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GEOPHYSICAL DATA, BEOWAWE GEOTHERMAL AREA, NEVADA

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ABSTRACT

The Beowawe geothermal system appears to be a typical Basin and Range fault-related hydrothermal system. The near surface geophysical expression of the convective Beowawe geothermal system is a zone of resistivities less than 10 ohm meters and an asymmetrical dipolar self-potential anomaly of over 500 millivolts. Large velocity contrasts within the volcanic section produce unusable 1000% CDPS high resolution seismic reflection data. A widespread conductor at roughly three kilometers depth and the influence of a major crustal conductor associated with the NNW striking Oregon-Nevada lineament dominate the regional magnetotelluric response. Self potential and seismic emission data indicate poor permeability in the shallow part of the major fault plane southwest of the surface geothermal manifestations.

GEOLOGIC SETTING

The Beowawe geothermal area is located on an ENE striking Basin and Range normal fault a few miles southwest of the town of Beowawe, within the Battle Mountain heat flow high in north-central Nevada. Sedimentary basement is the miogeosynclinal Paleozoic carbonate section. The Roberts Mountain thrust has placed a thick (over 5000 feet) section of the Ordovician Valmy Formation, a part of the eugeosynclinal Paleozoic sequence to the west, over the carbonates. Overlying the Paleozoic rocks are basaltic andesite flows related to a mid-Miocene rift, evidenced by a NNW zone of faulting, volcanic rocks, diabase dikes, and a prominent aeromagnetic anomaly (Stewart, et al., 1975), which passes a few miles to the west. Basin and Range faulting has superimposed a gentle regional dip to the SE.

Geothermal manifestations include a large siliceous sinter terrace, alteration, hot springs, fumaroles, and geysers. The Beowawe geothermal system is described in recent papers by Garside and Schilling (1979) and Zoback (1979). Chevron has drilled two exploration wells (Fig. 1): the Ginn 1-13 in 1973 to a total depth of 9563 feet and a bottom hole temperature of 412°F, and the Rossi 21-19 in 1976 to a total depth of 5686 feet and a bottom hole temperature of 394°F. These wells were drilled to intercept the Malpais fault to the southwest of the surface manifestations at the geysers. Permeability in the possible fault zone is good at the Ginn and poor at the Rossi. The ultimate deep reservoir is probably in fractured Paleozoic carbonates, with heat supplied by the enhanced sub crustal heat flow--not by recent volcanism.

GEOPHYSICAL DATA

Ten detailed geophysical surveys have been conducted for Chevron in the Beowawe area. Data from these surveys are now in the public domain as part of the Department of Energy/Division of Geothermal Energy's Industry Coupled Program. The location map shows line and station locations for some of these surveys (Fig. 1).

Gravity and magnetic data delineate the Malpais fault as following the topographic escarpment. Whirlwind Valley contains alluvium which thickens both to the southeast, to roughly 1500 feet against the Malpais at the geysers, and to the northeast. One major NNW striking cross fault (up to the northeast), one and one-half miles east of the geysers, is obvious in the gravity and magnetic data and may terminate the geothermal system to the east. Seismic reflection data from both a thumper and a modern 120-channel 1000% CDPS survey are too noisy, because of the interbedded volcanic section, to provide definitive structural information. The geysers area is within a minimum in regional groundnoise coverage but appears as a noise source relative to the Malpais fault plane to the southwest in a detailed seismic emission survey.

Low resistivity anomalies, which are caused by higher temperature, more saline waters, more permeable and/or more altered rocks, are characteristic of geothermal systems, and Beowawe is no exception. On reconnaissance dipole-dipole resistivity coverage using 2000-foot dipoles (Fig. 1), surface apparent resistivities of less than 10 ohm meters are measured at the short separations in the alluvium at the geysers area in the down dropped hanging wall of the Malpais fault. To the southwest, the anomaly in the alluvium deepens to roughly 1500 feet on Line 2 at the Ginn and Rossi wells and to roughly 2000 feet on Line 3. A low resistivity zone is located to the east on Line 6 in the foot-wall and probably reflects alteration or primary lithology in the Valmy Formation.

A reconnaissance magnetotelluric survey was conducted for Chevron (by Geotronics) to detect any low resistivity geothermal reservoirs in the high-resistivity carbonates. The MT results indicate that the carbonate section is not sufficiently thick or continuous to be detected in the presence of widespread, very low resistivity upper crustal rocks. The near surface tensor apparent resistivities are isotropic, but a pronounced electrical anisotropy occurs at the low frequencies, with a NNW electrical strike. Therefore, the MT is sensing a deep NNW striking conductive structure, parallel to the rift system to the west, and not the NE striking Malpais fault. This low frequency anisotropy and the magnitude of the low frequency TM mode apparent resistivities systematically decrease from SW to NE across the existing coverage, away from the dike swarm. Altered Valmy Formation, confined between resistive diabase dikes, could represent this strong, NNW striking conductor. In addition, a widespread, less than one ohm meter, conductor exists at depths of roughly three kilometers as interpreted from inversions of TE mode data from the most isotropic sites. A deep electrical conductor is common at geothermal prospects, such as at Grass Valley, Nevada, which is located roughly fifty miles to the west (Morrison, et al., 1979). At Beowawe, these conductive rocks are either a thick section of shaly units within the Valmy, thermal waters in the carbonates, or alteration caused by the enhanced heat flow.

Self-potential coverage best delineates the convective system at Beowawe. An asymmetrical dipolar SP anomaly of over 500 millivolts correlates with the area of the geysers and the sinter terrace. High amplitude, short wavelength positives occur to the north of the sinter terrace. A broader negative occurs across the terrace and extends to the hot spring to the southwest. The large dipolar anomaly terminates abruptly to the east and changes character to a series of lower amplitude, short wavelength positives to the southwest. Additional SP surveying to complete the coverage is in progress. Together with the results of the seismic emission survey, the SP data indicate that the Malpais fault plane is not open and permeable at shallow depths in Section 19 updip from the Rossi well.

Exploration, including comprehensive shallow thermal gradient coverage, an additional deep exploratory well, and more detailed interpretation of the geophysical data, is continuing at the Beowawe geothermal area.

ACKNOWLEDGEMENTS

These geophysical data are now in the public domain as part of the Department of Energy/Division of Geothermal Energy's Industry Coupled Program. Chevron Resources Company allowed publication of this paper.

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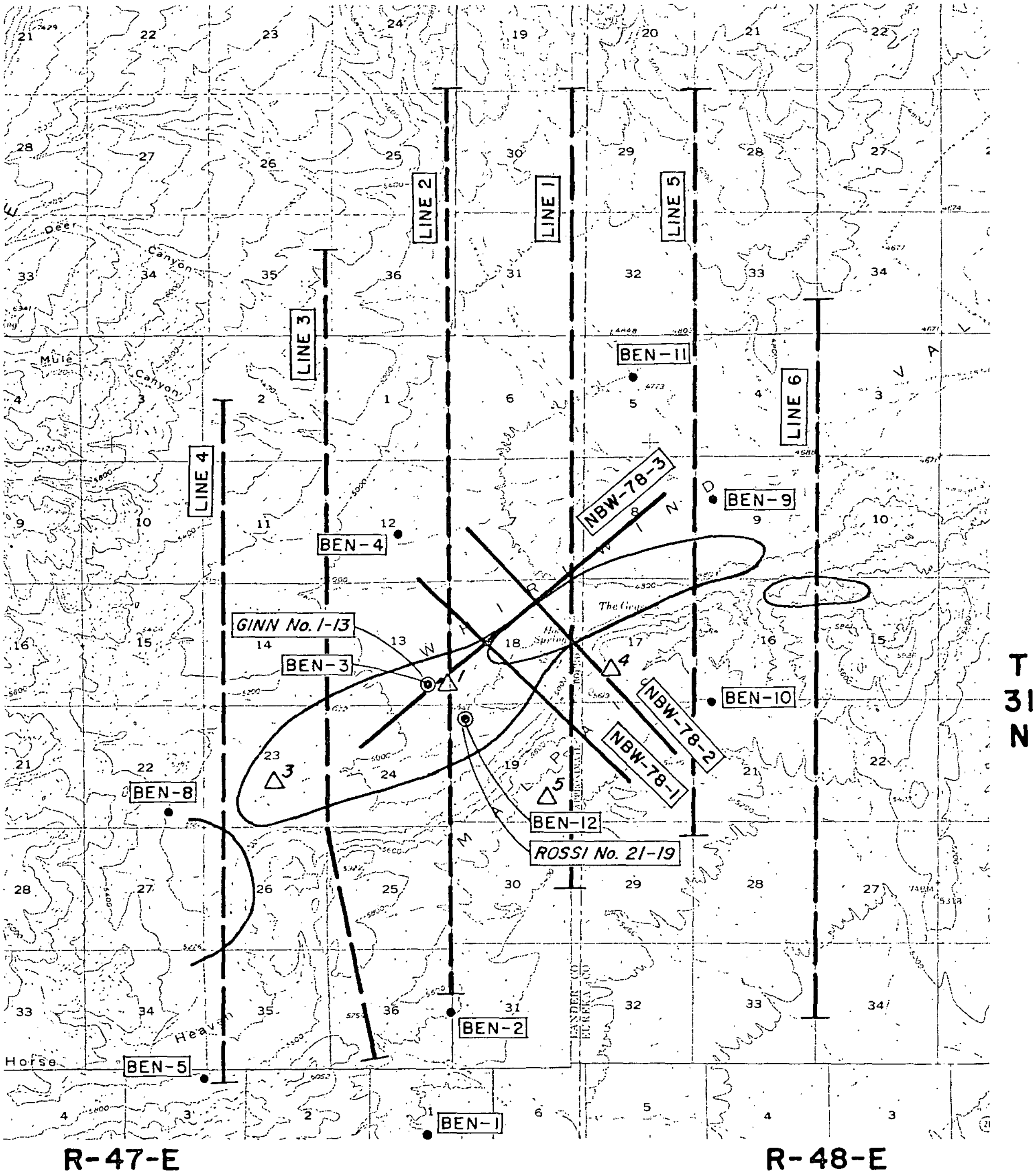

GEOPHYSICAL DATA
BEOWAWE GEOTHERMAL PROSPECT
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EXPLANATION

● MT STATION	O GEOTHERMAL WELL
△ SEISMIC EMISSION ARRAY	——— SEISMIC REFLECTION LINE
— — DIPOLE-DIPOLE RESISTIVITY LINE	⬭ INTERPRETED LOW RESISTIVITY ZONE