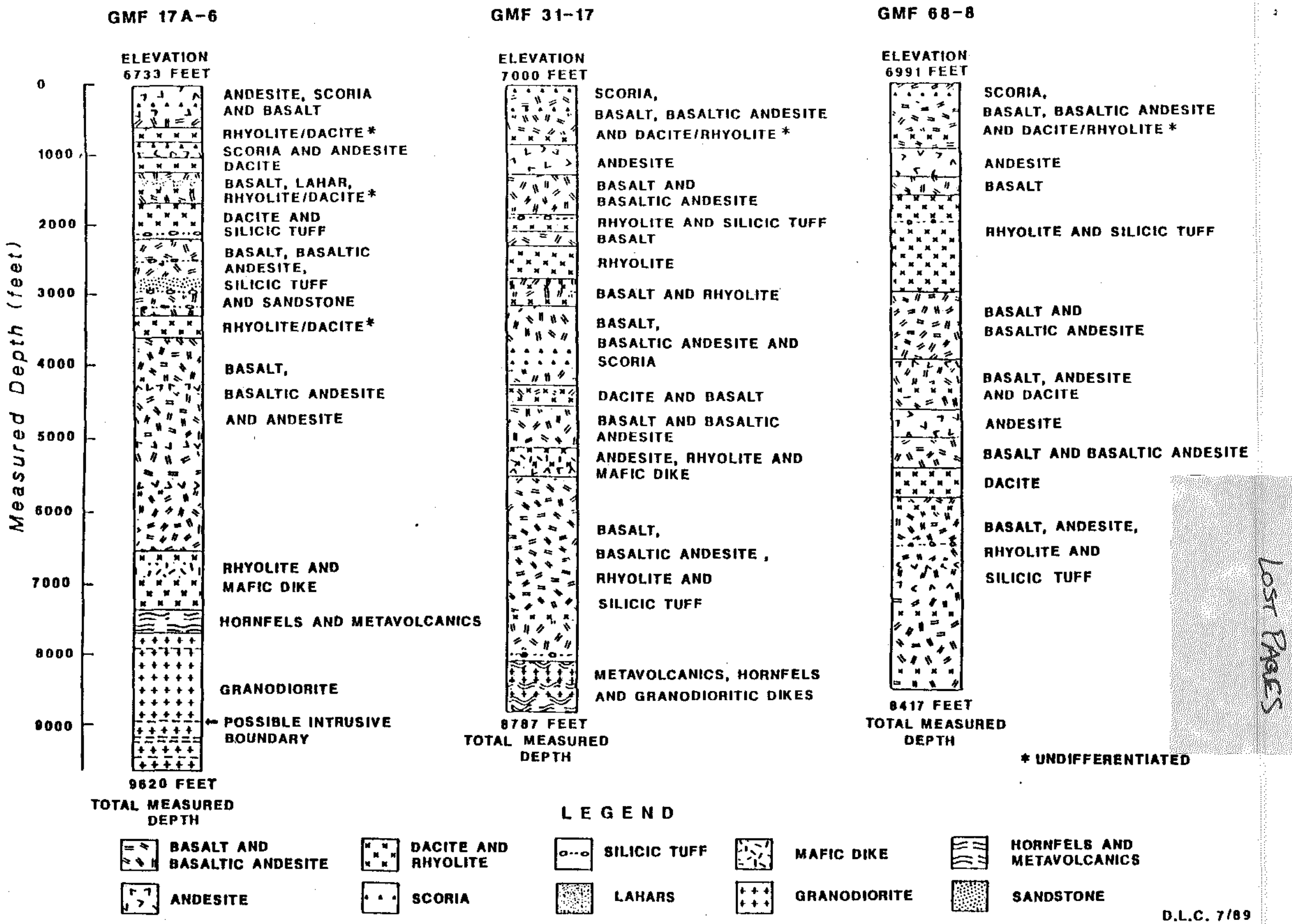

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Figure 2: Generalized lithologic profiles of GMF17A-6, GMF31-17, and GMF68-8.

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APPENDIX 1

SIGNIFICANCE AND LIMITATIONS OF THE OXYGEN-18 DATA

The "normal" range of $\delta^{18}O$ values for unaltered MLH volcanic rocks vary from 5.2 to 8.5 $^{o}/oo$ (Smith and others, 1986). The background A population for MLH rocks is statistically determined to have a threshold of 4.2 $^{o}/oo$, and includes values that represent no depletion and minor depletion. The physical boundary between no depletion and minor depletion is not sharp and depends upon the mineralogy of the rock (Taylor, 1979). This effect is exemplified by the 60° to 130°C range for the "crossover" temperatures for MLH rocks (see page 5 in text). Therefore, the 4.2 $\pm$ .2% threshold of the A population is considered to represent depletion that is significantly below the range of normal rocks.

The significance of the "high-temperature" populations is demonstrated when the equilibrium temperatures are calculated with the following simplistic assumptions: (1) quartz-H_2O equilibrium, (2) unexchanged MLH rocks have an average $\delta^{18}O$ value of 6 per mil (0/00), and (3) a geothermal fluid with the -13 0/00 $\delta^{18}O$ value of MLH meteoric water (Gallinatti, 1984). The result is a maximum temperature of formation of 180°C (355°F) for the threshold of the C population (-.1 0/00). However, if the $\delta^{18}O$ values of the geothermal fluids are actually shifted +4 0/00, such as at Steamboat Springs, Nevada (Tresdell and Hulston, 1980), then the maximum calculated temperature of formation is 255°C (490°F) for the threshold of the C population. Therefore, it is important to measure the $\delta^{18}O$ of the reservoir fluid either directly or through fluid inclusion prior to making temperature estimates from oxygen data.

The accurate estimate of temperatures utilizing $\delta^{18}O$ values assumes that uniform permeability exists in the hydrothermal system. No whole-rock oxygen-18 depletion will occur in a hot-dry rock environment except possibly through rock interaction with CO_2 gas (Smith, pers. comm.). Therefore, high temperatures can occur in areas where background oxygen-18 depletions are measured.

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APPENDIX 2

METHODS AND ERROR ANALYSIS

Trace Elements

A total of 1168 samples were analyzed for mercury and arsenic concentrations at Bondar-Clegg and Rocky Mountain Geochemical Corp. laboratories. The sampled intervals varied from 25 to 100 feet and the type of samples varied from drill chips to core on a borehole to borehole basis. The regularity of the core samples varied depending upon the completeness of the available core sample. Boreholes with complete sections of core were sampled routinely on an even interval basis and, boreholes with incomplete sections of core were sampled as the opportunity allowed.

The accuracy of the statistics applied to the trace element data is limited because (1) the size of the sample intervals varied, (2) the types of samples varied and (3) more than one laboratory was used for sample analysis. Collecting and analyzing composite samples over an interval rather than a discrete sample smooths an anomaly by averaging its magnitude over the interval length. The greater the sampled interval, the greater the anomaly is smoothed. Therefore, the absolute magnitude of values, particularly in the C population, are probably dampened. However, since the C population is already statistically under-sampled, the overall impact is probably minor. Similarly, drill-chip samples are a more homogeneous representation of an interval than core because the chips are small and often well mixed in the well bore. Chip samples generally produce anomalies that are smoother and have lower magnitudes than on individual core sample or intervals of core samples. Utilizing two different laboratories for analysis affects the data because each lab reports different detection limits and precision for their analysis. However, the background A populations are probably most affected by these limitations. Therefore, the impact on the interpretation of the data is likely negligible.

Oxygen Isotopes

A total of 285 samples were analyzed for whole-rock oxygen-isotopes by the Geochron Laboratories Division of Krueger Enterprises, Inc. and Brian Smith of Unocal Science and Technology in Brea, California. Drill chips and core were analyzed.

Statistical analysis of oxygen-18 data results in the identification of four anomalous populations. Since the reproducibility of rerun samples from MLH is generally ± .2 ^{o}/oo, the threshold values for each population is also probably accurate to ± .2^{o}/oo. Therefore, care is needed when interpreting numbers near the threshold values.

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APPENDIX 3

OBSERVATIONS AND INTERPRETATIONS FOR GMF 17A-6 AND SELECT BOREHOLES MENTIONED IN THE TEXT.

The observations and interpretations summarized below help to further illustrate the significance of the anomalous geochemical data in select boreholes and well GMF 17A-6. The distribution of the geochemical data is shown in Figure 7 for GMF 28-32, GMF 17A-6 (17-6), GMF 45-37, GMF 44-33 and ML 14-23, Figure 8 for GMF 56-3, and Figure 9 for GMF 87-13.

(1) GMF 28-32: The trace-element data are characterized by anomalous enrichment from 10' to 650' and 1910' to 3460'. No trace-element data were collected below 3460'. The oxygen-18 data are characterized by anomalous depletion at 440', and values that decrease uniformly from background levels at 3120' to strongly-depleted levels (D population) at 4252'. This is probably the result of a high-conductive temperature gradient over this interval. The coincidence of anomalous mercury and arsenic enrichment, and $\delta^{18}O$ values that decreases from background to low-level depletion in the 1910' to 3460' interval probably indicates of low to moderate hydrothermal activity. The occurrence of anomalous arsenic and $\delta^{18}O$ values in the 10' to 650' interval is probably indicative of the lateral flow of shallow, low to moderate-temperature thermal fluids.

(2) GMF 17A-6 (17-6): The geochemical data from GM 17A-6 is of particular interest because mafic to silicic intrusive rocks are present from 7720' to 9620' T.D. in the well. The data are characterized by arsenic enrichment in the 4000' to 6500' interval and strong oxygen depletion from 4750' to 9620'. The oxygen-18 values change abruptly from background levels to high-level depletion in the 4310' to 4750' interval.

The geochemical data indicate that at a depth $\geq$4000', high-temperature hydrothermal activity has probably occurred in the vicinity of GMF 17A-6. The best evidence for large-scale directed fluid flow occurs in the 4750' to 6500' interval where strong arsenic enrichment and oxygen depletion coincide. The oxygen data suggest that high-temperature fluids have also existed in the 6500' to 9620' interval. However, no arsenic enrichment is measured. This is possibly the result of either extremely high formation temperatures that have caused the arsenic to sublime, or the absence of large-scale directed fluid flow in this interval. The abrupt change of the oxygen-18 values in the shallower 4310' to 4750' interval does coincide with the occurrence of anomalous arsenic enrichment. This implies good formation permeability and suggests that a steep fluid temperature gradient (30 to 60°F/100') occurs in this interval and possibly results from the mixing of low and high-temperature fluids in the interval.

(3) GMF 45-36: The distribution of the geochemical data in this borehole is characterized by (a) minor mercury enrichment from 510' to 660', (b) arsenic enrichment from 2310' to 3060', and (c) oxygen-18 depletion from 2420' to 4000' TD. Although the oxygen data suggest that borehole temperatures generally increase with depth, the $\delta^{18}O$ values fluctuate widely in the 3020' to 4000' interval. This probably results from variations in either formation permeabilities, or fluid temperatures. The best evidence for large-scale directed fluid flow occurs in the 2310' to 3060' interval where arsenic and $\delta^{18}O$ anomalies coincide. However, the oxygen data suggest that temperatures in this interval probably range from low to moderate.

(4) GMF 44-33: The geochemical data from GMF 44-33 is of particular interest because this is the only borehole at MLH that flowed thermal fluids during drilling. Anomalous arsenic and mercury in GMF 44-33 generally correlate with intervals of lost circulation or hot-water entries. The longest interval of mercury enrichment is measured from 1245'-1545', and coincides with strong arsenic enrichment (C population) at 1485'-1515' and a lost circulation zone at 1440'.

(5) ML 14-23: Anomalous arsenic enrichment is measured but anomalous mercury and anomalous oxygen-depletion are not. The arsenic enrichment occurs in the 2450'-2800' interval and is probably the result of the direct flow low-temperature thermal fluids.

(6) Borehole GMF 56-3: Oxygen-18 depletion and trace-element enrichments in GMF 56-3 support the contention that hydrothermal activity has occurred in the vicinity of the borehole. The pattern of oxygen-18 depletion and arsenic enrichment (Figure 8) indicate moderate-temperature geothermal fluids have been present at depths near 1636' and low-temperature thermal fluids at depths near 1341'. Mercury and arsenic enrichment coincide at 816'-933', and possibly indicate low-temperature and low-pH fluid flow. Some vertical separation of mercury and arsenic enrichment occurs in the 649'-781' interval. This probably indicates vapor partitioning from the hydrothermal fluids, and is

APPENDIX 4

VERTICAL GEOCHEMICAL PROFILES

The distribution of mercury, arsenic, $\delta^{18}O$ and lithology are shown in this section for well GMF 17A-6 and each MLH borehole. The principal facts from the statistical analysis of the geochemical data are shown in Table 1 (see text).

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possibly the result of boiling. Mercury enrichment in the 258'-590' interval probably resulted from either HgS precipitation during steam condensation or from adsorption of mercury vapor on the surfaces of clay, organic, or organometallic compounds.

(7) Borehole GMF 87-13: Anomalous enrichment of mercury is found in 43% of the 242' to 908' interval of GMF 87-13 (Figure 9). However, arsenic enrichment and anomalous oxygen-18 depletion are not measured in the borehole. The mercury enrichment in GMF 87-13 has probably resulted from precipitation of HgS by steam condensation, or adsorption of mercury on the surface of clay, organic, and organometallic compounds. The anomalous distribution of mercury throughout the borehole and the magnitude of the enrichment (1000 ppb) probably indicates lateral or vertical partitioning of mercury from a nearby hydrothermal system.

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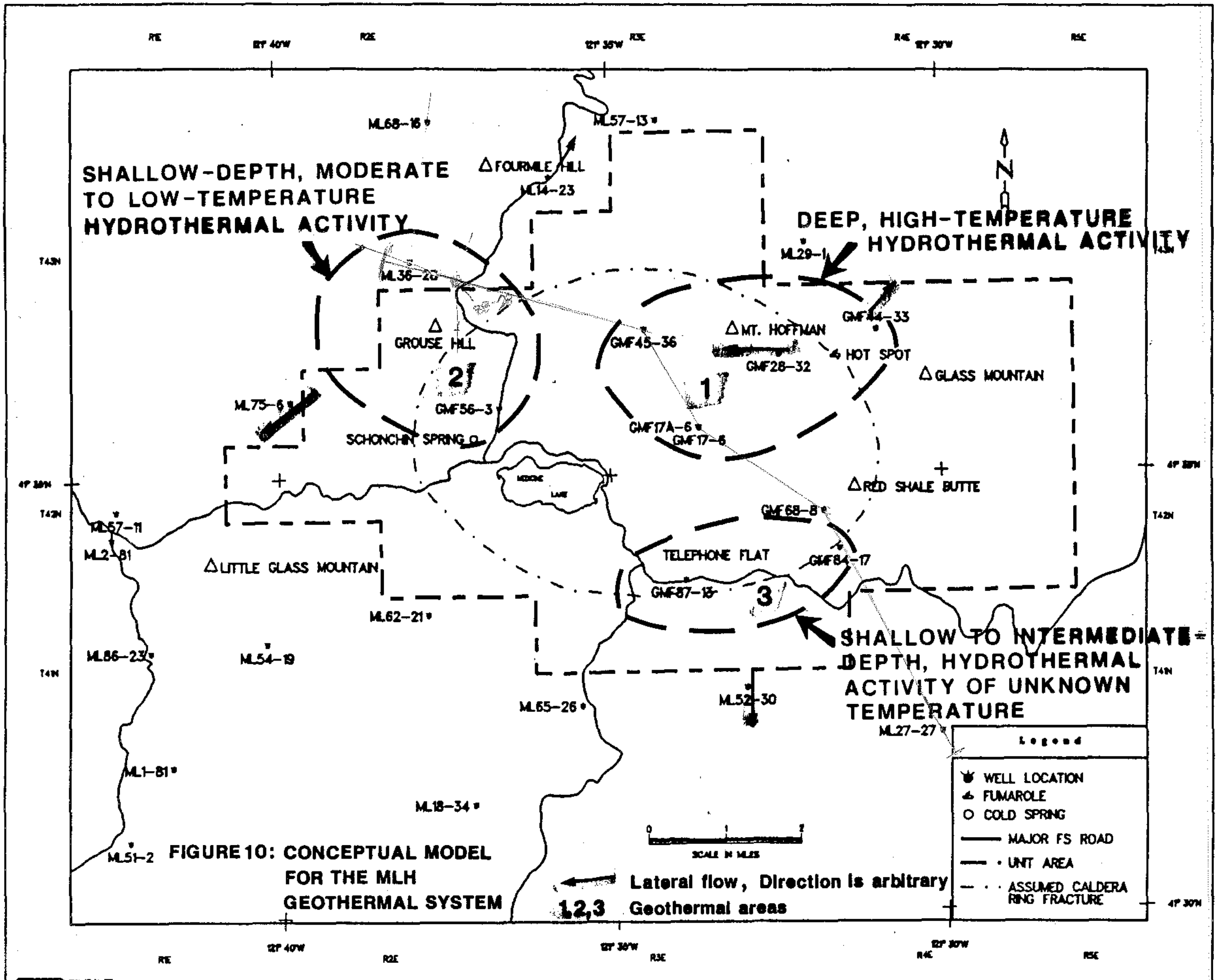

FIGURE 10: CONCEPTUAL MODEL FOR THE MLH GEOTHERMAL SYSTEM

TABLE 2: PARAMETERS USED TO CONSTRUCT THE CONCEPTUAL MODEL SHOWN IN FIGURE 10. THE RELATIVE TEMPERATURES WERE ESTIMATED FROM THE THRESHOLDS OF THE $\delta^{18}O$ POPULATIONS SHOWN IN TABLE 1.

TEMPERATURES

Low	$\delta^{18}O$:	A population (background)
Moderate	$\delta^{18}O$:	B and C populations
High	$\delta^{18}O$:	D and E populations

DEPTHS

Shallow	0-1999'
Intermediate	2000'-3999'
Deep	≥4000'

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the vicinity of these boreholes. The pattern of oxygen-18 depletion and arsenic enrichment in GMF 56-3 is indicative of moderate-temperature hydrothermal activity at 1636', and low-temperature hydrothermal activity at 1341'. Although no anomalous arsenic or oxygen-18 are measured in GMF 87-13, anomalous mercury is measured in 43% of the 242' to 908' interval and has a magnitude of about 1000 ppb. The strongly anomalous distribution of mercury throughout GMF 87-13 is probably indicative of the lateral or vertical partitioning of mercury from a nearby hydrothermal system.

C. GEOCHEMICAL CONCEPTUAL MODEL FOR THE MLH GEOTHERMAL SYSTEM

A conceptual model of the MLH geothermal system has been constructed using the parameters in Table 2, and is shown in Figure 10. Several factors limit the completeness and accuracy of the model. The large separation between boreholes (generally 1 mile) makes the model a broad-brush representation of the geothermal system. Since the model is based on geochemical data alone, and is not constrained by subsurface temperatures, it does not distinguish between current or extinct hydrothermal activity. Finally, deep ($\geq$4000') drilling has only been attempted near Mt. Hoffman. Therefore, that is the only area that displays direct evidence of a well developed high-temperature system. Nevertheless, three areas are identified where significant hydrothermal activity has occurred:

GEOTHERMAL AREA 1:
A well-developed geothermal system has probably existed and possibly still exists in the Mt. Hoffman area. The system is characterized by deep, high-temperature hydrothermal activity and intermediate-depth, moderate-temperature hydrothermal activity. This system is possibly manifested by shallow hydrothermal activity in the Hot Spot located near GMF 44-33.

GEOTHERMAL AREA 2:
Shallow-depth, moderate to low-temperature hydrothermal activity has probably occurred in the area north and northwest of Medicine Lake. This activity has possibly resulted in shallow, low-temperature, lateral outflow to the west and intermediate-depth, low-temperature, lateral outflow to the north.

GEOTHERMAL AREA 3:
Shallow and intermediate-depth hydrothermal activity of unknown temperature has probably occurred in the Telephone Flat-Red Shale Butte area. Shallow boiling has possibly been associated with the activity.

It is impossible to determine if the hydrothermal activity in each of the three areas share a common reservoir. However, the data do establish the occurrence of widespread hydrothermal activity at Medicine Lake Highland.

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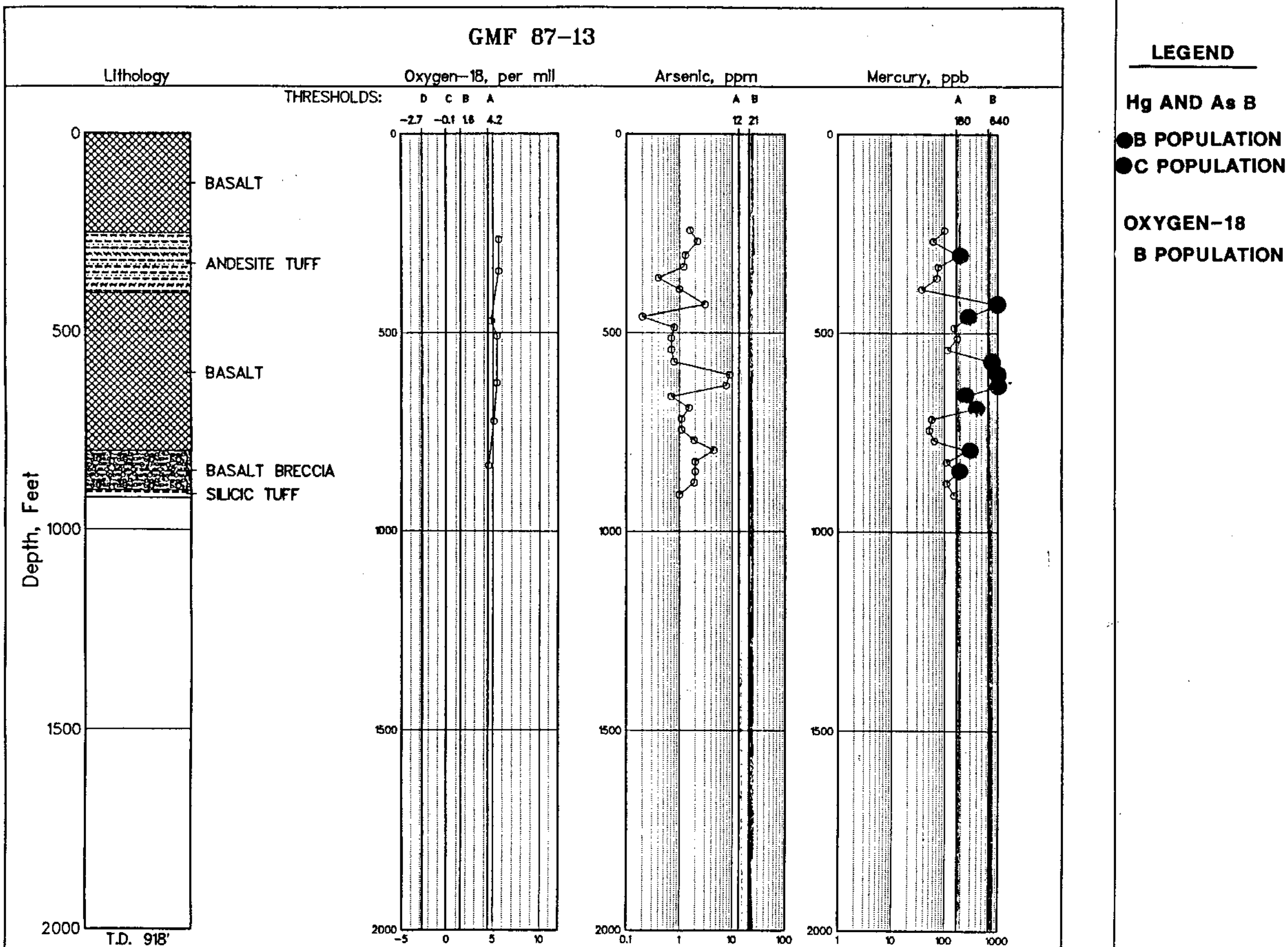

Fig 9: LITHOLOGICAL AND GEOCHEMICAL PR LE FOR BOREHOLE GMF 87-13

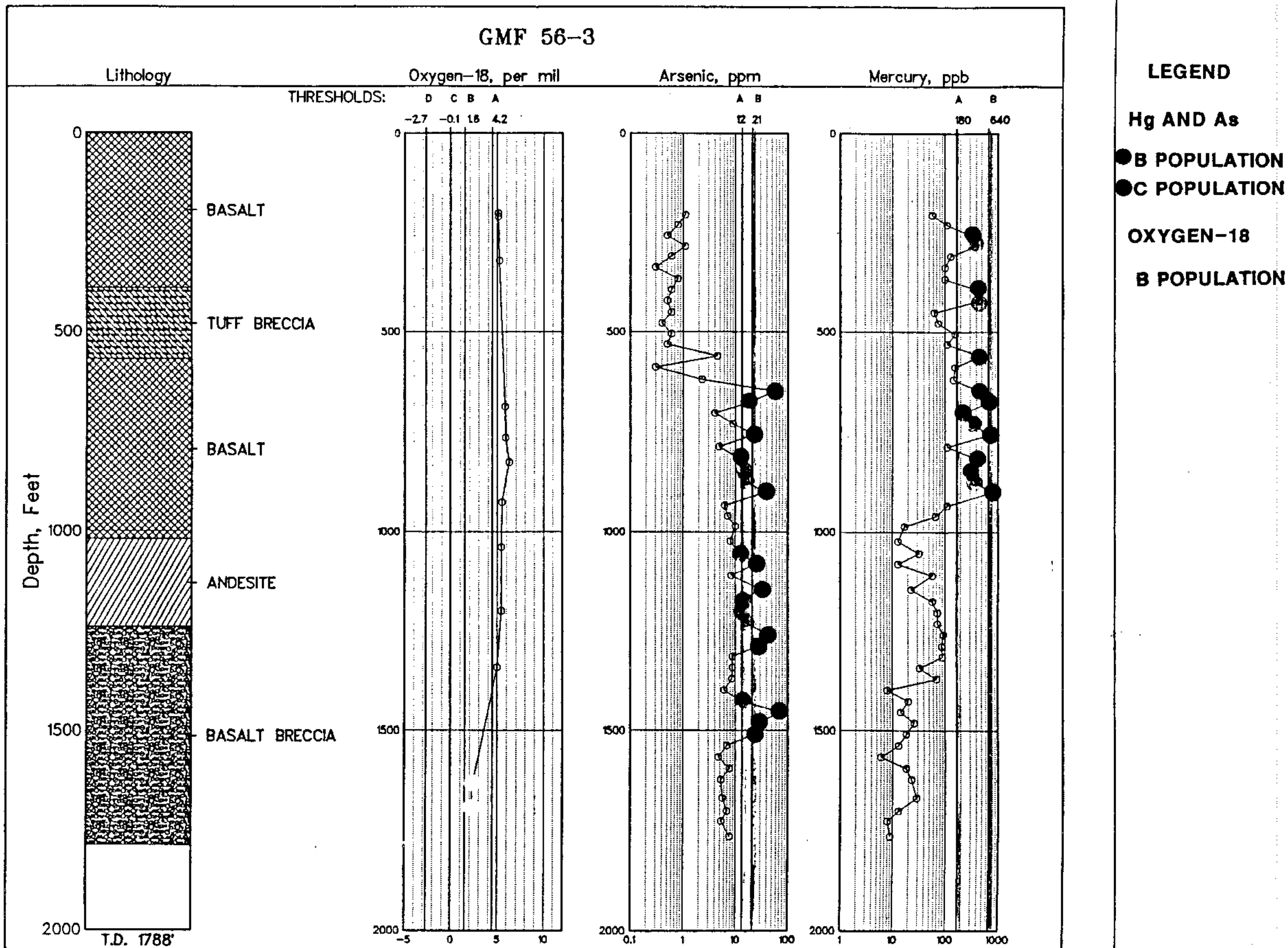

Figure 8: LITHOLOGICAL AND GEOCHEMICAL PROFILE FOR BOREHOLE GMF 56-3

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strongly anomalous oxygen depletion (D and E population) measured at 3000' to 5000' depths (about 2000' to 3000' above sea level) in GMF 28-32, GMF 45-36 and GMF 17A-6. Three other observations that characterize the hydrothermal activity at MLH can be made from the geochemical data in cross-section A-A'. First, trace element and oxygen anomalies are generally independent of lithology. Second, arsenic enrichment is measured in samples with all grades of oxygen-18 depletion (A to E populations). Finally, mercury enrichment is measured only in samples where anomalous oxygen depletion is not measured.

Deep well GMF 17A-6 (17-6) and borehole GMF 44-33 are unique from other MLH boreholes and wells. GMF 17A-6 contains the only thick section of intrusive rocks (7720' to 9620' T.D.) that has to date been drilled, and GMF 44-33 is the only borehole to flow fluids during drilling. Therefore, the geochemical profiles for GMF 17A-6 and GMF 44-33 are further detailed below. Detailed observations and interpretations are made in Appendix 3 for all the boreholes discussed in this section.

GMF 17A-6 (17-6): The geochemical data from GM 17A-6 is of particular interest because mafic to silicic intrusive rocks are present from 7720' to 9620' T.D. in the well. The data are characterized by arsenic enrichment in the 4000' to 6500' interval and strong oxygen depletion from 4750' to 9620'. The oxygen-18 values change abruptly from background levels to high-level depletion in the 4310' to 4750' interval.

The geochemical data indicate that deep (>4000'), high-temperature hydrothermal activity has probably occurred in the vicinity of GMF 17A-6. The best evidence for large-scale directed fluid flow occurs in the 4750' to 6500' interval where strong arsenic enrichment and oxygen depletion coincide. The oxygen data suggest that high-temperature fluids have also existed in the 6500' to 9620' interval. However, no arsenic enrichment is measured. This is possibly the result of either (a) extremely high formation temperatures that have caused the arsenic to sublime, or (b) the absence of large-scale directed fluid flow in this interval. The abrupt change of the oxygen-18 values in the shallower 4310' to 4750' interval does coincide with the occurrence of anomalous arsenic enrichment. This implies good formation permeability and suggests that a steep fluid temperature gradient (30 to 60°F/100') occurs in this interval and possibly results from the mixing of low and high-temperature fluids in the interval.

GMF 44-33: The geochemical data from GMF 44-33 is of particular interest because thermal fluids were produced from zones at 1012' and 2230'-2260' during drilling. Anomalous arsenic and mercury in GMF 44-33 generally correlate with intervals of lost circulation or hot-water entries. The longest interval of mercury enrichment is measured from 1245'-1545', and coincides with strong arsenic enrichment (C population) at 1485'-1515' and a lost circulation zone at 1440'.

The geochemical data from GMF 56-3 (Figure 8) and GMF 87-13 (Figure 9) support the contention that hydrothermal activity has occurred in

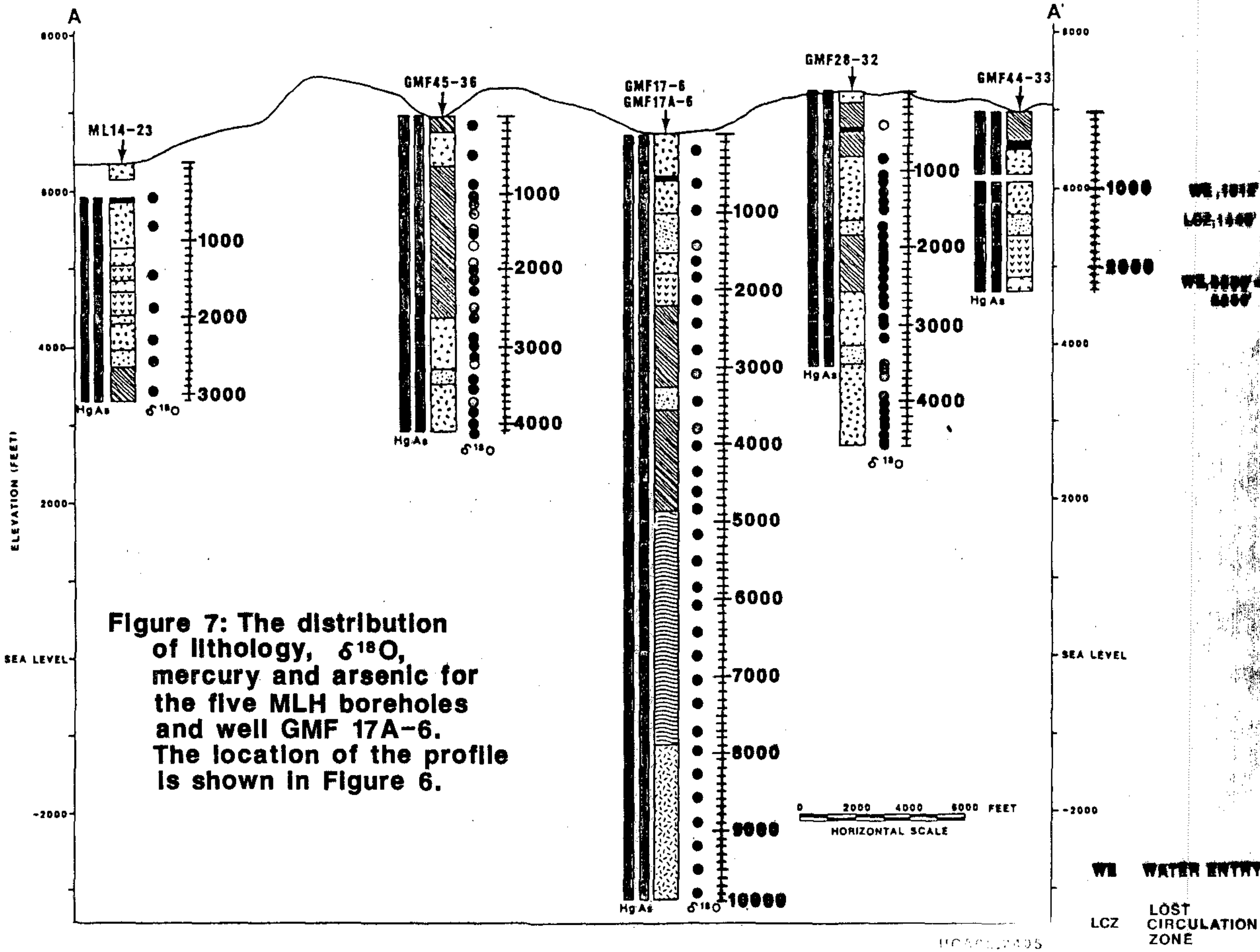

Figure 7: The distribution of lithology, $\delta^{18}O$, mercury and arsenic for the five MLH boreholes and well GMF 17A-6. The location of the profile is shown in Figure 6.

LITHOLOGIC KEY

RHYOLITE LAVAS	VOLCANIC SEDIMENTS
DACITE LAVAS	SILICIC TUFF
ANDESITE LAVAS	ANDESITE TUFF
BASALT LAVAS	STRONGLY ALTERED VOLCANIC ROCKS
MAFIC TO SILIC INTRUSIVE ROCKS	

MERCURY AND ARSENIC KEY

A POPULATION (BACKGROUND)

B POPULATION

C POPULATION

WHOLE-ROCK OXYGEN-ISOTOPE KEY

	RELATIVE* TEMP.
A POPULATION	LOW
B POPULATION	
C POPULATION	MODERATE
D POPULATION	
E POPULATION	HIGH

* See text for details.

FIGURE 7a: Legend to geochemical cross section A-A[1].

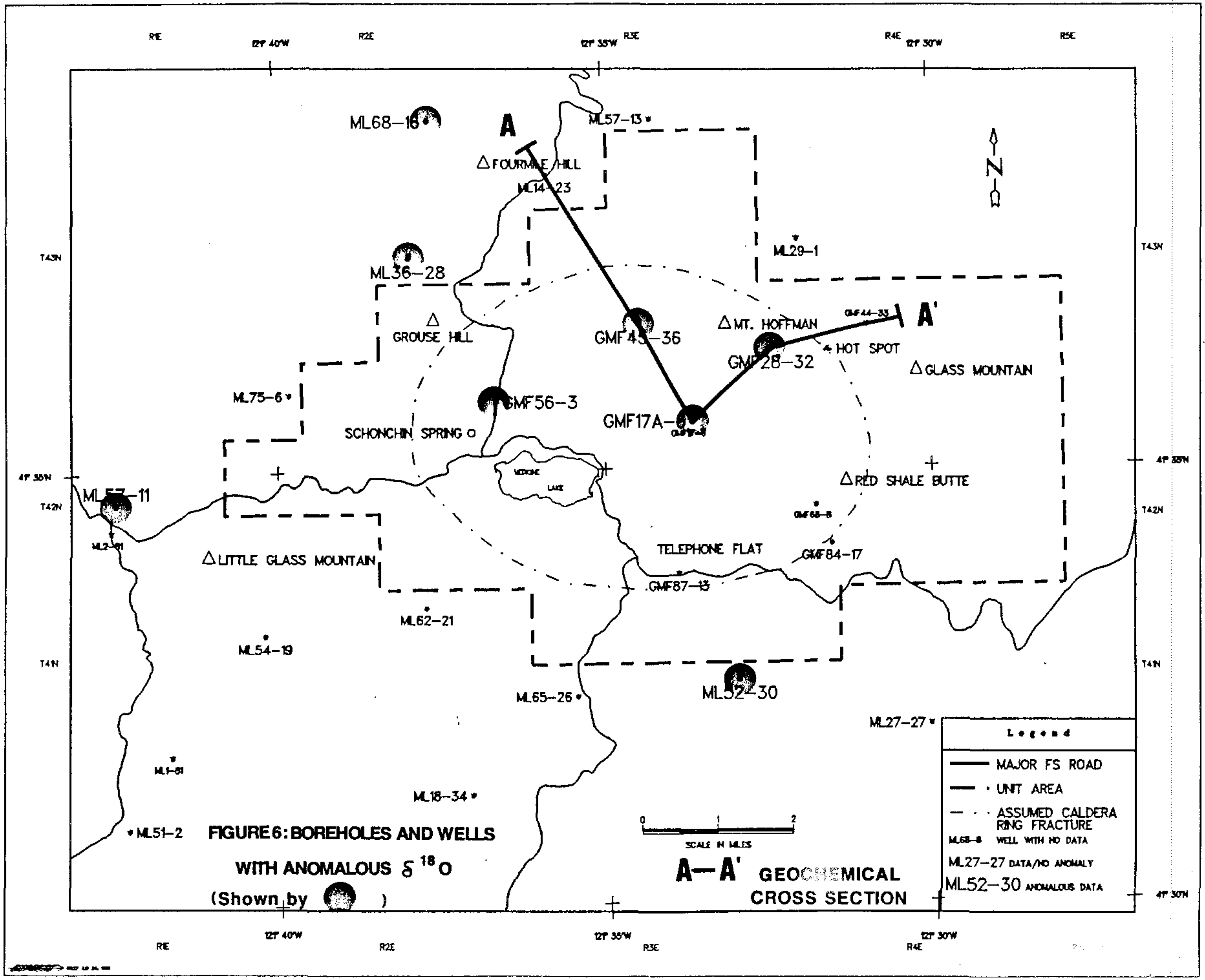

FIGURE 6: BOREHOLES AND WELLS WITH ANOMALOUS $\delta^{18}O$ (Shown by)

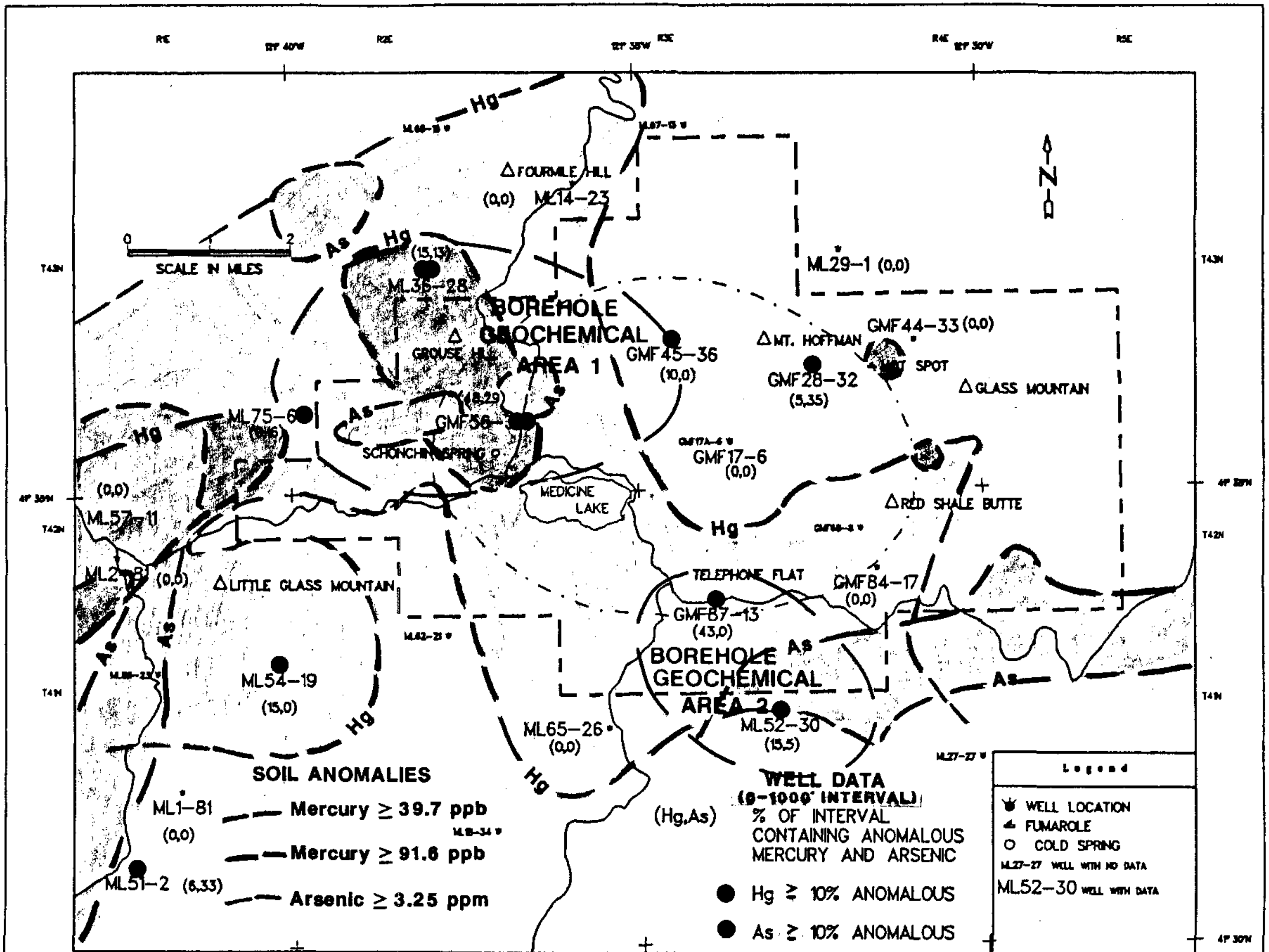

FIGURE 5: DISTRIBUTION OF MERCURY AND ARSENIC IN SOILS AT MLH. FIGURE IS MODIFIED FROM WILLIS (1983).

affected by widespread outflow. Alternatively, the distribution of the trace-elements could be lithologic controlled, and not related to current hydrothermal activity. The relationship between lithology and trace-element distribution is best examined in cross section, and this is done later in this report. Since data exist for only six boreholes in the 2000'-3000' interval, direct comparisons with shallower intervals are probably not reliable. However, the 2000'-3000' data do suggest the occurrence of moderate-depth hydrothermal activity in the Mt. Hoffman area.

The occurrence of anomalous mercury and arsenic in the 0-1000' interval is compared in Figure 5 with the distribution of the trace elements in soils (Willis, 1983). Although the soil anomalies are mapped utilizing a different statistical technique, there is good correlation between the soil and shallow borehole data. This is interpreted as further evidence that widespread, shallow hydrothermal activity (possibly outflow) has occurred at MLH. The one notable exception is in the western Little Glass Mountain area. There, strong trace-element anomalies are measured in soil samples but are completely absent in the 0-1000' interval of ML 57-11. This suggests the soil anomalies are possibly sedimentary and not the result of shallow subsurface hydrothermal activity.

B. AREAL DISTRIBUTION OF ROCK OXYGEN ISOTOPES

Twenty boreholes and the geothermal well GMF 17A-6 have been sampled for oxygen-isotopes (Figure 6). Samples from seven boreholes and GMF 17A-6 showed anomalous oxygen depletion. Two boreholes (ML 57-11 and ML 52-80) contain one point anomalies that are sandwiched between background values, and ML 36-28 and ML 68-16 had anomalous values only in the bottom hole sample. The distribution of $\delta^{18}O$ is best displayed in the cross sections presented in the next section.

C. VERTICAL DISTRIBUTION AND INTEGRATION OF TRACE ELEMENT AND OXYGEN ISOTOPE DATA

The distribution of trace elements, oxygen isotopes and lithology is shown in cross section and vertical profile for deep well GMF 17A-6 and seven boreholes in Figures 7, 8 and 9. Five boreholes and GMF 17A-6 are shown together in cross-section A-A' (Figure 7) in a comparison of data collected in the Mt. Hoffman area where the deepest drilling has occurred. Since the data from GMF 17A-6 are incomplete, data from GMF 17A-6 and GMF 17-6, which were drilled off the same pad, are combined to make a complete vertical profile for the cross section. No oxygen data exist for GMF 44-33. Boreholes GMF 56-3 and GMF 87-13 in Figures 8 and 9 compare the shallow (0-1000') geochemical anomalies outlined as Area 1 and Area 2, respectively, in Figure 2.

The geochemical data in cross-section A-A' indicate that moderate-depth, high-temperature hydrothermal activity has probably occurred over a large area of MLH. This is principally shown by the this report. The significance of the oxygen data and actual temperature estimates for the moderate and high temperature boundary are discussed further in Appendix 1.

RESULTS

A. AREAL DISTRIBUTION OF MERCURY AND ARSENIC

The distribution of mercury and arsenic in MLH boreholes and GMF 17A-6 is determined for the intervals of 0-1000', 1000'-2000', and 2000'-3000' depths, and plotted in plan view (Figures 2, 3 and 4). Greater depths are not considered since the available data were limited to well GMF 17A-6 and boreholes GMF 28-32 and GMF 17-6. The data are presented as the percent of anomalous values over a sampled interval (generally 1000'). The following general observations and interpretations can be made:

(1) <u>0-1000'</u>: Trace element concentrations have been measured in 19 boreholes (Figure 2). Seven boreholes contain anomalous mercury and five contain anomalous arsenic. Anomalous trace-element enrichment occurs in boreholes located north and northwest of Medicine Lake (Area 1) and at Telephone Flat (Area 2). Area 1 is characterized by anomalous mercury and arsenic enrichment, however, Area 2 is characterized primarily by anomalous mercury enrichment. Significantly anomalous arsenic (>30%) is also measured in the widely separated boreholes ML 51-2 and GMF 28-32 which are not located in Area 1 or Area 2.

(2) <u>1000'-2000'</u>: Trace element concentrations have been measured in 16 boreholes. Six boreholes contain anomalous mercury and two contain anomalous arsenic (Figure 3). Trace-element enrichment is ≥10% in only GMF 44-33 and ML 36-28 for mercury and GMF 56-3 and GMF 44-33 for arsenic. Significantly fewer boreholes contain anomalous mercury and arsenic concentrations in the 1000'-2000' interval than in the 0-1000' interval (Figure 2).

(3) <u>2000'-3000'</u>: Mercury and arsenic concentrations are determined for six boreholes (Figure 4). Mercury enrichment is measured in proportions ≥10% in ML 57-11 and GMF 28-32 and arsenic is measured in proportions ≥10% in GMF 28-32, GMF 45-36 and ML 14-23.

Implications

The areal distribution of trace-element data indicates that the occurrence of hydrothermal activity has been widespread at MLH. However, significantly fewer boreholes contain anomalous mercury and arsenic in the 1000'-2000' interval than in the 0-1000' interval. There are two possible explanations for this that are consistent with the data as presented. The preferred explanation is that formation or fracture permeability is less pervasive in the 1000'-2000' interval, and that the 0-1000' interval is possibly

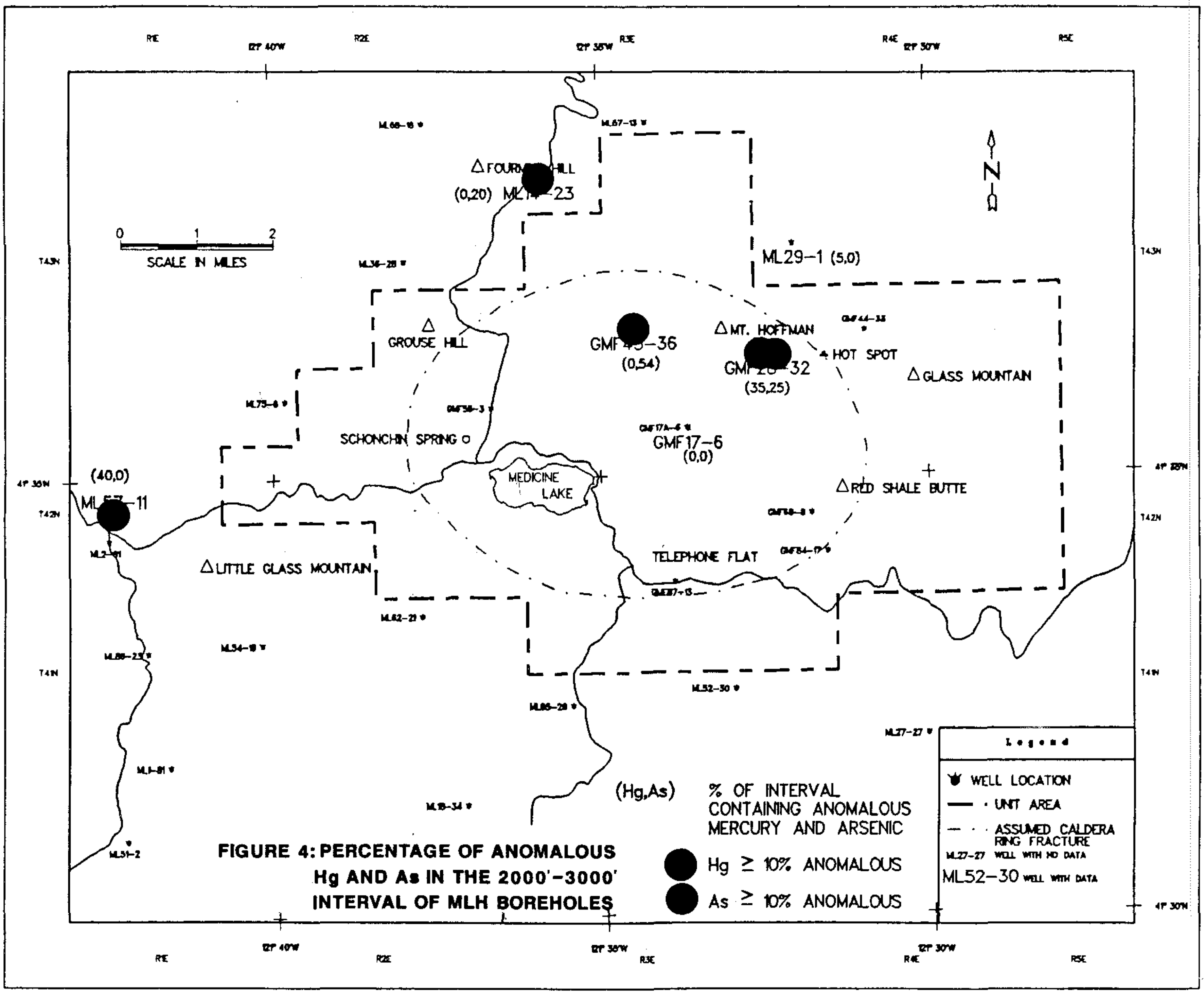

FIGURE 4: PERCENTAGE OF ANOMALOUS Hg AND As IN THE 2000'-3000' INTERVAL OF MLH BOREHOLES

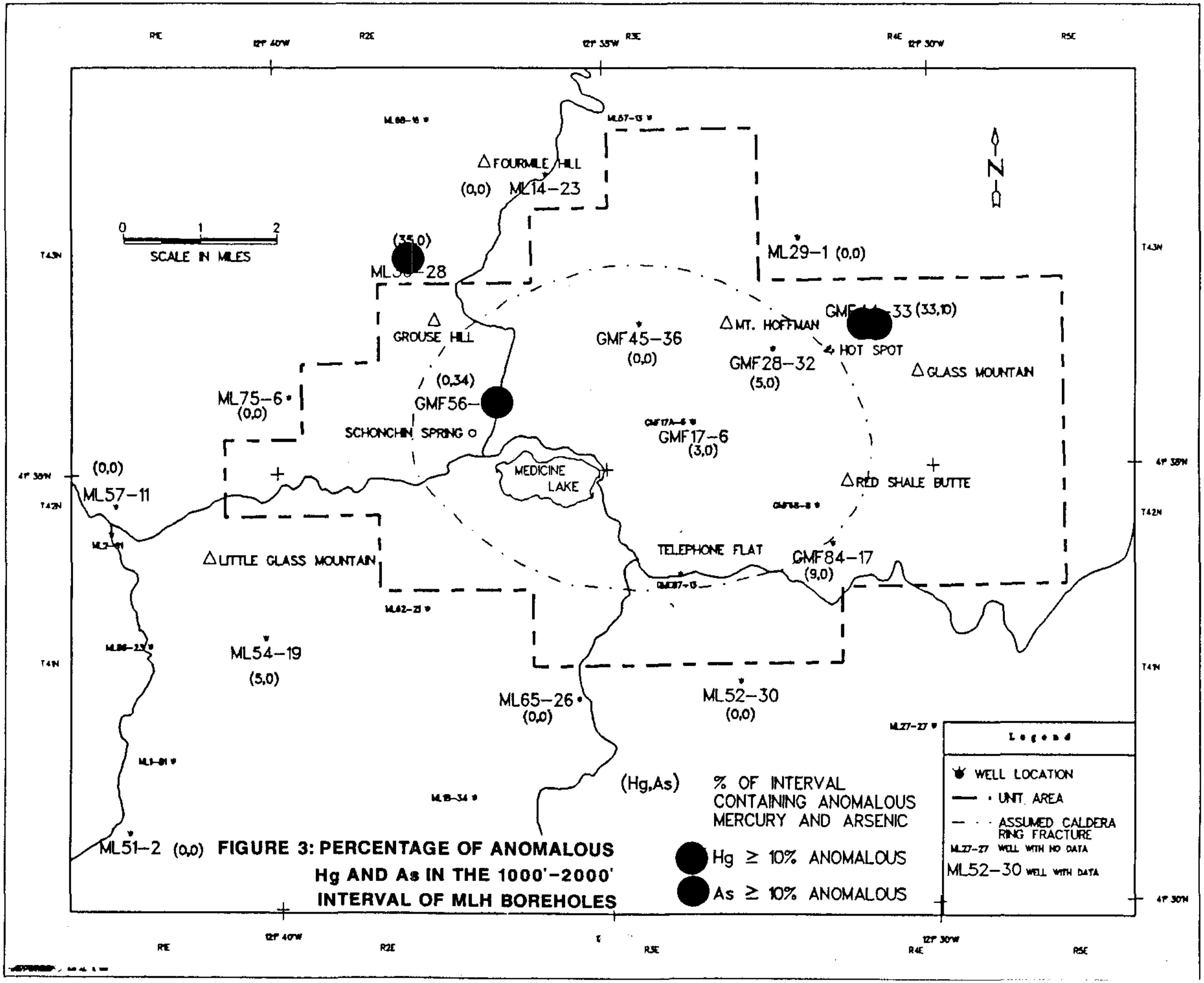

FIGURE 3: PERCENTAGE OF ANOMALOUS Hg AND As IN THE 1000'-2000' INTERVAL OF MLH BOREHOLES

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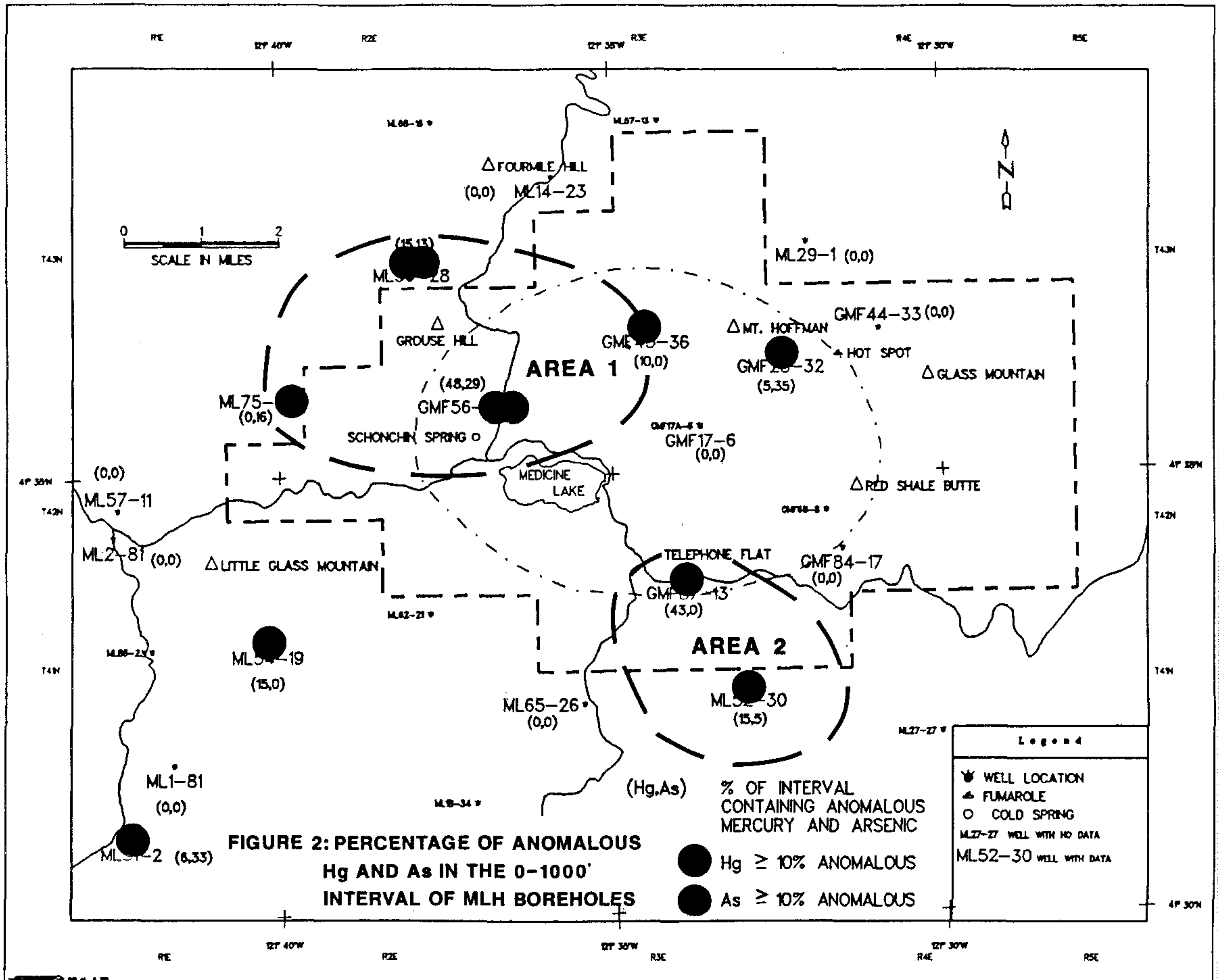

FIGURE 2: PERCENTAGE OF ANOMALOUS Hg AND As IN THE 0-1000' INTERVAL OF MLH BOREHOLES

TABLE 1: PRINCIPAL FACTS DERIVED FROM THE STATISTICAL ANALYSIS OF MERCURY, ARSENIC AND OXYGEN-18 DATA FROM MLH BOREHOLE SAMPLES

			BACKGROUND, A POPULATION				THRESHOLDS FOR THE ANOMALOUS POPULATIONS			
DATA SET	DISTRIBUTION	SAMPLE NUMBER	MEAN	*$\bar{X}+S$	$\bar{X}-S$	THRESHOLD	B	C	D	E
Mercury	log-normal	1168	28	63	15	180	>640	640	--	--
Arsenic	log-normal	1168	2.5	5.5	2.5	12	>21	21	--	--
$\delta^{18}O$	binomial	285	6.3	5.3	7.3	4.2	1.6	-.1	-2.7	<-2.7

* $\bar{X}$: mean, S: standard deviation.

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Although elemental arsenic and several arsenic salts are volatile, thermodynamic data indicate vapor phase partitioning of arsenic is probably not important in hydrothermal systems at temperatures 200°C (392°F) (Stauffer and Thompson, 1984). Dissolved arsenic readily forms anionic complexes and polymers that are mobile in both alkaline and acidic waters. Therefore, the distribution of anomalous arsenic often coincides with the discharge pattern of a geothermal system (Bamford and others, 1980). The deposition of arsenic from a geothermal fluid generally occurs through co-precipitation/absorption with hydrous ferric oxide or by absorption on clays or organic matter (Boyle and Jonasson, 1973).

Temperatures of hydrothermal fluids cannot be estimated from whole-rock trace-element distribution. However, mercury and arsenic are likely better permeability pathfinders than whole-rock oxygen-isotopes for fluids with temperatures less than the "crossover" temperature (60° to 130°C).

DATA REDUCTION

A total of 28 temperature boreholes and two geothermal exploration wells have been drilled at MLH since 1981. Core and rock chips from 19 boreholes were sampled for trace elements and 21 boreholes were sampled for whole-rock oxygen-isotopes. The two exploration wells (GMF 17A-6 and GMF 68-8) were also sampled for trace elements and rock oxygen. However, due to the sensitivity of leasing in the area, GMF 68-8 will not be discussed further in this report. Analysis of sampling methods, data reduction and error analysis is detailed in Appendix 1, and only the results of the data reduction are discussed here. The distribution of mercury, arsenic, $\delta^{18}O$ and lithology for well GMF 17A-6 and each borehole and is shown in Appendix 4.

The trace-element and oxygen-isotope data were analyzed statistically utilizing probability graphs (Sinclair,1981; Copp, 1985). The results are shown in Table 1. The distribution of the trace-element data is log-normal and the oxygen data is binomial. Population A in each case is considered the background population, and populations B, C, D and E are considered anomalous. Threshold values for the background populations of mercury, arsenic and $\delta^{18}O$ at MLH are 180 ppb, 12 ppm and 4.2 per mil ($\delta^{18}O$ values $\leq$4.2 are anomalous), respectively.

Statistical analysis of oxygen-18 data results in the identification of four anomalous populations. The threshold values for these populations are shown in Table 1. An approximate temperature of equilibrium for each threshold value can be estimated from calculated and experimentally derived fractionation curves (Taylor, 1979). However, to calculate accurate temperatures the oxygen-isotopic composition of the fluid in equilibrium with the exchanged rocks must be known. Since the $\delta^{18}O$ of MLH geothermal fluids is not known, the qualitative and relative terms of low temperature (background, A population), moderate temperature (B and C population) and high temperature (D and E population) are used in

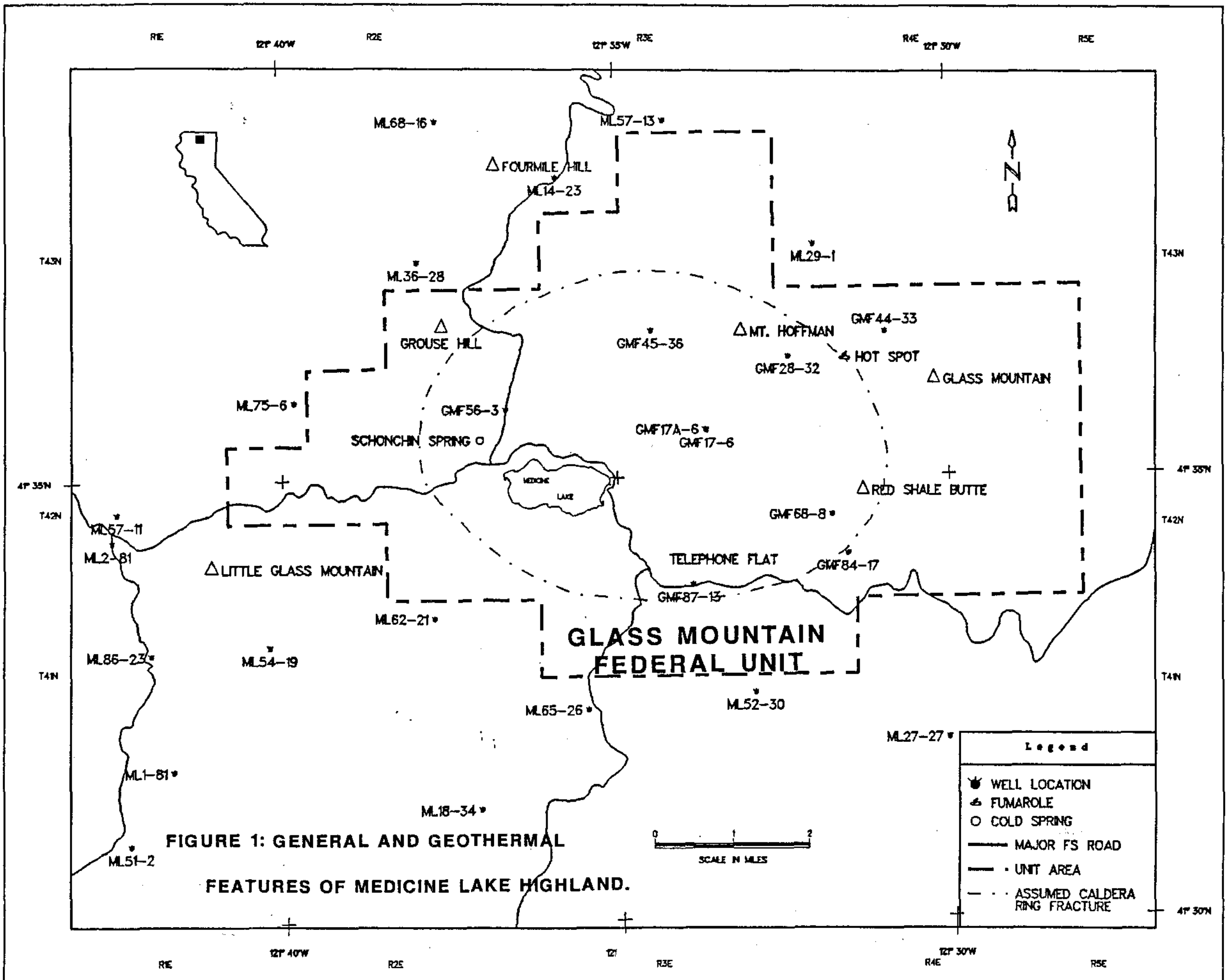
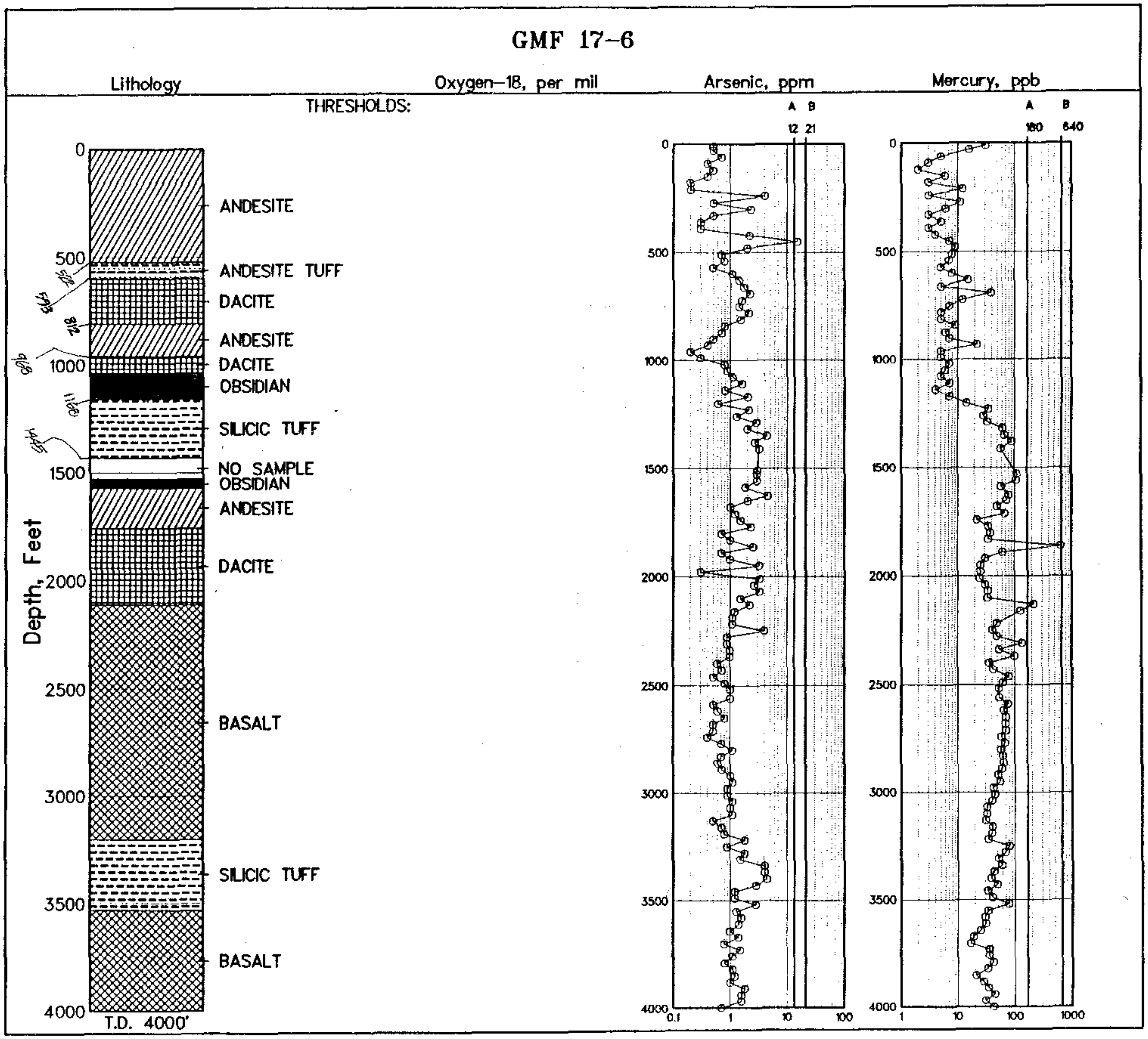


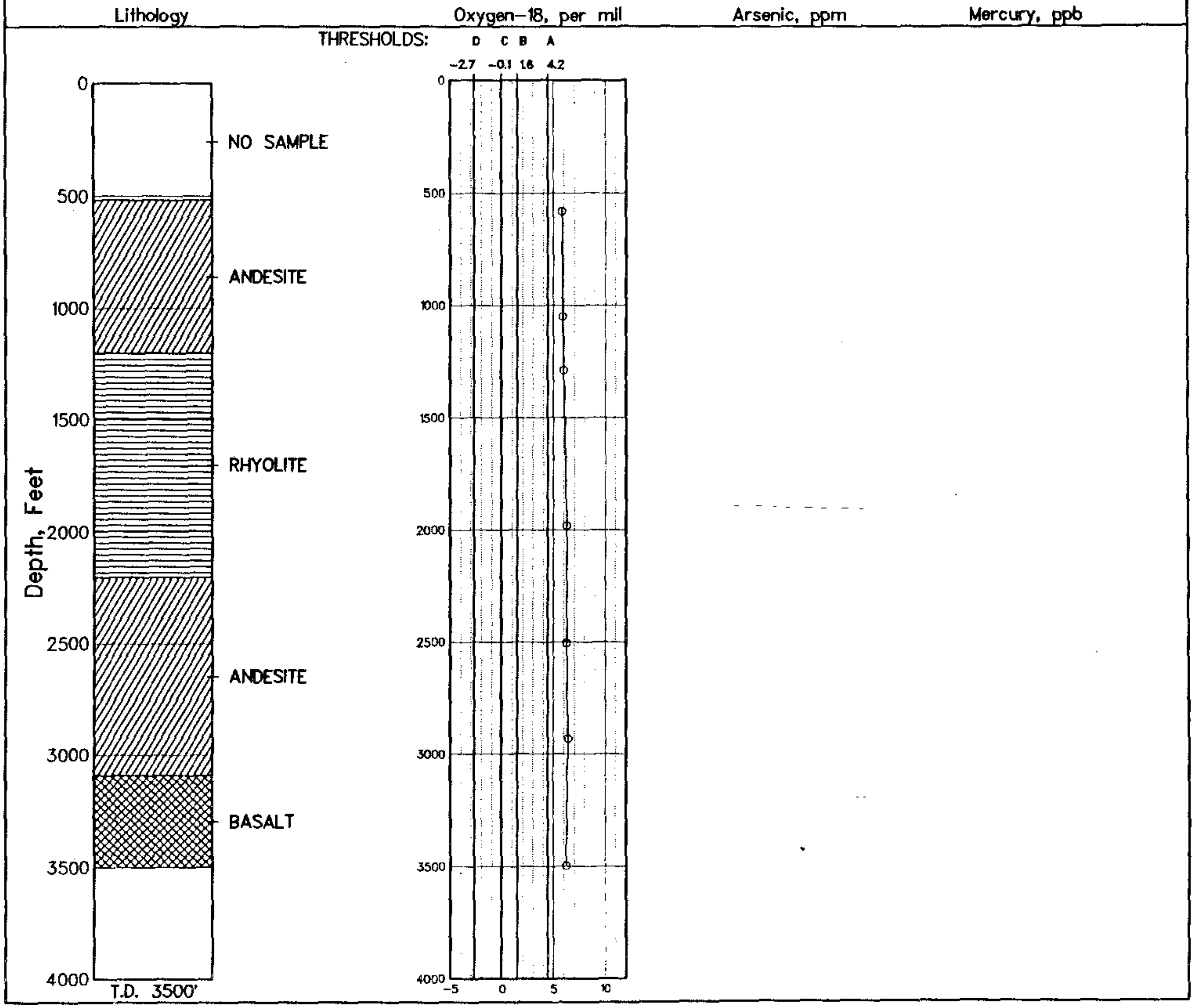
FIGURE 1: GENERAL AND GEOTHERMAL FEATURES OF MEDICINE LAKE HIGHLAND.



EXPRESS 14:26 JUL 9, 1986

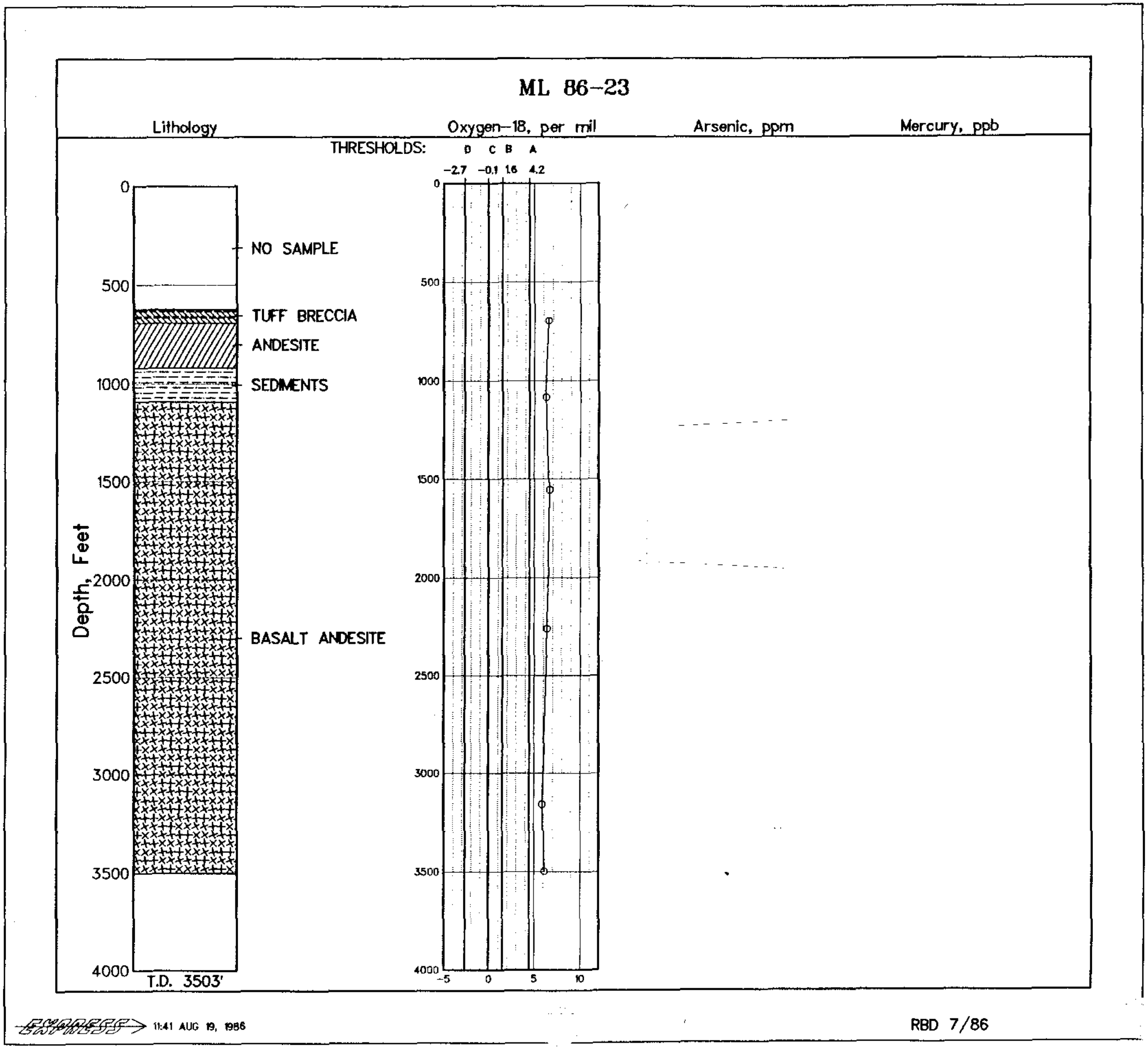
RBD 7/86

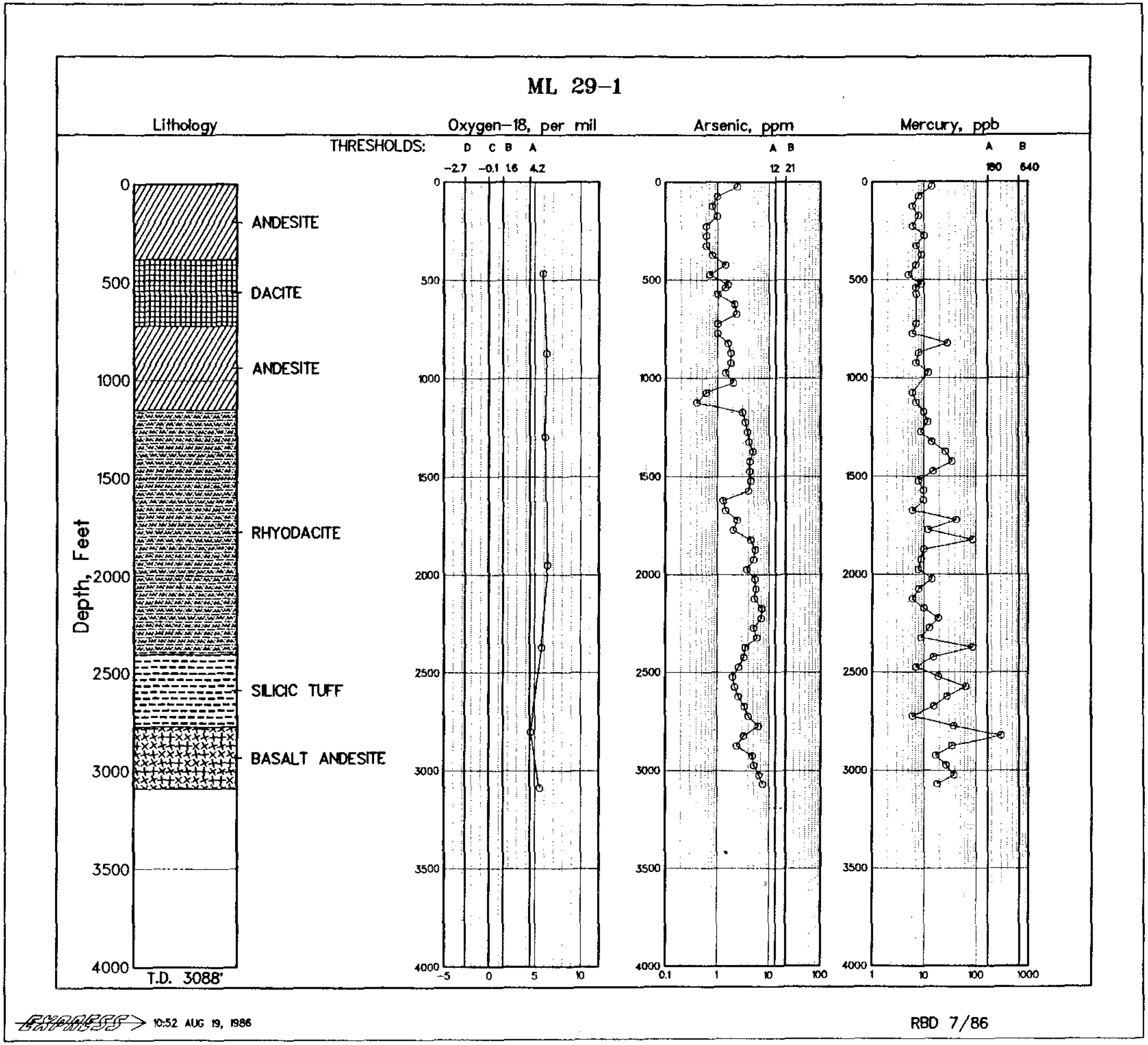
ML 18-34



11:44 AUG 19, 1986

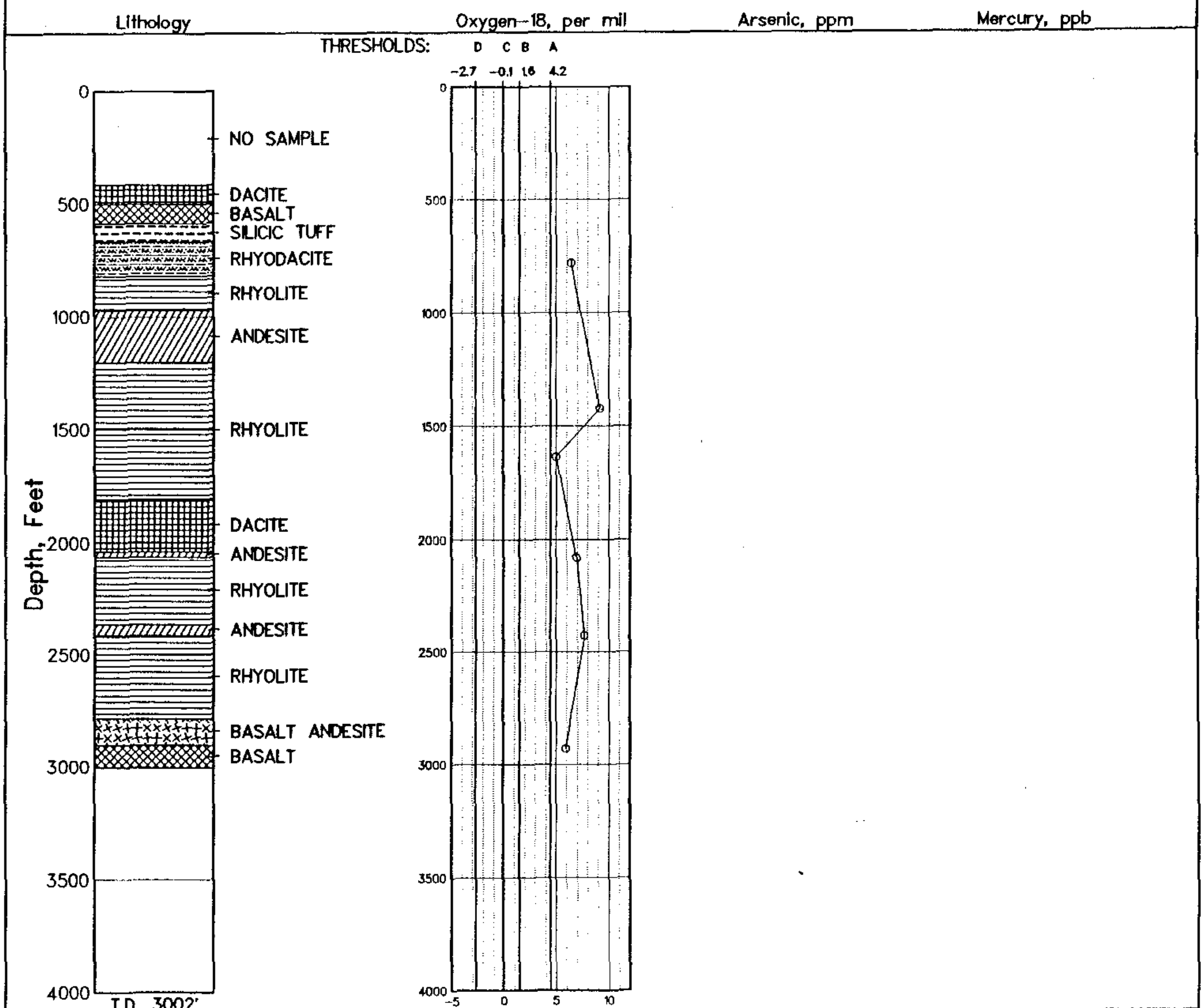
RBD 7/86


ML 86-23
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
D C B A
-2.7 -0.1 1.6 4.2
Depth, Feet
0
500
1000
1500
2000
2500
3000
3500
4000
NO SAMPLE
TUFF BRECCIA
ANDESITE
SEDIMENTS
BASALT ANDESITE
T.D. 3503'
-5
0
5
10
11:41 AUG 19, 1986
RBD 7/86



ML 29-1
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
D C B A
-2.7 -0.1 1.6 4.2
A B
12 21
A B
180 640
Depth, Feet
ANDESITE
DACITE
ANDESITE
RHYODACITE
SILICIC TUFF
BASALT ANDESITE
T.D. 3088'
0
500
1000
1500
2000
2500
3000
3500
4000
-5 0 5 10
0.1 1 10 100
1 10 100 1000
EXPRESS 10:52 AUG 19, 1986
RBD 7/86

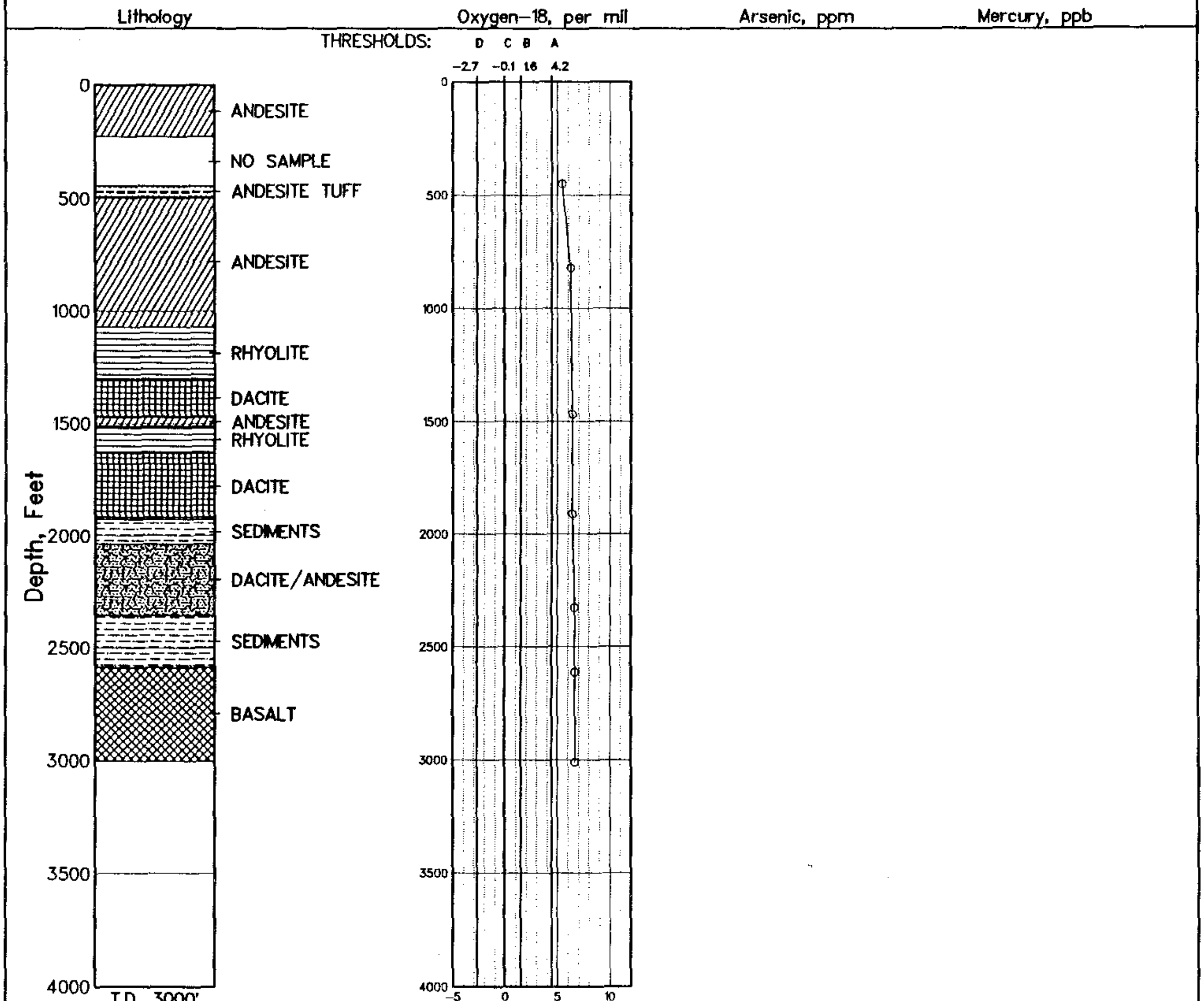
ML 57-13



11:48 AUG 19, 1986

RBD 7/86

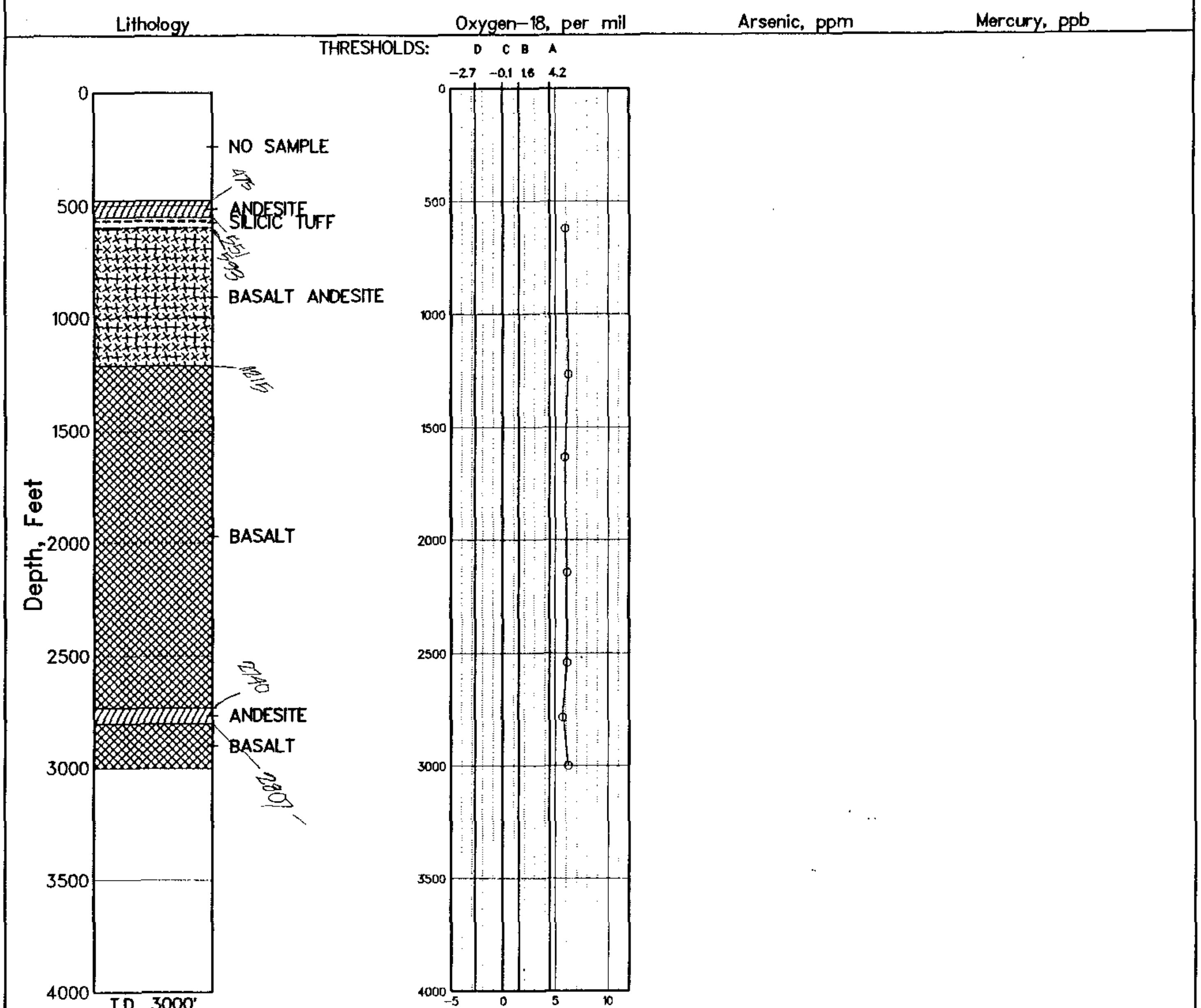
ML 14-23



11:52 AUG 19, 1986

RBD 7/86

ML 27-27



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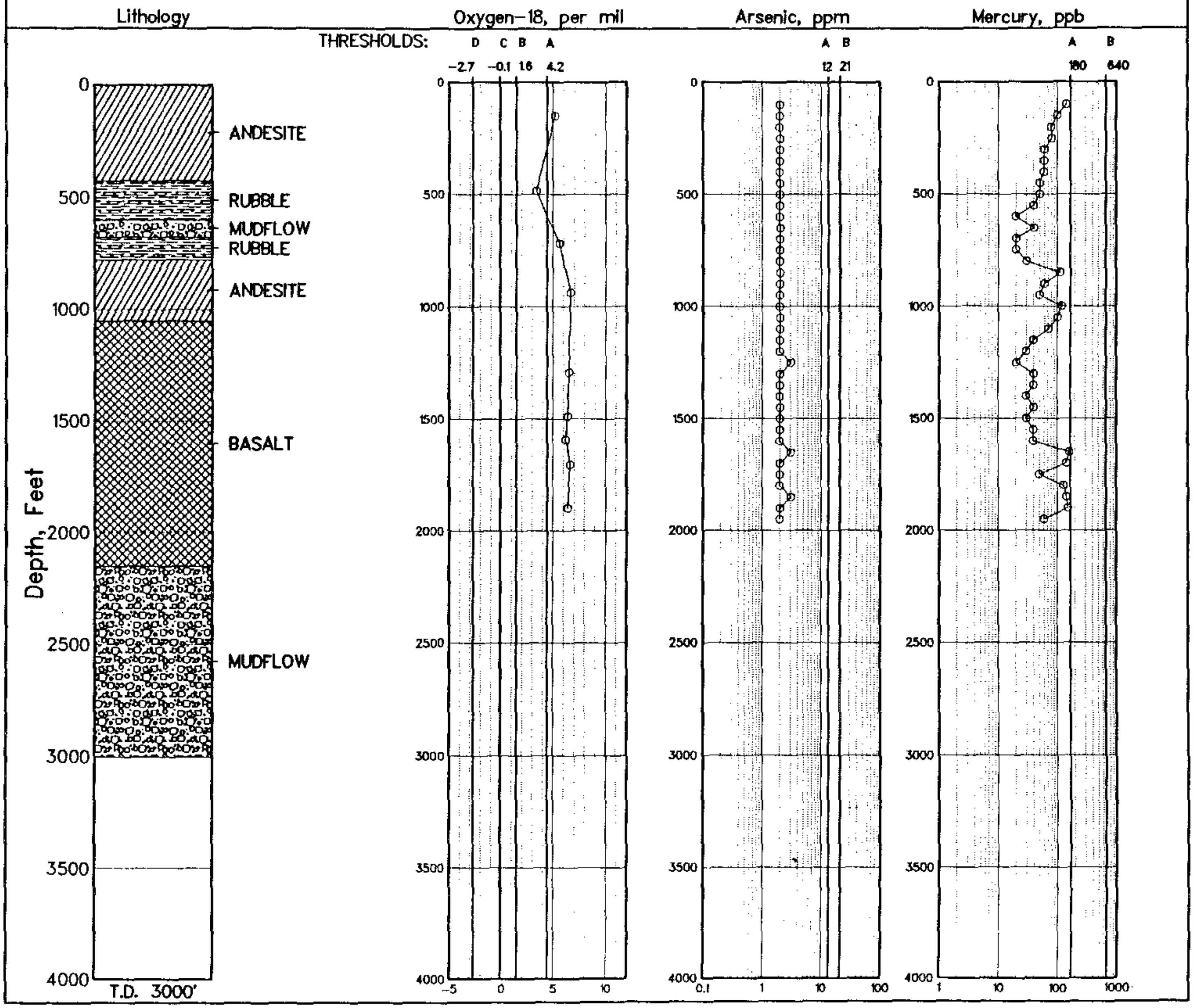
RBD 7/86

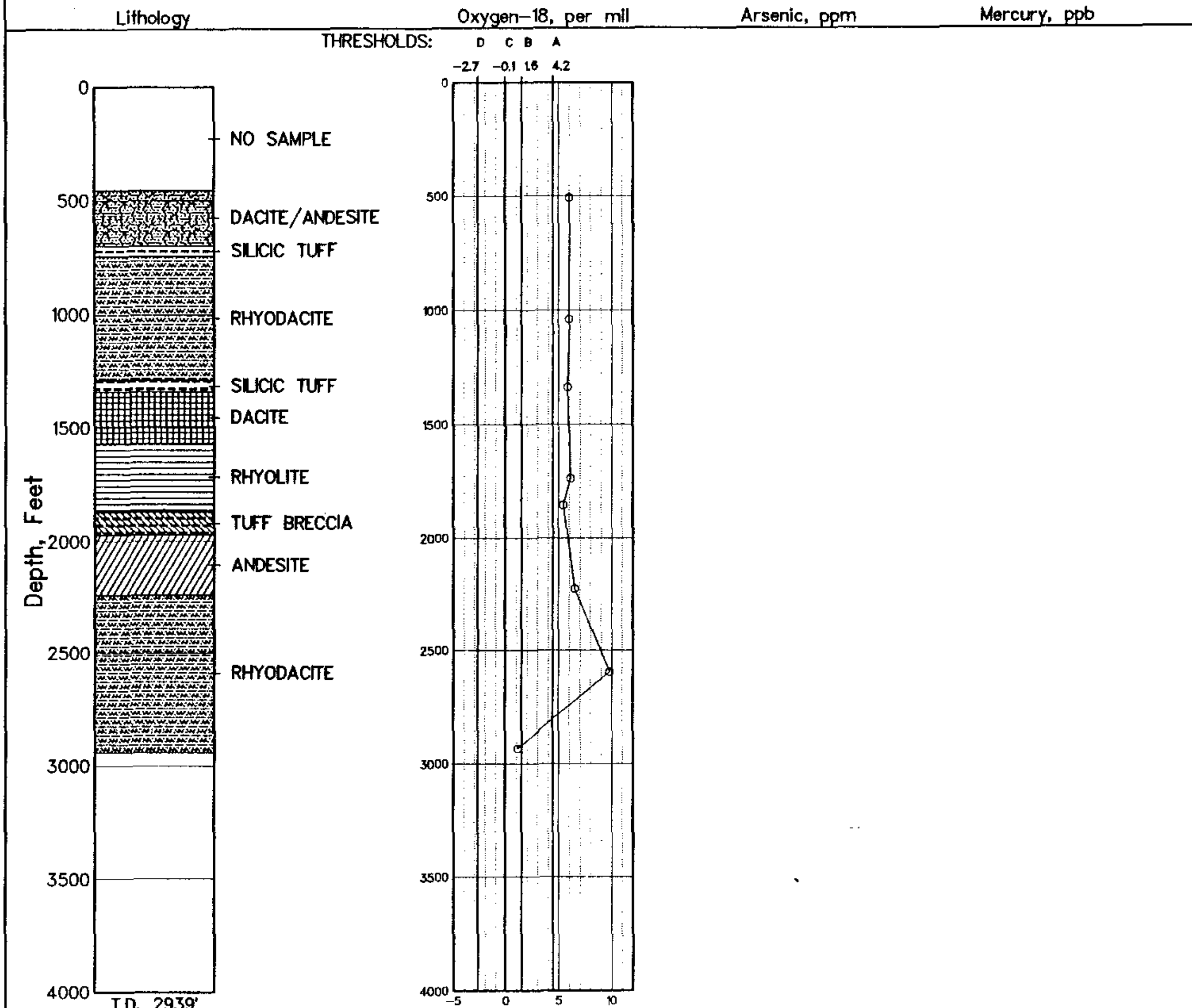
ML 57-11



10:47 AUG 19, 1986

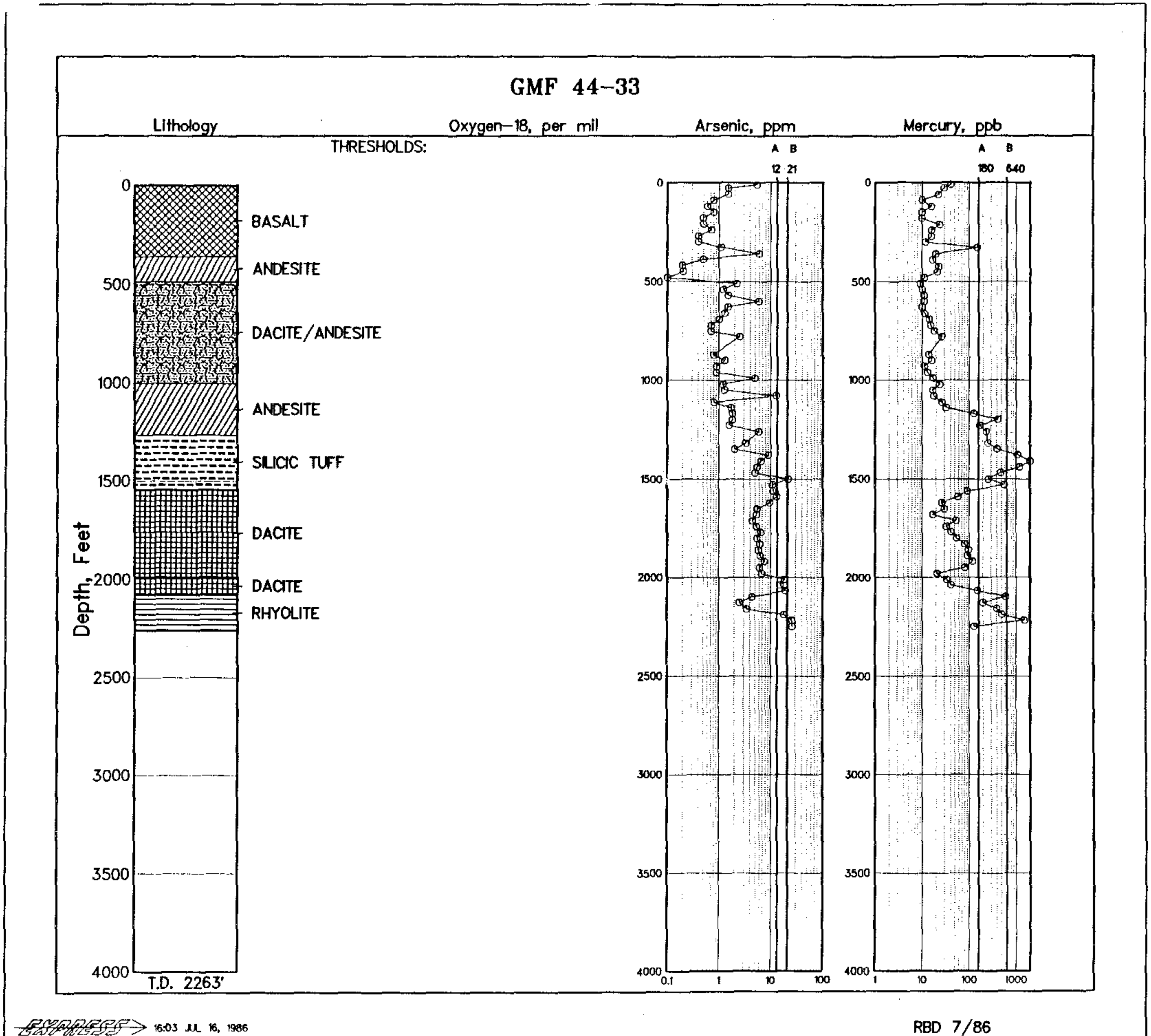
RBD 7/86

ML 68-16

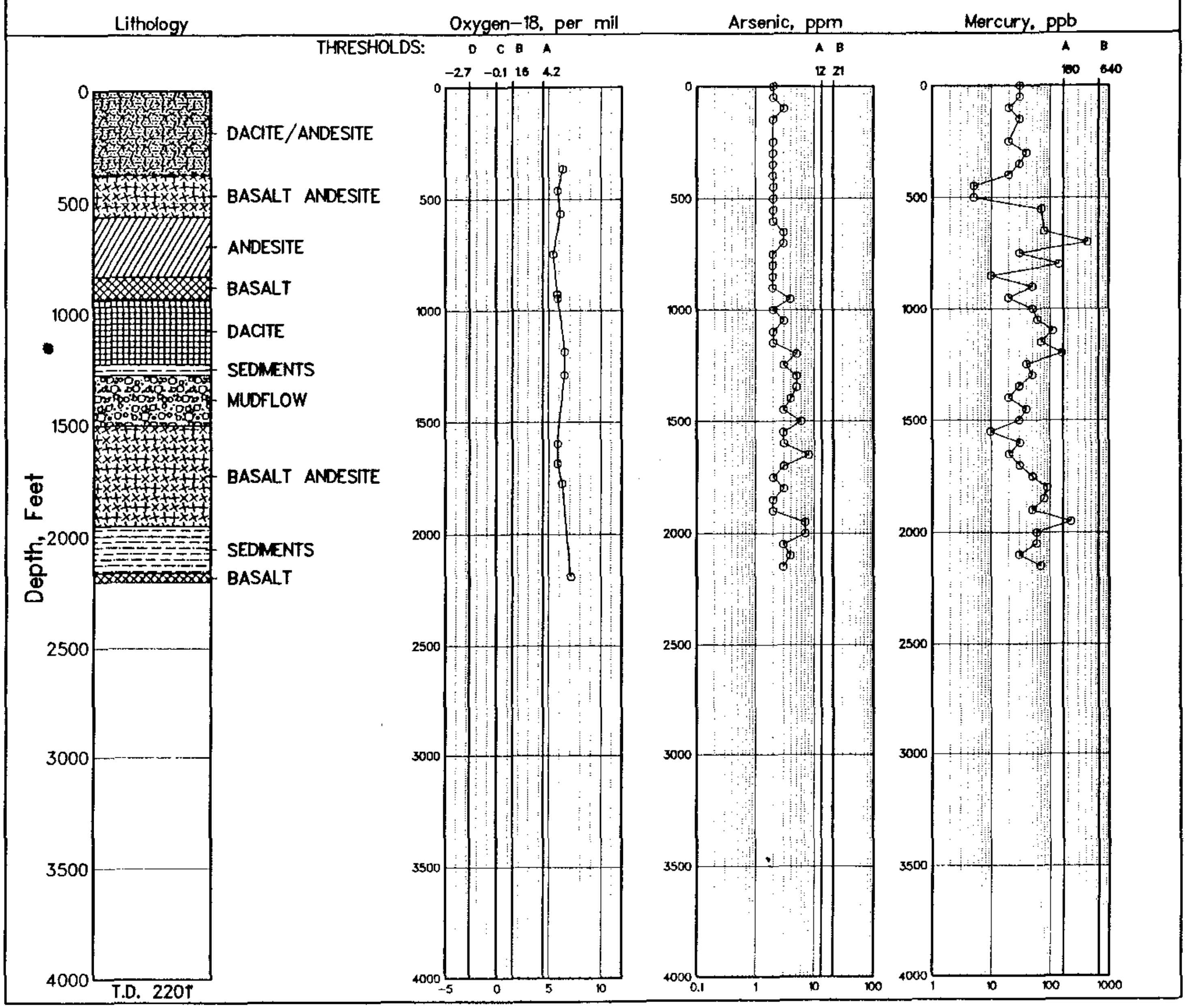


11:37 AUG 19, 1986

RBD 7/86

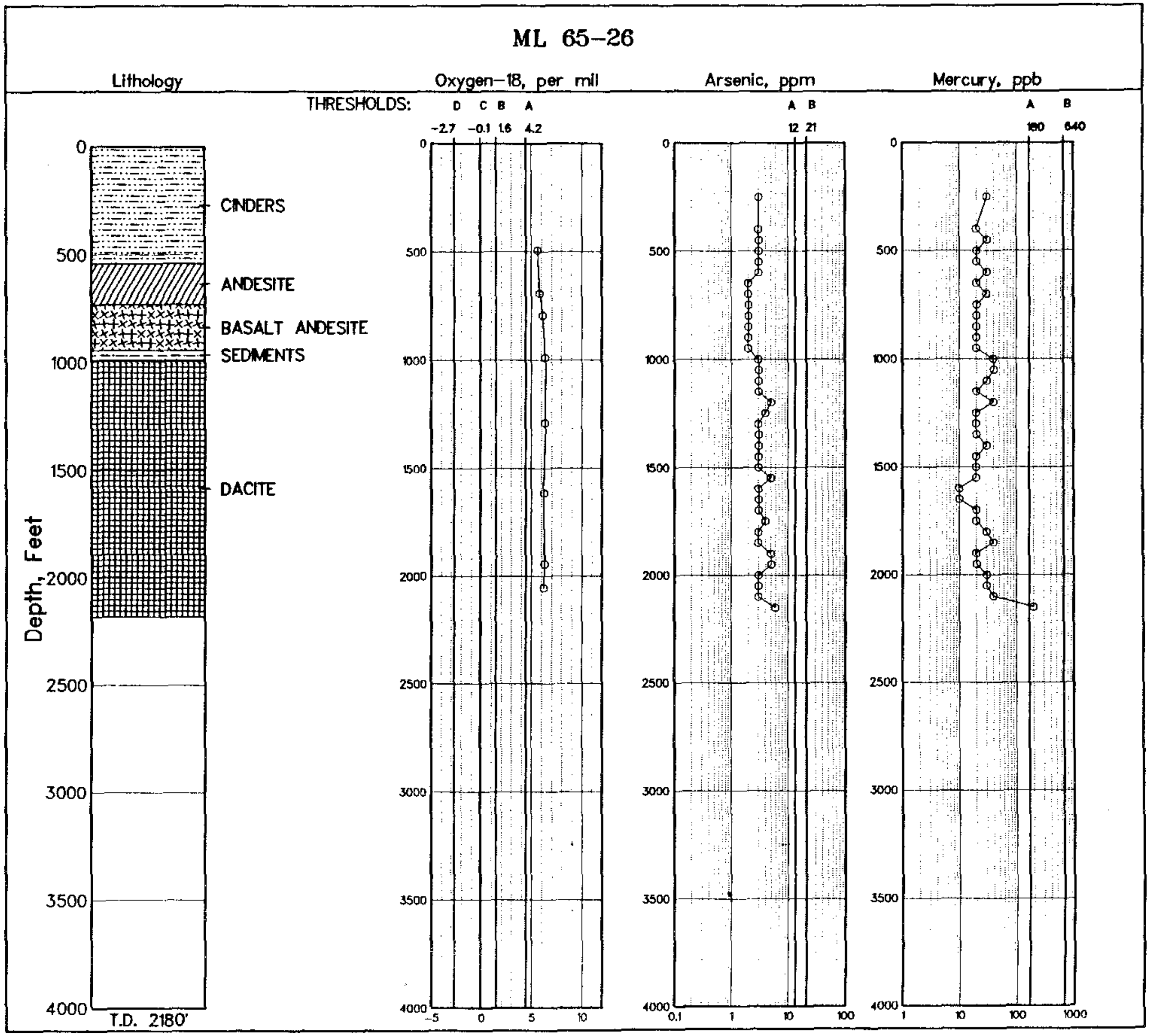

GMF 44-33
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
A B
12 21
A B
180 640
BASALT
ANDESITE
DACITE/ANDESITE
ANDESITE
SILICIC TUFF
DACITE
DACITE
RHYOLITE
Depth, Feet
0
500
1000
1500
2000
2500
3000
3500
4000
T.D. 2263'
0.1
1
10
100
1
10
100
1000
16:03 JUL 16, 1986
RBD 7/86

ML 54-19



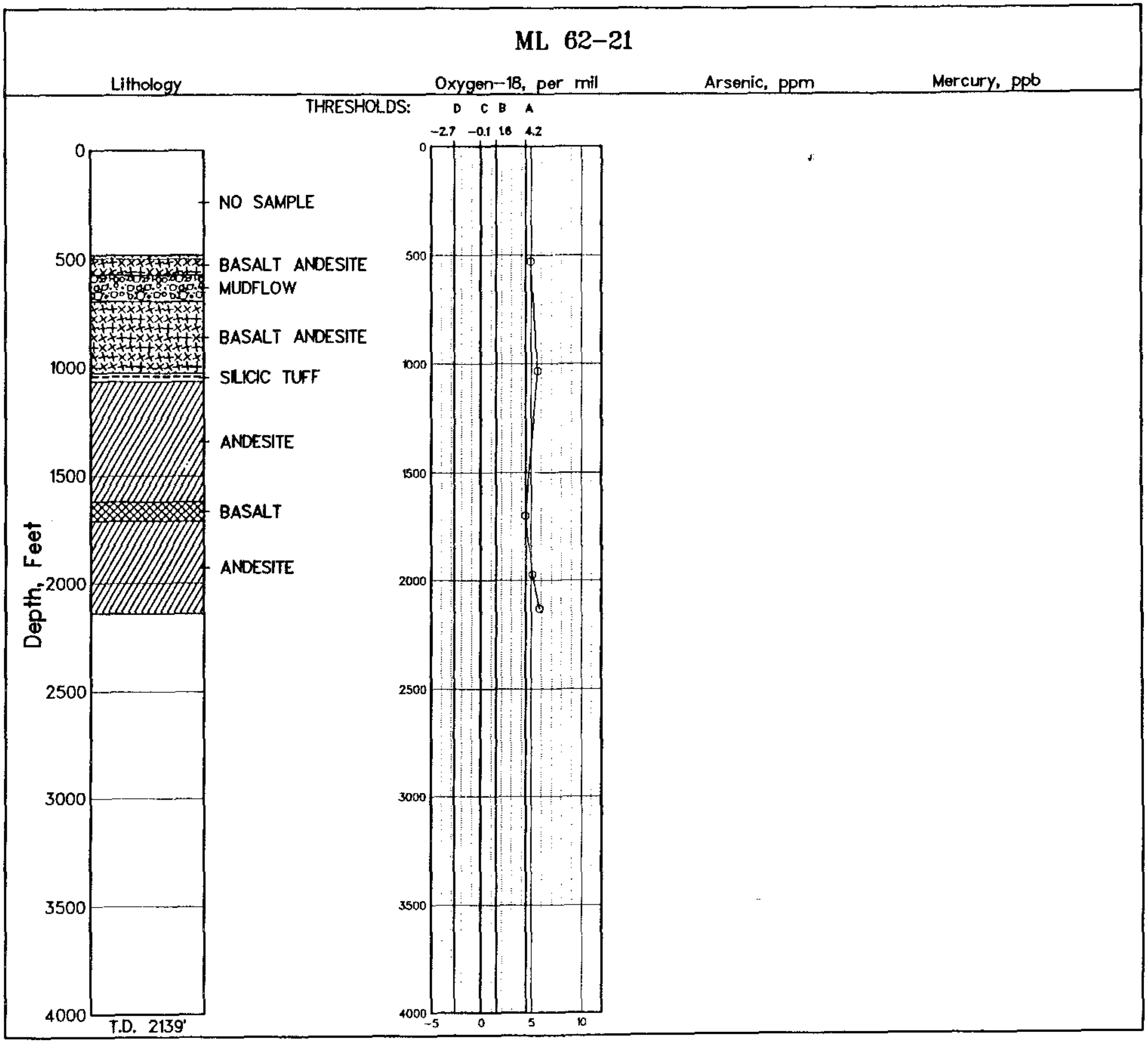
10:44 AUG 19, 1986

RBD 7/86



EXPRESS 11:16 AUG 19, 1986

RBD 7/86



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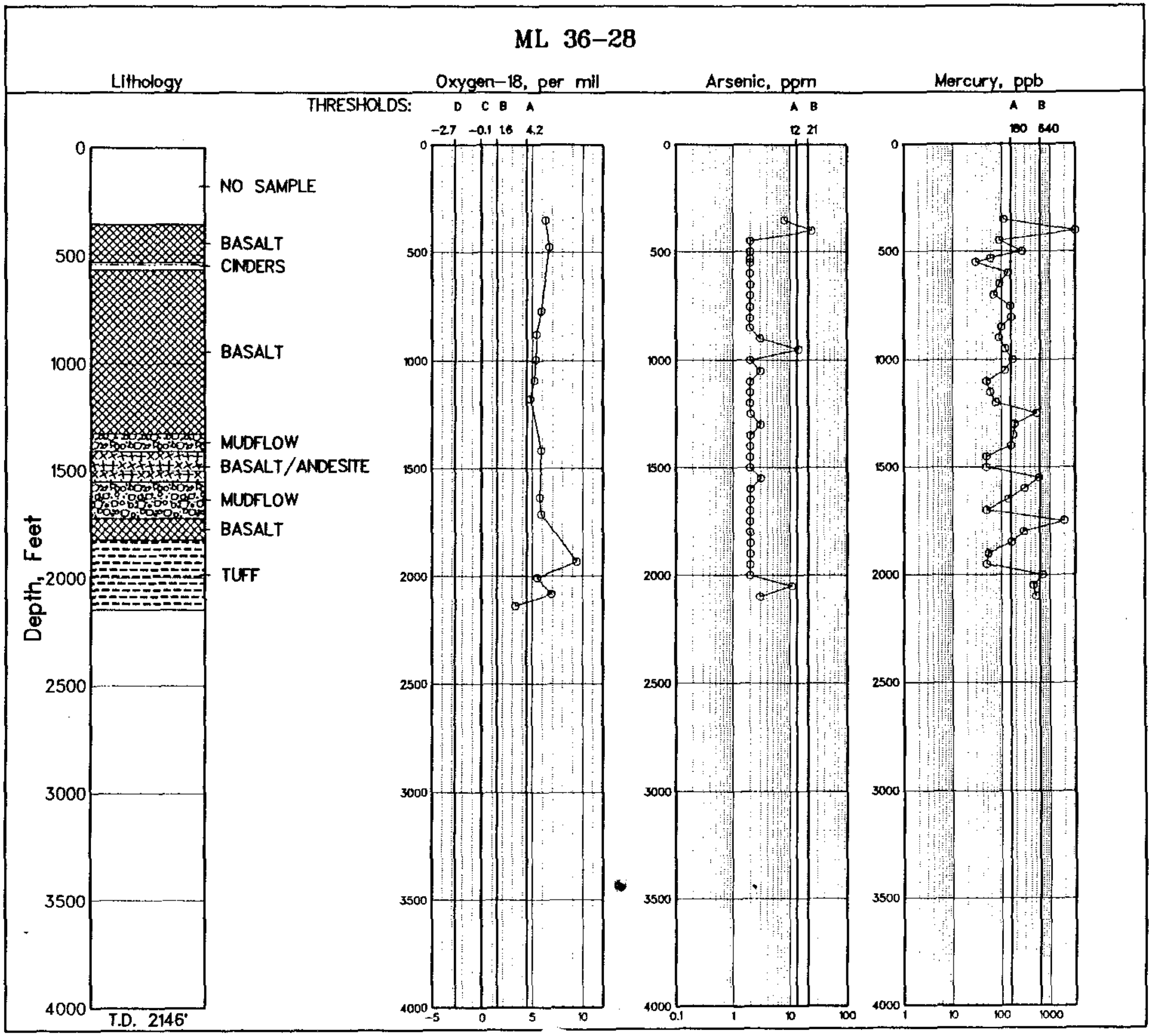
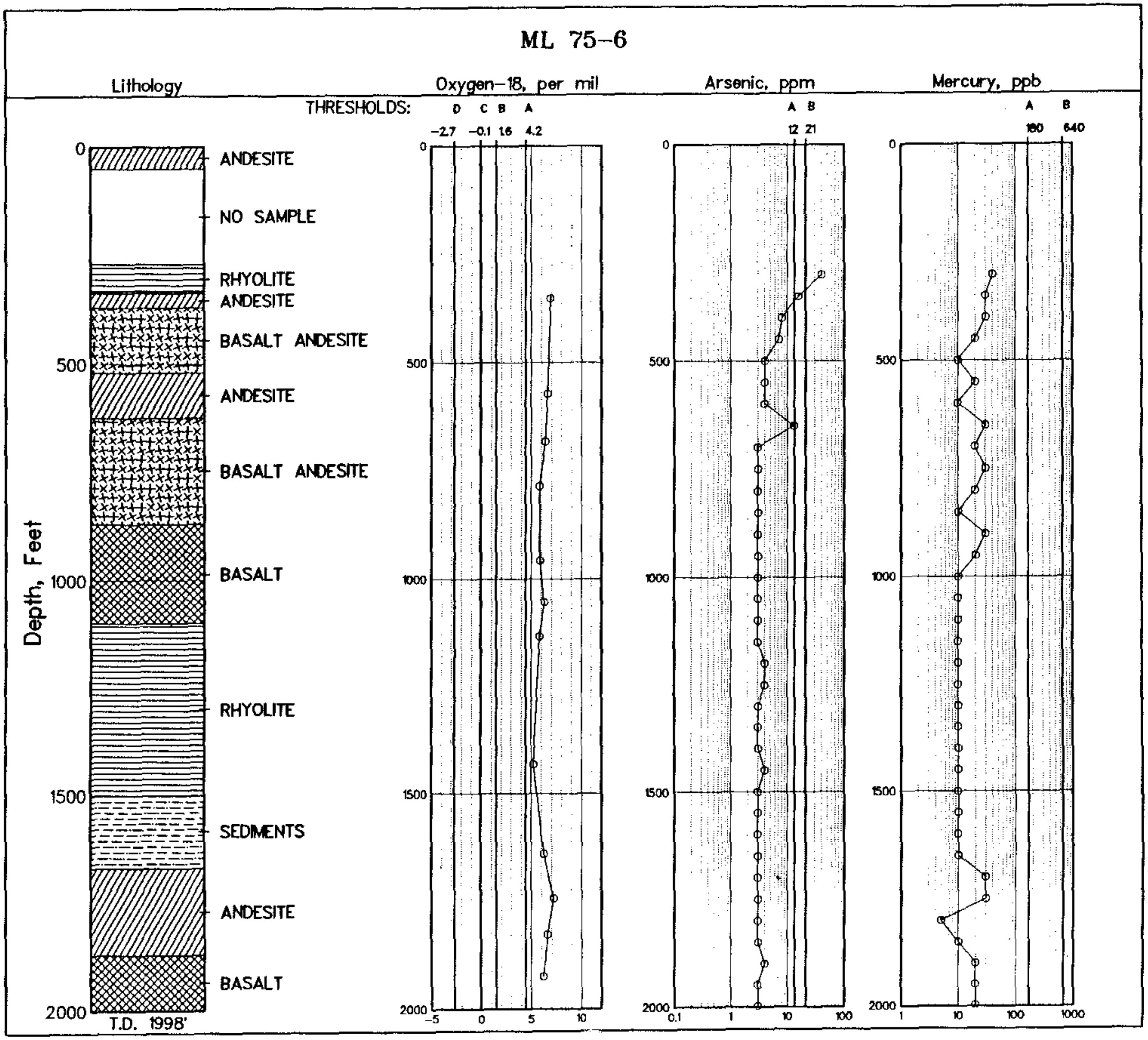
RBD 7/86



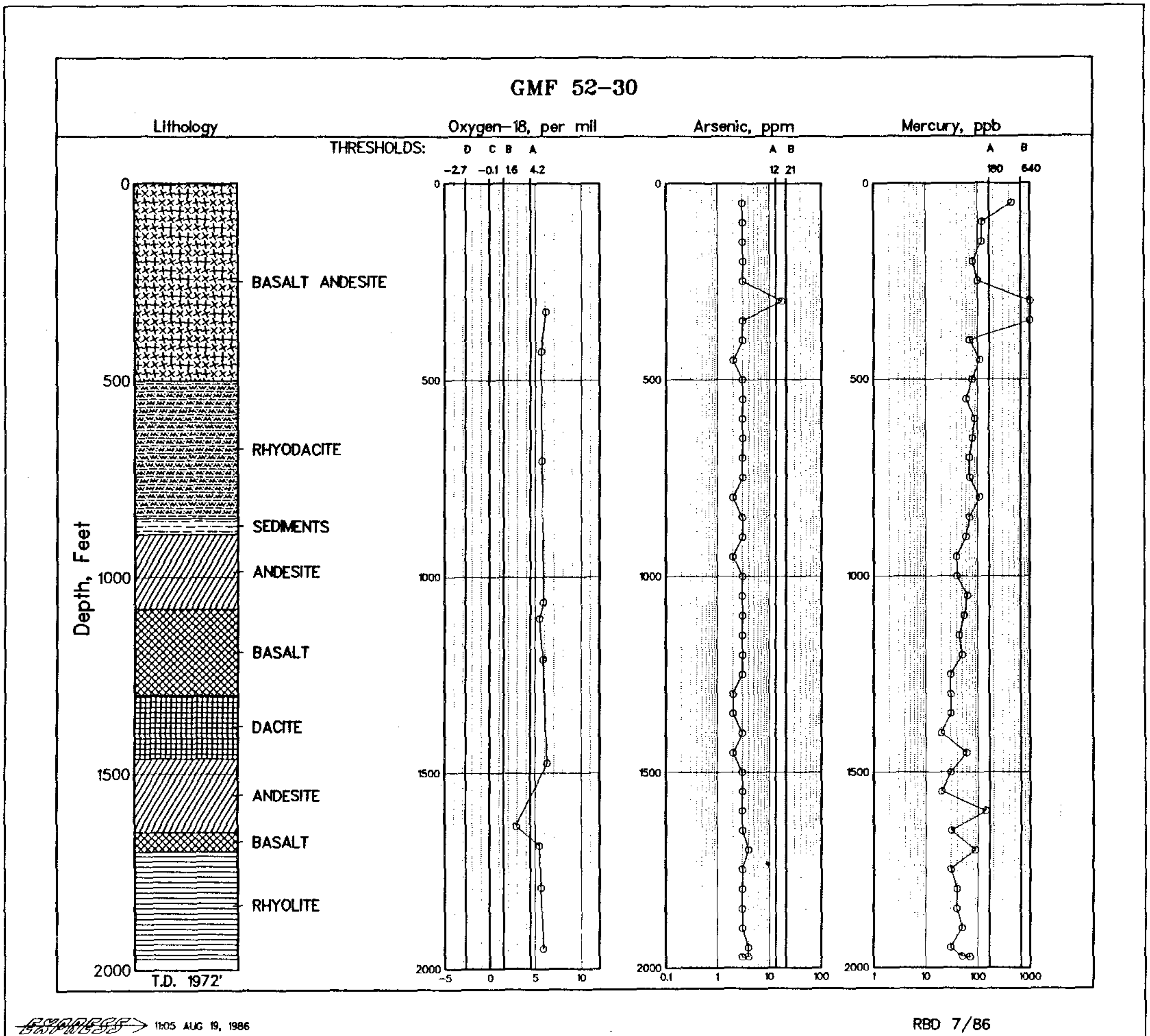
10:41 AUG 19, 1986

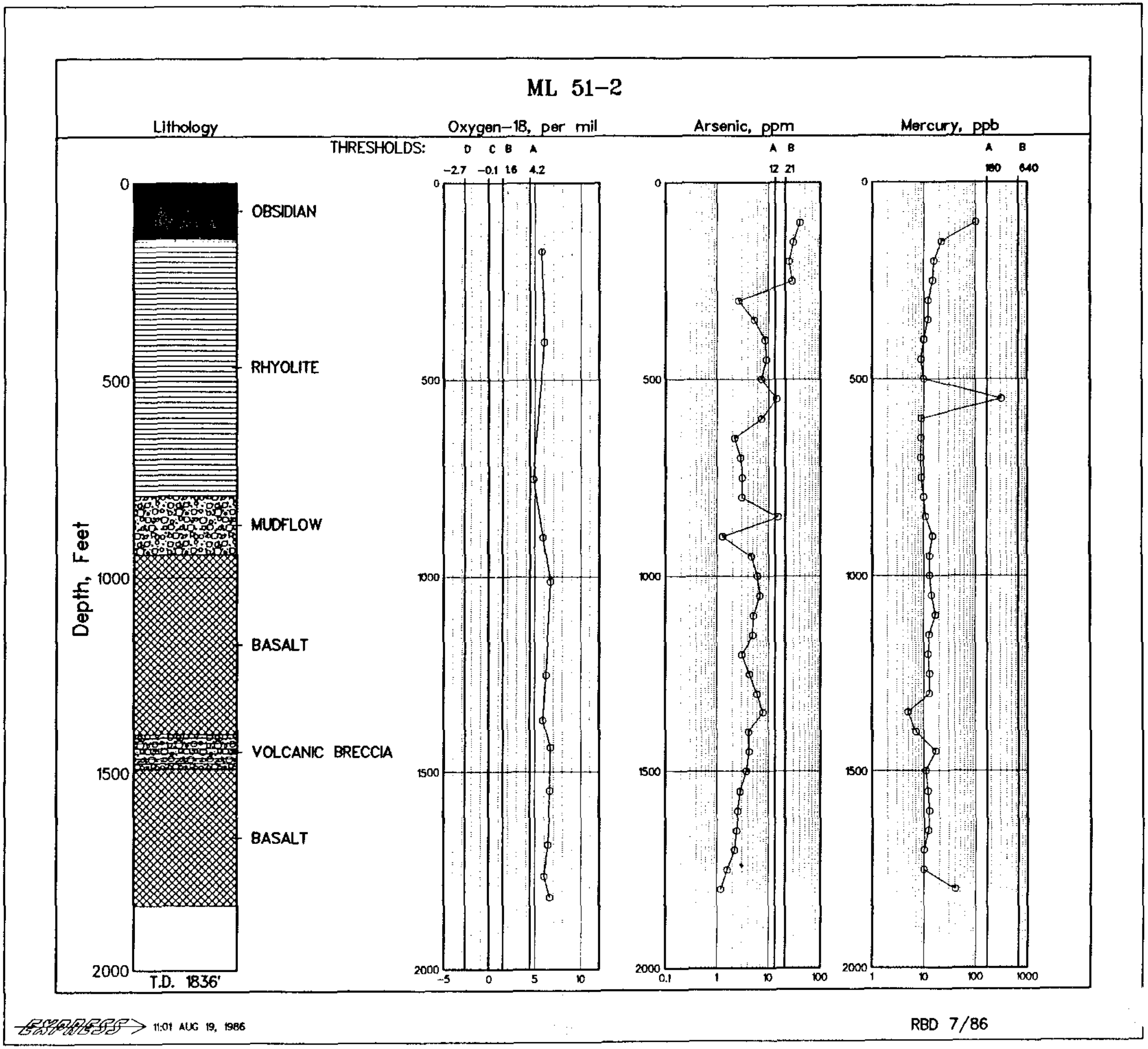
RBD 7/86

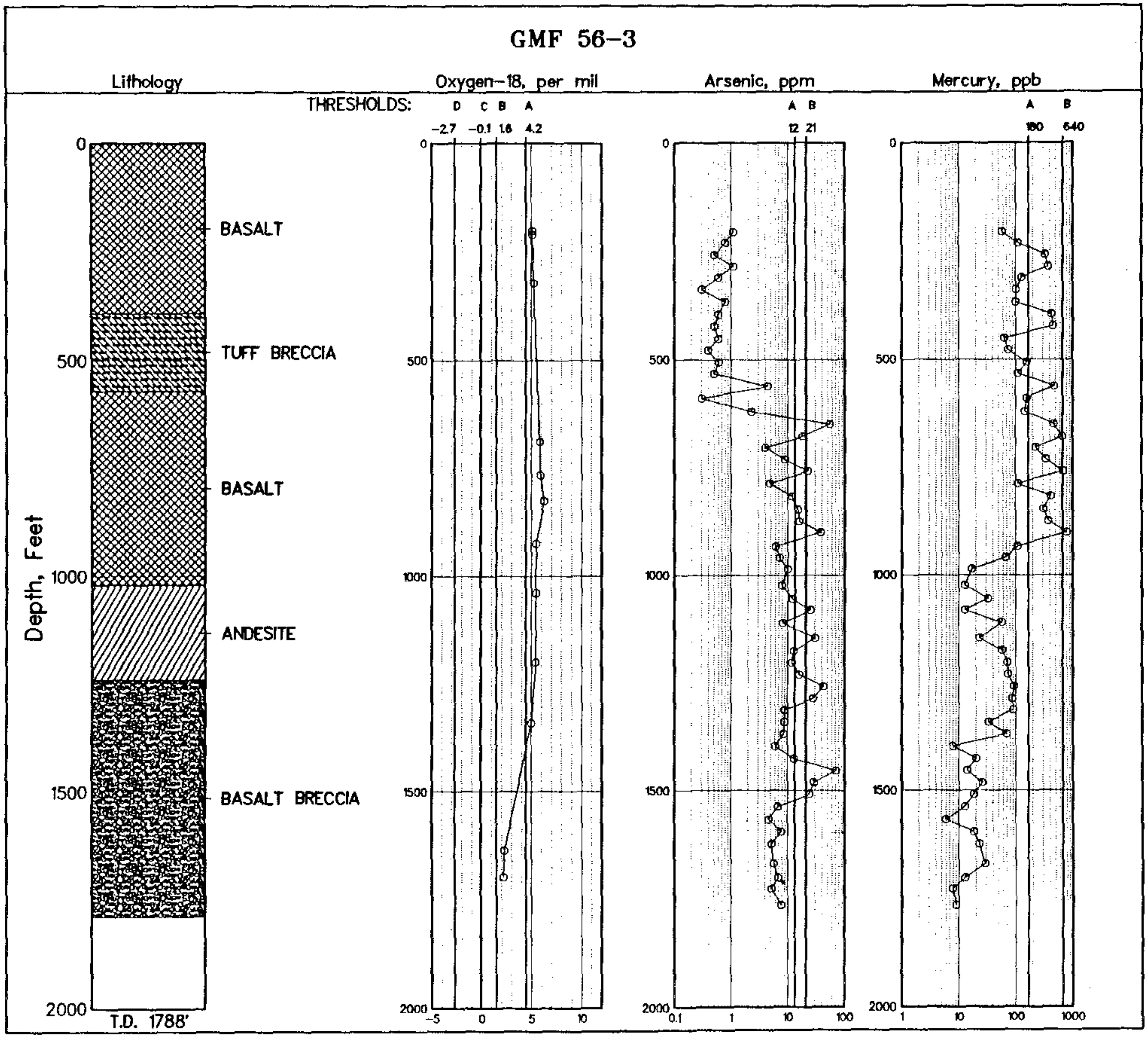


EXPRESS 11:09 AUG 19, 1986

RBD 7/86


GMF 52-30
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
D C B A
-2.7 -0.1 1.6 4.2
A B
12 21
A B
160 640
Depth, Feet
0
500
1000
1500
2000
BASALT ANDESITE
RHYODACITE
SEDIMENTS
ANDESITE
BASALT
DACITE
ANDESITE
BASALT
RHYOLITE
T.D. 1972'
-5 0 5 10
0.1 1 10 100
1 10 100 1000
11:05 AUG 19, 1986
RBD 7/86


ML 51-2
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
D C B A
-2.7 -0.1 1.6 4.2
A B
12 21
A B
180 640
OBSIDIAN
RHYOLITE
MUDFLOW
BASALT
VOLCANIC BRECCIA
BASALT
Depth, Feet
T.D. 1836'
11:01 AUG 19, 1986
RBD 7/86



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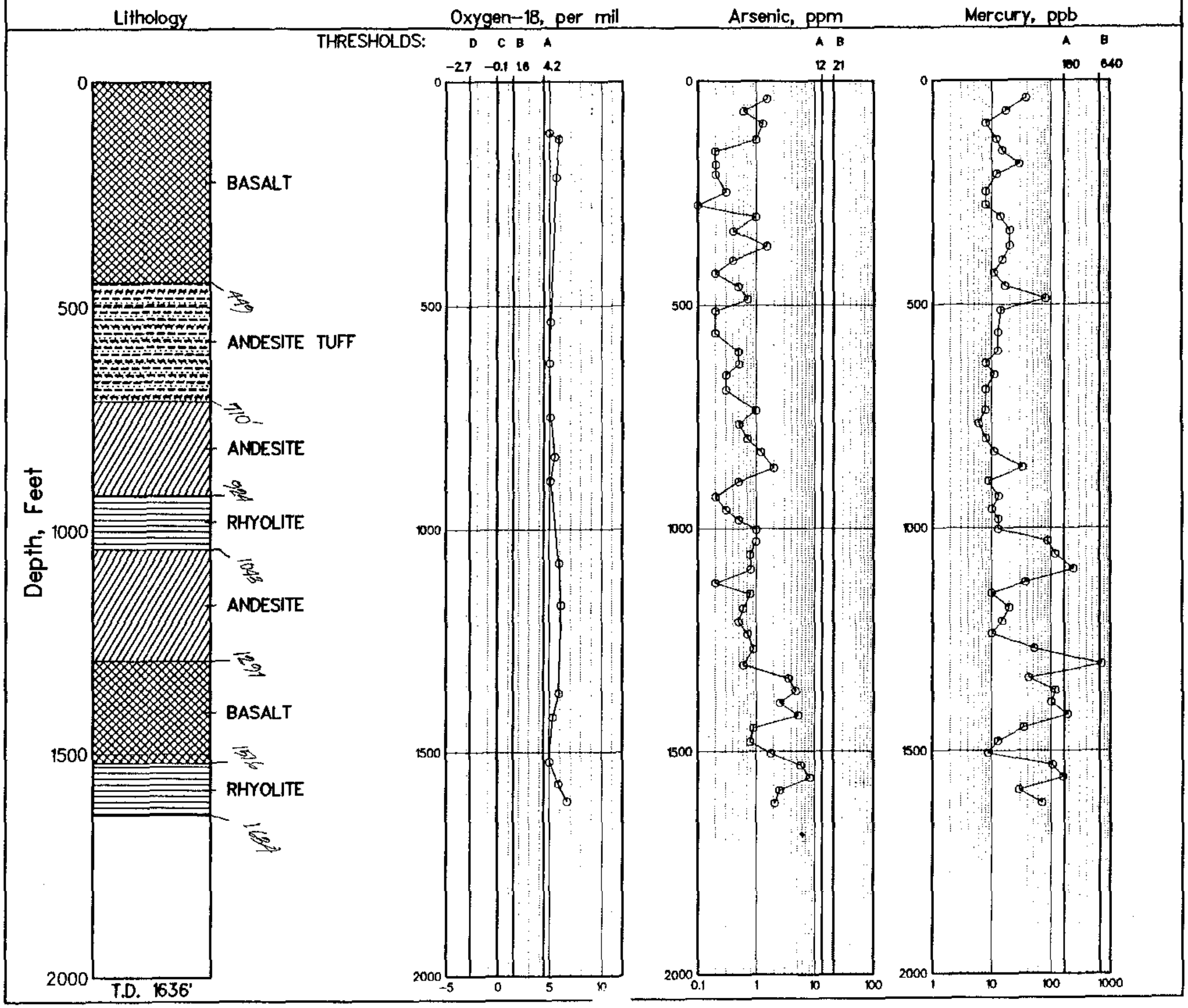
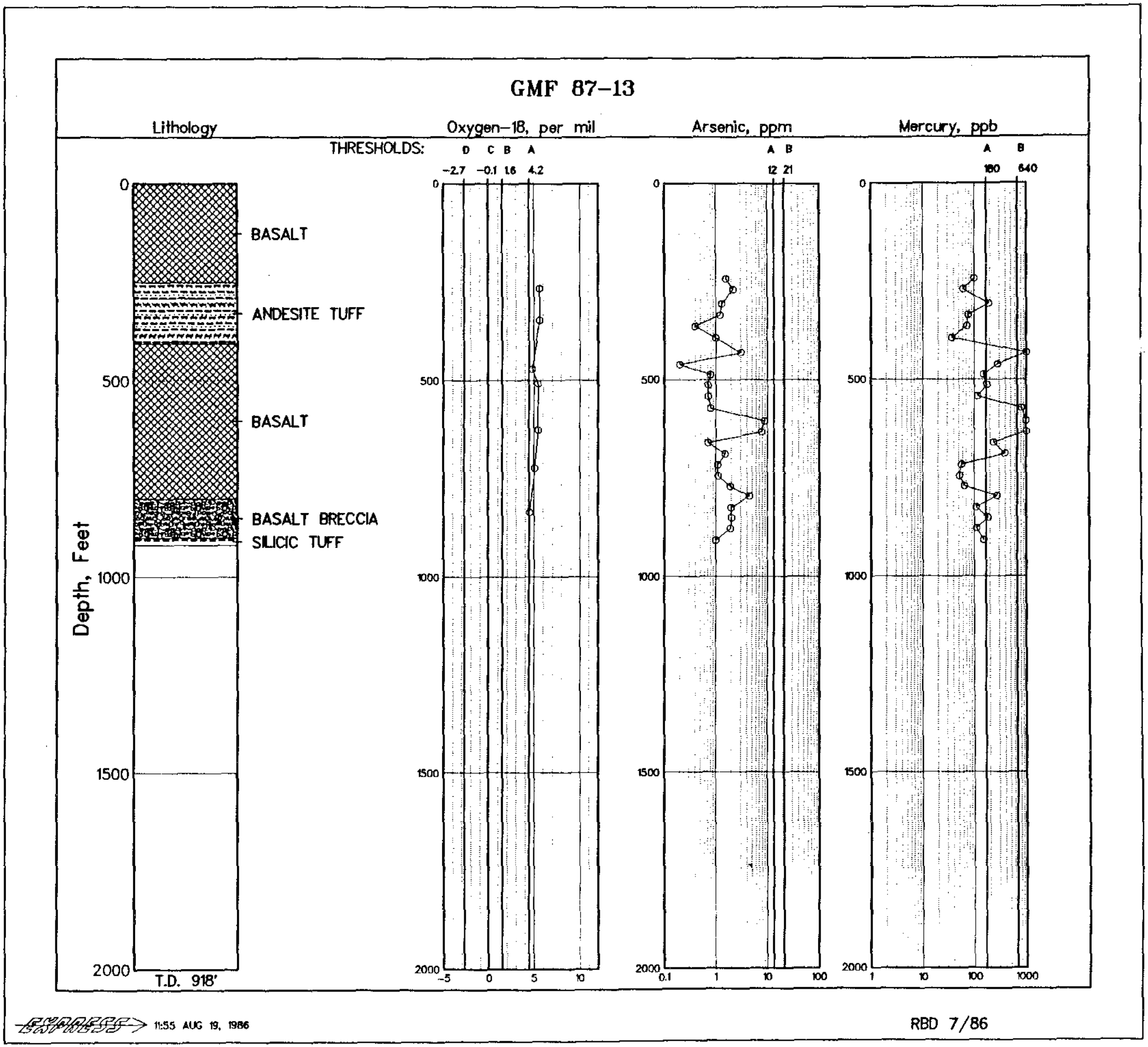
RBD 7/86

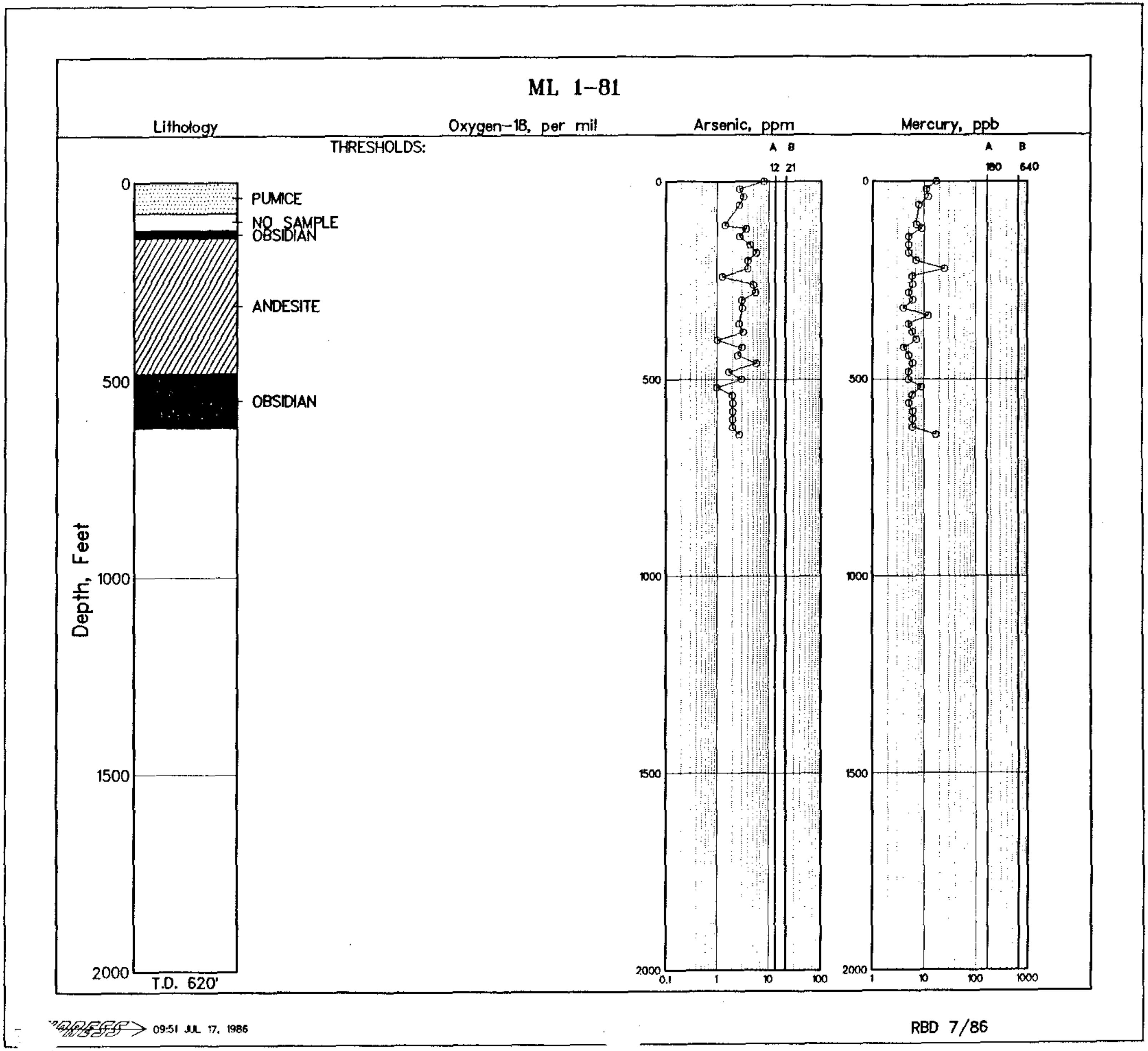
GMF 84-17



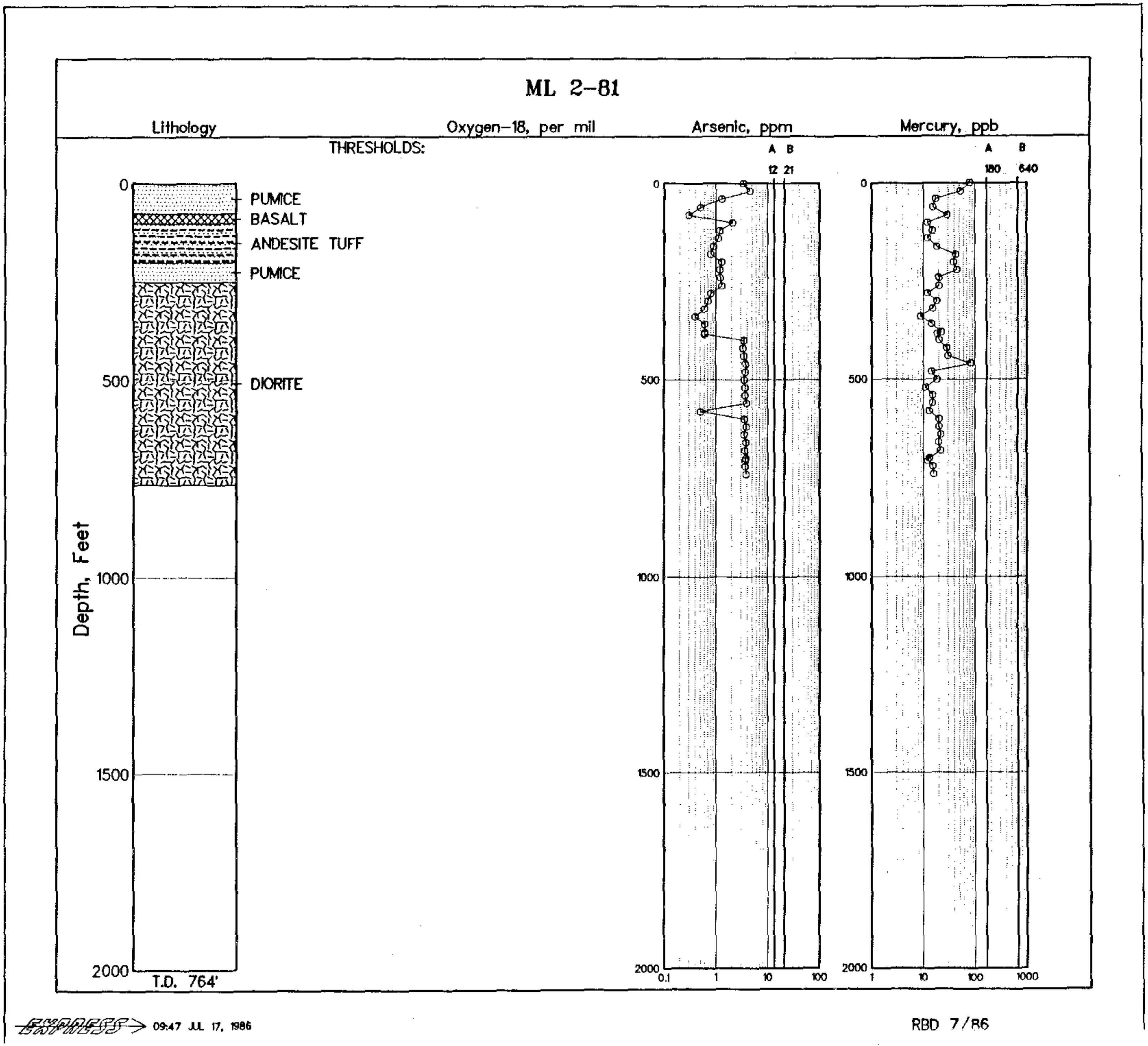
EXPRESS 11:12 AUG 19, 1986

RBD 7/86

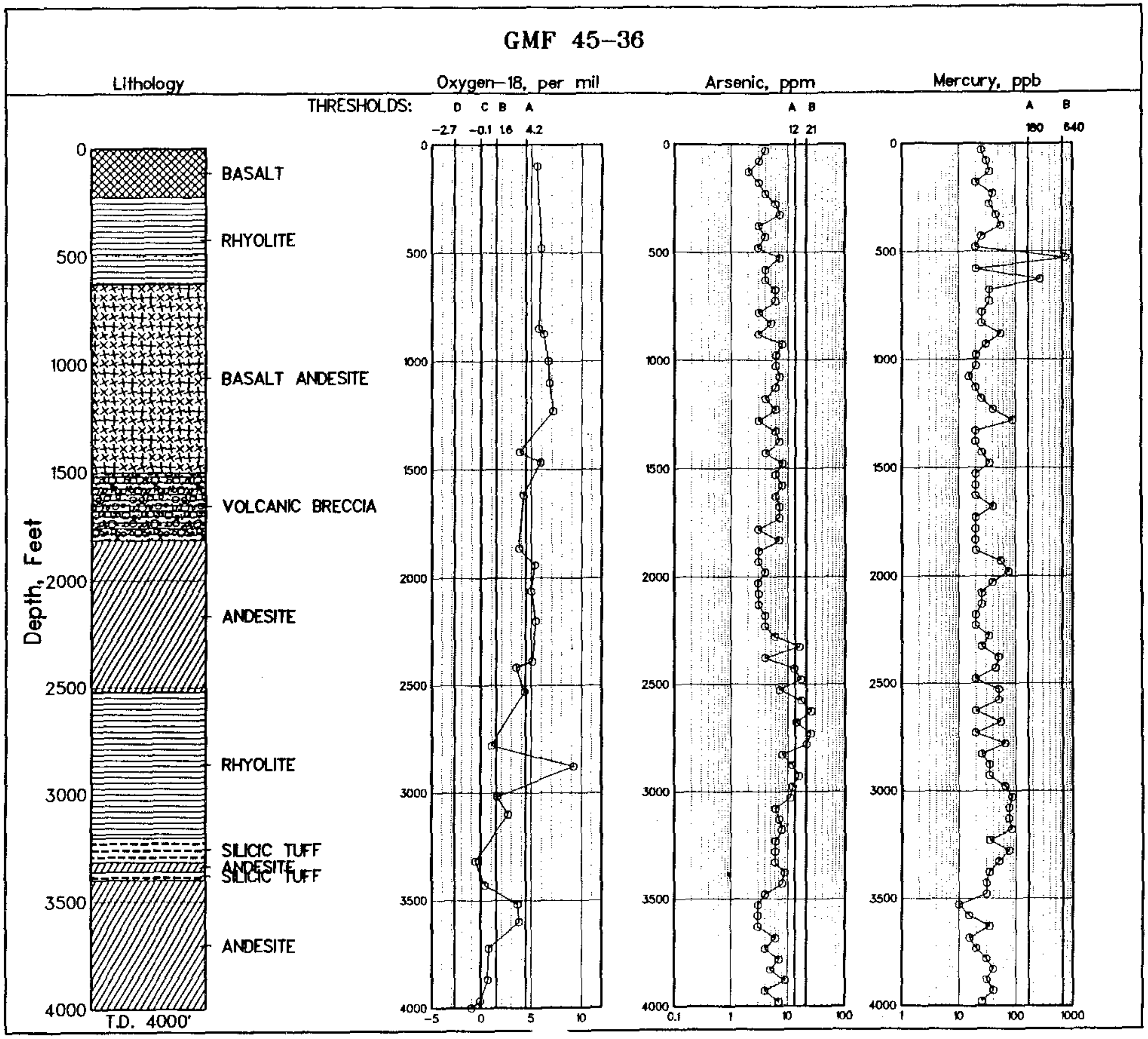

GMF 87-13
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
D C B A
-2.7 -0.1 1.6 4.2
A B
12 21
A B
160 640
BASALT
ANDESITE TUFF
BASALT
BASALT BRECCIA
SILICIC TUFF
Depth, Feet
0
500
1000
1500
2000
T.D. 918'
-5 0 5 10
0.1 1 10 100
1 10 100 1000
11:55 AUG 19, 1986
RBD 7/86



ML 1-81
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
A B
12 21
A B
180 640
Depth, Feet
0
500
1000
1500
2000
PUMICE
NO SAMPLE
OBSIDIAN
ANDESITE
OBSIDIAN
T.D. 620'
0.1
1
10
100
1
10
100
1000
09:51 JUL 17, 1986
RBD 7/86



ML 2-81
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
A B
12 21
A B
180 640
Depth, Feet
0
500
1000
1500
2000
PUMICE
BASALT
ANDESITE TUFF
PUMICE
DIORITE
T.D. 764'
0.1
1
10
100
1
10
100
1000
EXPRESS 09:47 JUL 17, 1986
RBD 7/86



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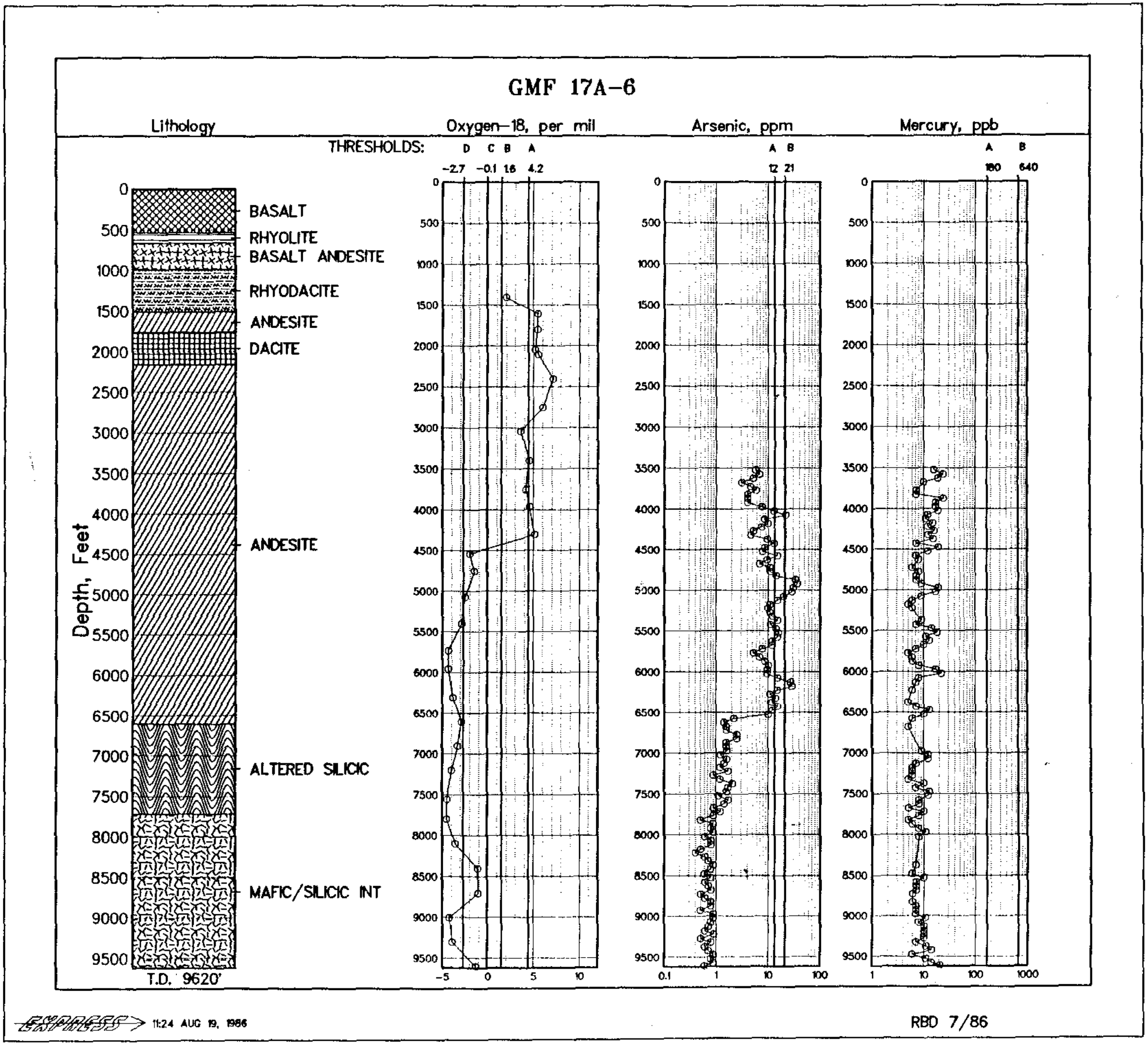
RBD 7/86


GMF 17A-6
Lithology
Oxygen-18, per mil
Arsenic, ppm
Mercury, ppb
THRESHOLDS:
D C B A
-2.7 -0.1 1.6 4.2
A B
12 21
A B
180 640
Depth, Feet
BASALT
RHYOLITE
BASALT ANDESITE
RHYODACITE
ANDESITE
DACITE
ANDESITE
ALTERED SILICIC
MAFIC/SILICIC INT
T.D. 9620'
RBD 7/86
11:24 AUG 19, 1986