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SUBSURFACE GEOLOGY OF THE RAFT RIVER GEOTHERMAL AREA, IDAHO

H. R. Covington

U.S. Geological Survey
Box 25046, Denver Federal Center
Denver, CO 80225

ABSTRACT

The Raft River Valley occupies an upper Cenozoic structural basin filled with nearly 1,600 m of fluvial silt, sand, and gravel. Rapid facies and thickness changes, steep initial dips (30°), and alteration make correlation of basin-fill depositional units very difficult. Hydrothermal alteration products in the form of clays and zeolites, and deposition of secondary calcite and silica increase with depth. The abundance of near-vertical open fractures also increases with depth, allowing greater movement of hydrothermal fluids near the base of the Cenozoic basin fill. The basin is floored with quartzites and schists that can be correlated with formations in the nearby Raft River Range. Beneath these rocks is a Precambrian adamellite basement complex. The Raft River geothermal system is a hot water convective system relying on deep circulation of meteoric water in a region of high geothermal gradients and open fractures near the base of the Tertiary basin fill.

INTRODUCTION

The Raft River geothermal anomaly near Bridge, Idaho, was designated a Known Geothermal Resource Area (KGRA) by the U.S. Geological Survey in 1971 (Godwin and others, 1971).

In 1973 the U.S. Geological Survey (USGS), in cooperation with the U.S. Energy Research and Development Administration (ERDA, now the Department of Energy, DOE), began an integrated geothermal exploration program in southern Idaho. This program was designed to provide a scientific framework for the evaluation of a geothermal resource and to test the applicability of various geological, geophysical, geochemical, and hydrological techniques to the study of geothermal resources. Williams and others (1976) summarized the early results of this program.

GEOLOGIC SETTING

The Raft River Valley is a north-trending Cenozoic basin located in the northern part of the Basin and Range province. The valley opens northward onto the Snake River Plain and is flanked on the east by the Sublette and Black Pine Mountains, on the west by the Jim Sage and Cotterel Mountains and on the south by the Raft River Range (fig. 1). The Jim Sage and Cotterel Mountains consist of Tertiary rhyolite lavas, ash flow tuffs, and tuffaceous sediments. The Sublette and Black Pine Mountains contain mainly folded and faulted allochthonous upper Paleozoic rocks. The Raft River Range south of the valley is composed of a Precambrian adamellite core mantled by Precambrian and lower Paleozoic metasedimentary rocks and allochthonous upper Paleozoic rocks. The Raft River basin is filled with nearly 1,600 m of Cenozoic tephra and sediments derived from the surrounding mountains. Locally these sediments are altered at the surface from gray to light green or yellow, with some accumulations of chalcedony. There are no tufa or sinter mounds within the valley. The principal faults exposed within the valley are two north-trending normal fault zones along the west side of the valley called the Bridge and Horsewell fault zones. There is also some geologic and geophysical evidence (Mabey and others, 1978) suggesting a possible basement shear, called the Narrows zone, that trends northeast across the valley.

DRILLING PROGRAM

Since the spring of 1974 a total of 84 boreholes ranging in depth from 30 m to 2,000 m have been drilled in the Raft River Valley in order to better define the geothermal resource in terms of the geologic setting and reservoir parameters. Most of these boreholes are in the upper 300 m of the valley fill and were drilled to sample and monitor the near-surface cold-water aquifer or to make heat flow measurements within the basin. Seven deep boreholes have been drilled within the KGRA to explore and develop the resource, of which five extended into the Precambrian adamellite basement. In addition to the deep geothermal drilling by ERDA, Standard American Oil Company has provided the USGS with cuttings and well logs from three petroleum test boreholes drilled in the valley.

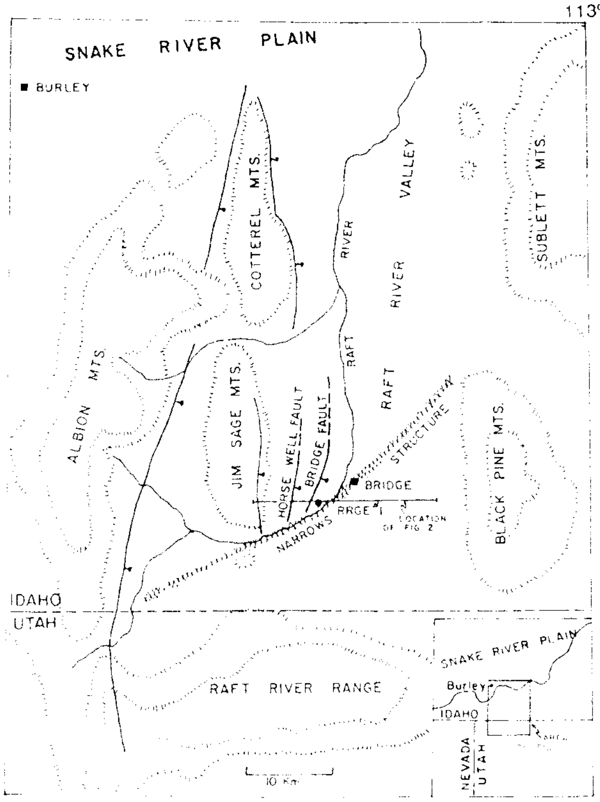

Figure 1.--Location map of the southern Raft River Valley region, Idaho. Faults shown as heavy lines with bar and ball on downthrown side. Raft River Geothermal Exploration well #1 (RRGE #1).

SUBSURFACE GEOLOGY

The Cenozoic basin fill of nearly 1,600 m of silt, sand, and gravel accumulated by fluvial processes that have been essentially continuous for at least the past 7 million years. Rapid lateral changes of both facies and thickness, dips as great as 30° and alteration of the sediments make basinwide correlation of any depositional unit very difficult. Widespread observations indicate a general decrease in the gravel content and increase in alteration downward. The entire Tertiary section contains volcanic glass shards; alteration is most evident in the types of clays derived from the glass, and in the formation of zeolites. In three of the deep boreholes studied, the clays change downward from montmorillonite to mixed-layering to illite while the zeolites change from clinoptilolite to analcite to wairakite to laumontite (Peter Kolesar, written commun., 1979). Near the base of the Cenozoic succession, deposition of silica and calcite is the dominant form of alteration. The silica tends to form a "caprock" above the geothermal reservoir, whereas the calcite preferentially fills cracks and openings. In some places calcite and silica replace the clay and volcanic glass in the sediments.

The abundance of faults and fractures also increases with depth. In the upper part of the basin fill the faults dip steeply (60°-80°); with depth these faults decrease in dip until they become nearly horizontal at the base of the Cenozoic fill (fig. 2). Movement on these concave-upward faults produced abundant, near vertical, open fractures and cracks near the base of the basin fill. Some of these faults are major structures that were forming during sedimentation in the basin and were the mechanism for translation of large blocks of Cenozoic sediments for long distances (Mabey and others, 1978).

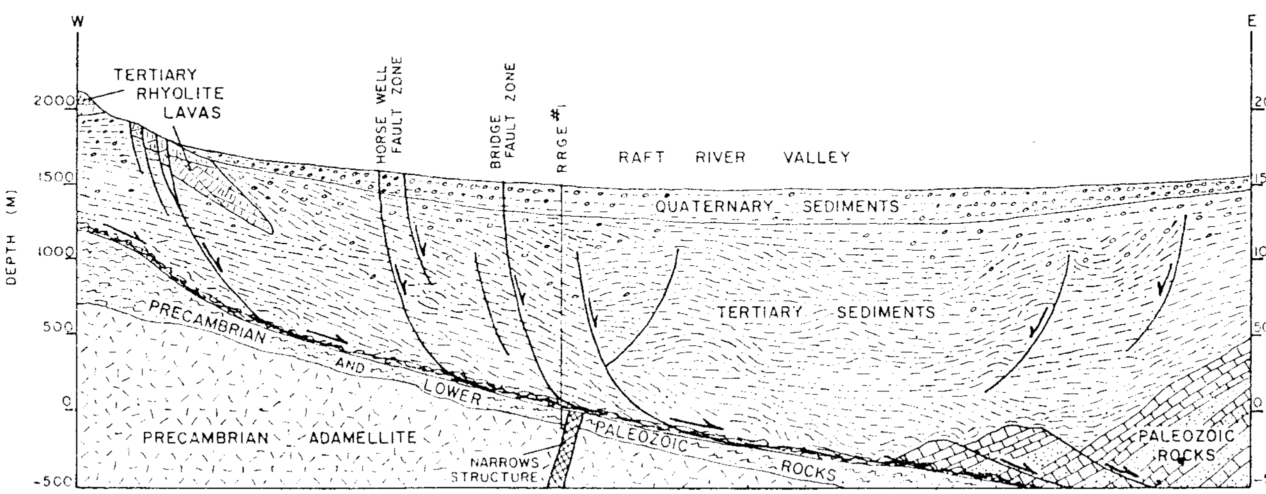

Figure 2.--Generalized cross section of the southern Raft River Valley, Idaho, showing interpretative subsurface geology and structure. Arrows show direction of fault movement. Raft River Geothermal Exploration well #1 (RRGE #1)

The basin is floored with autochthonous(?) Precambrian and Cambrian quartzites and schists that can be correlated with formations found in the Raft River Range. These formations are the quartzite of Yost (at the top), the schist of the Upper Narrows, the Elba Quartzite, and an unnamed schist. Beneath these units is the Precambrian adamellite. These autochthonous(?) formations as well as the adamellite basement are generally unaltered by the geothermal fluids, and even though they may be fractured in some areas, they do not contain a significant part of the geothermal resource.

GEOTHERMAL MODEL

The basic model for the Raft River geothermal system has not changed significantly from that proposed by Williams and others (1976), except for the recognition of major nearly horizontal faults and their implications regarding the geothermal reservoir. The geothermal system is the result of deep circulation of meteoric water presumably from the Albion, Goose Creek, and Raft River Mountains along major faults. With a high regional heat flow of 2-3 microcal/cm^2sec (Urban and Diment, 1975), part of this water need only descend to depths of 3-5 km to be heated to nearly 150°C. The heated water then migrates upward along the Narrows structure (figs. 1 and 2) to the base of the Cenozoic basin fill where it moves into the fracture-dominated reservoir.

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