TREE-1162

GEOTHERMAL POTENTIAL OF THE WEST BOISE AREA

LELAND L. MINK DAVID L. GRAHAM

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APPROVED:

J. F. Kunze
Deputy Director, Programs
and
Acting Manager Geothermal Program

F. H. Tingey
Director, Programs

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by

Leland L. Mink

and

David L. Graham

Boise State University

Project Direction by

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J. F. Kunze

and

R. C. Stoker

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ABSTRACT

With increased use being placed on natural gas, electricity, petroleum, and coal, alternative forms of energy have been sought to help release the pressures being placed on these resources. Geothermal energy is one of the major alternative forms. In portions of Boise, geothermal resources have been utilized for many years for heating of homes and several state office buildings.

Recent investigations in the Boise area have shown that hot water is abundant all along the Boise Foothills. This report discusses two areas showing good potential for future geothermal development. These areas are the Dry Creek Valley and the area between Pierce Gulch and Polecat Gulch. Both areas have water temperatures exceeding 37.8°C.

In the Boise area it is found that zones of hot water are associated with some type of structural control. The hot water zones associated with the Dry Creek Valley and the Pierce-Polecat area were found to be located at or near the intersection of major linears mapped along the Boise Foothills. These linears reflect a zone of weakness at depth in the rock allowing warm water to migrate upward from the granitic rock of the Idaho batholith below.

By mapping all known fault and linear patterns in the area, it is possible to correlate these zones of weakness with areas of hot water. At the intersection of two or more linears, where fracturing is greatest, the majority of geothermal water has been located.

ABOUT THE AUTHORS

Dr. Leland L. Mink was the principal investigator on this project. He was a hydrologist with the Idaho Bureau of Mines and Geology assigned to the Boise office during the early stages of the field work. Later, he accepted the position of an Associate Professor of Geology at Boise State University and completed the project in that capacity. Dr. Mink is currently the Program Manager of the Resource and Reservoir Assessment Branch of the Division of Geothermal Energy of ERDA, Washington, D.C.

Mr. David L. Graham was the chief field assistant on this project. He attended Southern Oregon College in Ashland, Oregon, for one year and then transferred to Boise State University where he received his B.S. Degree in geology in 1976. Mr. Graham is currently employed by the Bureau of Land Management in Burns, Oregon.

PREFACE

The work included in this report was performed by the Geology Department of Boise State University and was coordinated by the Geothermal Programs Division of EG&G Idaho, prime contractor to the Energy Research and Development Administration at the Idaho National Engineering Laboratory.

Financial support for this work was supplied through funds assigned by the Energy Research and Development Administration. These funds were made available to collect and assemble all pertinent geologic and hydrologic information that relate to the geothermal system in the northwest section of Boise, Idaho.

This report constitutes an area study extension of the confirmed geothermal resource that occurs to the north and northeast of Boise along the Boise Foothills. The report covering the confirmed area has been issued as TREE-1161 and this report is a companion to it.

The staff of the EG&G Idaho Geothermal Programs Division wish to thank the Boise State University authors, Dr. Leland L. Mink and Mr. David L. Graham and their cohorts for their fine work and valuable contribution.

J. F. Kunze, Deputy Manager
Programs

R. C. Stoker, Chief Geologist
Geothermal Programs

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1.0 INTRODUCTION

1.1 General Statement

Today, with the ever-decreasing supply of natural resources for energy, new forms of energy are being looked at with the idea of alleviating some of the burden being placed on the so called "traditional" forms of energy. Geothermal energy is one of these alternative forms and it appears to be quite abundant in the Boise area of Southwest Idaho.

In the Boise area, geothermal energy is playing a vital part in the heating of many homes. It is the purpose of this report to show that there are other potential areas of geothermal resources, other than those already studied, that could prove beneficial for further development. By utilizing these geothermal resources, lesser amounts of other forms of energy would have to be used.

Although this is only a preliminary report, it is intended to show that the potential for geothermal energy development in the Boise area is quite favorable. Further detailed work needs to be done in the areas located in and around Boise if the maximum geothermal potential is to be utilized.

1.2 Location of Study Area

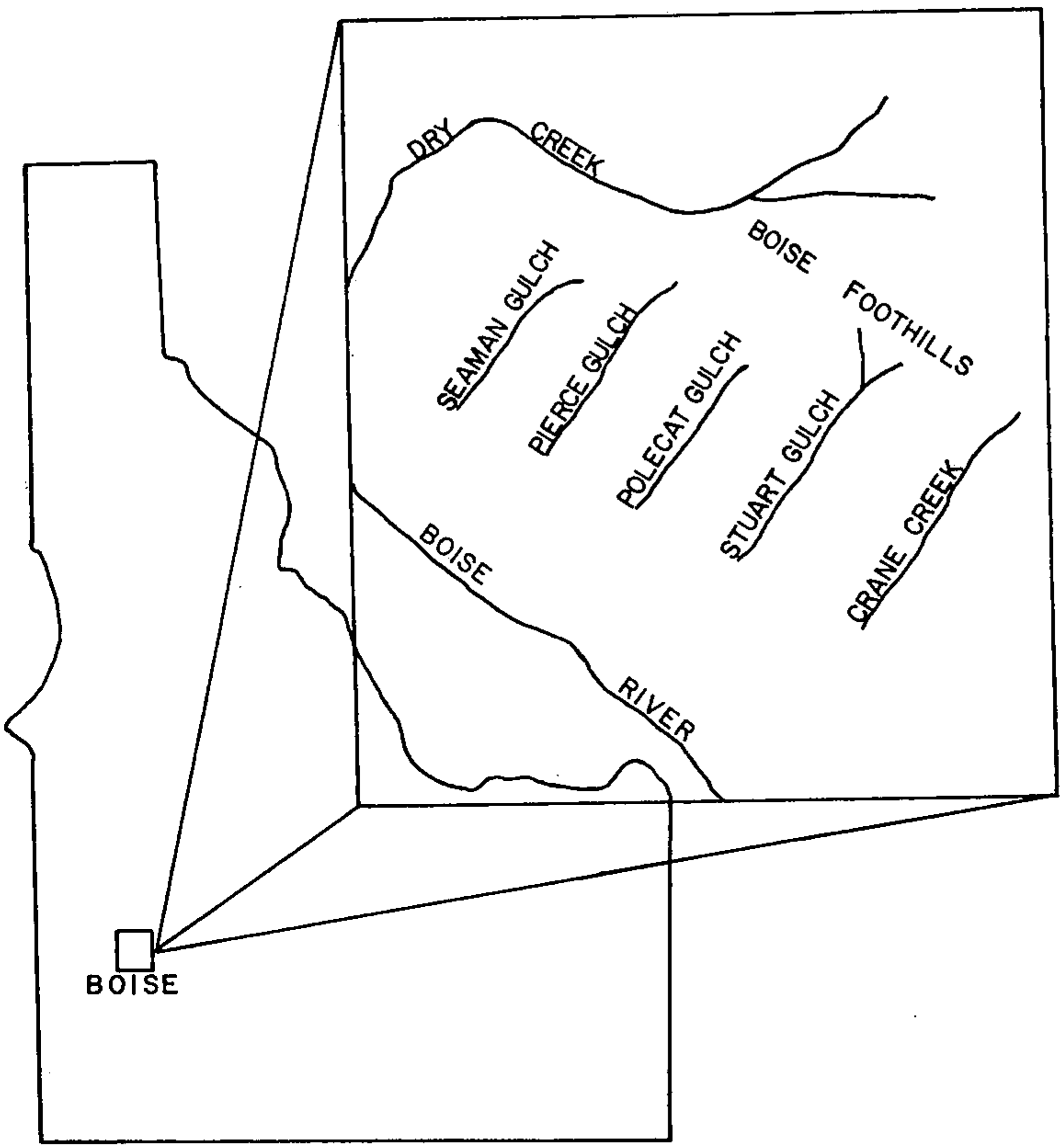
The study area is that part of the foothills of the Boise Ridge located between the Horseshoe Bend Highway (Hwy 55) in the west and Crane Creek to the east. Dry Creek Valley located on the western margin of the study area and the Pierce Gulch-Polecat Gulch area approximately in the middle of the study area were the two areas studied most extensively (Figure 1).

1.3 Methods of Study

Fundamental to all geothermal investigations is a good knowledge of the geology of the area being studied. For this purpose, the geology from Stuart Gulch to the Horseshoe Bend Highway was mapped. This new mapping in conjunction with work done earlier by Hollenbaugh, 1973, from Stuart Gulch east to the Table Rock area is shown in Figure 2.

Throughout the study area, structure was noted and related to known geothermal areas. Linears mapped by Hall, 1975, were used in the investigation and were found to be related to areas of hot water. Also known faults in the study area were correlated to explain the occurrence of zones of hot water.

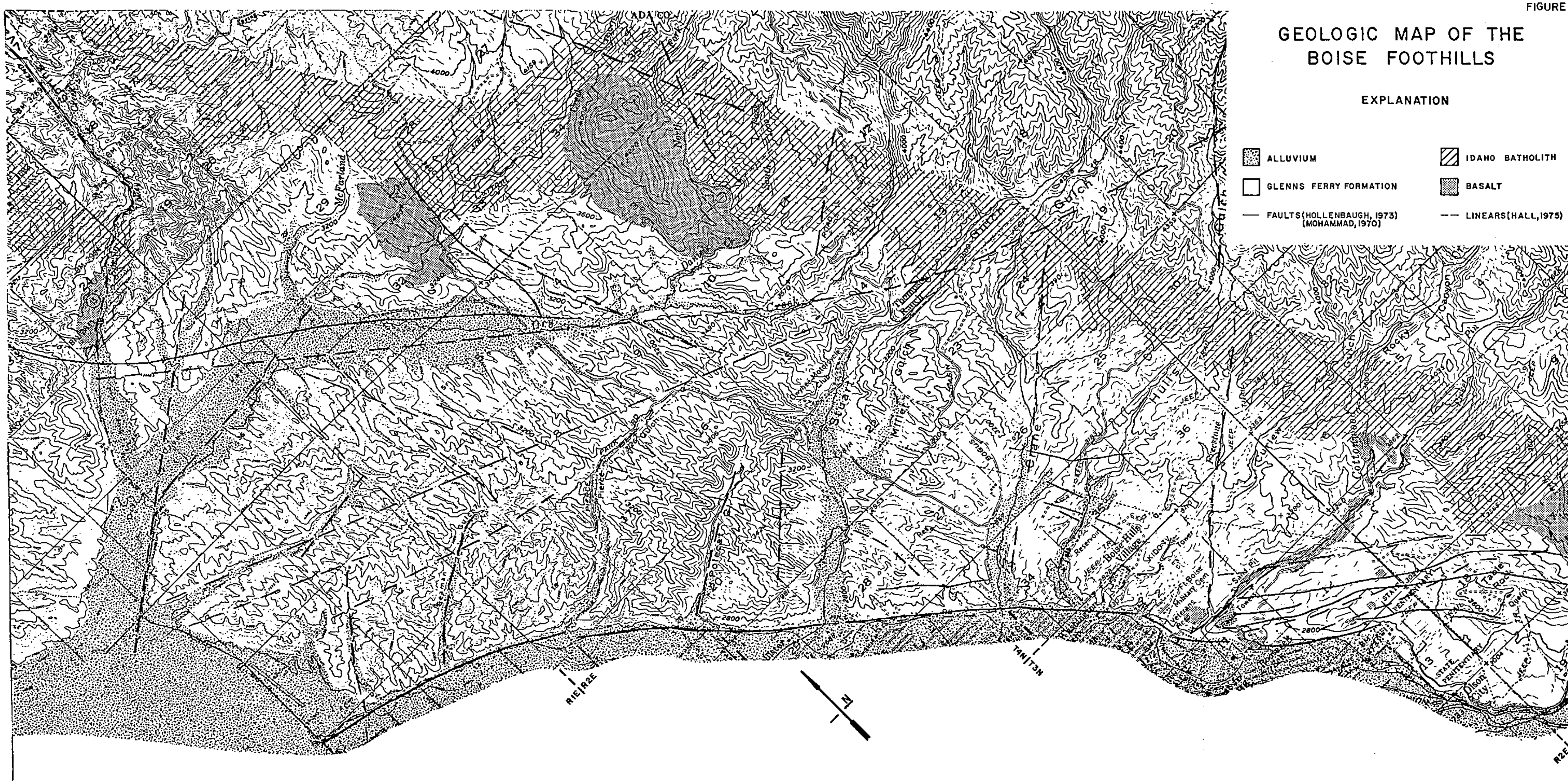
FIGURE I



BOISE FOOTHILLS AREA

FIGURE 2

GEOLOGIC MAP OF THE BOISE FOOTHILLS



Subsurface geologic correlation was used to show the relation of geology from one area to another. Due to the nature of the Glenns Ferry Formation correlation ranged from good to fair. Good trends do show up, however, and it is believed that these correlations show a definite relationship between all areas associated with hot water.

Where possible, temperatures were taken of wells and temperature profiles were attempted. Since most of the deep hot wells are flowing artesian wells, access for the purpose of probing was impossible due to the fact that most wells are capped off. Other warm wells not flowing were inaccessible because of pumps or other obstructions. In such cases, temperatures were taken by pumping and allowing the water to run for approximately ten minutes before taking the temperature.

1.4 Climate

The study area is characterized by arid to semi-arid climatic conditions. Due to the extreme variation in relief, weather conditions are quite diverse.

Temperature records for the area show a yearly mean of 10.7°C over a 30-year period. Summer days tend to be warm and dry. The average daily maximum temperature in the summer is 28.9°C, but temperatures well over 37.8°C have been recorded. Temperatures drop considerably in the winter months. The mean temperature for the month of January ranges from -5.6°C to 2.8°C with a 56-year mean of -1.2°C (Mohammad, 1970).

In the Boise area, most of the precipitation is received during the winter months. The yearly mean values for precipitation as measured at the U.S. Weather Station at the Boise Airport (elev. 2838) is 11.97 inches. Records for the Boise 7n station (elev. 3885) over a three-year period show an average of approximately 20 inches. The high relief and orographic effect of the Boise Ridge is the main reason for this extreme difference in precipitation.

1.5 Physiography - Geomorphology

The Boise area borders on two physiographic provinces. These are the northern Rocky Mountain physiographic province and the Columbia Intermountain province. The Boise Ridge is part of the Rocky Mountain province, while the flat lying flood plain of the Boise Valley is situated in the Columbia Intermountain province (Savage, 1958).

In the Boise Valley, several flat lying alluvial terraces are present. In contrast to these terraces is the Boise Ridge which exhibits a rugged topography. Irregular peaks rise up along the ridge to an elevation of 6025 feet at Boise Peak. The upper portion of the ridge is composed of the Cretaceous granitic material of the Idaho batholith, while the lower section is that of the younger Glenns Ferry Formation of Pliocene age.

The Boise Foothills area is characterized by smooth rolling slopes and round peaks (Illus. 1). To the west, the Foothills broaden as the contact of the Idaho batholith extends north. There is a definite break in slope at the contact of the Idaho batholith and the Glenns Ferry Formation with the granite producing somewhat steeper slopes. North and northwest of Boise, the Glenns Ferry Formation weathers to a very characteristic badlands-type topography.

Several ephemeral and intermittent streams drain the Boise Ridge. These streams trend in a general southwesterly direction. Some creeks, such as Dry Creek, receive water from snow melt and ground water seepage of several smaller drainages in the area. During the late summer months, however, these streams usually dry up with little or no flow occurring.

ILLUS. 1. Airphoto showing typical topography of the Boise Foothills. The color change (from light to dark) along the foothills roughly marks the contact between the Idaho Batholith and the Glenns Ferry Formation.

2.0 GEOLOGY

The major rock types in the Boise area range from Cretaceous to Pleistocene in age. The older rocks, those of the Idaho batholith, have been uplifted, faulted, and eroded due to many years of crustal unrest. These crystalline granitic rocks are unconformably overlain by the much younger Glenns Ferry Formation of the Idaho group.

The Idaho group is composed of clastic beds and interrelated basalt flows. It has been divided into seven major formations. The distribution of the Idaho group suggests the deposition of these formations took place in a subsiding basin. These formations range in age from early Plicene to middle Pleistocene (Malde, 1962). Figure 3 shows the major rock types in the Boise area.

3.0 DESCRIPTION OF ROCK TYPES

3.1 Idaho Batholith

The oldest rocks in the Boise area are those of the Idaho batholith. These coarse crystalline rocks are considered Cretaceous in age. They are exposed along the upper portion of the Boise Foothills and underlie most of the sedimentary rocks in the foothills area.

The granitic rocks of the batholith range from quartz monzonite to quartz diorite, but the average composition is that of granodiorite. The rocks exhibit an irregular and unsystematic jointing pattern, probably reflecting the intricate tectonic history of the area. Throughout the batholith, faulting and shearing, uplift episodes, and hydrothermal alteration is abundant (Savage, 1958). In the local area, numerous quartz veins, simple pegmatites, rhyolite, and basaltic dikes can be found intruding the granitic rock.

The batholith is composed of abundant large orthoclase phenocrysts. Biotite and muscovite micas are found at high elevations. Upon weathering, the batholite produces large quantities of feldspar and quartz which makes up the majority of the younger Glenns Ferry sediments.

At lower elevations the granitic rock weathers into rounded and convex slopes, but at higher elevations, rugged and craggy outcrops are common.

3.2 Glenns Ferry Formation

The lower portion of the Boise Foothills is made up of the Glenns Ferry Formation. In the study area, this formation unconformably overlies the older granitic rocks of the batholith. It is composed of mostly nonindurated, complexly intertonging lake and stream deposits. Three major facies can be recognized in the formation. These are lacustrine, fluviatile, and floodplain and they extend over a rather large area. From its source area near Glenns Ferry, Idaho it is reported to extend as far north as Ontario, Oregon.

Sand, silt, and clay make up the majority of the Glenns Ferry Formation with minor amounts of volcanic material present. The formation contains some basaltic lava flows as well as some siliceous volcanic ash in thin beds. The siliceous ash is fresh while the basaltic material is commonly altered (Malde, 1962).

Of the three facies recognized, the lacustrine is by far the greatest in extent. This facies is characterized by massive layers of tan silt which upon weathering, turn a drab color and show very little lithologic variation. The fluviatile facies is composed mainly of drab, very pale brownish sand and some silt. Some of the layers show ripple marks and crossbeds, but bedding planes between layers are parallel. Fine-grained, pale colored silt and dark clay in beds 1-3 feet thick make up the floodplain facies. Intercalated in these silts and clays are sands which appear to be floors of old stream channels (Malde, 1962).

FIGURE 3

MAJOR ROCK UNITS OF THE BOISE FRONT AREA AND THEIR PHYSICAL CHARACTERISTICS

QUATERNARY	Recent	Recent alluvium and surficial deposits	Unconsolidated clay, silt sand, and fine to coarse gravel of fluviatile origin. Overlies older deposits of the Glenns Ferry Fm. in the Boise Region.
TERTIARY AND QUATERNARY	Pleistocene	Snake River Basalt	Light to dark gray, vesicular, olivene basalt. Columnar jointing.
	Pliocene	Glenns Ferry Formation	Layered sediments of varied composition with interlayered basalts.
TERTIARY	Miocene	Late Columbia River Basalt	Light to dark gray, dense glassy basalt.
CRETACEOUS	Late to Mid Cretaceous	Idaho Batholith	Light to medium gray quartz monzonite and granodiorite.

The source material of the Glenns Ferry Formation in the Boise area is the granitic material of the Idaho batholith to the north. In the study area, the Glenns Ferry Formation is the most extensive formation.

The sandstone of the Glenns Ferry ranges from fine-grained to conglomeratic in size. A good example of this grading can be seen on Table Rock where coarse grained arkosic and conglomeratic material is found near the top with fine grained material being found nearer the bottom. On inspection it can be observed that some of the sandstone is very well consolidated; however, other sections seem to be very poorly consolidated and weather quite easily upon exposure.

Along most of the major faults and in some areas along the contact with the batholith, the Glenns Ferry Formation is well cemented due to hydrothermal activity. The main cementing material is secondary silica from the geothermal activity associated with these features.

The age of the Glenns Ferry Formation is uncertain. Through fossil correlations, however, it is believed that the age of the formation is late Pliocene or early Pleistocene.

3.3 Basalt

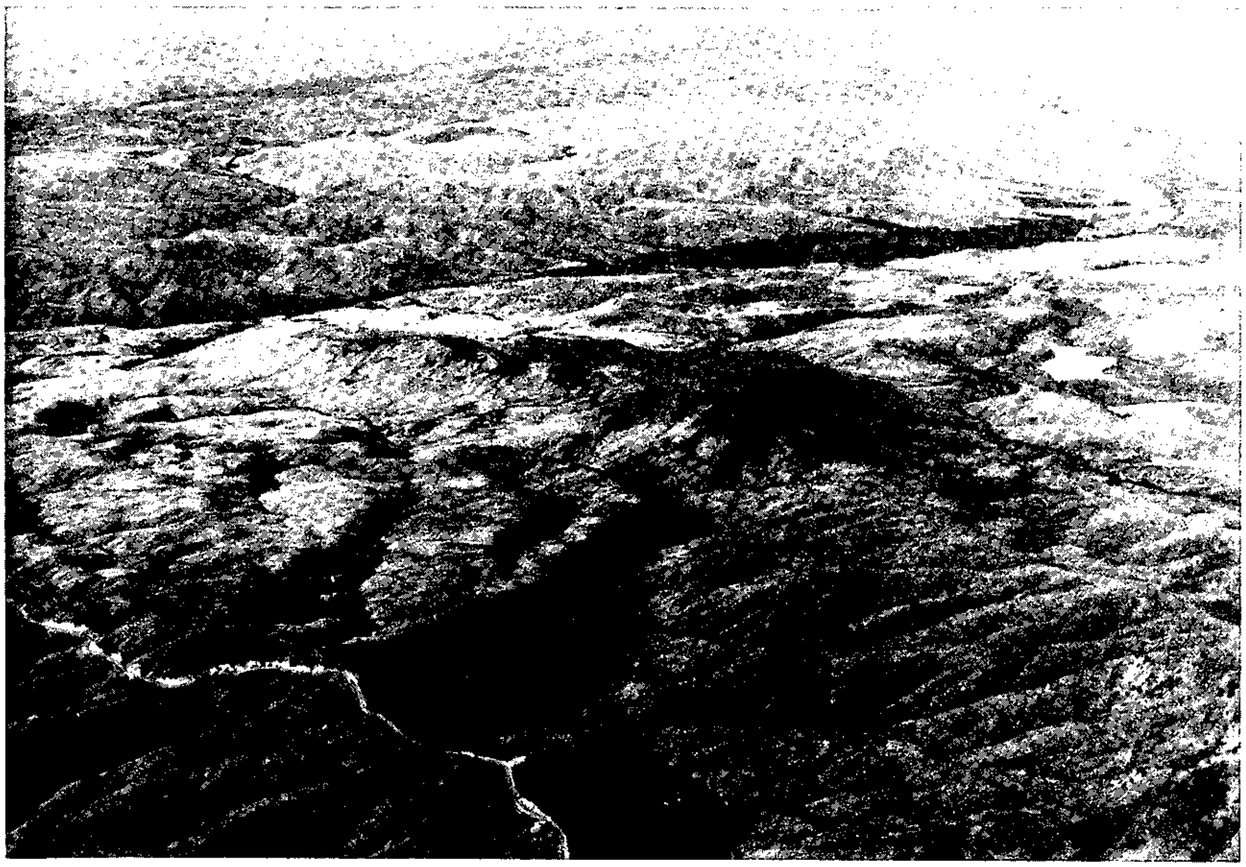
Several basalt flows occur along the foothills. The larger flows are found along the contact of the batholith and the Glenns Ferry Formation (Illus. 2). Savage has stated that some of these flows are associated with early and late Columbia River basalts while others are more closely related to early and late Snake River eruptives. This would place the basalt, with respect to geologic time, roughly the same age as the Glenns Ferry Formation.

Upon reviewing the literature available to the authors, it appears that some discrepancies exist as to the actual age of these basalts. It is evident from these discrepancies that further work needs to be carried out on the basalts before an acceptable age can be assigned. Due to the fact that so little is known as to the origin of these rocks, in this report they will be simply referred to as extrusive basalts associated with the Glenns Ferry Formation.

Through microprobe analysis of cores taken from the Glenns Ferry Formation, it was found that some of the basalts have been highly altered by hydrothermal fluids. These hot fluids have altered the feldspar minerals to a clay giving the rock a very different physical appearance. This is believed to be the reason why in most well drillers logs of this area "blue clay" or "blue shale" is the predominate rock type. In all reality this is merely a highly altered basalt.

3.4 Alluvium

In all the major stream beds and gullies flowing off the Boise Foothills alluvium has been deposited. This material consists mainly of reworked sediments from the Glenns Ferry Formation. In most places this material is only a few inches thick, but in some of the larger drainages tens of feet may be present.



ILLUS. 2. Large basalt flow located along the Boise Front. The contact of the Idaho batholith is along the broad margin of the flow to the middle-right of the photograph. Dry Creek can be seen in the distance in the upper-right of the photo.

3.5 Structure

Boise appears to be on the down-thrown block of a major fault known as the Foothills Fault (Hollenbaugh, 1973). The Boise Foothills are located on the upthrown block of this same fault. This fault extends for a distance of approximately nine miles along the base of the Foothills. According to Hollenbaugh, the Foothills Fault is not a single fault but instead is part of a system of faults that define a regional zone of weakness along the northern margin of the Snake River Plain.

In the southern portion of the study area the Glenns Ferry Formation exhibits a southeast-northwest trending fault system as mapped by Hollenbaugh. Several strong NE-SW trending linear patterns have also been noted by Hall, 1975 using photogeologic methods. These major linears correspond to the major drainages flowing in a southwesterly direction from the Boise Ridge and have been named the Freestone Trend (Hall, 1975).

In the Dry Creek area a large linear trending WNW has been mapped by Hall. This linear is only faintly expressed but traces a very straight line for more than 12 miles ending near the Horseshoe Bend Highway in the west. This feature cuts across several rock types but no significant surface displacement has been found.

In the western portion of the study area a primary linear pattern can be seen trending in a WNW direction. The linears in this group are several miles in length and are much larger than most other linears found in the area. A secondary linear pattern in which the linears are much smaller than the primary pattern can be detected trending in a NNW direction (See Figure 2).

3.6 Significance of Linears

Linears represent ground trends or features which are unusually straight or uniformly curved. These trends appear to be controlled by some condition which sets them apart from the region immediately surrounding the linear (Hall, 1975).

Linears detected by photogeologic methods can be attributed to several natural features or conditions. These features are usually some planar discontinuity such as faults, fractures in bedrock, fold axes, dikes, or steeply inclined beds. As a result of mapping these features, natural fracture systems in the bedrock of an area and strongly elongate fold trends can be detected (Hall, 1975).

Once a linears map has been constructed, it should be used in conjunction with other data such as geologic maps, geophysical data, and hydrological material. Without this additional data for correlation linears maps are of limited value.

It has been shown that sediments overlying basement rock reflect the structure of the underlying material. This phenomenon could prove to be very useful in geothermal exploration in the Boise area. By mapping the fault and joint patterns in the granite of the batholith and correlating these structures to the structures found in the overlying sediments of the Glenns Ferry Formation, potential geothermal well sites could be located.

GEOLOGIC CROSS SECTION OF WELLS 7-13

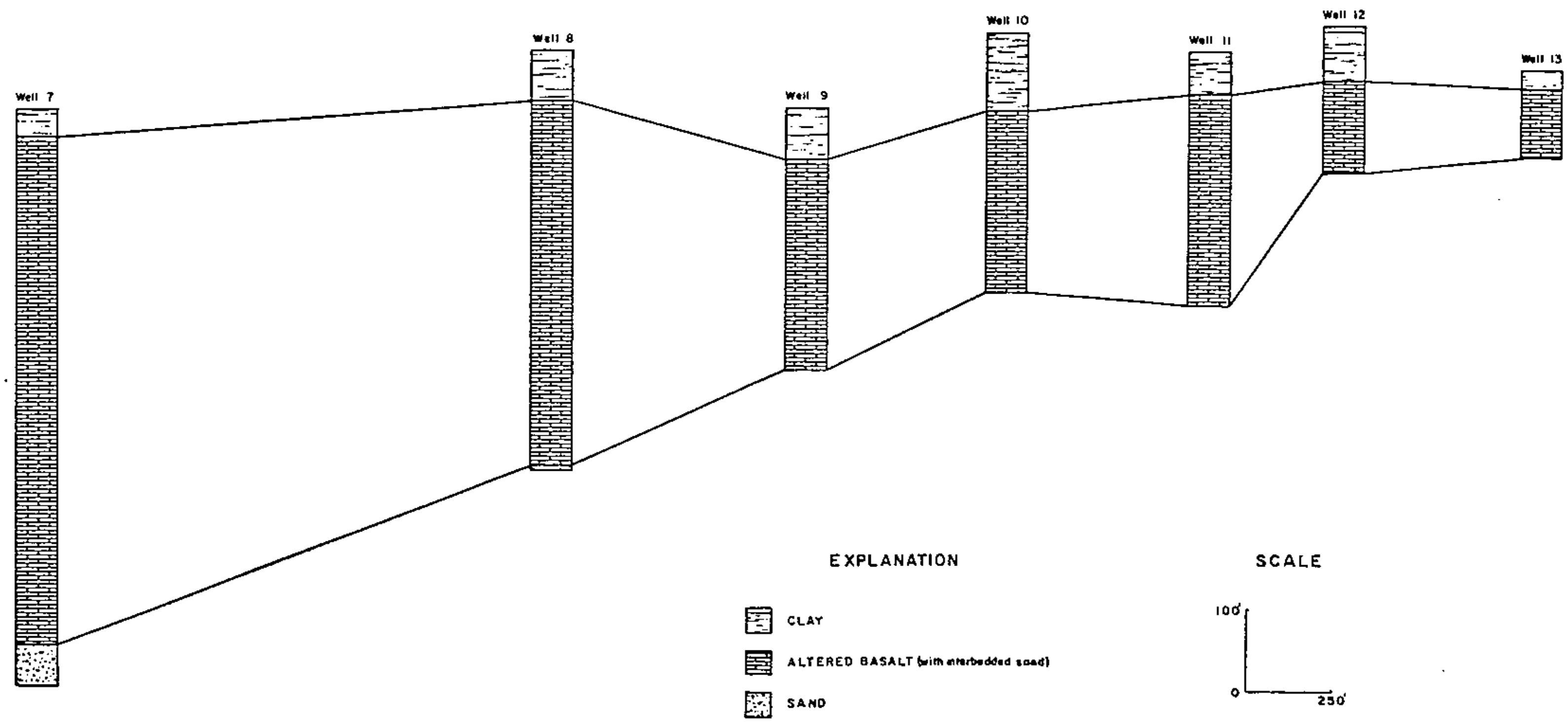
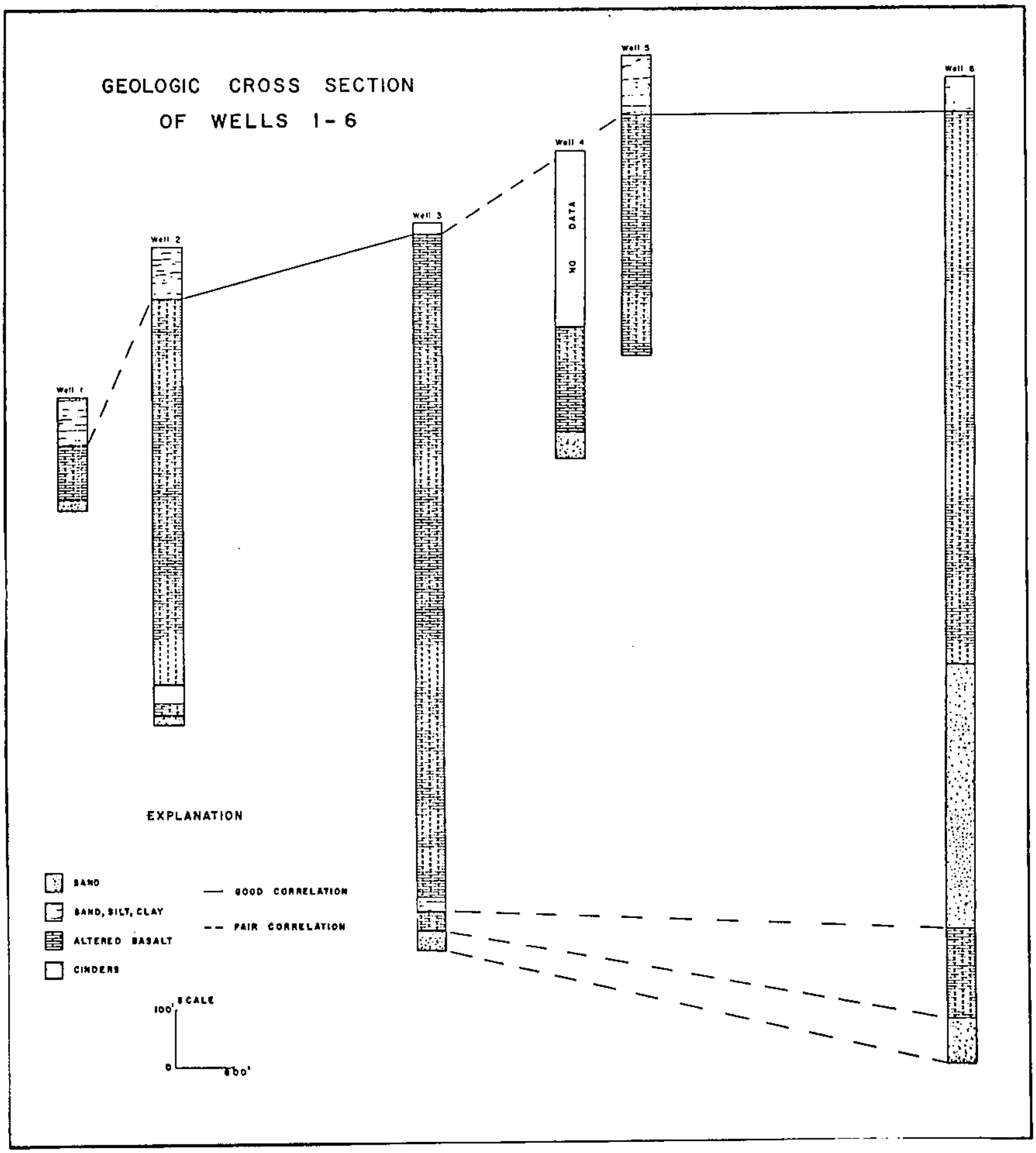


FIGURE 4

FIGURE 5


GEOLOGIC CROSS SECTION
OF WELLS 1-6
Well 1
Well 2
Well 3
Well 4
NO DATA
Well 5
Well 6
EXPLANATION
SAND
SAND, SILT, CLAY
ALTERED BASALT
CINDERS
GOOD CORRELATION
FAIR CORRELATION
SCALE
100'
0

The hot water in the Boise area is found in the Glenns Ferry Formation. The heat source for this water, however, is believed to come from the deep fracture systems of the batholith. By mapping the major structural trends on the batholith and doing the same in the Glenns Ferry Formation possible trends may carry over from one to the other. This methodology could be used to locate hot water that is rising from depth within the granite and flowing upward through the sediments of the Glenns Ferry Formation.

When the batholith was implaced and during later tectonic episodes, it developed many characteristic structural features. These features can be carried forth into the local country rock. When the granitic material of the batholith was covered by the Glenns Ferry sediments further movement still took place. This later movement could propagate up through the sediments giving rise to a fracture zone in the sediments. This zone may or may not be traceable on the ground surface but can be detected by photogeologic methods.

3.7 Subsurface Geology

Good subsurface correlation was obtained in the Dry Creek Valley when the well logs of the wells in the Spring Creek Estates (wells 7-13) were compared (Figure 4). A thin clay layer of varying thickness was found overlying altered basalt with interbedded sand in each well. From drillers logs it is seen that the water bearing zones are found to be in the interbedded sands.

In the Pierce-Polecat area, subsurface correlation was only fair (Figure 5). Because wells of varying depths were used, gaps resulted in the correlation leaving only room for speculation. It appears from the well log data that at depth more extensive lenses of sand and silt are found in the basalt. By comparing Well 16 with Well 13, it is evident a sand lens is pinching out between these wells. This pinching out of sand lenses within the basalt is a characteristic feature of the rock type in the area.

Figure 6 shows a correlation of subsurface geology across the study area. The location of this cross section is given in Figure 7 (back cover). Well 21 and 3 are located approximately at the same elevation and correlation between them is good. A thick sequence of altered basalt with interbedded sands and gravels predominates. Near the bottom a thick sequence of sand can be seen. Wells 7 and 16 are thought to exhibit the same sequence, although due to their shallow depth, this is only an assumption.

By comparing all three cross sections, it is obvious that localized conditions are fairly uniform. When correlating over long distances, however, the basalts and interbedded sands, silts, and clays must be considered one homogeneous section. In any two areas the correlation of individual interbeds is impossible. By grouping them into one major unit, general trends can be seen to follow for quite long distances.

All well logs have been simplified and insignificant interbeds have been omitted to allow an overall picture of the general subsurface geology. Most sand interbeds are water bearing strata. By grouping these strata together, we are considering these interbeds as a single water bearing system. To try and correlate these individual interbeds any other way would be impossible, except in extremely small local areas.

It appears that water is found in both the basalts and the sediments, although the sediments tend to produce the majority of the water. Well logs from different localities show somewhat different lithologies, but similar water bearing characteristics hold true in most localities. Because there is a slight difference in water bearing characteristics in different localities does not mean that the system as a whole is inhomogeneous, but instead, an aquifer which is composed of various interrelated beds which can be considered as a whole system. These beds are composed of basalts, sands, gravels, silts, and clays which all transmit water in varying degrees. The interaction of these beds results in an aquifer which is variable when observed in small separated sections, but which shows repetition of sequence when observed as a whole, thereby allowing the assumption that the aquifer is homogeneous.

GEOLOGIC CROSS SECTION OF WELLS ALONG THE BOISE FRONT

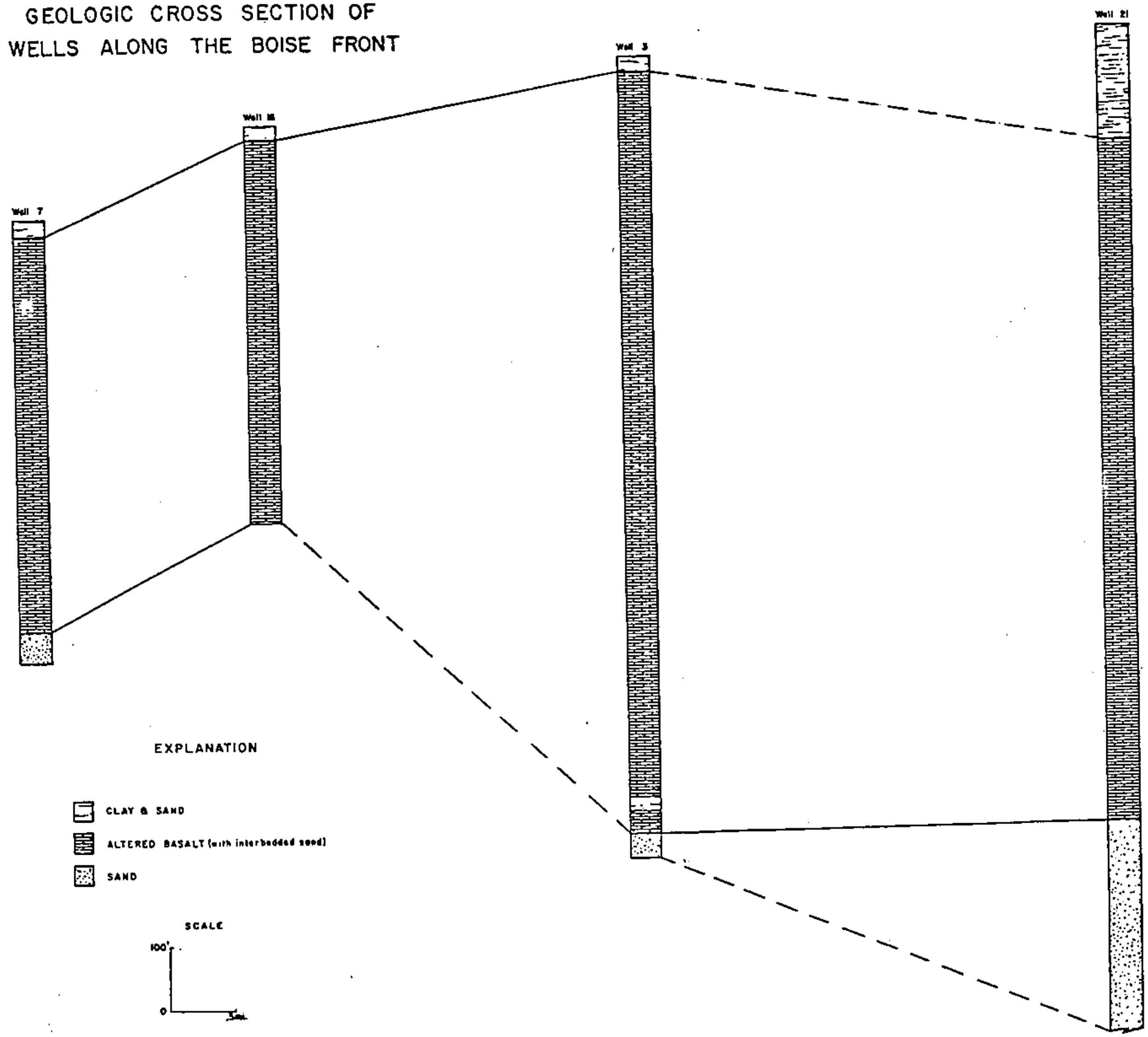


FIGURE 6

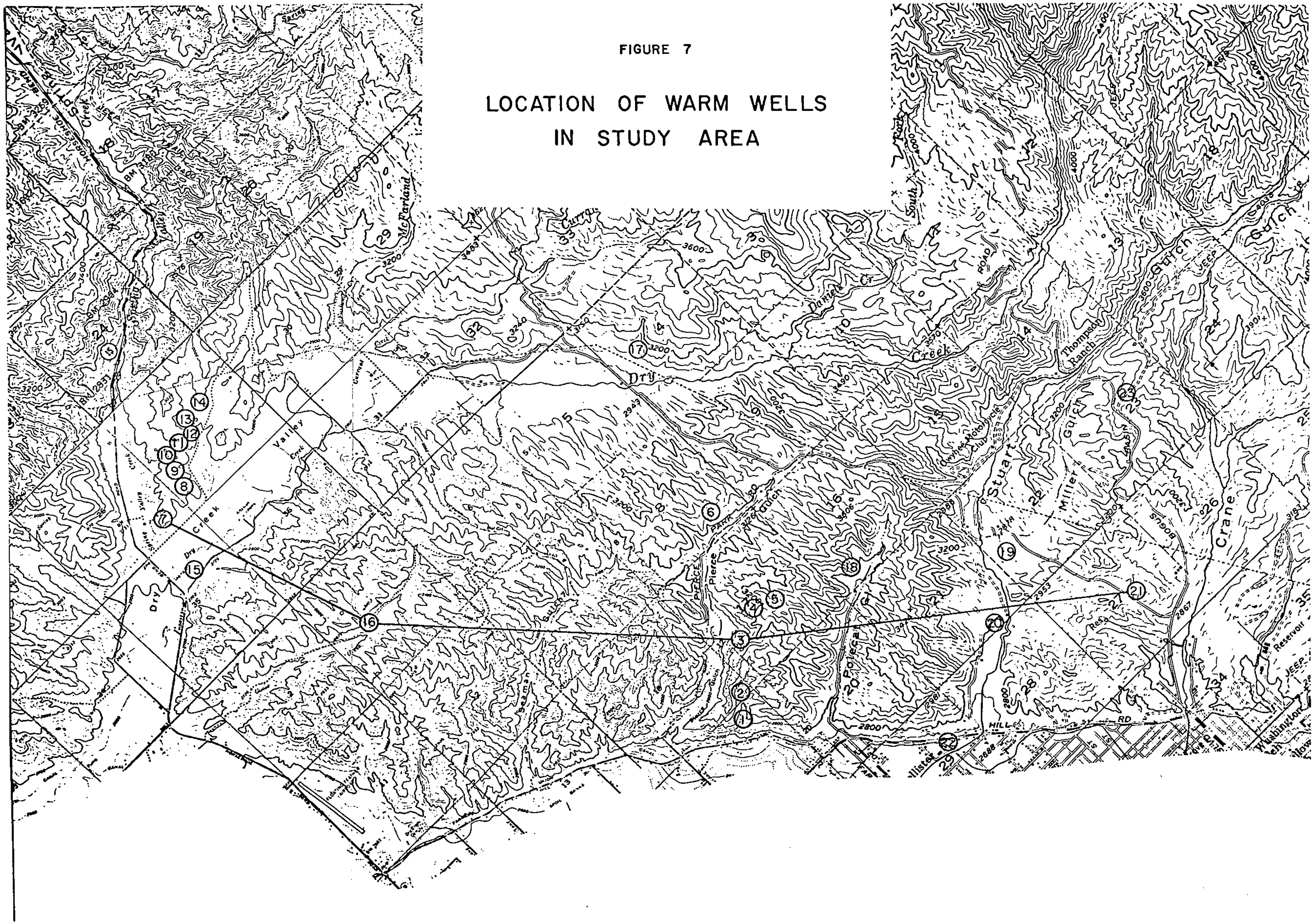


FIGURE 7

LOCATION OF WARM WELLS IN STUDY AREA

4.0 HYDROLOGY

In the study area there are three separate aquifer systems. These three systems are the shallow aquifer or the water table surface, the deep system which occurs under an artesian head (piezometric surface), and the geothermal system which originates deep in the fractures of the Idaho batholith and migrates upward. There is some interaction between all three systems; however, each has its own distinct water bearing characteristics allowing for the separation into the three systems.

4.1 Shallow Aquifer (Water Table Surface)

The shallow aquifer which is found under water table conditions derives most of its water from surface sources such as infiltration from rainfall, recharge from surface streams, and irrigation. The depth to this system is quite variable and it is highly dependent on seasonal variation and meteorological phenomenon. A single thunderstorm can add sufficient water to cause a local rise in the water level.

Figure 8 shows the water level contours for the shallow system. The water table in the study area more or less coincides with the topography. The water table tends to flow in a west-southwest direction. Along the Boise Ridge where contours are close together the gradient is quite high. This gradient decreases considerably as the floor to the valley is approached. This is evident by the more widely spaced contour lines.

A topographic high occurs in the water table system between Seamen Gulch and Dry Creek. This high creates a local flow system which has as a recharge area the foothills to the north and discharges to the topographic lows of the area. Seeps located on Seaman Gulch and the road between Pierce Gulch and Dry Creek are two discharge points for this system (Mohammad, 1970).

The water table surface along the Boise Ridge originates in the Glenns Ferry Formation. In the Dry Creek Valley the lower limit of this system seems to be located at approximately the bottom of the valley with the upper limit extending into the Glenns Ferry Formation along the hillsides.

This shallow system should not be confused with the shallow aquifer found in the Boise River Valley. Although they are probably interconnected, they are both separate systems. The water table located in the Boise Valley is found in river alluvium whereas the water table along the ridge is mainly located in the Glenns Ferry Formation.

4.2 Deep Aquifer (Piezometric Surface)

The deep aquifer of the Boise area is that system that occurs at depths in excess of 500 feet. Its source lies in the Glenns Ferry Formation where interbedded sands, silts and clays along with abundant amount on basalt make up the aquifer material.

This deep system is a confined aquifer occurring under considerable artesian head creating a piezometric surface. The configuration of the piezometric surface is given in Figure 9.

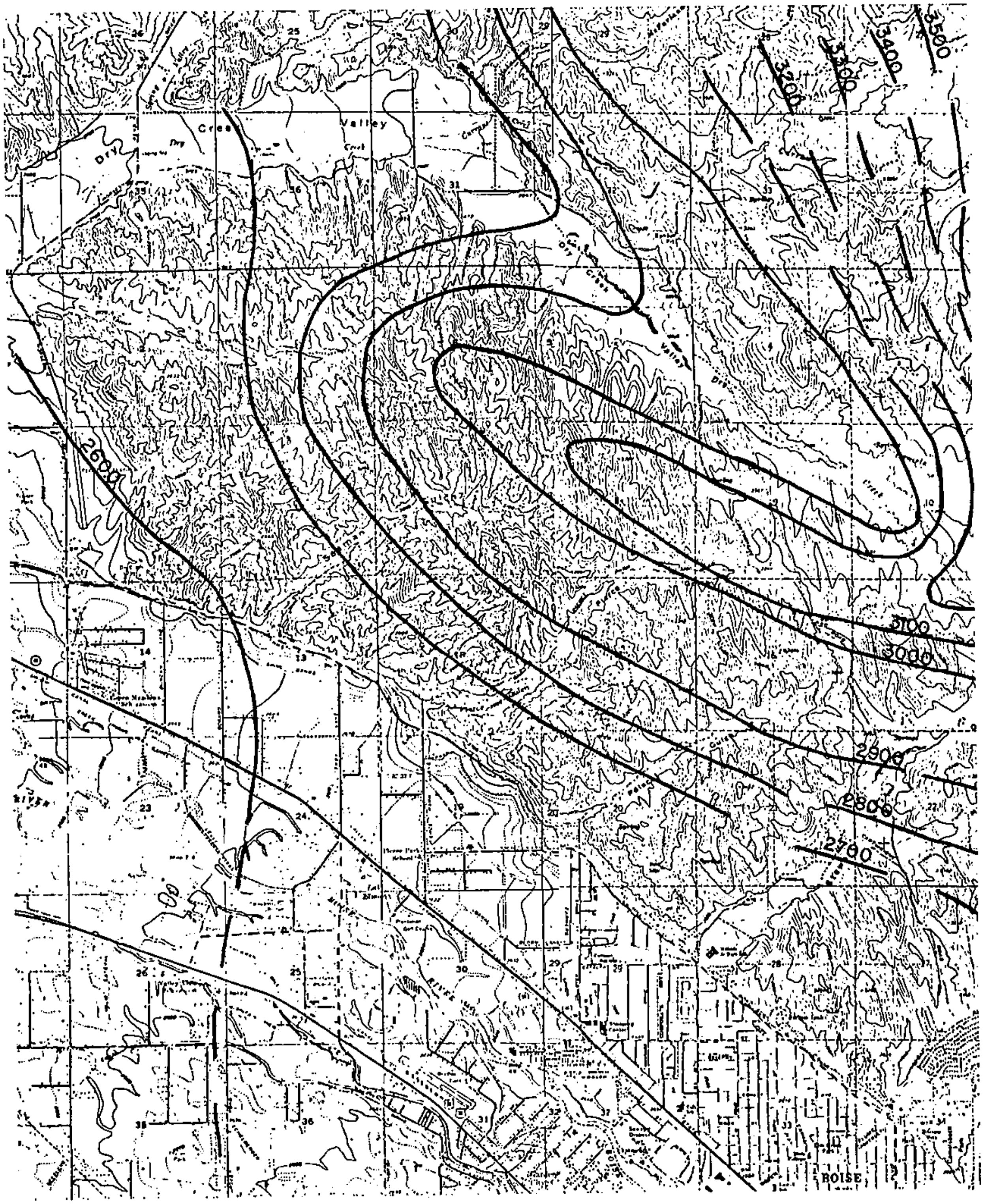


FIGURE 8

WATER TABLE ELEVATION

After Mohammad, 1970 Contour Interval 100'

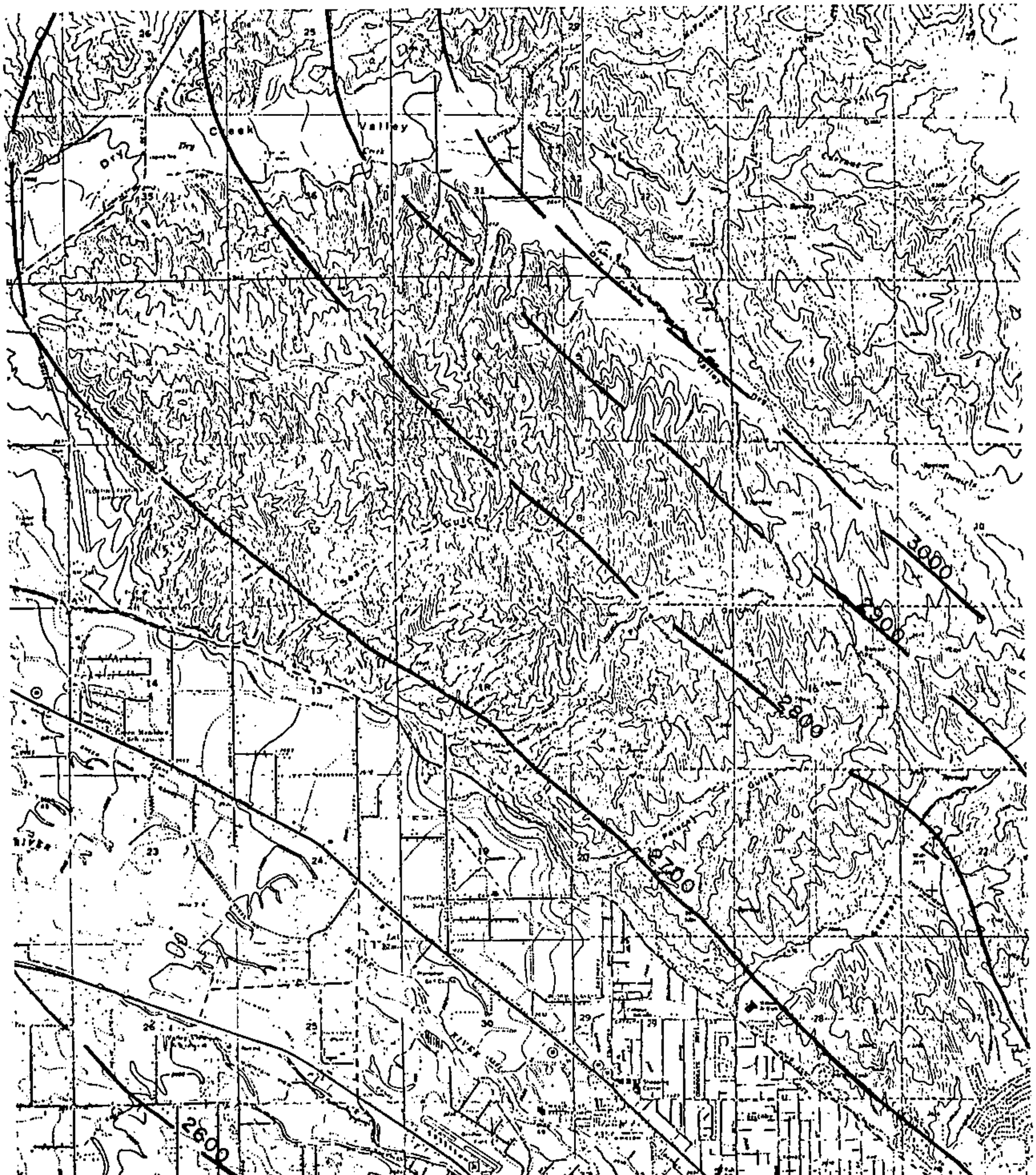


FIGURE 9

PIEZOMETRIC SURFACE

After Mohammad, 1970 Contour Interval 100'

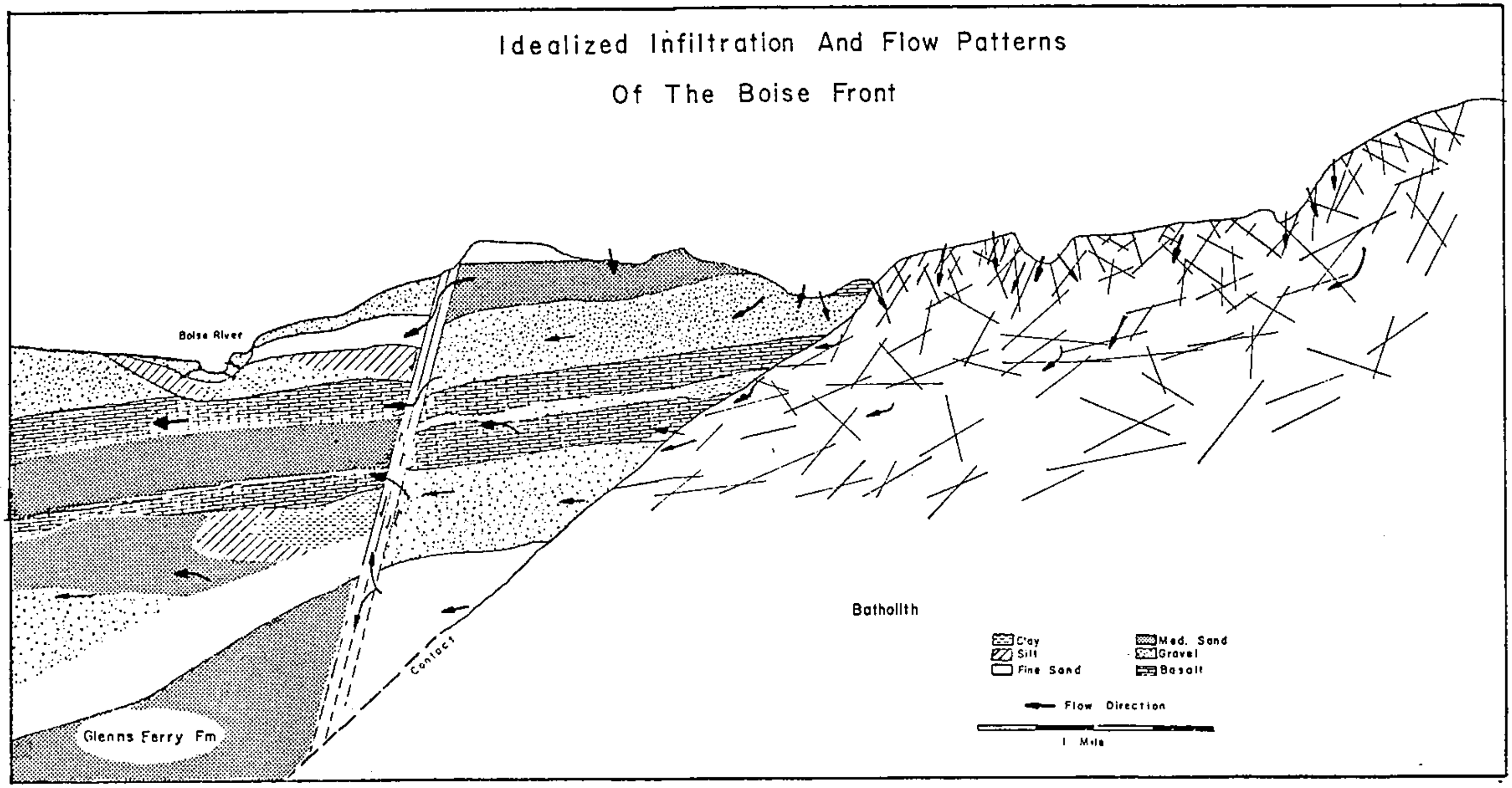
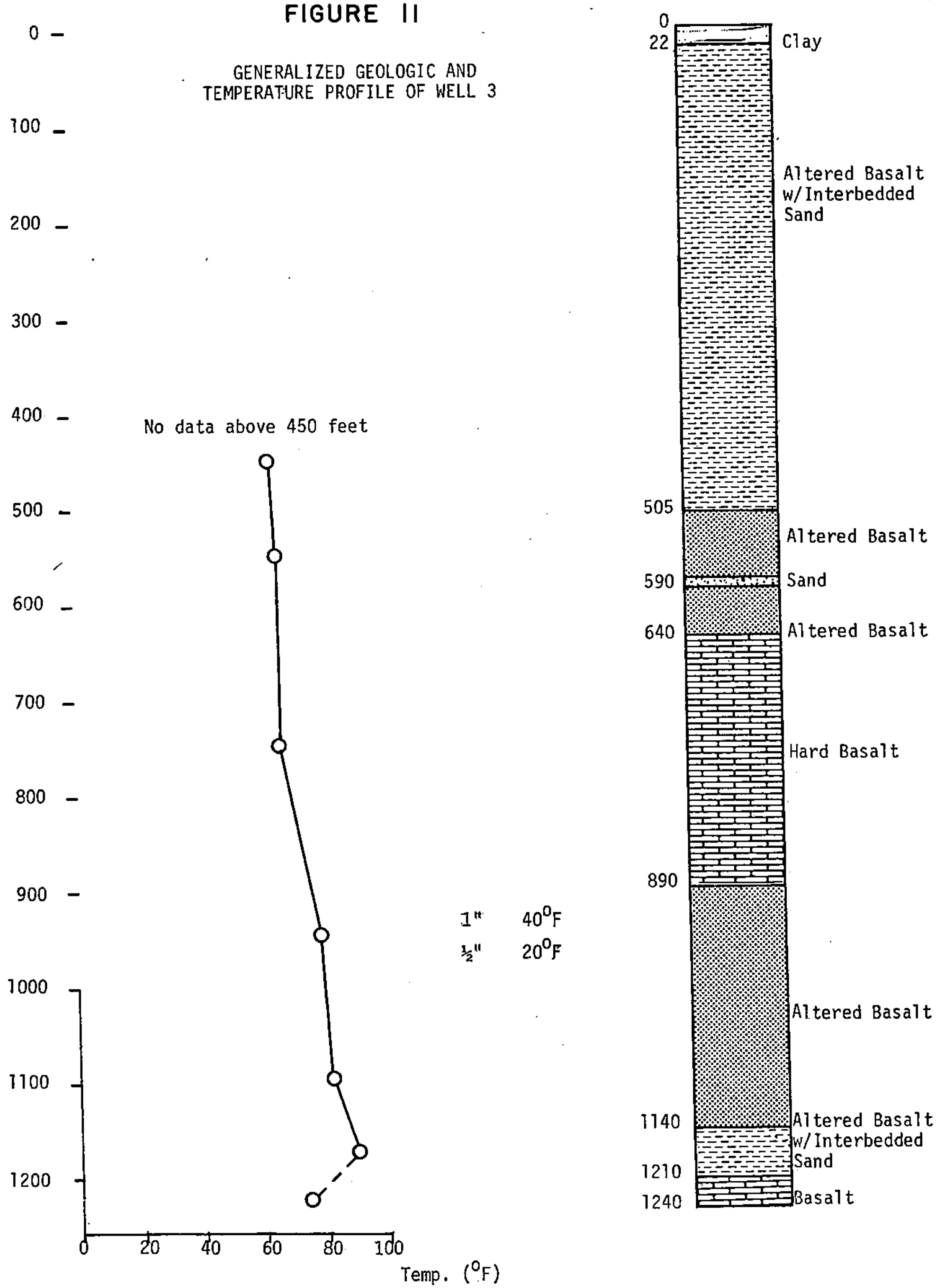

Idealized Infiltration And Flow Patterns
Of The Boise Front
Boise River
Batholith
Contact
Glenns Ferry Fm
Clay
Silt
Fine Sand
Med. Sand
Gravel
Basalt
Flow Direction
1 Mile

FIGURE 10

FIGURE 11

GENERALIZED GEOLOGIC AND
TEMPERATURE PROFILE OF WELL 3



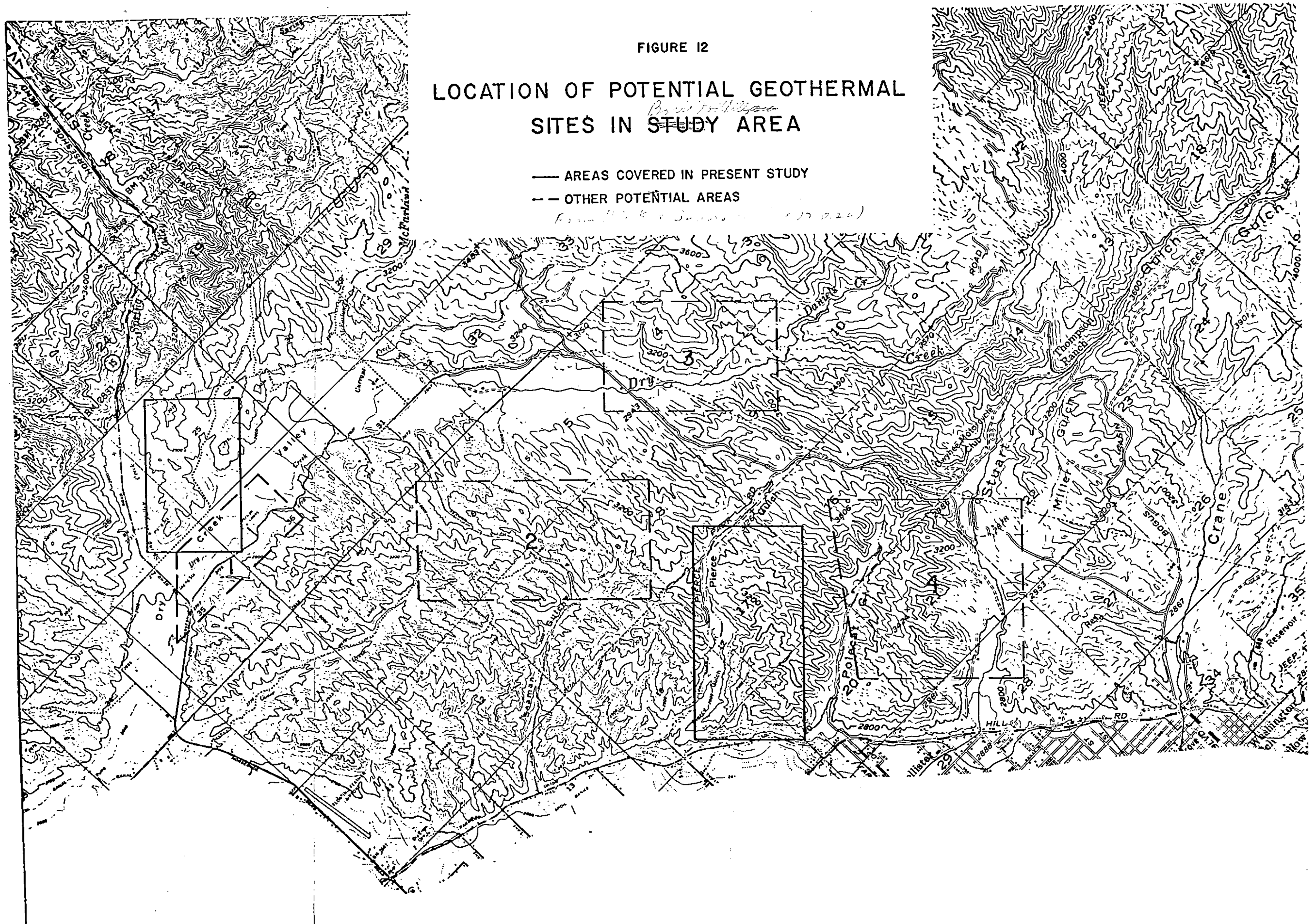


FIGURE 12

LOCATION OF POTENTIAL GEOTHERMAL SITES IN ~~STUDY~~ AREA

—— AREAS COVERED IN PRESENT STUDY

– – OTHER POTENTIAL AREAS

The Glenns Ferry Formation is composed of highly permeable sand layers interbedded with less permeable silt and clay. This contrast in permeabilities results in large volumes of ground water to flow in the sands, concentrate the discharge toward the downstream end of the discharge zone, and increase the vertical gradient in the less permeable layers as well as the overall vertical gradient of the formation. This situation creates favorable conditions for artesian flow (Freeze, 1967).

The direction of flow of the artesian system is approximately the same as that of the water table system. However, no points of discharge have been found indicating that it is a regional system (Mohammad, 1970). The main recharge area of the system is the Boise Ridge. The majority of the water available for recharge is the result of precipitation falling along the ridge. There are many potential channels available for infiltration and recharge of surface waters into the aquifer. Some of these include recharge directly through permeable sediments, the contact between the Glenns Ferry sediments and the batholith, and the many shears and fractures present in the granitic rocks of the batholith (Figure 10).

4.3 Geothermal System

The geothermal system may be related to the water of the deep artesian system in the Boise area. The warm water of the geothermal system have been found to be associated with major structural features. These structures include major faults in the area as well as numerous linears that have been mapped by photogeologic methods.

The heat source for the geothermal water is believed to originate from the deep fracture systems within the Idaho batholith. Water is heated at depth and moves along fault and fracture zones upward mixing and heating the water found in the Glenns Ferry Formation. This water is then intersected in wells tapping the Glenns Ferry sediments.

Geothermal gradients of wells in the Boise area indicate a normal increase in temperature with an increase in depth. Well 3 shows this typical increase in temperature (Figure 11). From data available for Well 3 a gradient of 2.58^{o} per 100 feet has been obtained. The normal gradient for Well 3 is interrupted at 1225 feet by the presence of a cold water source. By drilling past this zone of cold water, higher temperatures could possibly by obtained.

Table 1 gives pertinent data of the hot wells in the study area. The locations of these wells are found in Figure 7.

5.0 DISCUSSION OF POTENTIAL GEOTHERMAL AREAS

Two primary groupings of wells and several scattered wells within the study area show high potential as geothermal energy sources. All of these wells have been found to lie on or near major linears or at the intersection of two or more of these linears. As mentioned above, areas associated with linears are good potential areas for geothermal resources because of possible deep fracturing.

The two primary locations within the study area are the Dry Creek Valley and the area between Pierce Gulch and Polecat Gulch. Both areas have wells with recorded temperatures over 37.8°C. Somewhat hotter wells are found in the Pierce-Polecat area than in Dry Creek. This can be attributed to the fact that the majority of the wells in the Pierce-Polecat area are much deeper than those of the Dry Creek Valley.

5.1 Dry Creek Valley

The Spring Creek Estates subdividion is being developed along the northern margin of the Dry Creek Valley (Illus. 3). Numerous wells have been drilled and all have temperatures exceeding 15.6°C. Some of these wells have temperatures of approximately 20.0°C, which for geothermal purposes is not extremely hot. However, these wells are very shallow and the potential for much higher temperatures is great with increased depth.

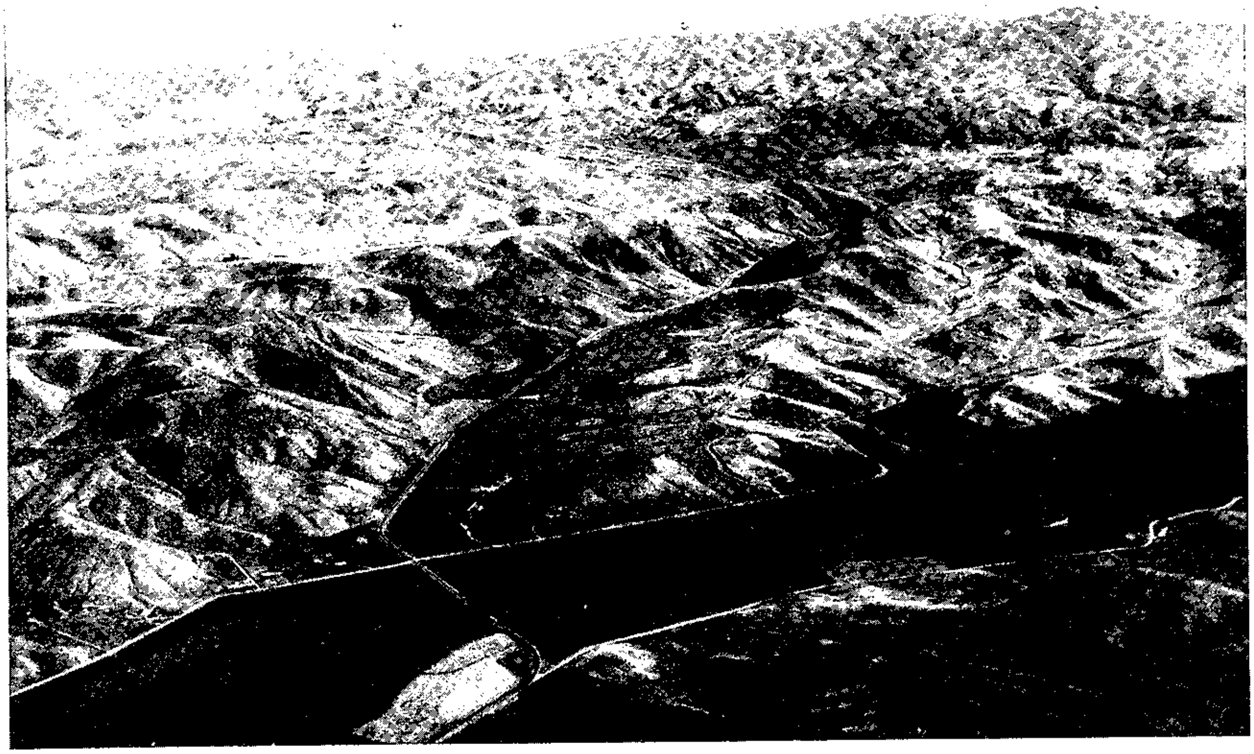
Evidence to back this statement can be found by comparing the temperatures of other wells in the area drilled to greater depths. Wells 7 and 8 (See Figure 7) are 688 feet and 500 feet respectively, and have temperatures of 30°C. By comparing this data with the much shallower wells, it is obvious that much higher temperatures are quite possible. An artesian well (Well 15) located on the south side of Dry Creek Valley is 1000 feet deep and is said by the owner to be 43.3°C. This is another indicator that temperature increases with increased depth.

Dry Creek Valley is controlled by some type of geologic structure. It appears that due to faulting, Dry Creek has been able to erode much faster than would normally be expected. As a result, all major streams flowing off the foothills from Stuart Gulch west have been disected. By looking at Figure 2, it can be seen that the normal direction of stream flow off the Boise Front is in a southwesterly direction. Seaman Gulch, Pierce Gulch, Polecat Gulch, and Stuart Gulch all flow in the southwesterly direction. The streams and gullies located north of Dry Creek show a somewhat similar southwesterly flow pattern (Illus. 4). In direct conflict to this scheme is Dry Creek which flows perpendicular to all other streams. The reason for this is that Dry Creek is structurally controlled.

Table 1

HOT WELLS IN STUDY AREA

Well Number	Legal Description	Depth (ft.)	Depth to Water (ft.)	Temp. (°F)	Remarks
1	NE 1/4 NE 1/4 Sec 19 T4N R2E	191	96	70+	
2	SE 1/4 SE 1/4 Sec 18 T4N R2E	815	--	80	
3	NW 1/4 SW 1/4 Sec 17 T4N R2E	1240	73	93	Temperature Log By Driller
4	NE 1/4 SW 1/4 Sec 17 T4N R2E	525	184	80	
5	NE 1/4 SW 1/4 Sec 17 T4N R2E	510	172	79	
6	SW 1/4 SE 1/4 Sec 8 T4N R2E	1685	240	105	
7	SE 1/4 SE 1/4 Sec 26 T5N R1E	688	Flowing	86	Used to heat house & pool
8	NW 1/4 SE 1/4 Sec 25 T5N R1E	500	86	86	
9	NW 1/4 SW 1/4 Sec 25 T5N R1E	312	60	64	
10	SW 1/4 NW 1/4 Sec 25 T5N R1E	313	138	65	
11	SW 1/4 NE 1/4 Sec 25 T5N R1E	303	112	75	
12	NE 1/4 NE 1/4 Sec 25 T5N R1E	175	54	73	
13	SE 1/4 SE 1/4 Sec 25 T5N R1E	105	48	62	
14	SE 1/4 SW 1/4 Sec 25 T5N R1E	205	92	63	
15	NE 1/4 SW 1/4 Sec 35 T5N R1E	1000	18	110	
16	NE 1/4 SW 1/4 Sec 1 T4N R1E	615	--	---	
17	SW 1/4 NW 1/4 Sec 4 T4N R2E	---	--	93-95	
18	SW 1/4 SW 1/4 Sec 16 T4N R2E	900	--	103	
19	SW 1/4 SW 1/4 Sec 22 T4N R2E	600	129	109	
20	NW 1/4 NE 1/4 Sec 28 T4N R2E	1200	--	118	
21 NW SE	NE 1/4 SW 1/4 Sec 27 T4N R2E	3770	250	115	Oil and Gas Well
22	SW 1/4 NE 1/4 Sec 29 T4N R2E	655	Flowing	---	Used to heat home
23	SW 1/4 NE 1/4 Sec 23 T4N R2E	362	282	60	



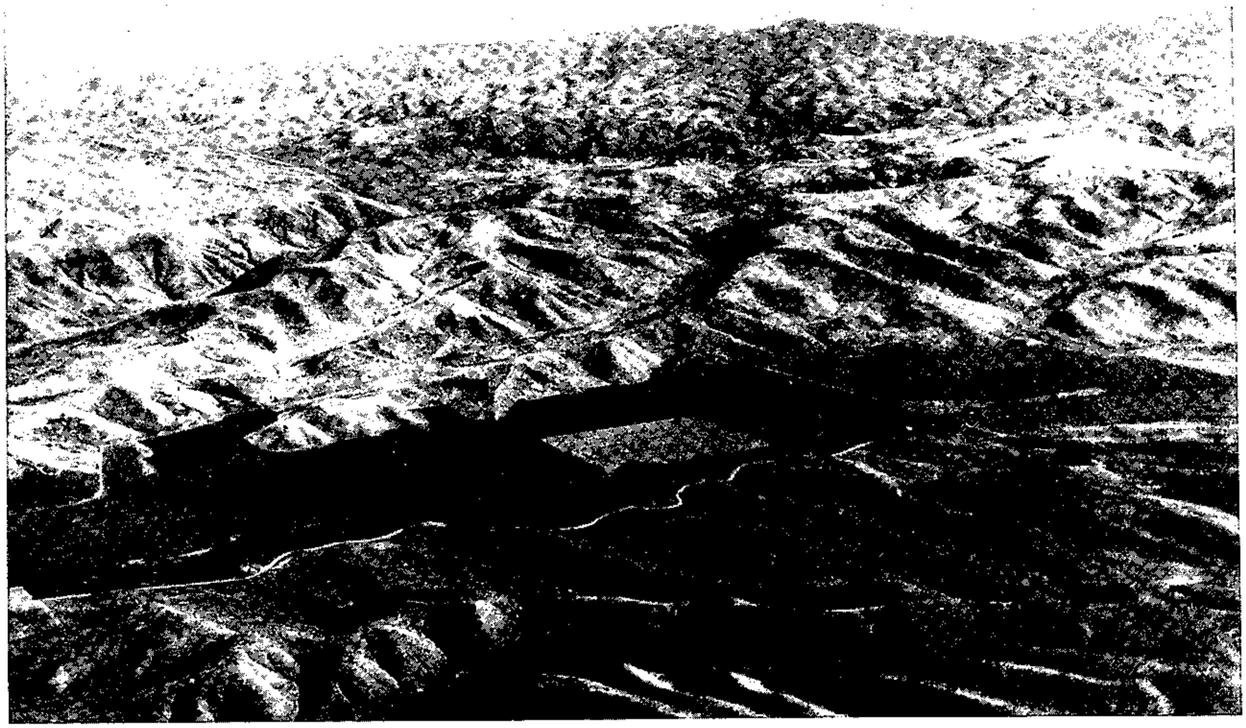
ILLUS. 3. Spring Creek Estates in the Dry Creek Valley are located along the middle ridge in the center of the photograph. In the lower portion of the photo, where Highway 55 and Dry Creek road converge, is the location of several artesian wells with temperatures exceeding 37.8°C.

By observing Figure 2, it can be seen that Dry Creek flows in a southwesterly manner until it reaches Section 14, T4N, R2E. Here it begins its northwesterly flow pattern. It is at this point in Section 14 that two major linears intersect. The largest of the two can be seen to trace through the present Dry Creek Valley. It is believed by the authors that this linear, although not observable on the surface, reflects a major weakness in the rock at depth in this area allowing Dry Creek to erode much easier, thus changing its course.

In 1970, Mohammad writing on the geohydrology of the Boise Ridge mapped a fault along the northern portion of the Dry Creek Valley. This fault coincides quite well with the major WNW trending linear mapped by Hall in 1975. These structural trends in the Dry Creek Valley are believed to control the movement of the hot water in this area.

As mentioned above, areas where faults or linears intersect are good potential sources for geothermal water. In the Dry Creek Valley existing wells indicate this theory holds true. At the extreme western margin of the study area another linear is found parallel to the Horseshoe Bend Highway. This linear disappears where Dry Creek makes a sharp turn to the east. At this bend, a southwest trending linear intersects the east-west trending linear thought to control the central portion of Dry Creek. Where these two linears intersect, hot wells now exist. The warmest of these wells is 43.3°C and under considerable artesian head.

Linears are extremely difficult to map in areas covered by surficial deposits such as the alluvium in the Dry Creek Valley. The southwest trending linear paralleling the Horseshoe Bend Highway was originally mapped to terminate midway through Section 35, T5N, R1E. It is believed that this linear does not stop at this point but instead can be extended through Dry Creek as shown (Figure 2). By extending this linear, it can be seen that at the intersection of this linear and the major WNW trending linear that traces the Dry Creek Valley coincides with hot water found in the area of the Spring Creek Estates. Also, the intersection of these two linears coincides quite well with the intersection of the southwest trending linear and the fault mapped by Mohammad. Linears are considered a zone of weakness and not a mere line as expressed on the map. At any point within this zone, hot water could possibly be located.



ILLUS. 4. Photograph illustrates how all streams and gullies flow perpendicular to the Dry Creek Valley. The Spring Creek Estates area is located in the middle-left portion of the photo.

5.2 Pierce-Polecat Area

In the Pierce-Polecat area a zone of seven hot wells exists. These wells, as in the Dry Creek area, are associated with linears. Two wells in this area are over 1000 feet deep and have temperatures at or exceeding 37.8°C. The coldest water is 21.1°C with the hottest being 40.6°C.

This zone of warm water is not as closely associated with mapped linears as that of the Dry Creek Valley. However, a major WNW trending linear system exists throughout this area. It must be remembered that although a well or a group of wells is not located directly on a linear, the fracture zone expressed at depth could be intersected by the well. This appears to be the case in the Pierce-Polecat area.

With such abnormally high temperatures being obtained in this area, it is obvious that some type of structural control is present. The WNW trending linear pattern can be seen intersecting numerous north-south trending linears (Figure 2). These intersections can produce very wide fracture zones that would transmit significant quantities of water. The significance of these fracture zones has been discussed previously and apply here as well.

Two wells located approximately one mile to the east in Stuart Gulch also exhibit high temperatures. These wells (19 and 20) are both over 37.8°C and are probably receiving their hot water from the same fracture zone as the one associated with the Pierce-Polecat area.

It is possible that the fracturing that is affecting the upper reaches of Dry Creek could also have some affect on this area of warm water. To what extent, if any, is impossible to deduce without detailed subsurface investigations in this portion of the Boise Front.

6.0 CONCLUSIONS

Within the study area, several areas of hot water exist along the Boise Front. Two major areas are the Dry Creek Valley and the zone between Pierce Gulch and Polecat Gulch. Temperatures exceeding 37.8°C have been found in both areas.

The hot water zones along the front have been found to be associated with mapped linears and known faults in the area. Zones of geothermal water exist due to the large amount of fracturing at depth associated with structural features. Both the deep fracturing in the Idaho batholith and the secondary fracturing expressed by the linears is very important in transmitting the hot geothermal water to the surface.

Although the majority of the water in the study area is not hot enough to produce electricity or heat numerous building complexes, it is of sufficient temperature to heat individual homes or several homes in a small area. By utilizing this resource to its greatest potential, it could help alleviate some of the problems caused by shortages of other forms of energy.

It is felt by the authors that further study should be carried on in the area to help stimulate the interest of the people and to show how this resource could be put to a beneficial use. In order to do this, more detailed field work needs to be done to isolate the zones of hot water more closely. Test drilling should be done to delineate the geology and to afford more information related to the geothermal gradient in the area so zones of hot water can be located more accurately.

Locations 1-4, as shown on Figure 12, have been chosen as potential areas for future geothermal investigations. These sites have been chosen based on the availability of existing warm water or their relationship to geologic structure or both. These areas in conjunction with Dry Creek and the Pierce-Polecat area show that the geothermal potential along the Boise Foothills is extremely high.

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