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November 30, 1987

TO: Alex Schriener

FM: Daniel L. Carrier RE: ANALYSIS OF MINERALOGY AND FLUID INCLUSION DATA
FROM GLASS MOUNTAIN AREA TEMPERATURE BOREHOLESEXECUTIVE SUMMARY

A high-temperature hydrothermal system probably exists in the eastern half of the Medicine Lake Basin. This is the most significant conclusion of a study on mineralogy and fluid inclusion data obtained from boreholes drilled in and around ~~of~~ the Glass Mountain Federal Unit. Alteration that occurs on the northwestern margin of the Basin is old and not in thermal equilibrium with observed temperatures. Weak argillic alteration of uncertain age is found about 1-2 miles outside the Basin to the west and southwest.

The best evidence for an active system is observed in GMF 28-32 located on the eastern flank of Mt. Hoffman. The pattern of alteration in the temperature borehole varies systematically from zeolite-smectite (2480') to argillic (2680') to propylitic (3460' to 4500'). In addition, fluid inclusion data indicate that vein mineralogy at 4022' in GMF 28-32 was probably formed at temperatures of 464-500°F by hydrothermal fluids with a salinity of <20,000 ppm. The geothermal system possibly exists at shallower depths in the vicinity of boreholes GMF 44-33 and GMF 87-13, and is evidenced by the shallower occurrence of argillic alteration. However, the total depths of the two boreholes are not great enough to confirm the presence of propylitic alteration in those areas.

Mineralogical data indicate a 410 to 455°F geothermal system has existed as shallow as 1500-2500' near the northwest margin of the Medicine Lake Basin. However, fluid inclusion data from vein minerals in boreholes GMF 56-3 (1786' TD) and GMF 45-36 (4000' TD) indicate the geothermal system has declined. It is uncertain whether a high-temperature resource still exists in the area at depths greater than the two boreholes. Evidence for the hydrothermal event is characterized in GMF 56-3 by the occurrence at 1426' of chlorite-smectite clays that typically have formation temperatures of 390° to 455°F. The hydrothermal event in GMF 45-36 is evidenced by propylitic mineral assemblages at 2500' to 3430' and 3720' to 4000' TD. The upper propylitic assemblage in GMF 45-36 is sandwiched between two zones of argillic alteration, and is probably a relic of hydrothermal outflow. Fluid inclusion data suggest the outflow occurred at a temperature of at least 410° to 445°F.

Anomalous argillic alteration is observed in ML 36-28 at 1820' and ML 62-21 at 2115'. ML 36-28 is located about 2 miles outside the Medicine Lake Basin in the Little Glass Mountain Structural Zone. ML 62-21 is located about one mile outside the southwestern margin of the Basin. It is not clear if the observed alteration in either area is caused by localized hydrothermal activity, or if the alteration is linked by upflow or outflow to activity that has existed on the Basin margin.

RECOMMENDATIONS

The results of this study lead to the following recommendations concerning potentially beneficial studies:

1. A detailed mineralogy and fluid inclusion study similar to this one should be completed for exploratory wells GMF 68-8 and GMF 17A-6. This study will contribute to the understanding of the Glass Mountain prospect, and will assist future exploration in the Glass Mountain Unit.
2. Mineralogy and fluid inclusion studies can be used in other prospects with intermediate temperature boreholes for locating areas of enhanced permeability. It is recommended that such studies be completed for the Lassen and Konocti prospects.

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HYDROTHERMAL ALTERATION

Introduction

Broadscale alteration zoning has been mapped in 24 temperature boreholes drilled in and around the Glass Mountain Federal Unit (Figure 1). The purpose of characterizing and outlining the alteration mineralogy observed in the boreholes is to help focus exploration efforts on the potentially hottest and most permeable areas. Fluid inclusion temperatures have also been measured on select samples to quantify the formation temperatures of the mineralogy.

Several factors affect the formation of hydrothermal minerals including temperature, pressure, primary lithology, permeability, fluid composition, and duration of the hydrothermal activity (Rose and Burt, 1979). The influence of primary lithology diminishes as formation temperatures are increased, and becomes insignificant when temperatures exceed 536°F (280°C) (Brown, 1978). In the case of Glass Mountain boreholes, the rock types drilled in the area range the full spectrum from basalts to rhyolites, and measured borehole temperatures are significantly less than 536°F. It is, therefore, likely primary lithology has some influence on the distribution of alteration observed in Glass Mountain boreholes. This possibly results in minor irregularities in the distribution of low-temperature alteration that are caused by lithologic differences rather than temperature or permeability.

Borehole depths must be considered when interpreting the mineralogy data in this report. The total drilled depths of the boreholes varied from 918'-4500'. This variability could

SIMPLIFIED GEOLOGY

 **YOUNG SILICICS**

 **FRACTURES**



GLASS MOUNTAIN

 **FEDERAL UNIT BOUNDARY**

 **BASIN OUTLINE**

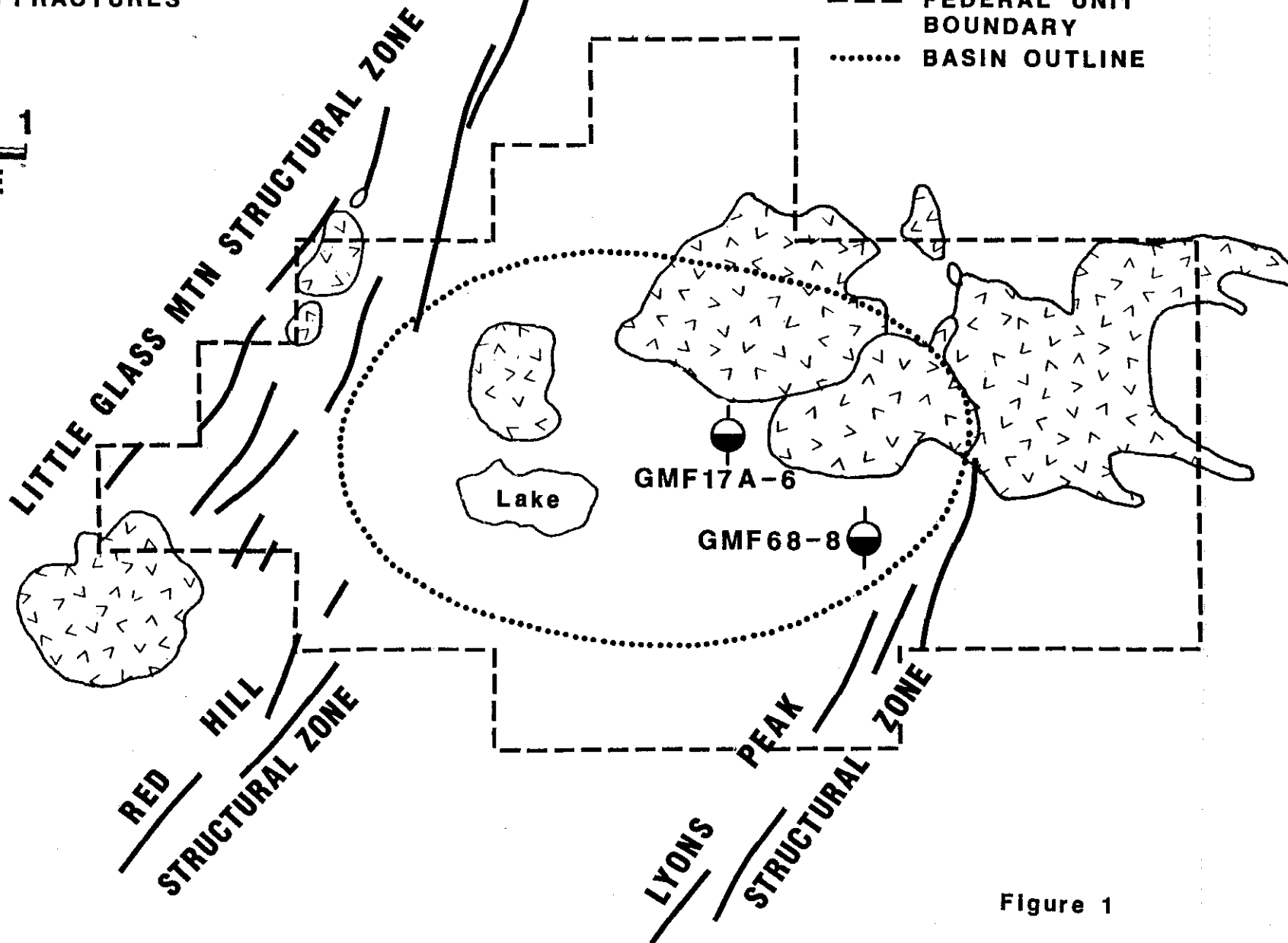


Figure 1

potentially result in the unequal evaluation of each borehole. Therefore, care has been exercised to insure that the absence of alteration zones in a shallow borehole is not the single criteria used to evaluate an area.

Methods and Data

Rock samples from 24 boreholes were sent to Dr. Jeff Hulen at the University of Utah Research Institute for bulk x-ray defraction analysis (Appendix 1). Thin sections were prepared and examined for 17 boreholes. Core and cutting samples were relogged in detail for five boreholes (ML 29-1, GMF 28-32, GMF 45-36, GMF 17-6 and GMF 44-33), and the scanning sets for several boreholes were examined as well.

Twelve samples from five temperature boreholes were sent to Dr. T. James Reynolds of Fluid Inc. for fluid inclusion analysis. The five boreholes sampled were ML 36-28, ML 65-26, GMF 28-32, GMF 45-36 and GMF 56-3. GMF 28-32, GMF 45-36 and GMF 56-3 contained a total of five samples with usable fluid inclusions.

Borehole Stratigraphy

Drilled stratigraphy broadly mirrors the surface geology mapped by Hausback (1984), although more lithologic detail is contained in the borehole data. Individual units of volcanic rock are difficult to correlate in Glass Mountain boreholes. Therefore, the rocks are classified into the following broad groups that are listed here in order of increasing age: bimodal rhyolites and basalts, shield-building mafics, flow-banded rhyolites and pyroclastics, and older mafics. In addition, the rock groups are sometimes discontinuous and the contacts between rock groups are not always sharp. For example, the transition from flow-banded rhyolite to the overlying and underlying mafic rocks is marked by a variable zone of interlayered mafic flows and pumaceous lithic tuffs. Similarly, a possible silicic horizon occurs only in boreholes drilled in and around the Medicine Lake Basin. This silicic horizon is found at depths of 300' to 1000'; and possibly correlates with the 0.10 + .01 m.y. old dacitic rocks mapped on the eastern flank of Glass Mountain (Mertzman, 1983). Geologic cross-sections that show some of these relationships will be presented in a later section. Additional stratigraphic analyses and correlation of rock types are needed before the rock groups can be further subdivided.

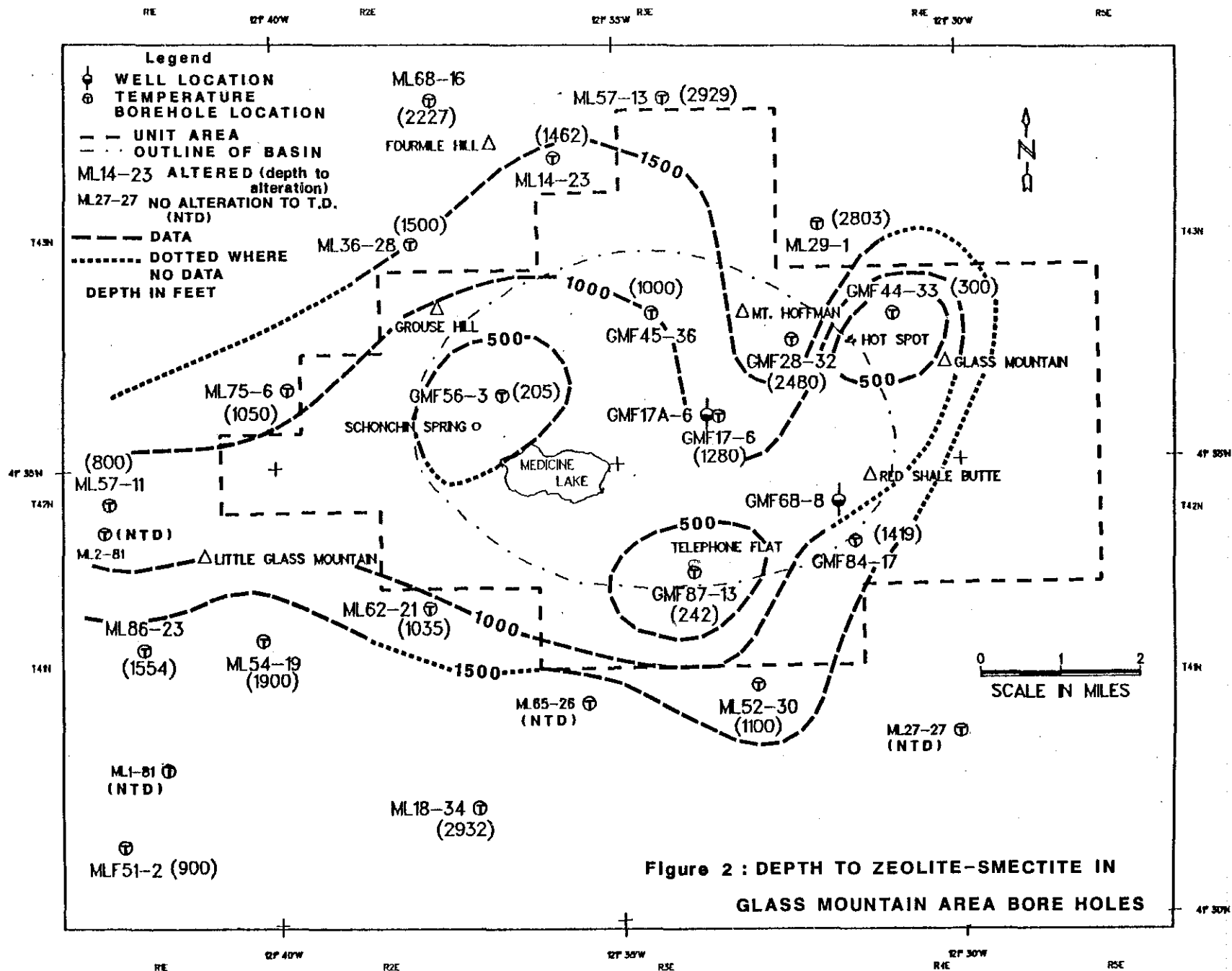
Alteration Zoning and Mineralogy

Hydrothermal alteration is classified into three distinctive types or zones: zeolite-smectite, argillic, and propylitic. This classification is a modification of those presented by Rose and Burt (1979) and Kristmannsdottier (1982). The classification is based on observed mineralogy and does not

directly utilize temperature or lithologic data. The zeolite-smectite alteration zone is defined by the presence of either low-temperature zeolites, such as mordenite, stilbite and clinoptilolite, or of smectite as 3-15% (designated as "minor concentrations" by Hulen) of the XRD samples. The argillic alteration zone is characterized by the presence of hydrothermal quartz and 15-50% hydrothermal clay (designated as "major concentrations" by Hulen) in XRD samples. The clays used to characterize the zone include smectite, illite, chlorite, kaoline and the mixed layered clays illite-smectite and chlorite-smectite. Rocks are considered to be in the propylitic alteration zone when two of the following three secondary mineral groups are present: sodic plagioclase, chlorite and epidote or calcite (replacing feldspar). The distribution of alteration zones in each borehole is summarized in Appendix 2.

The occurrence of zeolite-smectite alteration is shallowest in boreholes located near or inside the Medicine Lake Basin. The distribution of the alteration is shown in Figure 2. Since the width of the intervals sampled for XRD analysis range from 200' to 700', the contours shown in the figure actually only outline broad trends in the data. The zeolite-smectite zone occurs at the shallowest depths in three boreholes located near the margins of the Basin, GMF 56-3, GMF 87-13 and GMF 44-33. A second trend towards shallow zeolite-smectite alteration is measured in boreholes located along the Little Glass Mountain Structural Zone. The alteration zone in this area occurs at depths of 800'-1500' in boreholes ML 57-11, ML 75-6, ML 36-28 and ML 14-23. Only four boreholes in Figure 2, ML 27-27 (southeast), ML 65-26 (south), ML1-81 (southwest), and ML2-81 (west), do not contain zeolite-smectite alteration. The only alteration in MLF 51-2, located in the very southwestern part of the area, is zeolite-smectite alteration and it occurs in the 900' to 1150' interval. The borehole is unaltered from 1150' to 1836' T.D.

Argillic alteration occurs in eight area boreholes including all five boreholes drilled in the Medicine Lake Basin (Figure 3). The alteration zone is shallowest in boreholes GMF 56-3, GMF 87-13 and GMF 44-33, and only two boreholes completely penetrate the zone, GMF 28-32 and GMF 45-36. The greatest thickness of argillic alteration is found in GMF 17-6, where at least 1000' of argillic alteration is observed before the borehole reaches total depth. Boreholes ML 62-21 and ML 36-28, located on the outside margin of the basin, are only weakly altered. The absence of argillic alteration in GMF 84-17, and ML 75-6 is possibly due to the shallow depths of the boreholes relative to the local trends in the argillic zone. Both boreholes are located in areas of shallow zeolite-smectite alteration and contain zeolite-smectite alteration to total depth.



**Figure 2 : DEPTH TO ZEOLITE-SMECTITE IN
GLASS MOUNTAIN AREA BORE HOLES**

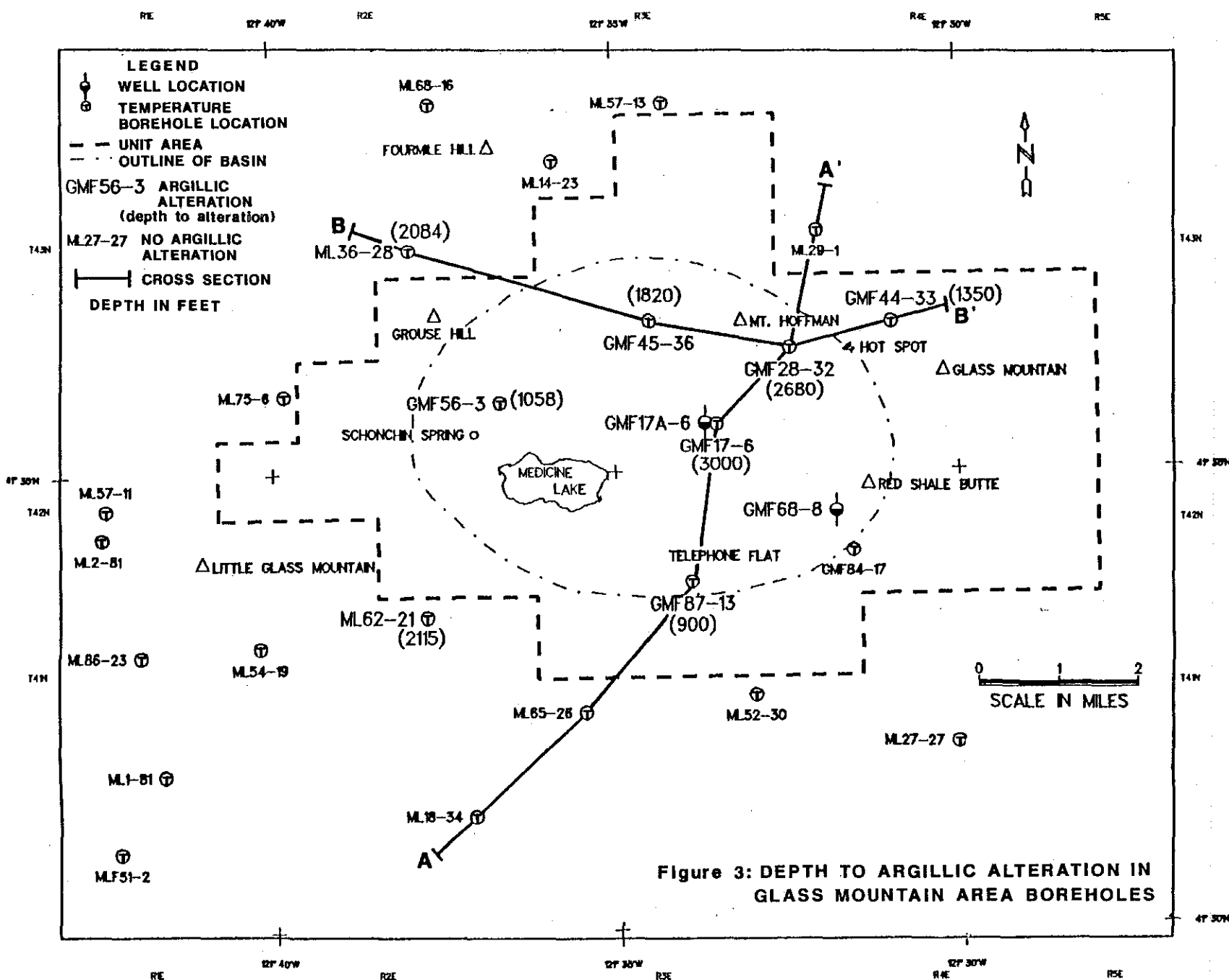


Figure 3: DEPTH TO ARGILLIC ALTERATION IN GLASS MOUNTAIN AREA BOREHOLES

GMF 28-32 and GMF 45-36 are the only two boreholes to contain propylitic alteration. The alteration zone occurs at a depth of 3460' in GMF 28-32 and 2500' in GMF 45-36. The boreholes are located within the Basin at its northern margin.

General Stratigraphy and Alteration Patterns in Cross-Section

The pattern and intensity of alteration in the Glass Mountain KGRA appears to be generally independent of rock type. This is demonstrated in the two cross-sections shown in Figures 4 and 5 that integrate the alteration zoning and general geology observed in several of the deepest boreholes. Cross-section A-A' trends roughly north-south and extends through the eastern half of the Basin (Figure 3). Cross-section B-B' trends roughly east-west and includes boreholes located on the northern margin of the Basin. The alteration zones observed in the cross-sections are well developed, and transitions between zones are systematic and not marked by abrupt hiatuses.

Cross-section A-A' (Figure 4) clearly illustrates the trend of shallowing alteration with increased proximity to the Medicine Lake Basin. Argillic alteration is observed only in boreholes located in the basin, and is shallowest at the margins in GMF 28-32 and GMF 87-13. Propylitic alteration is observed only in one of the deepest boreholes, GMF 28-32.

Cross-section B-B' (Figure 5) is not as clear as A-A' in demonstrating a trend towards shallowing alteration with increased proximity to the Medicine Lake Basin. The shallowest argillic alteration is actually found just outside the basin in GMF 44-33, which is located near the Hot Spot. Argillic alteration is found in boreholes GMF 28-32, GMF 45-36, and ML 36-28 at depths that vary by only about 500'. Propylitic alteration is observed in boreholes GMF 45-36 and GMF 28-32. Borehole GMF 45-36 shows the pattern of reverse mineralization that is suggestive of lateral flow. The direction of lateral flow is unknown and is arbitrarily drawn.

Fluid Inclusions

Fluid inclusion data are presented in Table 1 for samples from the three boreholes that contained minerals with measureable inclusions, GMF 45-36, GMF 28-32, and GMF 56-3. The characteristics of fluid inclusions and the several techniques and problems specific to fluid inclusions are detailed in Roedder (1972) and Bodnar and others (1985), and are only briefly discussed below. All the inclusions surveyed are of primary origin and formed during the growth of the secondary host crystals. The minerals surveyed include quartz, calcite, calcium zeolites (wairakite and laumontite), vein prehnite(?) and wallrock prehnite(?). The salinities observed varied from <1-2 wt% NaCl equivalent in the vein minerals. A salinity of <3.5 wt% NaCl equivalent was measured for the samples of

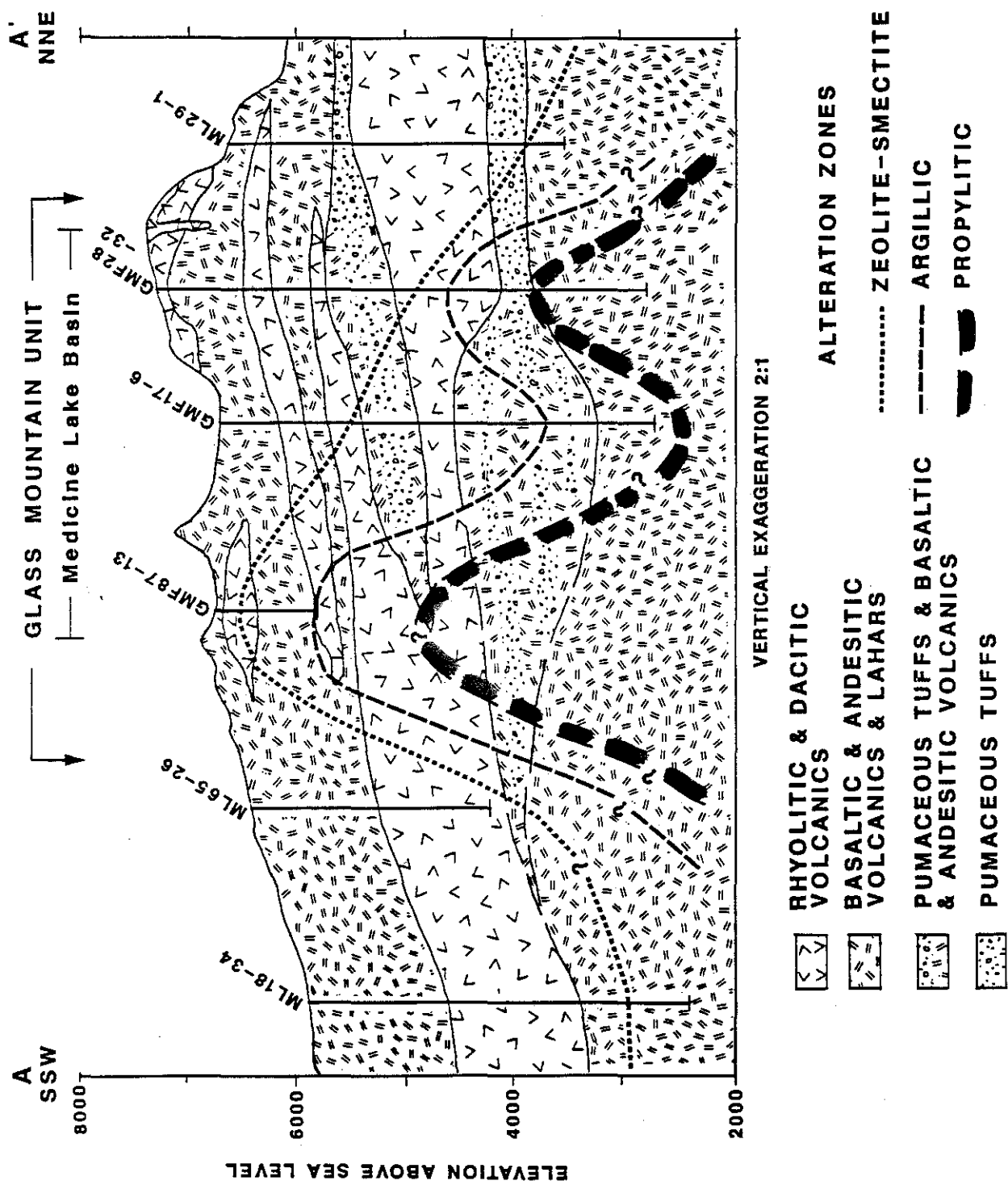


Figure 4: CROSS SECTION A-A' INTERGRATING ALTERATION ZONING AND GENERAL GEOLOGY FOR SEVERAL BOREHOLES LOCATED IN THE EASTERN HALF OF THE GLASS MTN. AREA

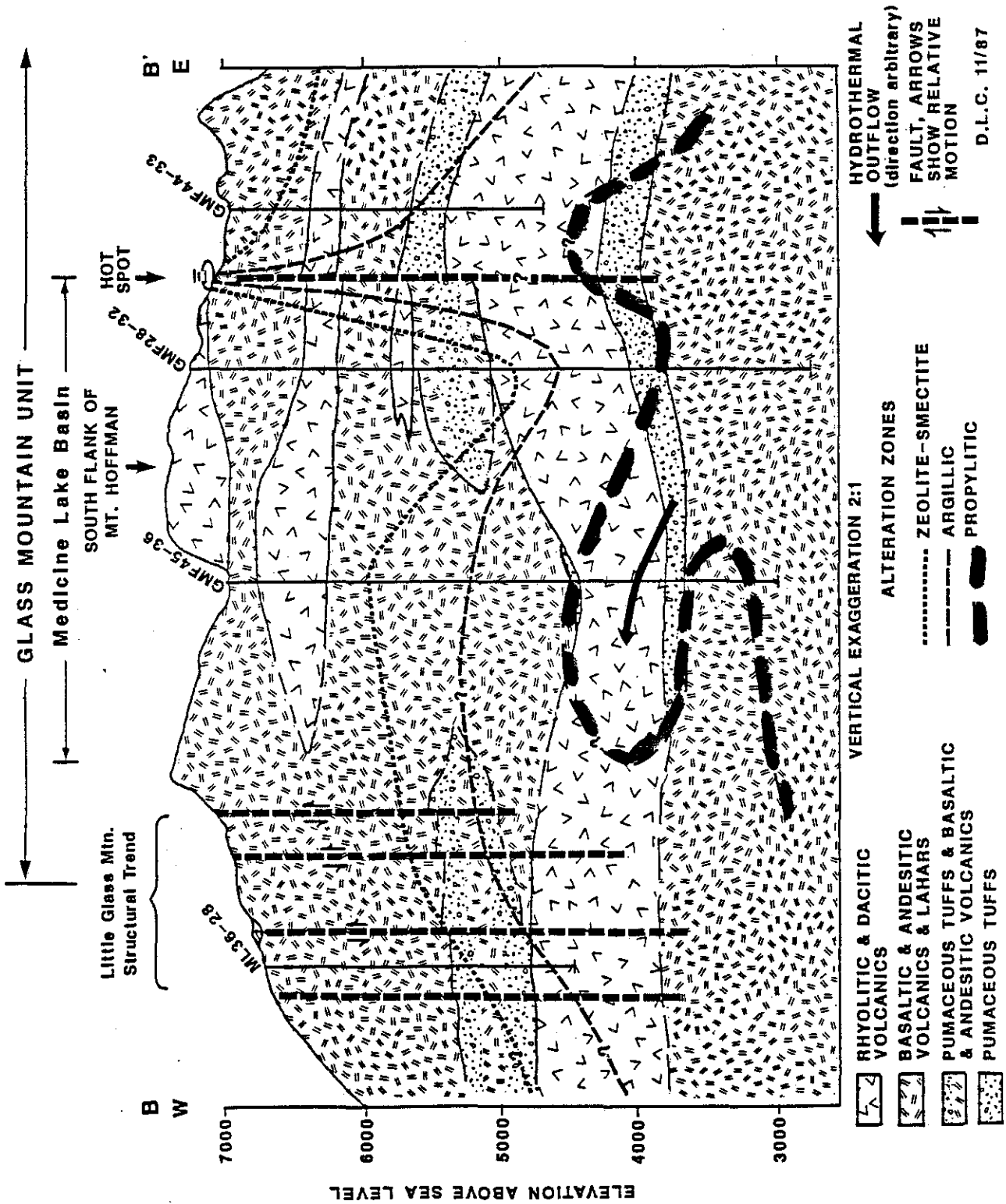


Figure 5: CROSS SECTION B-B' INTEGRATING ALTERATION ZONING AND GENERAL GEOLOGY FOR SEVERAL BOREHOLES LOCATED IN THE NORTHERN HALF OF THE GLASS Mtn. AREA

Table 1. Fluid inclusion data obtained on samples from three temperature boreholes drilled in the Glass Mountain area. Analysis were made by T. James Reynolds of Fluid Inc.

<u>Borehole</u>	<u>Sample Depth</u>	<u>No. Inclusions Measured</u>	<u>Mineral*</u>	<u>Homogenization Temperature</u>	<u>Weight-% NaCl Equivalent</u>
GMF 28-32	4022'	12	Calcite	464-500°F	<1.5
		8	Quartz	464-477°F	
GMF 45-36	2757'	17	Calcite	410-446°F	<1.5
		8	Quartz	437-446°F	<2
	3448'	10	Wallrock Prehnite	347-365°F	<1
		8	Quartz	338-356°F	<1
		10	Calcite	320-347°F	<1
	3905'	18	Wallrock Prehnite	347-365°F	<3.5
		11	Quartz	356-374°F	<1
		7	Prehnite	338-356°F	
		17	Calcium Zeolite	374-428°F	<1
GMF 56-3	1723.5'	4	Calcium Zeolite I	286-300°F	<3
		3	Calcium Zeolite IX	212-241°F	<3
		5	Quartz	235-261°F	<1.5

*All minerals are vein minerals unless otherwise stated.

wallrock prehnite found in GMF 45-36. A salinity of 1 wt% NaCl equivalent is approximately the same as a TDS of 10,000 ppm. The principal assumption made is that the salinity of an inclusion is due solely to dissolved sodium, potassium and calcium chlorides. However, if CO₂ is trapped in an inclusion, then measured salinities will be too high (Bodnar and others, 1985).

Fluid inclusion geothermometry is useful in determining the temperatures at which the secondary mineral formed (also called homogenization temperatures). These temperatures are best thought of as the minimum formation temperatures for the minerals. Because hydrothermal systems are dynamic, it is not appropriate for fluid inclusion temperature data to stand alone. Therefore, the geothermometry data are discussed below in conjunction with the petrological data. Measured temperature data are not integrated into this discussion due to an upcoming lease sale.

Case Study of Mineralogy, and Fluid Inclusion Data for Three Boreholes

GMF 28-32

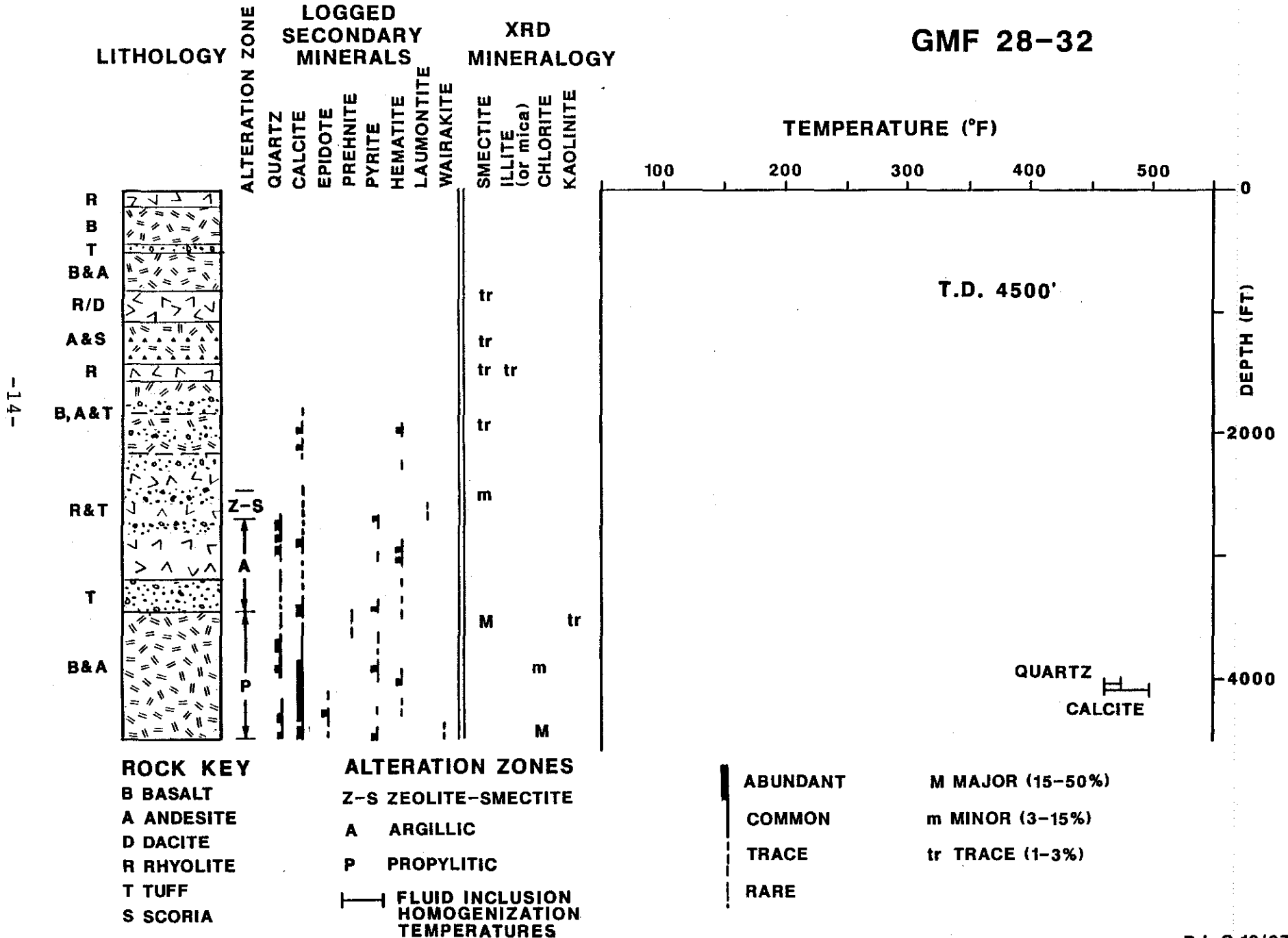
Fluid inclusion temperatures and mineralogy correlate well for GMF 28-32, and indicate the likely occurrence of an active hydrothermal system in the vicinity of the borehole (Figure 6). The sequence of alteration in GMF 28-32 is straight forward and begins with the occurrence of zeolite-smectite alteration near a depth of 2480'. Argillic alteration begins in the borehole at 2680' and is followed by weak propylitic alteration at 3460'. The essential secondary minerals present at this depth are calcite, which is replacing plagioclase, and chlorite. The grade of alteration becomes stronger with depth and is distinguished by the first occurrence of epidote at 4330'. Other secondary minerals found in the borehole samples include prehnite, pyrite, wairakite and hematite.

Homogenization temperatures measured on a sample from 4022' in GMF 28-32 are 464-476°F for secondary quartz and 464-500°F for secondary calcite. These are the highest homogenization temperatures observed in samples from any of the boreholes and are reasonable temperatures for propylitic alteration. Salinities of ≤ 2 wt% NaCl equivalent (approximately 20,000 ppm) are measured in the inclusions and are possibly indicative of the local salinities expected for the active hydrothermal system.

GMF 45-36

The integration of the fluid inclusion and mineralogical data sets indicate the observed alteration in GMF 45-36 is old, and that more than one hydrothermal event has probably occurred in

GMF 28-32



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the area. The pattern of alteration in GMF 45-36 (Figure 7) suggests that high-temperature hydrothermal outflow has probably occurred in the area. Secondary mineralogy in the borehole is initially straight forward with the occurrence of the zeolite-smectite zone at 1000' and the argillic zone at 1820'. The distribution of secondary mineralogy becomes more complicated with depth, as evidenced by the occurrence of two layers of propylitic alteration at 2500' to 3430' and 3720' to 4000' T.D. It is likely that the propylitic alteration in the 2500' to 3430' interval is the result of hydrothermal outflow. The two propylitic alteration zones are separated by a thin zone of argillic alteration. The essential secondary minerals in the upper layer of propylitic alteration are chlorite, albite, and from 3220' to 3430', calcite. The essential secondary minerals in the lower layer are chlorite, calcite and epidote. Other secondary minerals that are present in either of the propylitic layers include prehnite, pyrite, hematite, laumontite and possible K-feldspar and wairakite.

The relationship between the fluid inclusion and mineralogical data is not straightforward. Homogenization temperatures of secondary minerals in the upper propylitic layer at 2757' are 410-445°F and in the sandwiched argillic zone at 3448' are 320-365°F. These homogenization temperatures are probably consistent with the observed pattern of propylitic to argillic alteration. However, temperatures measured on fluid inclusions obtained from 3905' are complex and probably not indicative of the bottom hole propylitic assemblage. Vein quartz, vein prehnite and wallrock prehnite are all in equilibrium with a hydrothermal event of 338-374°F and not the 392°F+ event needed to form the epidote in the host rocks (Bird and others, 1984). Sampled veins are also filled by a calcium zeolite (probably wairakite) with a higher homogenization temperature of 374-428°F. These data suggest that two hydrothermal events are probably recorded in the mineralogy of GMF 45-36 at 3905'. The first event probably caused the propylitic alteration of the host rocks. Later, as this hydrothermal system declined, secondary quartz and prehnite were formed in the fracture at 338-374°F. A second thermal event followed that resulted in the filling of the still open fractures by calcium zeolites at 374-428°F. The probable source of the thermal events is either a single growing system, in which temperature slowly increased over time, or two distinct hydrothermal systems.

GMF 56-3

Fluid inclusion data collected on vein minerals indicate the observed bulk-rock secondary mineralogy in GMF 56-3 is out of thermal equilibrium, and that the causative hydrothermal system has declined. Alteration in GMF 56-3 begins with zeolite-smectite alteration at a depth <205' and extends to 1031'. The argillic zone begins at 1031' and is the best developed sequence of argillic alteration (Figure 8) in any of

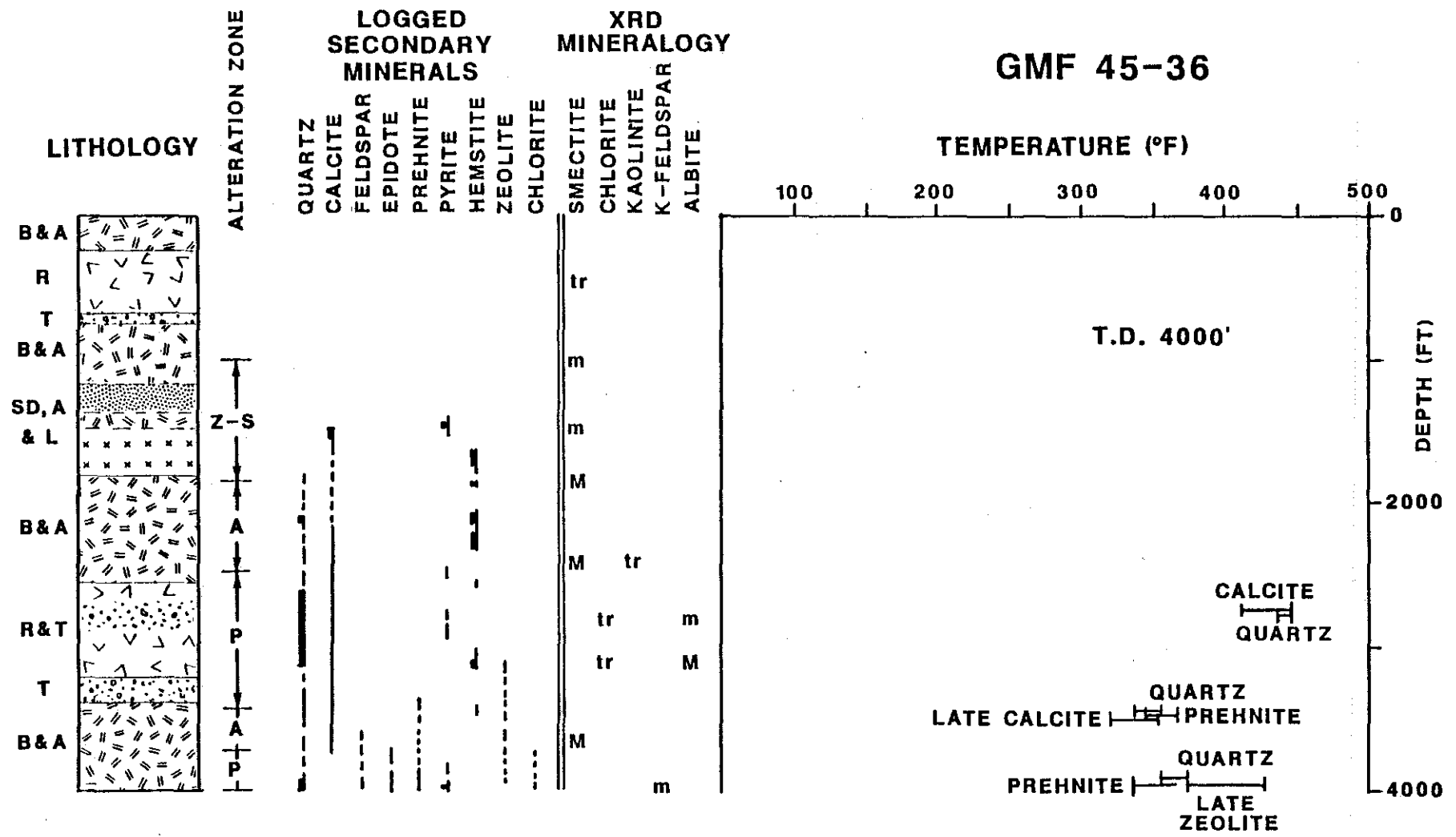


Figure 7

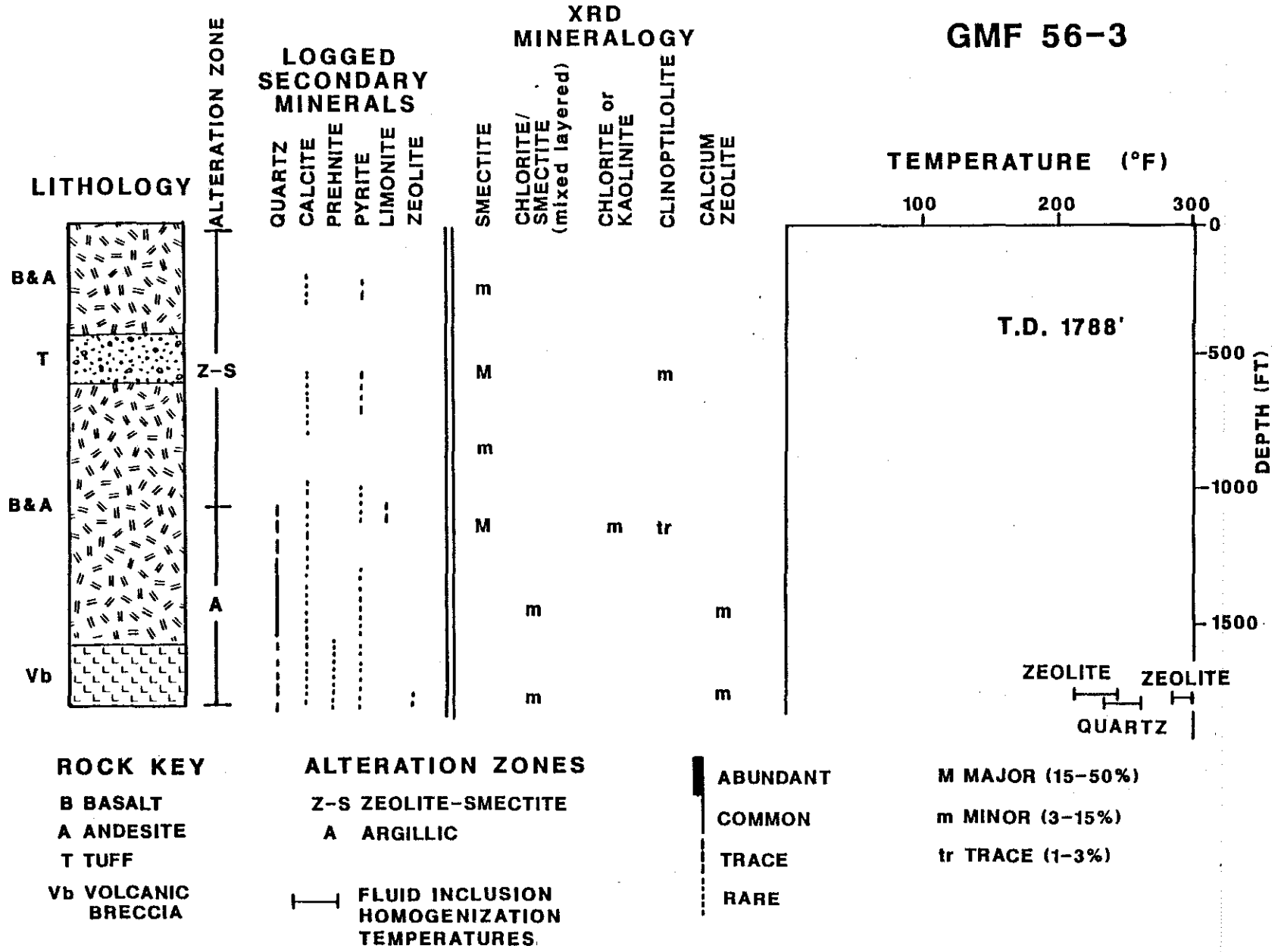


Figure 8

the area boreholes. Secondary mineralization in the alteration zone consists of the characteristic minerals quartz, smectite and intermittent kaolinite. As the depth of the borehole increases, the mineralogy evolves toward the higher temperature minerals of chlorite-smectite, and wairakite (1426'-1459' and 1727'-1760'). This assemblage is indicative of the higher temperature end of the argillic alteration zone (Brown, 1978; Bird and others, 1984), and is approaching propylitic alteration. Chlorite-smectite clays are mapped in Iceland by Kristmannsdottier (1982) as a separate alteration zone that occurs in mafic igneous rocks at temperatures of 390° to 455°F (200° to 230°C).

The fluid inclusion data from secondary vein minerals in GMF 56-3 record the decline of the hydrothermal system in two generations of inclusions. These fluid inclusions are observed in quartz and calcium zeolites that are contained in a sample collected at 1723.5'. Homogenization temperatures in these inclusions systematically vary from 285-300°F and 212-260°F, and are probably the remnants of a slowly cooling system. The latest vein-filling mineral is calcite, which is barren of inclusions and probably deposited at temperatures less than 212°F.

CONCEPTUAL MODEL

Integrated mineralogy and fluid inclusion data are used to construct a conceptual model of the geothermal system in the Glass Mountain area. The completeness and accuracy of the model is limited by the variability in temperature borehole total depth. This variability makes borehole to borehole correlations difficult and incomplete, and probably impacts the observed distribution of argillic and propylitic alteration. However, this limitation notwithstanding, it is believed that the general trends presented below are probably correct.

Four areas in the Glass Mountain Unit area are found to contain anomalous hydrothermal alteration. The locations of these four areas are shown in Figure 9. It is uncertain whether the alteration observed in each area is the result of a distinct hydrothermal event, or if any or all the areas outlined result from the same geothermal event. Nevertheless, the data do establish the occurrence of widespread hydrothermal activity in the area. The salient features of each area are discussed below.

Area 1

A high-temperature geothermal system probably exists along the eastern margin of the Medicine Lake Basin. The most direct evidence for a system is contained in GMF 28-32 drilled along the eastern flanks of Mt. Hoffman. Fluid inclusion and mineralogical data are probably in thermal equilibrium, and

CONCEPTUAL MODEL FOR GEOHERMAL ACTIVITY IN THE GLASS MOUNTAIN UNIT AREA

ARGILLIC
ALTERATION,
EVIDENT AT 2000'

ML36-28

AREA 3

AREA 2

PROPYLLITIC
ALTERATION,
ACTIVITY HAS
DECLINED

PROPYLLITIC
ALTERATION,
SYSTEM PROBABLY
STILL ACTIVE

GMF

44-33

GMF28-32

GMF45-36

GMF56-3

Lake

AREA 1

GMF87-13

AREA 4

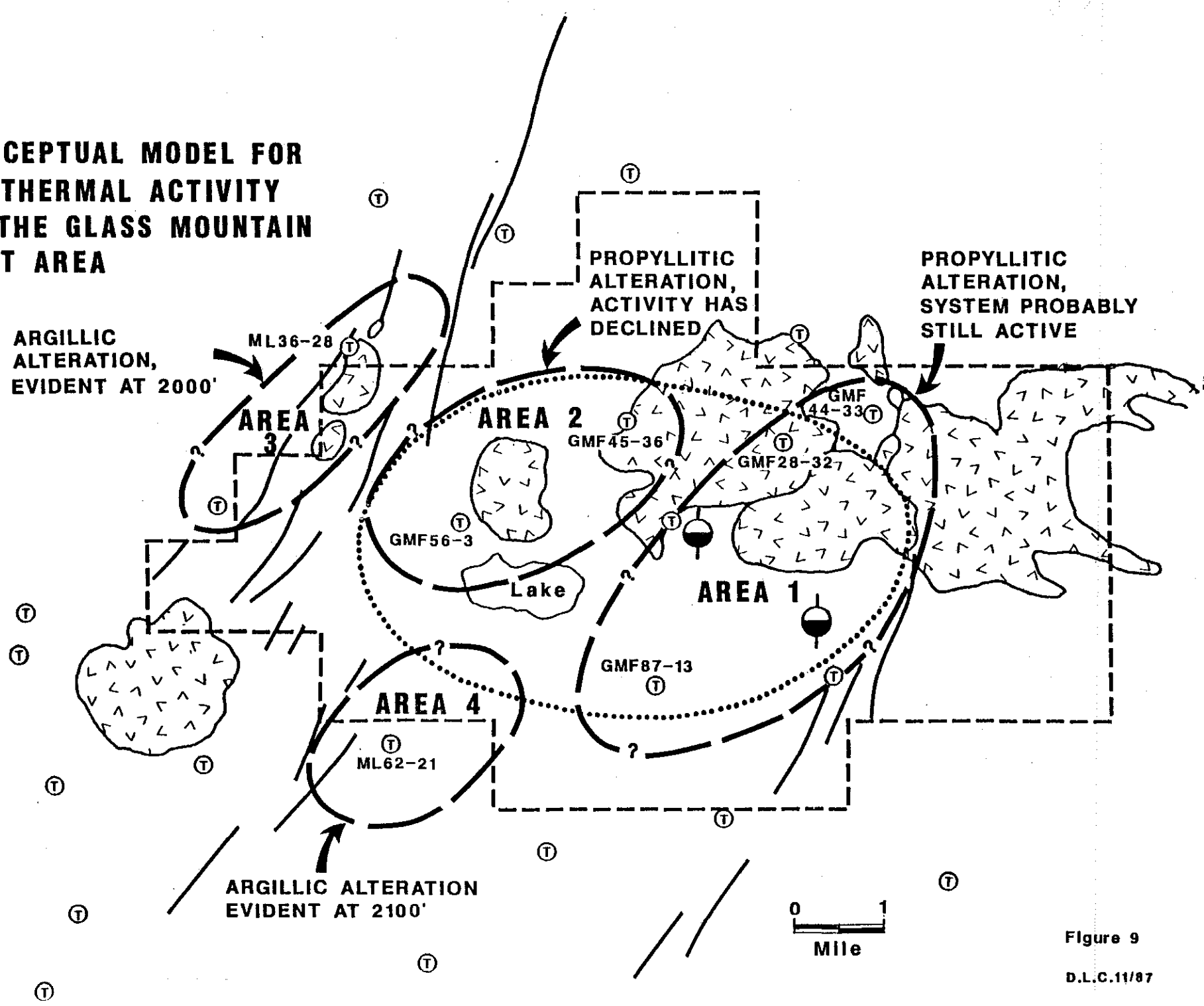
ML62-21

ARGILLIC ALTERATION
EVIDENT AT 2100'



Figure 9
D.L.C.11/87

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that hydrothermal fluids associated with the alteration probably have a salinity of <20,000 ppm. Argillic alteration is also found at 900' in GMF 87-13, located near Telephone Flats, and at 1350' in GMF 44-33, located near the Hot Spot. The argillic alteration in the two boreholes occurs at depths that are shallower than the same alteration in GMF 28-32 (2680'). Because GMF 87-13 and GMF 44-33 are shallow, no propylitic alteration is observed in the boreholes. Nevertheless, the available data suggest that the hydrothermal system is found at shallower depths at GMF 87-13 and GMF 44-33 than at GMF 28-32.

Area 2

High-temperature hydrothermal activity has occurred and possibly is still occurring along the western and northwestern margin of Medicine Lake Basin in the vicinity of GMF 56-3 (1788' TD) and GMF 45-36 (4000' TD). Estimated temperatures from bulk-rock secondary mineralogy and measured fluid inclusion temperatures are not in equilibrium and suggest that hydrothermal activity has declined in this area. It is uncertain whether it still exists at depths greater than the total depths of the boreholes.

Area 3

Moderate-temperature hydrothermal activity has and is possible still occurring in the vicinity of the Little Glass Mountain Structural Zone. The highest grade of alteration is observed at 2084' in GMF 36-28, and consists of weak argillic alteration. It is uncertain whether the alteration is the result of a distinct hydrothermal event associated with volcanic activity in the Little Glass Mountain Structural Zone, or if it is related to high-temperature hydrothermal activity in Area 2.

Area 4

Moderate-temperature hydrothermal activity has and is possibly still occurring in the Red Hill Structural Zone located about one mile southwest of the Medicine Lake Basin. The activity is characterized by weak argillic alteration observed at 2115' in ML 62-21. It is uncertain whether the alteration is the result of a local hydrothermal event, or possibly related to high-temperature activity in Area 1 or Area 2.

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APPENDIX 1

UURI

EARTH SCIENCE LABORATORY
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TELEPHONE 801-581-5283

April 16, 1984

Alex Schriener
Area Geologist
Union Geothermal Division
Union Oil Company of California
2099 Range Avenue
Santa Rosa, CA 95406

Dear Alex:

The 34 geochemical pulp samples you submitted earlier this year have been mineralogically analyzed by qualitative X-ray diffraction (XRD). Preliminary results for 13 bulk samples, and for clay fractions extracted from seven of these, were reported to you in my letter of March 5. The present report documents analyses for the entire sample suite, and briefly discusses implications of these analyses for geothermal exploration.

Bulk samples can be grouped broadly into two categories: 1) those dominated by plagioclase and 2) those containing sanidine and cristobalite with minor tridymite and a trace of quartz. These two sample types probably correspond, respectively, to intermediate to mafic volcanic rocks and felsic volcanic rocks.

Plagioclase in type 1 rocks is a variety more calcic than albite, probably andesine or labradorite; it may be accompanied by trace to minor clinopyroxene and apatite, but the X-ray signatures of these phases, if present, are obscured or concealed by the strong, numerous, crowded peaks of the overwhelmingly dominant plagioclase; petrographic examination is suggested for definite identification. Ilmenite, pyrite or marcasite and hematite are other probable trace constituents of many plagioclase-rich samples.

Cristobalite-sanidine rocks are probably rich in devitrified felsic glass. In several of these rocks, such as well no. 3, 750-800', devitrification may not have proceeded to completion; a prominent, broad glass "hump" is apparent between about 18 and 34°2θ. Alternatively, but less likely, the "hump" could reflect the presence of opal.

Zeolites occur only in wells 1 and 2. In well 1, mordenite is a major constituent of the sample spanning 1900-1950'. In well number 2, zeolites are

zoned with depth; clinoptilolite occurring above 1145' and analcime or wairakite (too little of this phase for a definite identification) below this footage.

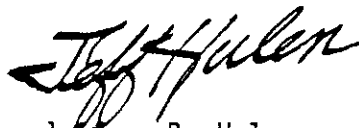
Clay minerals occur in all wells, but are most abundant in wells 1 and (particularly) 2. Smectite, the most common, is found in 16 of the 34 bulk samples; it is a major component of three. With a basal spacing of about 14A, the smectite probably contains calcium and/or (less likely) magnesium as the principal interlayer cation(s). Illite occurs only in well no. 1; at a depth of 1900' in this well it is accompanied by a trace of randomly-ordered, mixed-layer illite-smectite. Chlorite or kaolinite occur in two samples--one each in wells 2 and 4.

Well number 2 displays a distinct layer silicate zoning which mirrors the zoning of coexisting zeolites. Smectite occurs in the four samples above 1145'; in two of these samples it is accompanied by clinoptilolite. The two samples below 1145' contain conspicuous mixed-layer chlorite-smectite--an ordered variety with about 55% chlorite (Reynolds, 1980). This phase is accompanied in both samples by analcime or wairakite.

Of the five wells investigated, number 2 would appear to be the most encouraging for discovery of a concealed geothermal resource. Its well-developed zeolite and clay mineral zoning may indicate progressively higher-temperature, hydrothermal fluid circulation with increasing depth. Ordered, mixed-layer clays such as those of well 2 almost always develop at relatively high temperatures under conditions of deep diagenesis or hydrothermal alteration (Dunoyer de Segonzac, 1970). Mixed-layer, ordered chlorite-smectites were found in cuttings above productive reservoir at the Tiwi system, Philippines (UURI/ESL reports to Thomas Powell; Nov. 21, 1983 and Feb. 14, 1984), and in cuttings from your Geysers well KC88-24 (UURI/ESL report to Barbara Gallinatti; April 2, 1984), strengthening speculation that an active geothermal system could be present below the sampled depths of well 2. In research well Y-1 at Yellowstone (Honda and Muffler, 1970) clinoptilolite in less altered, high-level rocks gives way to analcime in deeper, more highly altered rocks; this zeolite zoning sequence is very similar to that observed in well 2. Of course, the alteration of well 2 could be entirely paleohydrothermal, so all other downhole data should be compared with the alteration assemblages to determine the probability of a concealed thermal resource at this site.

Thank you very much for submitting these rocks for X-ray analysis. I realize you've had to wait quite a while for the results, and appreciate your patience. The analyses are intriguing; I hope they enable you to bring in a new field.

Sincerely yours,



Jeffrey B. Hulen
Geologist

JBH/jp

REFERENCES

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- Honda, S., and Muffler, L. J. P., 1970, Hydrothermal alteration in core from research drill hole Y-1, Upper Geyser Basin, Yellowstone National Park, Wyoming: *American Mineralogist*, vol. 55, p. 1714-1737.
- Reynolds, R. C., 1980, Interstratified clay minerals in Brindley, G. W., and Brown, G., eds., *Crystal structures of clay minerals and their X-ray identification*: London, Mineralogical Soc. Mon. 5, p. 411-438.

GMF 56-3

WELL No. 2
BULK CUTTINGS

MINERALOGY, APPROX. WT.% (or) RELATIVE ABUNDANCE

GMF 56-3

SAMPLE NO.

QUARTZ
CRISTOBALITE
TRIDYMITE
K-FELDSPAR
PLAGIOCLASE
HEMATITE
ILMENITE
PYRITE OR
MARGASITE
GOETHITE
ILLITE
SMECTITE
CHLORITE OR
KAOLINITE OR
MIXED-LAYER
CHLOR-LAYER
MIXED-SMEC.
ILLITE-LAYER
SMECT.
CLINORTILOLITE
ANALCIME OR
VAIRAKITE
CALCITE

205-301'				MM		Tr?	Tr?	Tr?		m									
506-562'				MM			Tr?			M				m					
787-886'				MM			Tr?			m									
1110-1145'	m			MM	?		m?			M	m			Tr?					
1426-1459'	m			MM	?		m?					m			m				m
1727-1760'	m			MM		m						m			m				

TABLE 2.

WELL No. 2

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS
UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

ML 51-2

WELL No. 3
BULK CUTTINGS

MINERALOGY, APPROX. WT.% (or) RELATIVE ABUNDANCE

ML 51-2
SAMPLE NO.

QUARTZ
CRISTOBALITE
TRIDYMITITE
K-FELDSPAR
PLAGIOCLASE
HEMATITE
ILMENITE
PYRITE OR
MARGASITE
ILLITE
SMECTITE
CHLORITE
KAOLINITE OR
MIXED-LAYER
CHLORITE
MIXED-LAYER
ILLITE-SMEC.
ILLITE-SMEC.

NOTES / OTHER PHASES

SAMPLE NO.	QUARTZ	CRISTOBALITE	TRIDYMITITE	K-FELDSPAR	PLAGIOCLASE	HEMATITE	ILMENITE	PYRITE OR MARGASITE	ILLITE	SMECTITE	CHLORITE	KAOLINITE OR MIXED-LAYER	CHLORITE	MIXED-LAYER ILLITE-SMEC.	ILLITE-SMEC.	NOTES / OTHER PHASES
150-200'	TR	M	TR		M											
500-550'	TR	M	M		M											
750-800'		M	TR		M											PROBABLY ABUNDANT GLASS
900-950'	m				MM				M							
1150-1200'					MM	-		TR?								
1500-1550'					MM		TR?	TR?								
1800-1840'					MM		TR?	TR?								

TABLE 3

WELL No. 3

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS
UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

ML 52-30

WELL No. 4
BULK CUTTINGS

MINERALOGY, APPROX. WT.% (or) RELATIVE ABUNDANCE

ML 52-30

SAMPLE NO.

QUARTZ	CRISTOBALITE	TRIDYMITE	K-FELDSPAR	PLAGIOCLASE	HEMATITE	ALMENITE	PYRITE OR MARCASITE	ILLITE	SMECTITE	CHLORITE OR KAOLINITE OR MIXED-LAYER	CALORITE	MIXED-LAYER SMECTITE	ILLITE-SMEC.	OTHER PHASES
--------	--------------	-----------	------------	-------------	----------	----------	------------------------	--------	----------	--	----------	-------------------------	--------------	--------------

NOTES/ OTHER PHASES

250-300'					MM	m			TR	TR							
500-550'					M												PROBABLY ABUNDANT GLASS
800-850'		M		m	M	TR?											
1100-1150'					MM				m								
1450-1500'	TR	M	TR		M	M			m								
1700-1750'		M	TR		M	TR?			TR?								
1900-1950'	TR	M	m		M												

TABLE 4.

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION

WELL No. 4



SUMMARY OF X-RAY DIFFRACTION ANALYSIS
UNIVERSITY OF UTAH RESEARCH INSTITUTE , EARTH SCIENCE LABORATORY

ML 54-19

WELL No. 5
BULK CUTTINGS

ML-54-19

MINERALOGY, APPROX. WT.% (or) RELATIVE ABUNDANCE

SAMPLE NO.

QUARTZ	CRISTOBALITE	TRIDYMITE	K-FELDSPAR	PLAGIOCLASE	HEMATITE	ALMENITE	PYRITE OR MARCASITE	ILLITE	SMECTITE	CHLORITE OR KAOLINITE OR MIXED-LAYER	CHLORITE-LAYER	MIXED-LAYER ILLITE-SMEC		
--------	--------------	-----------	------------	-------------	----------	----------	---------------------	--------	----------	--------------------------------------	----------------	-------------------------	--	--

NOTES/OTHER PHASES

TABLE 5

150-200'				MM			Tr?											
500-550'				MM														
850-900'				MM	m?													
1300-1350'				MM	m													
1500-1550'				MM	Tr?				Tr?									
1550-1600'				MM			Tr?											
1900-1950'				MM			Tr?		m									
2150-2200'				MM					m									

halloite
Cm, H, M, H₂O

ALSO UNKNOWN 744A
PHASE
PROBABLE ABUNDANT
GLASS

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION

WELL No. 5



SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

WELL Nos. 6 & 7 BULK CUTTINGS	MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>														NOTES/OTHER PHASES	
SAMPLE NO.	QUARTZ	CRISTOBALITE	TRIDYMITITE	K-FELDSPAR	PLAGIOCLASE	HEMATITE	ALMENITE	PYRITE	ILLITE	SMECTITE	CHLORITE	KAOLINITE OR MIXED-LAYER	SILOR-LAYER MIXED-LAYER	ILLITE-SMEC. ILLITE-SMEC.		
WELL No. 6 ML 75-6																
350-400'					MM		TR?									
600-650'					MM			TR?								
800-850'					MM		m	TR								
1050-1100'					MM		TR?	TR			m					
1450-1500'	m				TR?	m					m					ABUNDANT GLASS
1750-1800'	TR				MM						m					
1950-2000'					MM						m					
ML-2-B1																
WELL No. 7																
700-750'	TR	m			m?	MM					TR					

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS
 UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

prob. 90-80%
 25%

WELL Nos 8, 10, 11 BULK CUTTINGS (WELL No. 9 ON FOLLOWING PAGE)	MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>														NOTES/ OTHER PHASES	
	QUARTZ	CRISTOBALITE	TRIDYMITE	K-FELDSPAR	PLAGIOCLASE	HEMATITE	ILMENITE	PYRITE	ILLITE	SMECTITE	CHLORITE	MIXED-LAYER ILLITE-SMECT.	MIXED-LAYER CHLOR-SMECT.	CLINOPTILOL.		ANALCIME
Sample No. 8 GMF 27-13																
242-270'	M			M	m					m						
461-487'					M	M				m					m	
633-661'					MM	m				M					m	
825-851'					MM	m	Tr?			M					Tr	
GMF 44-37																
Sample No. 10																
300-390'					MM	m				m						
570-630'	M			M	m		* Tr?			Tr						PROBABLY ABUNDANT GLASS
870-930'					M					Tr						"
1170-1230'					M					m						"
1440-1470'	m			Tr	M											"
1710-1740'	M	m		M							Tr?					
1920-1950'	M	m		M												
2200-2230'	M	m		M			m			m						
ML 57-11																
Sample No. 11																
300-350'					MM											
550-600'					MM											
800-850'					MM	Tr?	Tr?			m						
1100-1150'					MM					m						
1450-1500'					MM					m						
1850-1900'					MM					m	Tr?					

* OR MARCASITE

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS

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WELL No. 9 BULK CUTTINGS		MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>														NOTES/ OTHER PHASES			
GmF 17-6 SAMPLE NO.		QUARTZ	CRISTOBALITE	TRIDYMITITE	K-FELDSPAR	PLAGIOCLASE	HEMATITE	ZINCHENITE	PYRITE	ILLITE	SMECTITE	CHLORITE	MIXED-LAYER ILLITE-SMEC.	MIXED-LAYER CHLOR-SMEC.	CLINOPTILOL.		ANALCIME		
270-330'					MM		TR	TR			TR								
420-470'					TR? MM		TR	TR			TR								
720-780'		M	TR		M						TR								
960-1020'					MM		TR				TR								
1260-1380'					MM						m				m	m			
1770-1860'					MM		TR				m								
2280-2300'					MM						m								
2620-2680'					MM		TR				m								
3040-3100'					MM		m	TR			m								
3400-3460'		M			m? MM				TR?		TR	m							
3460-3670'		m			MM						m			m					
3940-3990'		m			MM		TR				m	TR*							

† OR MARCASITE
* OR KAOLINITE

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

WELL Nos. 12 & 13 BULK CUTTINGS		MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>														OTHER PHASES NOTES		
# ML65-26 SAMPLE NO.		QUARTZ	CRISTOBALITE	TRIDYMITITE	K-FELDSPAR	PLAGIOCLASE	HEMATITE	ILMENITE	PYRITE	ILLITE OR MICA	SMECTITE	MIXED-LAYER ILLITE-SMEC.	MIXED-LAYER CHLOR.-SMEC.	STILBITE				
WELL No. 12																		
450-500'						MM												
750-800'						MM	m											
1050-1100'						MM		Tr?										
1350-1400'		Tr	M	m		M												
1600-1650'		Tr	M	Tr		M												
1850-1900'			M	m		M				m								
2100-2150'			m	M		M				Tr?								
GMF 84-17																		
WELL No. 13																		
304-336'						M												PROBABLY ABUNDANT GLASS
564-605'						MM												
829-863'			M			M												
1178-1208'						MM					Tr							
1419-1448'						M	m				M				m			
1588-1617'			M			M					m							

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS
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* MAY INCLUDE OTHER AMORPHOUS PHASES SUCH AS OPAL.

SAMPLE NO.	MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>															OTHER PHASES POSSIBLY PRESENT IN TRACE TO MINOR AM'TS.		
	QUARTZ	CRISTOBAL.	TRIDYMITE	K-FELDSP.	PLAGIOCL.	ILMENITE	HEMATITE	MAGNETITE	SMECTITE	ILLITE # OR MICA # OR	CHLORITE	KAOHLIN # OR SERPENTINE	CALCITE	GLASS *	ANALCIME OR WAIRAKITE		CLINOPTILOL.	OPAL - CIT
WELL 62-21																		
530'				MM	<m	<m		<m					m?					CPX, OX, AP
1035'				MM		<m		M					m?		<m	<m?		
1700'				MM				M				<m	m?					CPX, AP
1973'				MM		<m	<m?	M				<m?	m?		<m			CPX, AP
2132'				MM	<m?	<m		M					m?					CPX, AP
WELL 68-16																		
508'	M		MM	m		<m												
1039'	M		MM	m		<m		<m?										
1338'				m										MM				
1740'				M				<m						M				CPX,
1857'				m				<m	<m?					MM				
2227'				MM		<m?		m						m?				CPX, AP
2599'	MM	m	M			<m												
2936'	MM		M			<m		<m										
WELL 86-23																		
694'				MM		<m		<m						m?				CPX, AP
1085'				MM		<m		<m						m?				CPX, OX, AP
1554'				MM		m		m						m?				CPX, AP
2258'				MM		<m		<m						m?				CPX, AP
3157'				MM		<m		M						m?				CPX, OX, AP
3497'				M				M						m?	<m			CPX, AP

MM = PREDOMINANT M = MAJOR m = MINOR <m = <5wt.% ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

* MAY INCLUDE OTHER AMORPHOUS PHASES SUCH AS OPAL

SAMPLE NO.	MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>														OTHER PHASES POSSIBLY PRESENT IN TRACE, TO MINOR, AM'TS.		
	QUARTZ	CRISTOBAL.	TRIPYMITE	K-FELDSP.	PLAGIOCL.	ILMENITE	HEMATITE	MAGNET.	SMECTITE	ILLITE #/OX	MICA #/OX	CHLORITE	KAO LIN OR SERPENTINE	CALCITE		GLASS*	PYRITE
WELL 45-36																	
100'					MM	<M	<M							M?			CPX, OX, AP
480'	m	M	m	MM				<M									
1000'					MM		<M	M						M?			CPX, OX, AP
1470'					MM	<M	<M	M						M?			CPX, OX, AP
1860'					MM	<M	M	M						M?			AP
2390'					MM	<M	<M	M			<M			M?			AP
2780'	M			M	m		<M?			<M					<M		
3100'	M			M	M		<M?			<M							NOTE: PLAGIOCLASE IS PROBABLY ALBITE
3600'	m				MM	<M?		M						M?			CPX, AP
4000'	m			m	MM			<M		m				M?			AMPH
WELL 57-13																	
781'															MM		CPX
1423'															MM		
1637'															MM		
2079'	m	<M	M	MM			<M	<M	<M								
2426'															MM		
2929'															M?		CPX

MM = PREDOMINANT M = MAJOR m = MINOR <M = <5wt.% ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

*MAY INCLUDE OTHER AMORPHOUS PHASES SUCH AS CPAL.

SAMPLE NO.	MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>														OTHER PHASES POSSIBLY PRE- SENT IN TRACE TO MINOR AMOUNTS		
	QUARTZ	CRISTOBAL.	TRIDYMIT	K-FELDSP.	PLAGIOCL.	ILMENITE	HEMATITE	MAGNETITE	SMECTITE	ILLITE	MICA #/OR	CHLORITE	KAOLIN #/OR SERPENTINE	CALCITE		GLASS *	ANALCIME NAIRAKITE
WELL 28-32																	
440'		M	m	MM	<m?	<m											
860'	m	M	m	MM				<m									
1280'		M		M	m			<m									
1500'	m	M		M	m			<m?	<m								
1950'	<m?			<m?	MM	M		<m						m?			CPX, AP
2480'		M		M		<m?		m									2710' Qt veined
2950'	M			MM		<m											
3532'	m			<m?	MM	<m	<m	<m?	M		<m?		m?				CPX, AP
3968'	M			m?	M		m			m		<m					
4500'	m			m?	M					<m	M	<m		<m	m		
WELL 29-1																	
467'						MM								M			AP
1297'		M	m	MM				<m									
1951'		m	M	MM				<m									
2375'								<m						MM			AP
2803'	<m?			<m?	MM	<m?		<m?	M					m?			AP
3088'					MM			<m?	m					m?			CPX, AP

MM = PREDOMINANT M = MAJOR m = MINOR <m = <5 WT.% ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

27-27, 3000': → ± 2.71 Å PEAK (NOT PY. OR MARC.) MAY BE IMPURE HEMATITE
 * MAY INCLUDE OTHER AMORPHOUS PHASES SUCH AS OPAL

SAMPLE NO.	MINERALOGY, APPROX. WT.% <input type="checkbox"/> (or) RELATIVE ABUNDANCE <input checked="" type="checkbox"/>													OTHER PHASES POSSIBLY PRE- SENT IN TRACE TO MINOR AM'TS.		
	QUARTZ	CRISTOBAL.	TRIDYMIT	K-FELDSP.	PLAGIOCL.	ILMENITE	HEMATITE	MAGNET.	SMECTITE	ILLITE	MICA #/X	CHLORITE	KAO LIN OR SERPENTINE		CALCITE	GLASS*
WELL 14-23																
444'	<M				MM	<M	<M?							M?		CPX, OPX, AP
816'					M	<M								M		AP, GOE
1462'					MM		M?	M						M?		AP
1903'		M			M									MM		
2325'	<M	M?	M	M	M			<M								
2599'					MM		<M?	<M?	M							AP
2998'					MM		<M?	<M						M?		AP
WELL 18-34																
583'					MM	<M								M?		AP, OLV
1289'														MM		
1983'	M	M	M	M			<M	<M	<M?							
2507'		M		M	M									M?		
2932'					MM	<M	<M		M					M?		AP
3498'					MM	<M	<M?		M					M?		OPX, AP
WELL 27-27																
619'					MM									M?		CPX, AP
1266'					MM		<M?							M?		AP, OLV
1635'					M									M		OLV
2145'					MM	<M	<M?							M?		CPX, AP, OLV
2543'					MM	<M	<M?	<M?						M?		CPX, AP, OLV
3000'					MM		M?	<M						M?		AP, OLV

MM = PREDOMINANT M = MAJOR m = MINOR <M = <5WT% ? = TENTATIVE IDENTIFICATION



SUMMARY OF X-RAY DIFFRACTION ANALYSIS

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Appendix 2

The distribution of alteration zones observed in temperature boreholes drilled in the Glass Mountain Area.

<u>Well Name</u>	<u>Total Sampled Depth (T.D.)</u>	<u>Alteration Zones</u>	<u>Interval</u>
GMF 56-3	1760'	Zeolite-Smectite Argillic	<205'-1058' 1058'-T.D.
GMF 45-36	4000'	Unaltered Zeolite-Smectite Argillic Prophyllitic	0 -1000' 1000'-1820' 1820'-2500' 3430'-3720' 2500'-3430' 3720'-T.D.
GMF 28-32	4500'	Unaltered Zeolite-Smectite Argillic Propylitic	0 -2480' 2480'-2680' 2680'-3460' 3460'-T.D.
GMF 44-33	2263'	Unaltered Zeolite-Smectite Argillic	0 -300' 300'-1350' 1350'-T.D.
GMF 17-6	4009'	Unaltered Zeolite-Smectite Argillic	0 -1280' 1280'-2680' 2680'-T.D.
GMF 84-17	1636'	Unaltered Zeolite-Smectite	0 -1419' 1419'-T.D.
GMF 87-13	916'	Unaltered Zeolite-Smectite Argillic	0 -242' 242'-900' 900'-T.D.
ML 68-16	2939'	Unaltered Zeolite-Smectite	0 -2227' 2227'-T.D.
ML 57-13	2929'	Unaltered Zeolite-Smectite	0 -2928' 2929'-T.D.
ML 14-23	3003'	Unaltered Zeolite-Smectite	0 -1462' 1462'-T.D.
ML 29-1	3088'	Unaltered Zeolite-Smectite	0 -2803' 2803'-T.D.

Appendix 2 (Cont.)

<u>Well Name</u>	<u>Total Sampled Depth (T.D.)</u>	<u>Alteration Zones</u>	<u>Interval</u>
ML 36-28	2246'	Unaltered Zeolite-Smectite Argillic	0 -1500' 1500'-2084' 2084'-T.D.
ML 75-6	1998'	Unaltered Zeolite-Smectite	0 -1050' 1050'-T.D.
ML 57-11	3002'	Unaltered Zeolite-Smectite	0 -800' 800'-T.D.
ML 2-81	740'	Unaltered	0 -T.D.
ML 86-23	3503'	Unaltered Zeolite-Smectite	0 -1554' 1554'-3503'
ML 54-19	2201'	Unaltered Zeolite-Smectite	0 -1900' 1900'-T.D.
ML 62-21	2142'	Unaltered Zeolite-Smectite Argillic	0 -1035' 1035'-2115' 2115'-T.D.
ML 65-26	2180'	Unaltered	0 -T.D.
ML 52-30	1972'	Unaltered Zeolite-Smectite	0 -1100' 1100'-T.D.
ML 27-27	3000'	Unaltered	0 -T.D.
ML 1-81	640'	Unaltered	0 -640'
ML 18-34	3500'	Unaltered Zeolite-Smectite	0 -2932' 2932'-T.D.
MLF 51-2	1836'	Unaltered Zeolite-Smectite	0 -900' 1150'-T.D. 900'-1150'