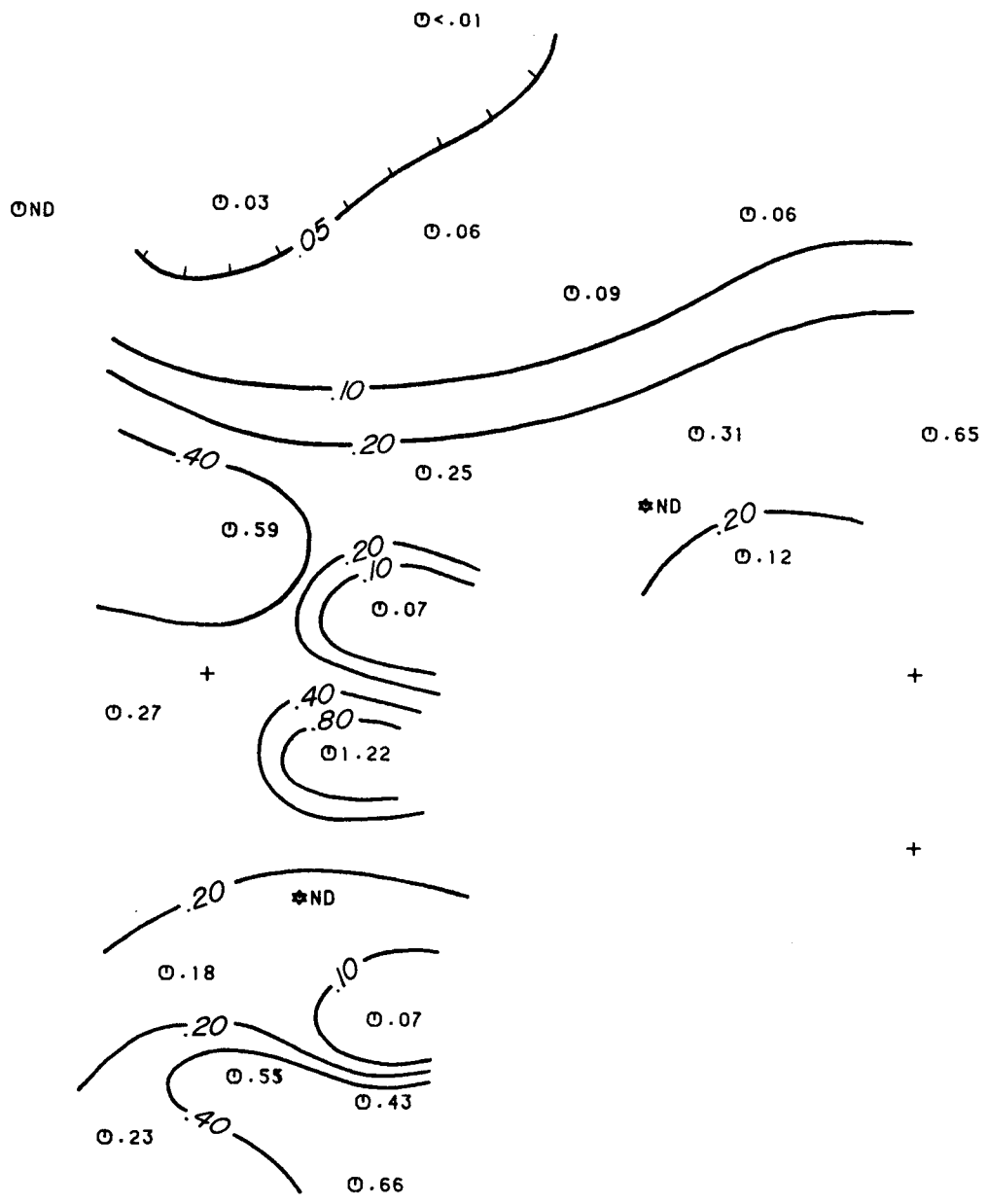
4000 FEET

FIGURE: IIB

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

1000 (AS + .1HG) / (PB + ZN) , $\frac{100}{2000 \text{ FT.}}$
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD:

+



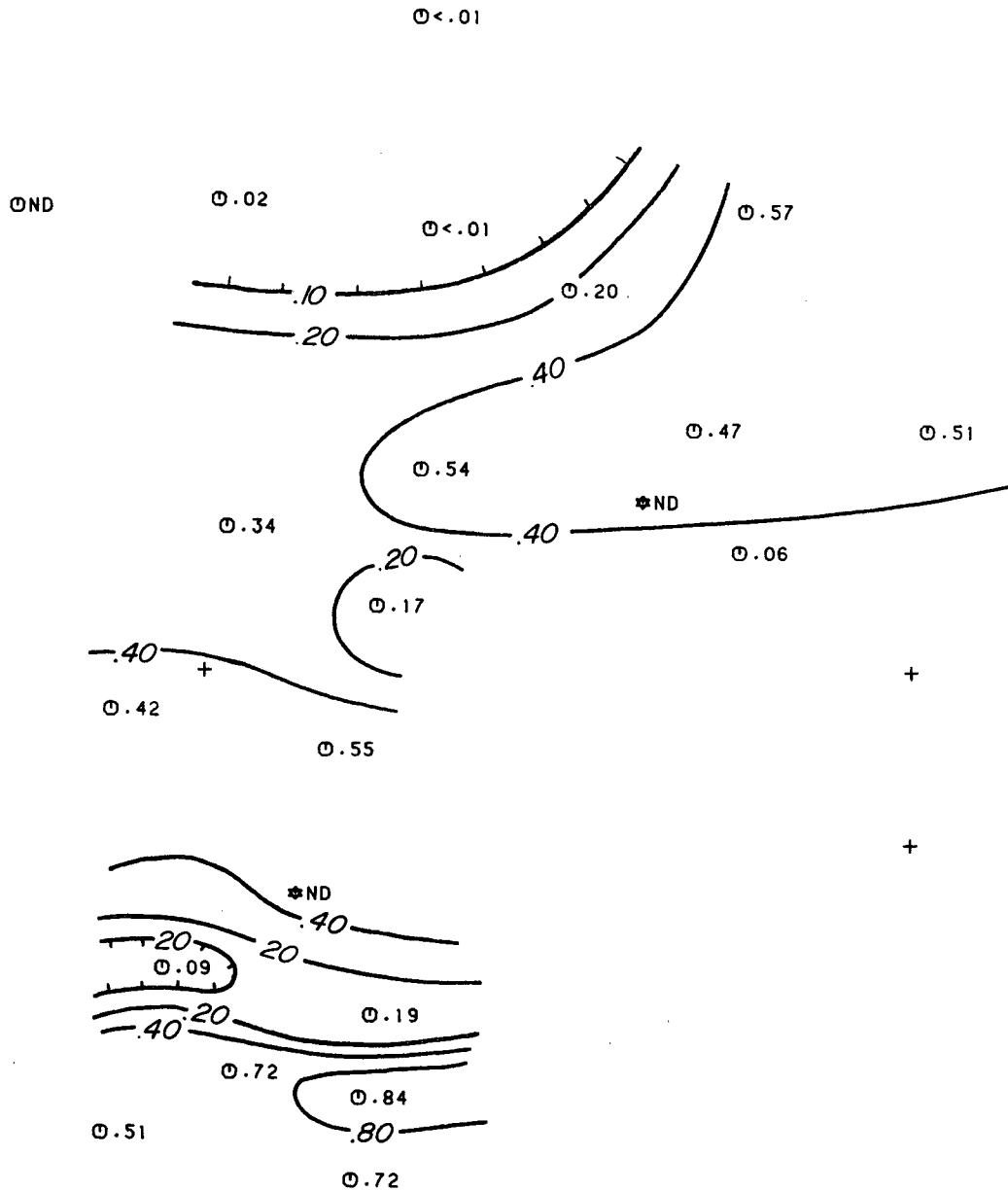
4000 FEET

FIGURE: 12A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

WT % +3.3 LESS MAG 0-100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD:

+

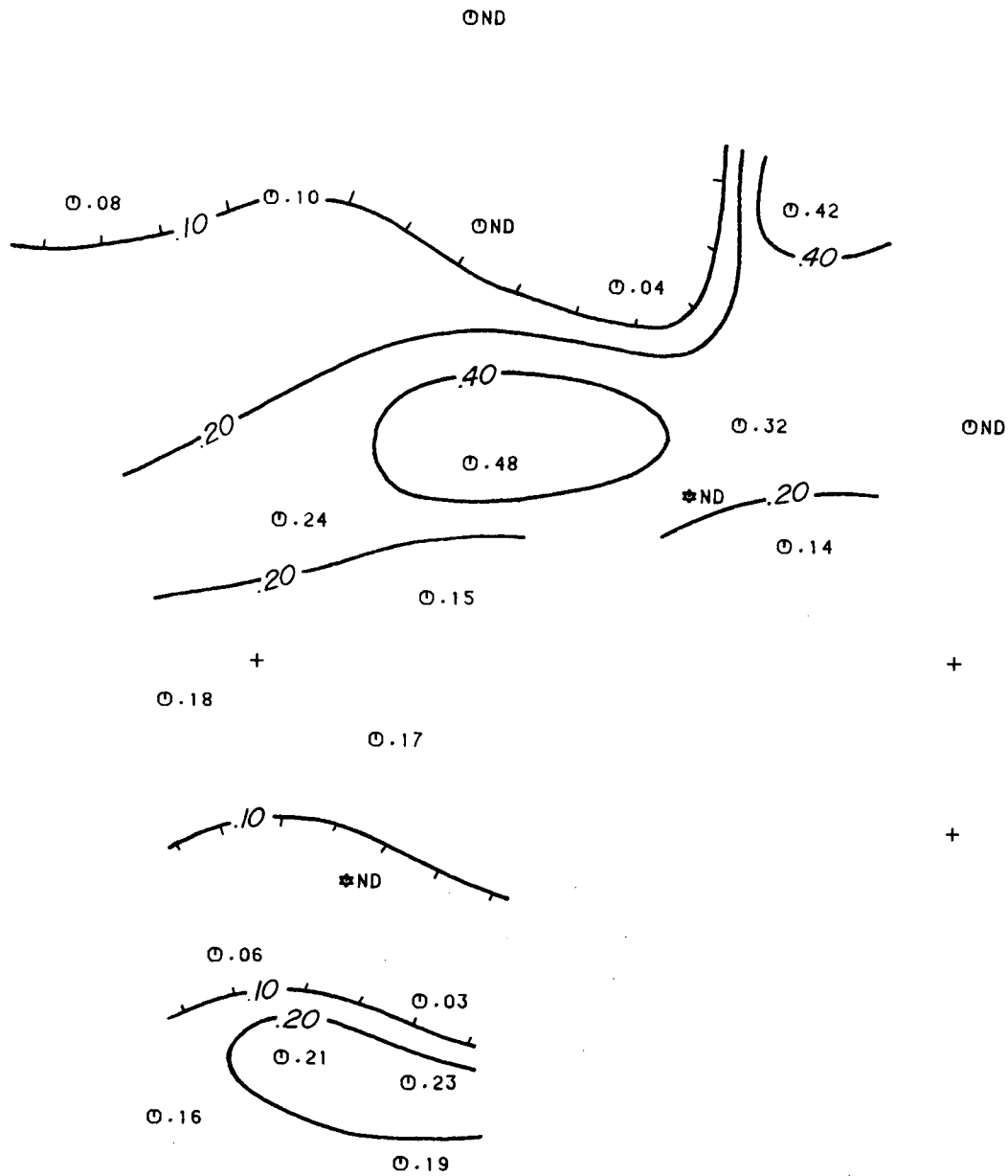


4000 FEET

FIGURE: 13A

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

WT % MAGNETITE 0-100 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD:

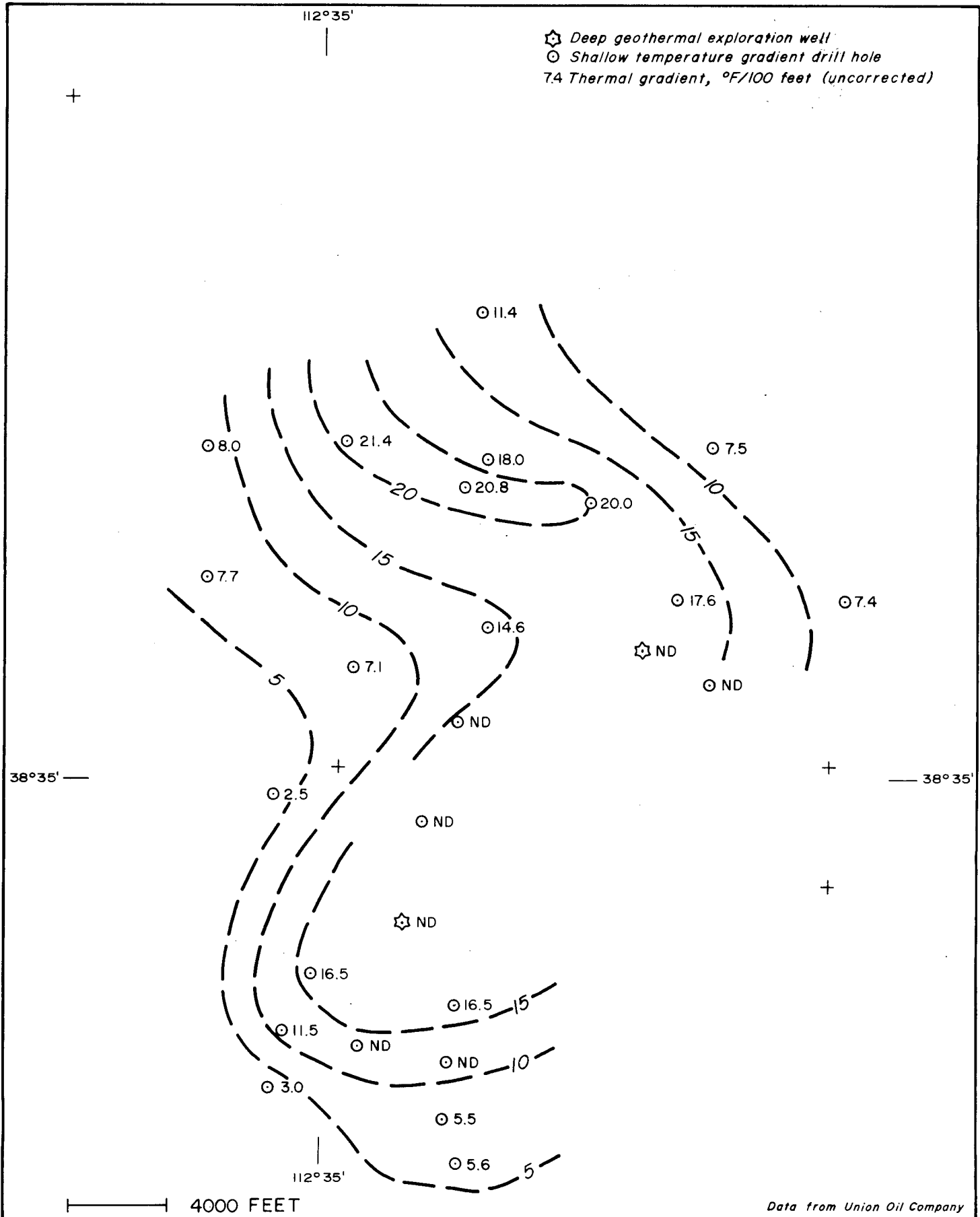


4000 FEET

FIGURE: 13B

COVE FORT-SULPHURDALE KGRA
MILLARD & BEAVER COS., UTAH

WT % MAGNETITE 100-200 FT.
SAMPLE TYPE: WHOLE ROCK
ANALYTICAL METHOD:



**FIGURE 14 - TEMPERATURE GRADIENT MAP
COVE FORT-SULPHURDALE KGRA
BEAVER AND MILLARD COUNTIES, UTAH**

TABLE 1
ESTIMATED THRESHOLD VALUES FOR COVE FORT-SULPHURDALE GEOCHEMICAL DATA

	<u>+3.3 CONCENTRATE</u>	<u>WHOLE ROCK</u>
As* (ppm)	50	8
Hg (ppb)	--	40
Pb (ppm)	250	40
Zn (ppm)	400	150

*As analytical methods: +3.3 by ICPQ and whole rock by colorimetric.

Table 2 - SUMMARY OF PERTINENT DRILL HOLE SAMPLE DATA

Drill hole Sample Interval	+3.3 (WT.%)	Sulfide (WT.%)	Magnetite (WT.%)	As (ppm)**		Hg (ppb)		Pb (ppm)		Zn (ppm)		Rock* Type	Sulfide (Vol %, Est.)
				+3.3	WR	WR	WR	+3.3	WR	+3.3	WR		
77-1 0-100	1.20	<.01	.55	28	4	13	351	31	257	67	Qa1	-	
100-200	.14	<.01	.17	32 (20)	5	36	245	48	234	79	Qa1	-	
200-250	.15	<.01	.13	27	4	-	415	47	293	72	Qa1	-	
77-2 0-100	.07	<.01	.17	27	6	9	1690	38	401	52	Qa1	-	
100-200	.14	<.01	.15	44	10	11	289	42	293	66	Qa1	-	
200-250	.20	<.01	.12	32 (28)	7	-	192	42	274	70	Qa1	.15% over 10'	
77-3 0-100	.43	<.01	.84	36 (18)	5	6	51	23	147	71	Qa1 (60), Tuff (40)	.10% over 10'	
100-230	.03	<.01	.23	126	4	7	106	20	115	63	Tuff	-	
77-4 0-100	.55	<.01	.72	28 (15)	12	5	39	25	175	70	Qa1	-	
100-200	.25	<.01	.21	44 (27)	6	14	106	26	256	60	Qa1	-	
200-250	.18	<.01	.08	<16 (12)	4	-	154	22	335	58	Qa1 (80), Dacite? (20)	-	
77-5 0-100	.12	<.01	.06	25	4	3	171	26	300	68	Qa1 (40), Tuff? (60)	-	
100-180	.34	<.01	.14	38 (25)	13	3	172	20	411	66	Tuff (60)	-	
74-1 0-100	.18	<.01	.09	41 (28)	6	191	108	31	223	66	Qa1	-	
100-200	.08	<.01	.06	70	6	60	326	37	1020	80	Qa1	.30%/180-200'	
200-300	.05	<.01	.12	44	2	-	196	27	519	117	Qa1 (80), Tuff? (20)	-	
74-2 0-110	<.01	<.01	<.01	-	12	744	-	<10	-	41	Qa1 (25), Quartzite (75)	.10%/40-110'	
74-3 0-100	.03	<.01	.02	-	44	103	-	13	-	98	Qa1	-	
100-200	.03	<.01	.10	229	14	144	342	20	1020	90	Tuff	-	
200-300	.02	<.01	.04	-	15	-	-	18	-	108	Tuff	3%/260-300'	
74-4 0- 90	.06	.04	<.01	970	40	47	32	16	1520	95	Qa1 (10), Tuff (90)	3%/30-70'	
74-5 0-100	.09	<.01	.20	87	7	16	48	21	576	107	Qa1	-	
100-200	.13	.09	.04	30	5	9	45	21	401	103	Qa1 (70), Tuff (30)	3%/180-200'	
200-300	.12	.07	.02	53	8	-	504	49	3890	226	Tuff	2% over 50'	
74-6 150-200	.27	<.01	.08	<16	<1	15	93	14	1140	414	Qa1 (15), Tuff (85)	.10%/160-200'	
200-250	.11	<.01	.07	<16	2	-	81	25	569	228	Tuff	.10%/200-220'	

*Data from chip logs

**As analytical method: +3.3 by ICPQ, parenthesized +3.3 check values and whole rock by colorimetric.

Drill Hole Sample Interval		Table 2 - Continued											Sulfide (Vol %, Est.)	
		+3.3 (WT.%)	Sulfide (WT.%)	Magnetite (WT.%)	As (ppm)**		Hg (ppb)		Pb (ppm)		Zn (ppm)			Rock* Type
					+3.3	WR	WR	WR	+3.3	WR	+3.3	WR		
74-8	0-100	.31	<.01	.47	23 (15)	9	12	63	25	320	75	Qa1	.30% over 30'	
	100-200	.17	<.01	.32	<16	6	13	70	29	386	80	Qa1	.20% over 10'	
	200-300	.16	<.01	.28	<16	4	-	77	33	682	94	Qa1	.10% over 10'	
74-9	0-100	.27	<.01	.42	33 (25)	3	8	86	24	392	194	Qa1	-	
	100-200	.14	<.01	.18	35	10	14	85	29	653	220	Qa1	-	
	200-300	.04	<.01	.01	88	11	-	74	27	1100	117	Qa1	.30%/250-280'	
74-10	0-100	.59	<.01	.34	<16 (10)	6	9	45	21	493	346	Qa1 (10), Dacite (90)	-	
	100-200	.12	<.01	.24	42	5	15	302	29	541	156	Dacite (30), Tuff (70)	-	
	200-250	.12	<.01	.27	27	5	-	201	37	577	301	Tuff	.15% over 30'	
74-11	0-100	.23	<.01	.51	49 (32)	4	9	72	23	375	105	Qa1 (80), Latite (20)	-	
	100-200	.01	<.01	.16	47	4	3	116	24	844	223	Latite	.20%/170-200'	
	200-300	.04	<.01	.24	-	2	-	-	24	-	193	Latite	.15%/200-240'	
74-12	0-100	.25	<.01	.54	34 (21)	2	19	141	23	311	288	Qa1	-	
	100-200	.54	<.01	.48	28 (15)	4	31	95	27	351	297	Qa1	-	
	200-250	.79	<.01	.16	34 (25)	10	-	101	22	293	272	Qa1	-	
74-13	0-100	.07	<.01	.19	42	3	7	93	21	406	79	Qa1 (60), Dacite (40)	-	
	100-200	.06	.04	.03	83	8	108	48	23	282	328	Dacite (10), Tuff (90)	.25% over 70'	
	200-250	.09	.07	.23	63	5	-	63	26	278	424	Tuff	.10% over 30'	
74-14	0-100	.06	<.01	.57	37	4	11	9890	23	402	164	Qa1 (25), Tuff (75)	-	
	100-200	.47	<.01	.42	<16 (5)	2	3	50	23	556	129	Tuff	-	
	200-250	.68	<.01	.48	<16 (10)	1	-	51	21	542	179	Tuff	-	
74-15	0-120	.65	<.01	.51	<16 (5)	6	5	113	22	667	520	Latite (15), Tuff (85)	-	
74-22	0-100	.66	<.01	.72	50 (30)	-	45	126	22	273	253	Qa1 (40), Tuff (60)	-	
	100-200	.41	<.01	.19	75 (35)	24	41	153	25	354	190	Tuff	-	
	200-250	.47	<.01	.18	176(160)	50	-	104	22	265	123	Tuff	-	

*Data from chip logs

** As analytical method: +3.3 by ICPQ, parenthesized +3.3 check values and whole rock by colorimetric.

Table 3 - SURFACE SAMPLE WHOLE ROCK GEOCHEMICAL DATA

Sample Number	As* (ppm)	Hg (ppb)	Pb (ppm)	Zn (ppm)	Sample Description and Location
UT/CV 501	10	—	23	10	Rock chip composite from open pit sulfur mine about 300 feet south of drill hole 74-5.
UT/CV 502	12	—	36	7	Black colored alluvium (ca. 20' below original surface) from pit wall near 501 sample location.
UT/CV 503	10	37	64	74	Red hematitic alluvium (ca. 4' below original surface) from pit wall near 501 sample location.
UT/CV 504	12	—	14	7	Rock chip composite from Excelsior Sulfur Pit, about 200 feet southwest of drill hole 74-4.
UT/CV 505	494	1356	33	58	Chip composite of siliceous limonitic material along structure about 1000 feet southwest of drill hole 74-4.
UT/CV 506	125	103	60	106	Rock chip composite from bedrock, Rain Bow fluorite deposit, about 2000 feet northeast of drill hole 74-3.
UT/CV 507	48	683	41	8	Rock chip composite from alluvium, Rain Bow fluorite deposit (loc. as above).

*As determined by ICPQ.

DISTRIBUTION LIST

External

David N. Anderson	Geothermal Resources Council, Davis, CA.
James K. Applegate	Boise State University, Boise, ID.
Sam Arentz, Jr.	Steam Corporation of America, Salt Lake City, UT.
Lawrence Axtell	Geothermal Services, Inc., San Diego, CA.
C. Forest Bacon	California Division of Mines & Geology, Sacramento, CA.
Larry Ball	DOE-URE, Grand Junction, CO.
Ronald Barr	Earth Power Corporation, Tulsa, OK.
H. C. Bemis	Fluid Energy Corp., Denver, CO.
David D. Blackwell	Southern Methodist University, Dallas, TX.
C.M. Bonar	Atlantic Richfield Co., Dallas, TX.
David Boore	Stanford University, Stanford, CA.
Roger L. Bowers	Hunt Energy Corporation, Dallas, TX.
Tom Box	Aminoil USA, Inc., Santa Rosa, CA.
A.J. Brinker	Al-Aquitaine Exploration Ltd., Denver, CO.
G.P. Brophy	DOE/DGE, Washington, DC.
R. Brownlee	Los Alamos Scientific Laboratory, Jemez Springs, NM.
William D. Brumbaugh	Conoco, Ponca City, OK.
Larry Burdge	EG&G Idaho, Idaho Falls, ID.
David R. Butler	Chevron Resources Company, San Francisco, CA.
E.F. Butler, Jr.	Duval Corporation, Reno, NV.
Scott W. Butters	Terra Tek, Salt Lake City, UT.
Glen Campbell	Gulf Min. Resource Company, Denver, CO.
Larry Cathles	Pennsylvania State University, State College, PA.
Ray Chantler	McCulloch Geothermal Corp., Los Angeles, CA.
Bob Christiansen	USGS, Menlo Park, CA.
Eugene V. Ciancanelli	Consulting Geologist, San Diego, CA.
Larry Cochran	Shell Oil Co., Houston, TX.
F. Dale Corman	O'Brien Resources, Inc., Kentfield, CA.
Ritchie Coryell	National Science Foundation, Washington, DC.
John Costain	Virginia Polytechnical Institute, Blacksburg, VA.
James Cotter	DOE/NV, Las Vegas, NV.
Gary Crosby	Phillips Petroleum Company, Del Mar, CA.
Louis DeLeon	Thermal Power Co., San Francisco, CA.
Jere Denton	Southland Royalty Company, Fort Worth, TX.
William Dolan	Amex Exploration Inc., Denver, CO.
W.L. D'Olier	Thermal Power Company, San Francisco, CA.
Richard F. Dondanville	Union Oil Co., Santa Rosa, CA.
Earth Sciences Division Library	Lawrence Berkeley Laboratory, Berkeley, CA.
Gordon Eaton	USGS, Hilo, HI.
Samuel M. Eisenstat	Geothermal Exploration Company, New York, NY.
Wilf Elders	University of California, Riverside, CA.
Domenic J. Falcone	Geothermal Resources International, Marina del Rey, CA.
Glen Faulkner	USGS, Water Resources Division, Menlo Park, CA.

Val A. Finlayson
James A. Finley
Joseph N. Fiore
Robert B. Forbes

Robert T. Forest
Robert O. Fournier
Robert Furgerson
Gary Galyardt
James Gilfillan
N. Sylvia Goeltz
N.E. Goldstein
Bob Greider
John Griffith
Jim Grubb
Donald L. Gustafson
J.H. Hafenbrack
W.R. Hahman

Dee C. Hansen
V. Noble Harbinson

Norman Harthill
Charles Helsley
John J. Hermance
Margaret E. Hinkle
John V. Howard
S. Morris Hubbard
Don Hull

R. Hume
Gerald W. Hutterer

J. J. Hylands
Cohut I. Ioan
Jimmy J. Jacobson
David Jarzabek
Claude Jenkins
George R. Jiracek
Richard L. Jodry
Max Jones
Paul Kasameyer
Gerald Katz
George Keller
Robert Kingston
Peter Kirwin
Don Klick
John W. Knox
James B. Koenig
Robert P. Koeppen

Utah Power and Light Company, Salt Lake City, UT.
Chevron Oil Field Research Co., La Habra, CA.
DOE/NV, Las Vegas, NV.
Alaska Geological and Geophysical Consultants,
Lopez, WA.
Phillips Petroleum Company, Reno, NV.
USGS, Menlo Park, CA.
Argonaut Enterprises, Denver, CO.
U.S. Geological Survey, Denver, CO.
Thermogenics, Santa Rosa, CA.
UV Industries, Salt Lake City, UT.
Lawrence Berkeley Laboratory, Berkeley, CA.
Intercontinental Energy Co., Denver, CO.
DOE/ID, Idaho Falls, ID.
Aminoil, Santa Rosa, CA.
Homestake Mining Co., Reno, NV.
Exxon Co. USA, Denver, CO.
Arizona Bureau of Geology & Mineral Technology
Tucson, AZ.
Utah State Engineer, Salt Lake City, UT.
O'Brien Resources, Incorporated, Toronto,
Ontario, Canada.
Group Seven, Incorporated, Golden, CO.
USGS, Hilo, HI.
Brown Univ., Dept. Geology Sci., Providence, RI.
USGS-Exploration Research, Golden, CO.
Lawrence Berkeley Laboratory, Berkeley, CA.
Denison Mines, Inc., Spokane, WA.
Oregon Dept. of Geology & Mineral Industries,
Portland, OR.
Al-Aquitaine Exploration, Ltd., Denver, CO.
Intercontinental Energy Corporation,
Englewood, CO.
Canex Placer Limited, Vancouver, B.C.
Hydrologist, Rumania
Battelle Pacific Northwest Labs., Richland, WA.
Geothermal Services, San Diego, CA.
Aminoil, Santa Rosa, CA.
University of New Mexico, Albuquerque, NM.
Richardson, TX
Sierra Pacific Power, Reno, NV.
Lawrence Livermore Laboratory, Livermore, CA.
DOE-San Francisco Operations, Oakland, CA.
Colorado School of Mines, Golden, CO.
KRTA Ltd., Auckland, New Zealand
Continental Oil Co., Denver, CO.
USGS, Reston, VA.
Sunoco Energy Development Company, Dallas, TX.
Geothermex, Berkeley, CA.
Oregon Institute Technology, Klamath Falls, OR.

George A. Kolstad
Roger Kolvoord
Mark Landisman
Art Lange
L.T. Larson
A.W. Laughlin

Guy W. Leach
R.C. Lenzer
Librarian
Paul Lienau
Mark A. Liggett
Don R. Mabey
Steven J. Maione
Skip Matlick
Robert B. McEuen
G.E. McKelvey
Don C. McMillan

Dennis S. McMurdie
J.R. McNitt

Tsvi Meidav
Frank G. Metcalfe
L. L. Mink
John Mitchell
Martin W. Molloy
Paul Morgan
Frank Morrison
L.J. Patrick Muffler
Ton A. Netelbeck
Clayton Nichols
H.E. Nissen
Denis Norton
Richard E. Nosker
James Nugent
Terry Offield
Franklin Olmsted
Carel Otte
Harold L. Overton
Richard H. Pearl
Sidney L. Phillips

Werner Raab
Alan O. Ramo
Robert W. Rex
Barbara Ritzma

David E. Robertson
George Rouse

DOE, Washington, DC.
Diversified Exploration Services, Lewisville, TX.
University of Texas, Dallas, Richardson, TX.
AMAX Exploration, Incorporated, Denver, CO.
University of Nevada, Reno, NV.
Los Alamos Scientific Laboratory, Los Alamos,
NM.

Santa Fe Energy Company, Amarillo, TX.
Phillips Petroleum Company, Del Mar, CA.
New Mexico Energy Institute, Las Cruces, NM.
OIT, Klamath Falls, OR.
Cyprus Georesearch Company, Los Angeles, CA.
USGS, Salt Lake City, UT.
Union Oil Company, Los Angeles, CA.
Republic Geothermal, Santa Fe Springs, CA.
Woodward Clyde Consultants, San Francisco, CA.
Cominco American, Spokane, WA
Utah Geological & Mineral Survey, Salt Lake City,
UT.

Southland Royalty Co., Fort Worth, TX.
Energy and Mineral Development Branch, United
Nations, NY.

Consultant, Berkeley, CA.
Geothermal Power Corporation, Novato, CA.
DOE-Idaho Falls Operations Office, Idaho Falls, ID.
Idaho Dept. of Water Resources, Boise, ID.
DOE-San Francisco Operations Office, Oakland, CA.
New Mexico State University, Las Cruces, NM.
University of California, Berkeley, CA.
USGS, Menlo Park, CA.
Pioneer Nuclear, Inc., Amarillo, TX.
DOE/DGE, Idaho Falls, ID.
Aminoil USA, Houston, TX.
University of Arizona, Tucson, AZ.
Thermogenics, Inc., Santa Rosa, CA.
New Albion Resources, San Diego, CA.
USGS, Denver, CO.
USGS, Menlo Park, CA.
Union Oil Company, Los Angeles, CA.
Consultant, Houston, TX.
Colorado Geological Survey, Denver, CO.
National Geothermal Information Resource, LBL,
Berkeley, CA.

Anaconda, Denver, CO.
Sunoco Energy Development Company, Dallas, TX.
Republic Geothermal, Inc., Santa Fe Springs, CA.
Science & Engineering Department, University of
Utah, Salt Lake City, UT.
Battelle Pacific Northwest Labs., Richland, WA.
Earth Sciences, Inc., Golden, CO.

Jack Salisbury
Konosuke Sato
John J. Schneider
Robert Schultz
John V.A. Sharp
Wayne Shaw
Donald W. Smellie
John Sonderegger
Neil Stefanides
R.C. Stoker
Reid Stone
Paul V. Storm
Gene Suemnicht
Chandler Swanberg
Charles M. Swift, Jr.
Robert L. Tabbert
Maren A. Tielman
J. Mike Thompson
Ronald Toms
Dennis T. Trexler
John Tsiaperas
A.H. Truesdell
Don Turner
USGS Library

Jack Von Hoene
D. Roger Wall
Richard B. Weiss
Gehard Westra
Don E. White
Maggie Widmayer
Gordon Wieduwilt
Syd Willard
Barry Williams
Paul Witherspoon
Harold Wollenberg
B.J. Wynat
Walter Youngquist
Paul C. Yuen
S.H. Yungul
Eliot J. Zais

Internal

W. Ursenbach
S.H. Ward (2)
P.M. Wright
H.P. Ross
J.R. Bowman
W.T. Parry
J.N. Moore
D.L. Nielson
D. Foley
Master Report File

DOE/DGE, Washington, DC.
Metal Mining Agency of Japan, Minato-Ku, Tokyo.
Shell Oil Company, Houston, TX.
EG&G Idaho, Idaho Falls, ID.
Hydrosearch, Inc., Reno, NV.
Getty Oil Company, Bakersfield, CA.
Gulf Minerals Canada Ltd., Toronto, Canada
Montana Bureau of Mines & Geology, Butte, MT.
Union Oil Company, Los Angeles, CA.
Forsgren Perkins & Assoc., Rexburg, ID.
USGS, Menlo Park, CA.
California Energy Company, Santa Rosa, CA.
Union Oil Co., Santa Rosa, CA.
New Mexico State University, Las Cruces, NM.
Chevron Oil Company, San Francisco, CA.
Atlantic Richfield Company, Dallas, TX.
International Engineering Co., San Francisco, CA.
U.S.G.S., Menlo Park, CA.
DOE/DGE, Washington, DC.
Nevada Bureau of Mines & Geology, Reno, NV.
Shell Oil Company, Houston, TX.
USGS, Menlo Park, CA.
University of Alaska, Fairbanks, AK.
Menlo Park, CA.
Denver, CO.
Reston, VA.
Davon, Inc., Milford, UT.
Aminoil USA, Inc., Santa Rosa, CA.
Harding-Lawson Assoc., San Rafael, CA.
Exxon Co., USA, Tucson, AZ.
USGS, Menlo Park, CA.
DOE/ID, Idaho Falls, ID.
Mining Geophysical Surveys, Inc., Tucson, AZ.
California Energy Commission, Sacramento, CA.
Geothermal Services, San Diego, CA.
Lawrence Berkeley Laboratory, Berkeley, CA.
Lawrence Berkeley Laboratory, Berkeley, CA.
Occidental Geothermal, Inc., Bakersfield, CA.
Consultant, Eugene, OR.
University of Hawaii @ Manoa, Honolulu, HI.
Chevron Resources Company, San Francisco, CA.
Elliot Zais & Associates, Corvallis, OR.

UURI, Salt Lake City, UT.
GG/UU, Salt Lake City, UT.
ESL/UURI, Salt Lake City, UT.
ESL/UURI, Salt Lake City, UT.
GG/UU, Salt Lake City, UT.
GG/UU, Salt Lake City, UT.
ESL/UURI, Salt Lake City, UT.
ESL/UURI, Salt Lake City, UT.
ESL/UURI, Salt Lake City, UT.
ESL/UURI, Salt Lake City, UT.
ESL/UURI, Salt Lake City, UT.