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CHARACTERIZATION OF THE GEOTHERMAL RESOURCES OF SOUTHEASTERN IDAHO

By

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Abstract

Much of southeastern Idaho displays the complex geology of the "overthrust belt" and the Basin and Range geomorphic province. Thrust and normal faults are important in controlling groundwater movement, however, the thrust faults do not appear to create layers of either significantly higher or lower permeability. The hottest thermal discharges in the region are associated with deep normal faults. The hottest waters in the area have Na and Cl as the dominant ions, while lower temperature hydrothermal waters are characteristically Ca/Mg and HCO_3 waters. Limited data from deep drill holes in the area do not indicate a high geothermal gradient.

Introduction

This paper is based on work done by graduate students at the University of Idaho under the direction of Dr. Dale R. Ralston (Ralston, et al., 1981). The Idaho Department of Water Resources did reconnaissance work on the hydrothermal occurrences in the area in the mid-1970's (Mitchell, 1976a, 1976b). Recent oil and gas drilling in the area suggested that high temperatures exist at accessible depths, but no aquifers have been penetrated at

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depth. A study effort was arranged through the Idaho Water and Energy Institute at the University of Idaho to do a more detailed study of the geothermal occurrences in the area. Particular emphasis was to be placed on the structural controls of the hydrothermal flow systems in the area. These study efforts are to be completed during the summer of 1982.

Geology of the Thrust Zone

Southeastern Idaho's relationship to the "overthrust belt" is displayed in Figure 1. The western edge of the "overthrust belt" is poorly understood, but lies well to the west of the Paris-Willard fault trace and west of Precambrian age rocks near Pocatello (Blackstone, 1977). The geology of the area is further complicated by postcompression normal faulting which produced the horst and graben structures typical of the Basin and Range. A diagrammatic east-west cross section of the "overthrust belt" (Figure 2) shows how the thrust faults in the area control the regional geology. A logical hypothesis to examine is--do the thrust faults exert a similar control over groundwater flow systems?

This question was attacked in a very direct fashion by examining outcrops of thrust fault traces and preparing thin sections of rock units from the outcrop areas. Field work quickly showed that only thin breccia zones (less than 10 m.) were associated with observable thrust faults in competent rock units. In ductile rock units, the faulting appears to primarily follow bedding planes with little or no associated brecciation.

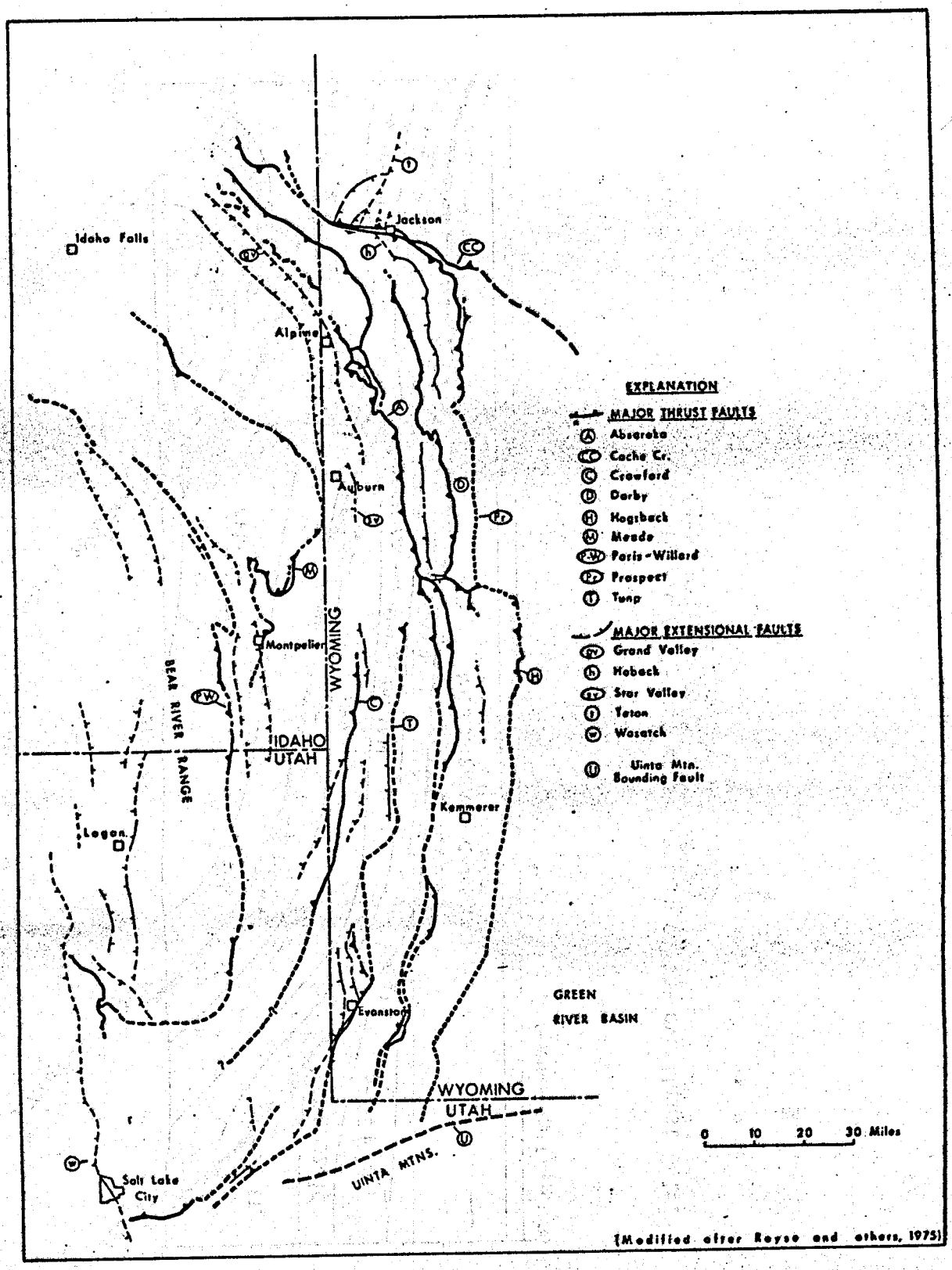

Figure 1. Generalized structural map of the overthrust belt in southeastern Idaho, western Wyoming and northern Utah. (from Ralston et al, 1981, p.8)

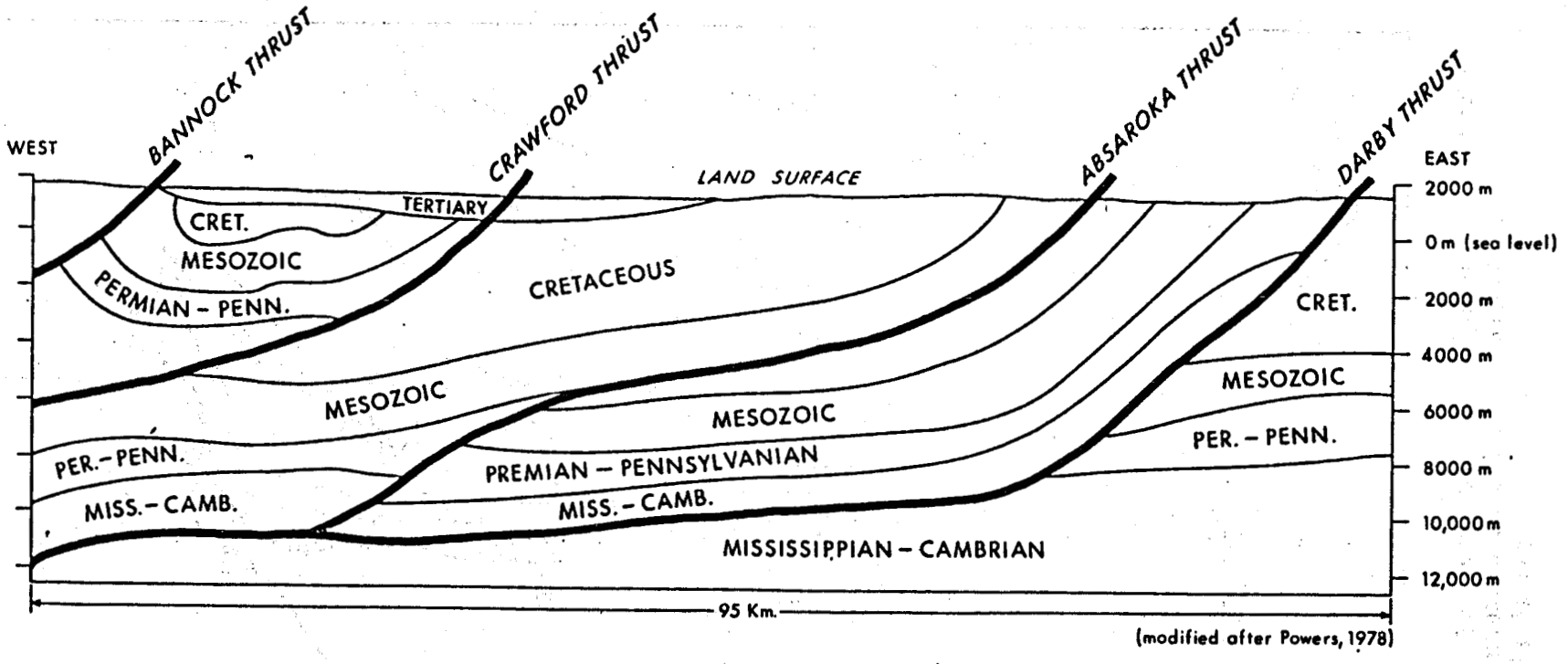

Figure 2. Typical diagrammatic east-west cross section of the overthrust belt. (from Ralston et al, 1981, p.86)

These early field results coupled with the basic geologic theory of thrust faulting suggests that the thrust faults do not act as primary controls of hydrothermal flow systems in the area for the following reasons:

1) Thrust faults generally cover great lateral distances in incompetent rock units and "step" upward through competent strata.

2) Thrust breccias and fault gouge examined in competent rock in the area do have increased porosity and problematic permeability when compared to the same rock outside the disturbed zone associated with the fault. However, because of the complex geologic history of folding, thrusting, and tensional faulting, nearly all competent rock units in the area are jointed and fractured. These rock units have sufficient large-scale permeability to mask the permeability associated with the thrust planes.

3) Theoretically, ductile deformation within incompetent strata could create zones of denser material with attendant lowered permeability. Just how effective this mechanism would be is questionable with most movement occurring along bedding planes. At any rate, the incompetent rock units of the area are of such low permeability that the thrust zones do not seem to change the role of these strata in the flow regime.

Of course, the thrust may exert a significant secondary influence on the groundwater flow systems by positioning high permeability lithologies against less permeable units.

Strong support for this reasoning is supplied by data from deep drilling in the area. Figure 3 is a generalized temperature log from an oil and gas test hole in the area. The geologic log for the hole indicates a thrust fault at a depth of 1556 meters. The temperature log shows no deflection at this depth, implying that the thrust does not control the hydrothermal system. In fact, thrust faults are recognized in drill holes in the area only by lithology. Not only do there not seem to be any temperature effects associated with the fault zones, there are usually no mud gains or losses associated with drilling through these zones.

Data from Deep Drill Holes

Wildcat drilling for oil and gas has gone on in southeastern Idaho since 1926. Forty-two exploration holes have been drilled to date with only minor shows reported. All holes have been abandoned. Little data are available from the older wells, and data from the recent wells is proprietary.

Geologic information was obtained for 13 wells. Temperature data were obtained from 12 wells. Figure 4 shows the location of these wells and a calculated temperature gradient for each location reported as degrees Celsius per 100 meters. The gradients

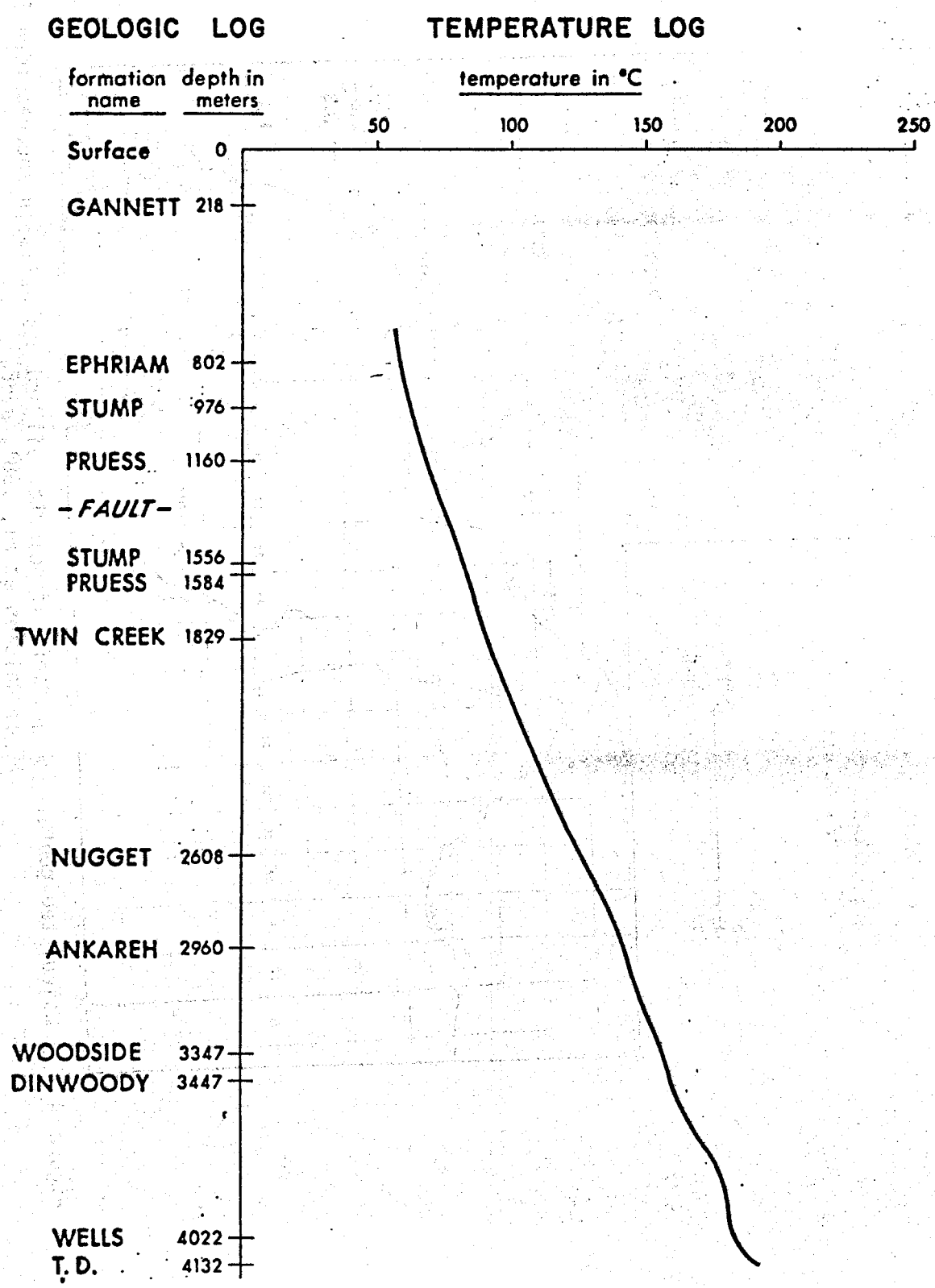

Figure 3. Geologic log and temperature log of well King 2-1. (from Ralston et al, 1981, p.89)

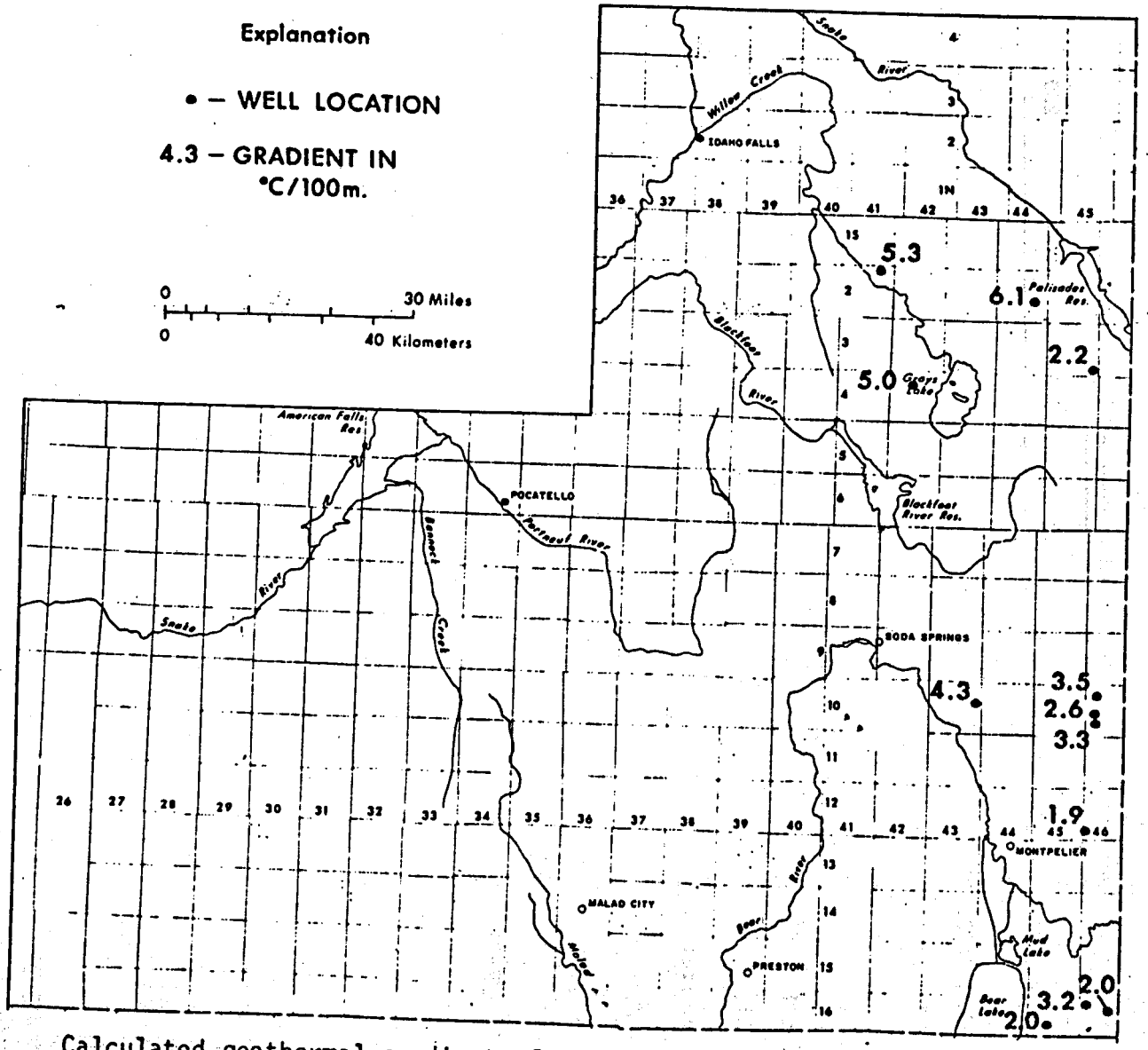

Figure 4. Calculated geothermal gradient of selected oil and gas wells in southeastern Idaho. (from Ralston et al, 1981, p.86)

in the southeast area suggest that a high temperature resource is unlikely to be encountered. The higher gradients clustered in the northern part of the area, however, may indicate a geothermal resource there.

Efforts are continuing to obtain more data concerning the deep drill holes in southeastern Idaho. However, given the distribution of the data already available, it seems that any radical changes in interpretation are unlikely.

Hydrochemistry

One of the major contributions of a study of this type is the basic data base generated by compiling existing data and generating new data from hydrothermal occurrences. By combining data generated by this study with data from the Idaho Department of Water Resources, the Utah Geological and Mineral Survey, and the Geologic Survey of Wyoming, a data set of approximately 100 hydrochemical analyses can be created.

Much of the current work effort in the area is an attempt to relate the stratigraphic and structural features that seem to control the groundwater flow at a site to the hydrochemistry of the water. Isotope data are being analyzed in an effort to age date some of the thermal waters. Age dates should make a major contribution to understanding the hydrothermal flow systems.

Chemical characteristics of thermal occurrences vary widely over the study area as do the temperatures of thermal springs and wells. As an example, total dissolved solids range from values

of 300-400 mg/l up to 43,500 mg/l at Crystal Hot Springs in the lower Bear River Valley in Utah. Temperatures range from the cut-off value of 14.5°C, to 82°C at Squaw Hot Springs well in the Cache Valley near Preston, Idaho. The highest temperature waters are generally high in Na and Cl and appear to be associated with deep normal faults along which recent movement has occurred.

There appear to be four hydrothermal waters in the area associated with geographic areas and/or structural features. These are the waters associated with the boundary faults of the Swan, Grand and Star valleys in Idaho and Wyoming. These waters are of the Na-Cl type with total dissolved solids ranging from 6000-9000 mg/l. Temeperatures range from 23°C to 62°C.

Temperatures of thermal waters associated with the Meade Peak thrust block are below 26°C and are uniformly of the Ca/HCO_3 type. Total dissolved solids generally range from 800 to 1500 mg/l. The thrust block is broken by shallow normal faults which apparently control a shallow groundwater flow system. Basin and Range thermal waters are similar to the Swan-Star Valley waters in that NA-Cl are the dominant ions, they usually have high total dissolved solids (several exceed 10,000 mg/l), and are associated with normal boundary faults. However, Basin and Range waters are severely depleted in the other major ions. Thermal waters associated with Basin and Range type valleys tributary to the Snake Plain are an exception to this generalization. Waters in these valleys have low total dissolved solids

and are variable in the relative concentrations of major ion species.

A geologic transition zone between the Basin and Range province and the Middle Rocky Mountain province is characterized by Transition Zone thermal waters. These waters appear to represent a transition between the Na-Cl waters of the Basin and Range waters and the Ca/HCO_3 type waters of the thrust blocks.

Conclusions

Conclusions drawn while a study is still in progress are tentative at best. However, based on the work completed to date, the following conclusions appear valid:

1) Thermal discharges in the study area are located along structural features with the hottest waters being associated with deep normal faults.

2) The hottest thermal discharges have Na and Cl as the dominant ions while lower temperature thermal waters are characterized by Ca-Mg and HCO_3.

3) Temperature data from deep wells in the area do not indicate a high geothermal gradient.

4) The thrust faults do not appear to create layers of significantly high or low permeability.

5) Within the most intensively studied thrust block (the Meade Peak) thermal springs discharge water of less than 26°C and are apparently representative of a shallow groundwater flow system.

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