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MODEL FOR A DEEP CONDUIT TO THE BEOWAWE GEOTHERMAL SYSTEM, EUREKA AND LANDER COUNTIES, NEVADA

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ABSTRACT

A fault set trending N15-35W formed the eastern boundary of a major graben in the Beowawe area in the Late Tertiary. Geologic mapping and dipole-dipole resistivity data suggest that this fault set may have been and continues to be a deep conduit to the Beowawe geothermal system.

INTRODUCTION

The Beowawe Geysers have formed a 850 m long sinter terrace at the base of the Malpais scarp near Battle Mountain, Nevada. They have attracted exploration for geothermal electric power generation. The high-temperature (200+ °C) hydrothermal system appears to be controlled by the intersection of fault sets that tap deeply circulating water in an area with high regional heat flow (>100 mW · m^{-2}).

DISCUSSION

Aerial photographs reveal a strong north-northwest-trending topographic lineament that transects the Malpais Rim east of White Canyon. We refer to this fracture set as the Dunphy Pass Fault zone (replacing the name Whirlwind-Crescent Fault zone of Smith et al., 1979 to avoid confusion with other similarly named faults in the area). The Malpais scarp slope, immediately east of White Canyon, reveals the juxtaposition of Ordovician Valmy Formation quartzite and siltstone against Tertiary pyroxene dacite flows along north-northwest-trending faults (Figure 1). In White Canyon and on the Malpais dip slope, the N15-35W fault trend forms a horsetail pattern on the map (Plate 1). These faults produced dip-slip motion to the west-southwest. Lithologies encountered in the Ginn and Rossi wells (Chevron, 1979; Smith et al., 1979) and in the Batz well (Zoback, 1979) indicate that as much as 1200 m of Miocene volcanics and younger alluvium accumulated west of the fault zone prior to the growth of the Malpais scarp. Additional northwest-trending faults with small displacements cut the Malpais scarp immediately west and east of White Canyon.

Exposures of veins and alteration reveal that the intersection of the Malpais Fault with the Dunphy Pass Fault zone has been the focus of intense hydrothermal activity. Uplift on the Malpais Fault has exposed a dense swarm of east-west-trending chalcedony-carbonate veins cutting pyroxene dacite at the mouth of White Canyon (Figure 2). Several large, near-vertical veins of one to two m thick stand in relief over a 0.6 km strike length. Adjacent fault breccia, gouge, and country rock are pervasively argillized or silicified. The major veins are not traceable to the east of the north-northwest-trending fault contact between the dacite and the Valmy quartzites and siltstones. However, abundant chalcedony veinlets and veins with thicknesses up to 0.3 m continue eastward through the highly fractured Valmy to the young landslide. The abundance of chalcedony veins drops drastically in Valmy exposures to the east of the landslide. The exposed vein swarm and attendant zone of alteration extends 0.2 km south of the mouth of White Canyon. A linear zone of chalcedony and opal-filled fractures and open spaces in a paleo-colluvium or dacite flow breccia unit on the eastern wall of White Canyon continues southward from the vein swarm for one km up the canyon. Several thin chalcedony veins strike N70E, and cross this zone in the middle of the White Canyon gorge. These veins appear to follow fractures subsidiary to the main Malpais Fault. The Malpais Fault truncates the veins to the west at the edge of Whirlwind Valley.

The elevation of the top of the alteration zone increases in a steplike manner eastward along the Malpais scarp slope on the west side of the landslide detachment zone. The observed displacements of the alteration zone indicate renewal of motion on the Dunphy Pass Fault zone subsequent to the deposition of the chalcedony veins. The Dunphy Pass Fault zone may, therefore, be permeable at depth.

The alteration features appear to decrease in age westward from this fault intersection to the active sinter terrace. Sealing of the shallow portions of the conduit may have diverted hydrothermal fluids to the west along the Malpais Fault zone, ultimately producing the sinter terrace above permeable fault intersections.

Numerical modeling of 2000 ft. dipole-dipole resistivity data taken along north-south lines in

July, 1974 (Smith, 1979) suggest a 5 ohm-m low-resistivity zone below a depth of 915 m at the intersection of the Malpais and Dunphy Pass Fault zones. This zone extends to the west and crops out at the sinter terrace. These data do not distinguish whether this and other low-resistivity zones indicate hydrothermally altered rock or active conduits for hot water. However, just east of White Canyon, a 300 ohm-m body above the low-resistivity anomaly may reveal a silicified cap of Ordovician and Tertiary rocks above a deep conduit.

The intense hydrothermal activity on the sinter terrace, at the structural intersections of the Malpais Fault zone and the two cross faults indicates that fracture conduits within the Malpais Fault zone lie beneath the sinter terrace. East-west fractures passing through and north of the sinter terrace are probable conduits feeding hot springs on the flats at the foot of the terrace. Small deposits of old sinter along the South Cross Fault (Oesterling, 1962) at the top and base of the Malpais scarp indicate former shallow permeability on this cross fault. However, the traces of the cross faults are obscure and surficial evidence of hydrothermal activity are lacking on the Malpais dip slope to the south.

Models of the north-south dipole-dipole data reveal an anomalous low-resistivity zone that extends below the Malpais Rim southeast of The Geysers (Figure 4). However, the southern margin and lateral extent of the anomaly can not be resolved. To define better the resistivity distribution of the Malpais Rim, data were taken along three additional dipole-dipole lines oriented perpendicular to the Dunphy Pass Fault zone in April, 1980. Numerical modeling of these data incorporate the complex effects due to topography and confirm and refine the location of the low resistivity zone. Figure 4 shows the interpreted intrinsic resistivity at 915 m elevation, 550-800 m depth.

Resistivities less than 30 ohm-m follow a straight and narrow zone that trends southeast of The Geysers. This linear anomaly cuts the Malpais Rim for a distance of at least 4250 m and is rarely wider than 900 m. The lowest interpreted resistivity (10 ohm-m) occurs not at The Geysers where they might be expected but 1200-1800 m to the southeast on the west flank of White Canyon. Conduction by clay minerals produced during episodes of hydrothermal activity prior to the establishment of the present system may be the sole cause of the resistivity anomaly. However, the anomaly lies between the southeastward projection of the cross - faults that bound the area of modern surficial hydrothermal activity. If hot water within or between the faults causes the resistivity anomaly, there may be hot water below the dip slope of the Malpais Rim along segments of the Dunphy Pass Fault zone. Possible aquifers include fractured or jointed volcanic rocks or quartzite.

CONCLUSIONS

We have identified two structurally controlled zones that may link the Beowawe Geysers to a major north-northwest-trending fault zone. Thermal gradient holes to be drilled in the summer of 1980 will test both suggested links. The Dunphy Pass fault zone is the deepest structure crossing the Malpais Rim. Its intersection with the Malpais fault zone is therefore the most likely structure in the Beowawe area to accomodate deep conduits to the hydrothermal system.

ACKNOWLEDGEMENTS

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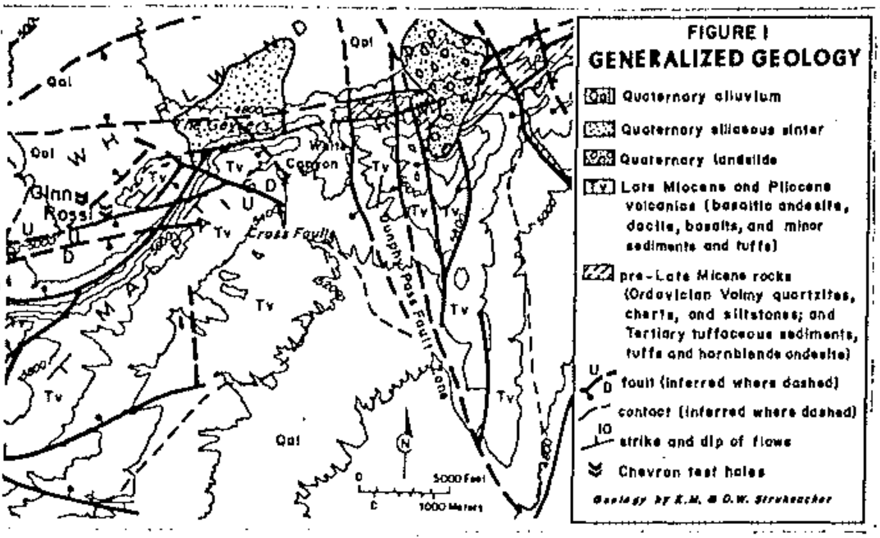

FIGURE 1
GENERALIZED GEOLOGY

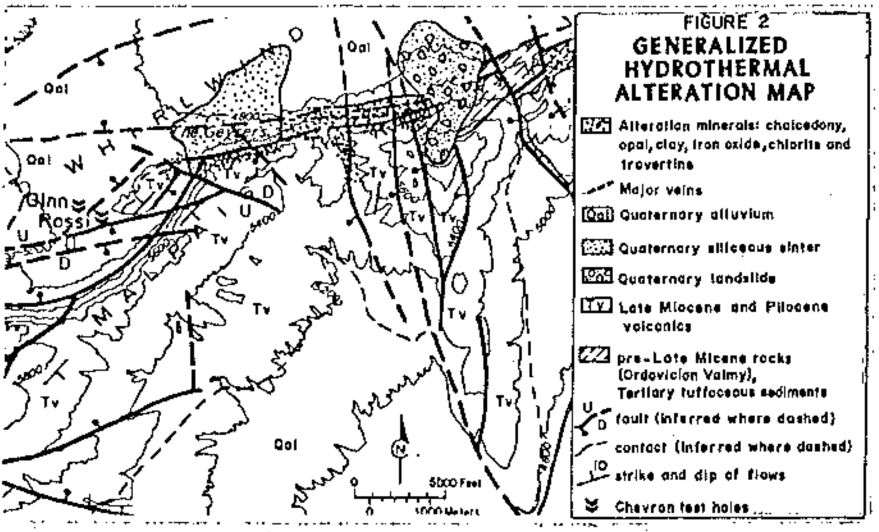

FIGURE 2
GENERALIZED HYDROTHERMAL ALTERATION MAP

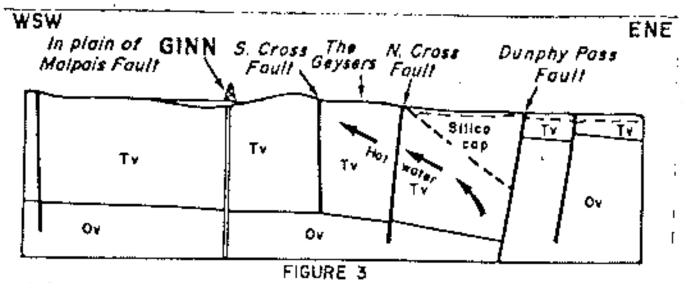

FIGURE 3

Schematic Cross Section Orthogonal to Dunphy Pass Fault

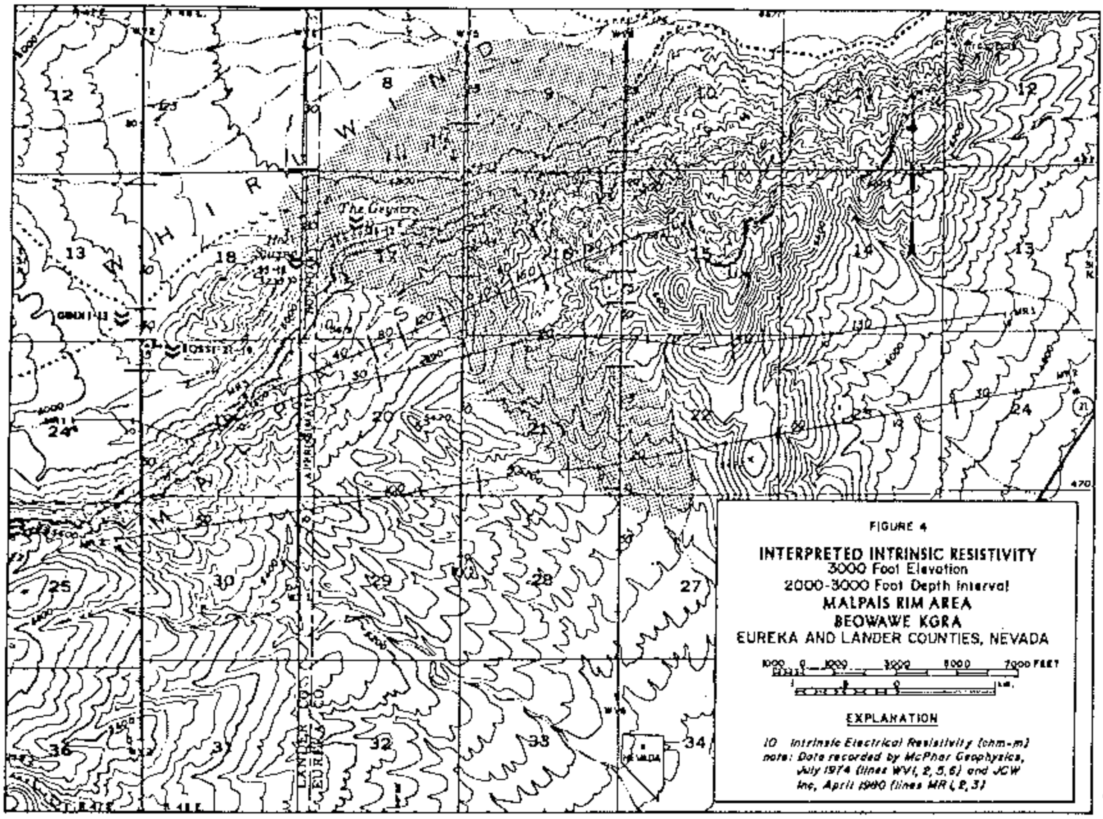

FIGURE 4

INTERPRETED INTRINSIC RESISTIVITY
3000 Foot Elevation
2000-3000 Foot Depth Interval
MALPAIS RIM AREA
BEOWAWE KGRA
EUREKA AND LANDER COUNTIES, NEVADA

EXPLANATION

10 Intrinsic Electrical Resistivity (ohm-m)
note: Data recorded by McPhar Geophysics, July 1974 (lines WV1, 2, 5, 6) and JCW Inc, April 1980 (lines MR 1, 2, 3)