GEOTHERMAL EXPLORATION AT THE TUSCARORA PROSPECT IN ELKO COUNTY, NEVADA

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ABSTRACT

The Tuscarora prospect was discovered in 1977 at the north end of Independence Valley approximately 90 kilometers north-northwest of Elko, Nevada. Independence Valley is a fault basin on the west side of Independence Range in the area where the Basin and Range structures abut with the Snake River downwarp. Geothermal manifestations include over twenty-five thermal springs which issue along a 4.8 kilometer linear zone trending north-northeast. A siliceous sinter deposit is present for about 1.6 kilometers along the zone. Water chemistry using a mixing model indicates a minimum subsurface temperature of 216°C.

INTRODUCTION

The Tuscarora geothermal prospect was discovered in the summer of 1977 during the course of regional geothermal reconnaissance in Nevada. Hot Sulphur Springs was sampled and the hydrogeochemical analyses indicated a possible reservoir with a minimum subsurface temperature of 216°C based upon a mixing model.

The Tuscarora prospect comprises approximately 30,000 acres of land. Approximately 16,500 acres are fee leases and the remainder are federal leases. A federal geothermal unit comprising 23,898.56 acres has been approved by the U. S. Geological Survey. The prospect is situated in the low rolling hills at the north end of Independence Valley.

The area is 90 kilometers north-northwest of Elko, Nevada and can be reached by means of Nevada State Highways 225 and 226. Nevada State Highway 226 traverses the east side of the prospect.

During 1978, AMAX submitted a proposal in response to the Department of Energy (DOE) RFP No. ET-78-R-08-0003, Geothermal Reservoir Assessment Case Study and was awarded a contract providing partial funding for exploration at the property. Detailed results of the exploration funded by DOE will be published through the University of Utah Research Institute under DOE contract DE-AC08-79ET27011, Geothermal Reservoir Assessment Case Study, Northern Basin and Range, Tuscarora area.

GEOLOGY

The Independence Mountains are composed of a thick sequence of Paleozoic sedimentary rocks (Figure 1). The present day Independence Range area was located near the tectonic boundary between the miogeosyncline to the east and the eugeosyncline to the west. Several thousand feet of limestones, cherty limestones, siltstones and quartzites of the miogeosynclinal facies accumulated from Cambrian to early Devonian time. To the west, in the eugeosyncline, up to 50,000 feet of chert, siltstone, quartzite and volcanics were deposited. During late Devonian time the rocks were folded, uplifted and the western facies rocks were thrust eastward along the Roberts Mountain thrust.

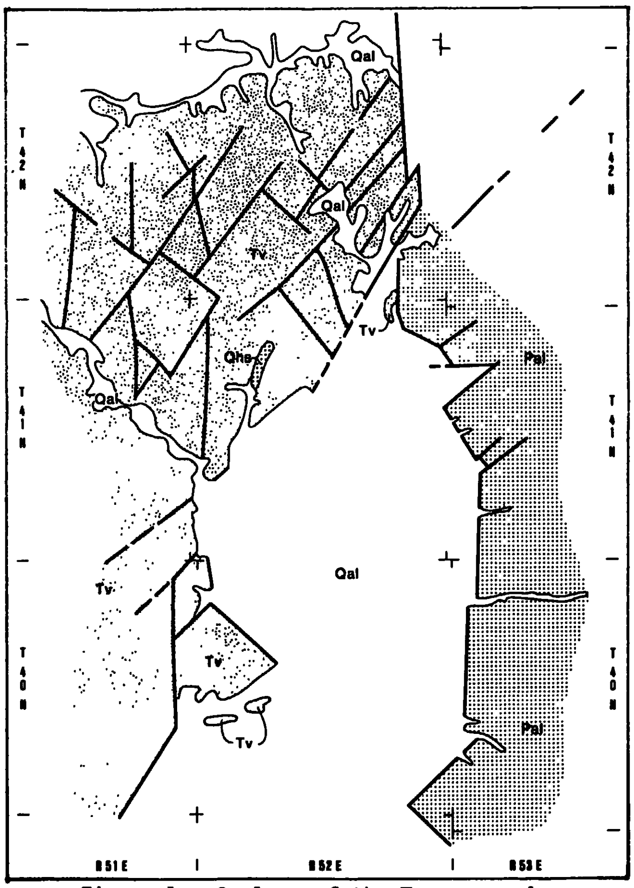

Figure 1. Geology of the Tuscarora Area

Carboniferous and Permian formations in the Independence Mountains consist of siliceous rocks and associated volcanic rocks of the Upper Paleozoic eugeosyncline. The section probably exceeds 10,000 feet but may be in part duplicated by faulting and isoclinal folds.

The Tertiary rocks in the Tuscarora area are a thick sequence of intercalated sediments of fluvial and lacustrine origin with tuffs, crystal tuffs and minor flows of volcanic origin. The rocks range in age from Late Eocene or Early Oligocene (41-34 m.y.) to Late Miocene to Early Pliocene (17-6 m.y.). The Tertiary sediments and volcaniclastic rocks thicken northward into Bull Run Basin where thicknesses of 2,000 to 5,000 feet are reported.

The flanks of Independence Valley contain rather extensive deposits of terrace gravels related to modern streams. The deposits are thin, usually 30 to 60 feet, with a coarse bouldery surface. Recent valley fill and alluvium occur along all major valleys. Siliceous sinter has been deposited by the Hot Sulphur Springs for a considerable period of time.

STRUCTURE

The Tuscarora area has had a long and complex structural history. The Antler Orogeny developed isoclinal folds with east-west fold axes. The deformation culminated in major low-angle thrusts which carried the western facies rocks many miles eastward over the miogeosynclinal rocks.

The earliest Cenozoic structures in the area were volcano-tectonic features associated with the 34-41 m.y. old crystal tuffs. Contemporaneously the area was subjected to extensional forces resulting in Basin and Range structures. Independence Valley represents a basin formed by such extension.

Within the Tuscarora area the Basin and Range structures are offset by two sets of strike-slip faults (Figure 1). The northeast trending left-lateral faults are part of the Midas Trench lineament system. The second set are right-lateral faults which trend northwest and become the dominant structural grain northward into the Owyhee uplift. Movement along these conjugate shear directions began about 15 m.y. ago and has continued to the present.

EXPLORATION

A total of 14 springs in the Tuscarora area were investigated during the 1977 hydrogeochemical reconnaissance program. The following chemical analyses, (Table I), compare our water chemistry for Hot Sulphur Springs with that reported by Mariner, et al. (1974).

Table 1. Chemical Analyses

	AMAX Hot Sulphur Sprs. Sec. 8, T41N, R52E	AMAX Hot Sulphur Sprs. Sec. 5, T41N, R52E	Mariner Hot Sulphur Sprs. Sec. 8, T41N, R52E
Temp.(°C)	95.0	89.0	90.0
Flow(gpm)	100.0	3.0	NA
pH	9.2	7.6	7.0
Cl(ppm)	15.0	15.0	40.0
F	7.6	9.8	7.2
SO	60.0	70.0	18.0
HCO	202.0	320.0	1180.0
CO	93.0	0.0	NA
SiO	170.0	170.0	84.0
Na	150.0	190.0	390.0
K	21.0	17.0	41.0
Ca	1.0	12.0	49.0
Mg	0.2	0.3	13.0
Li	0.8	1.0	0.7
B	1.0	0.9	0.8
NH	0.9	1.1	NA
TDS	704.1	806.7	NA
T SiO °C	167.0	169.0	128.0
T Na/K	227.0	171.0	190.0
T Na/K/Ca	228.0	181.0	191.0

The waters contain relatively low total dissolved solids and are characterized as sodium bicarbonate waters. The discrepancy between the silica and alkali geothermometers is thought to be related to cold water mixing. The Cl-SiO_2-enthalpy mixing model gives a subsurface temperature of 216°C with a cold water fraction of 54 percent. The correlation between the mixing model temperature and the alkali temperature lends credibility to both calculations.

Geophysical exploration at the Tuscarora prospect includes a thermal gradient drill hole program, gravity survey, aeromagnetic survey, electrical surveys and a passive seismic survey. The thermal anomaly constitues the most positive of the geophysical anomalies.

The thermal anomaly at Tuscarora (Figure 2) is based upon data collectd from 38 temperature gradient holes which range from 40 to 522 meters deep. The gradients range from 13 to 2,558°C/km. The heatflow varies from less than 2.0 to as much as 49.1 H.F.U., with a significant area above 10 H.F.U. The temperature at 100 meters is another useful parameter of the thermal anomaly. The maximum measured temperature is 117°C at a depth of 522 meters.

The residual magnetic intensity map (Figure 3) exhibits several significant anomalies. A major magnetic low occurs at the north end of Independence Valley. The two magnetic highs along the north side of the area probably represent intrusions. A series of linear trends along the magnetic contours trend northeast across the map and represent faults associated with the Midas lineament. Magnetic profile inversions indicate a 1.5 km wide alteration zone along Hot Creek with *in situ* destruction of magnetite to a depth of at least 2 km.

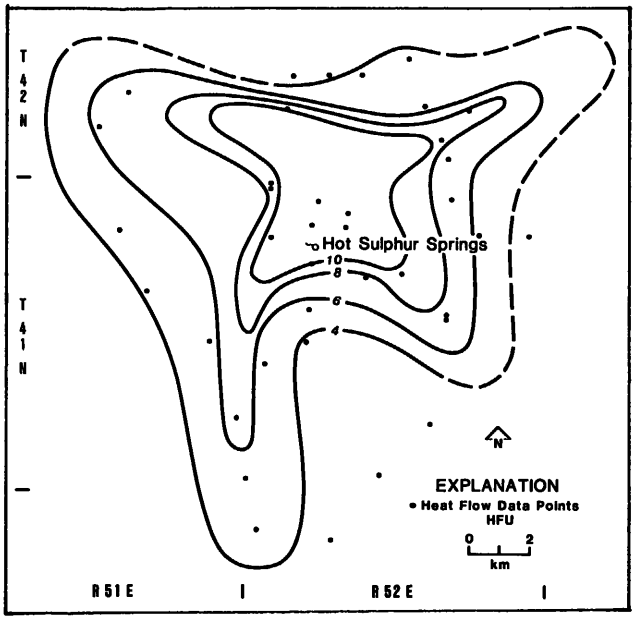

Figure 2. Heatflow

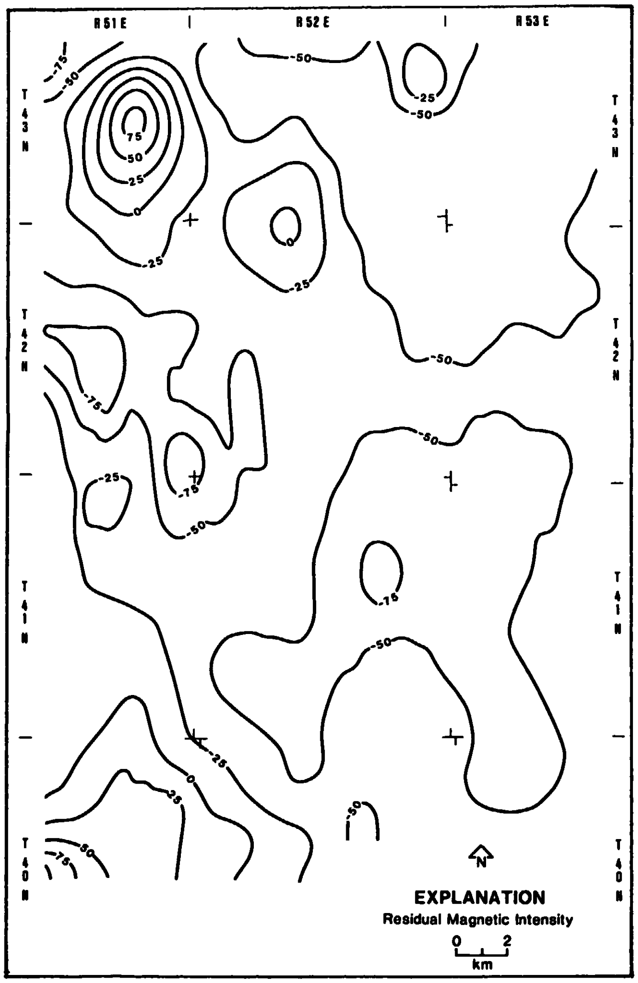

Figure 3. Residual Magnetic

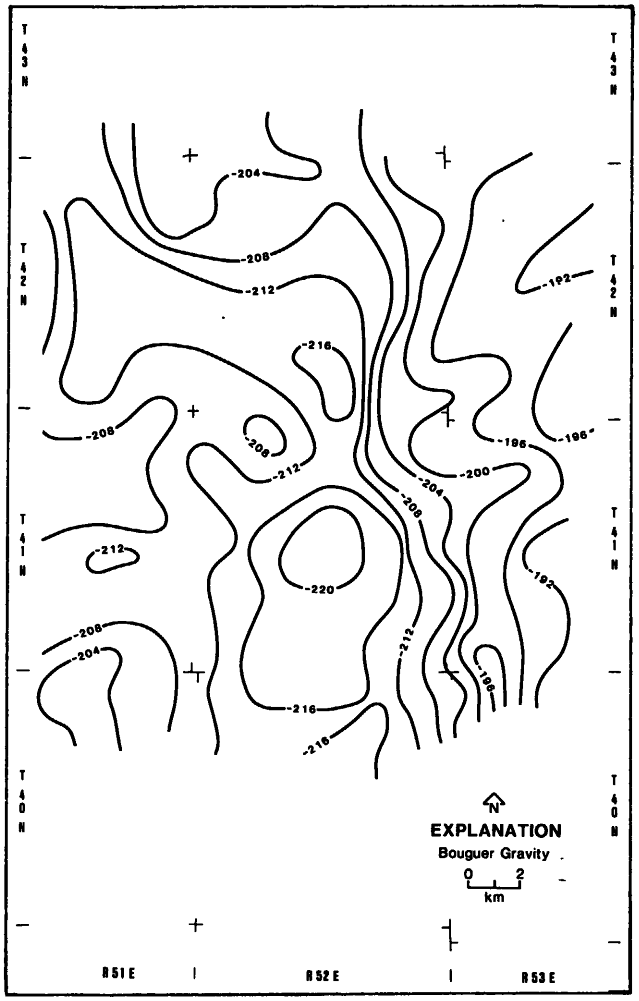

Figure 4. Bouguer Gravity

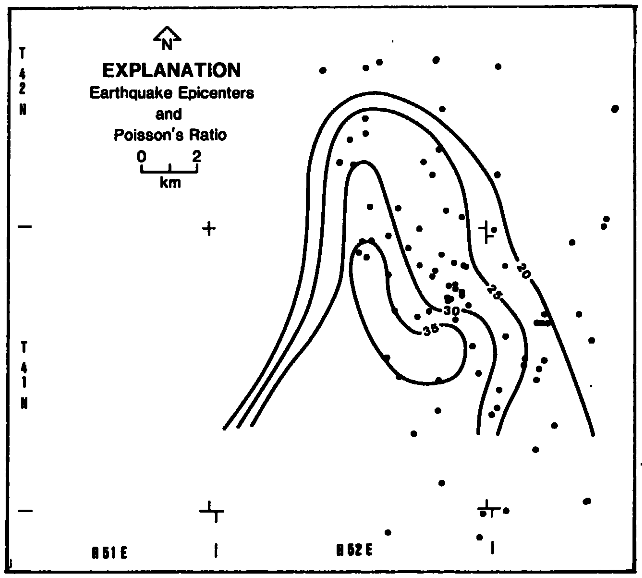

Figure 5. Microearthquake Distribution

The complete Bouguer gravity map (Figure 4) shows the northeasterly trending Midas structure extending across the north-south Basin and Range structure of Independence Valley. The bounding faults of the Basin and Range structure appear as pronounced north-south gradients. A gravity low coincident with the magnetic low occurs at the north end of Independence Valley.

A passive seismic survey was conducted over a 12-day period in September 1978. Figure 5 shows the distribution of the epicenters. In general, the events ranged from 3 to 13 km deep with most below 8 km. The activity is concentrated along a nearly vertical fault which trends northwestward and has a strong right-lateral component. Poisson's ratio is contoured for depths less than 5 km and shows a concentration of high values at the north end of Independence Valley.

Electrical surveys conducted at Tuscarora include a self-potential survey, a dipole-dipole resistivity survey and a magnetotelluric survey. In general, the Midas trend and the resistive rocks of the Independence Range show up on the SP survey. A dipole-dipole resistivity survey was done along three lines across the thermal anomaly. A conductive zone (Figure 6) was found across the high heatflow area. The central anomaly appears to be related to clay alteration and the upwelling thermal waters. The bounding fault of the Independence Range shows up as a pronounced electrical contrast.

A magnetotelluric survey was run along the same lines as the dipole-dipole survey. Two conductors were recognized. A shallow zone is found at the center of the thermal anomaly (Figure 7) which correlates with the dipole-dipole anomaly. A deep conductor occurs along the eastern side of Independence Valley northward to Chicken Summit. The zone correlates with the microearthquake activity and the gravity low. The magnetotelluric profile below the hot springs shows a break in the resistive blocks which may allow communication between the shallow conductive zone and a deep conductor.

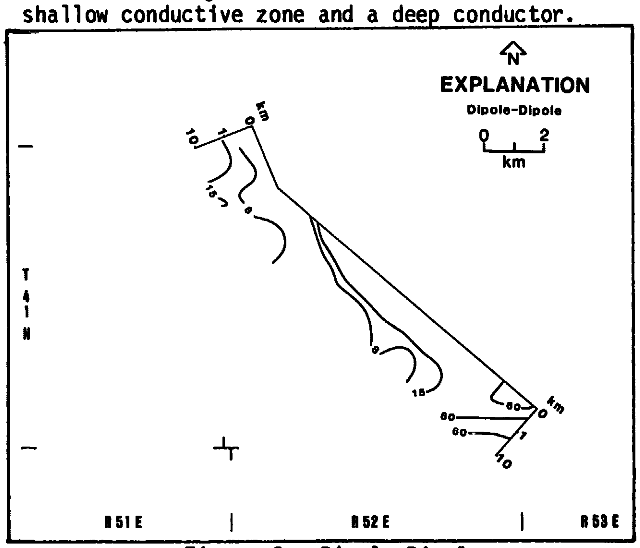

Figure 6. Dipole-Dipole

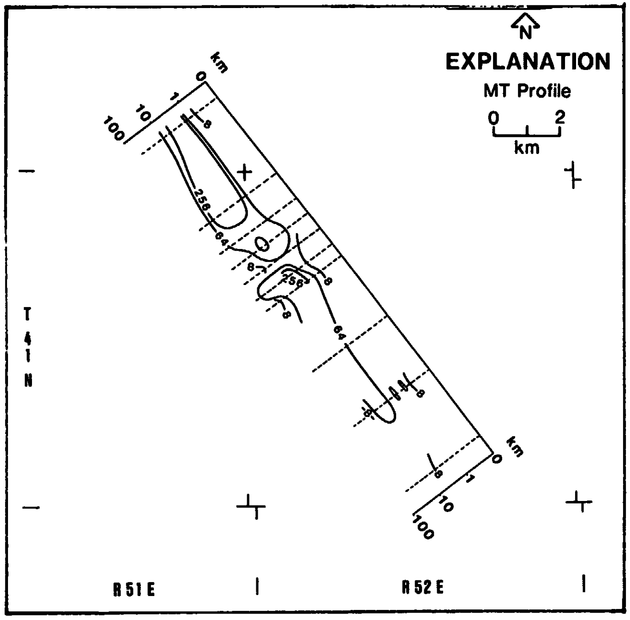

Figure 7. MT Profile

CONCLUSIONS

The Tuscarora prospect is considered to be a prime geothermal target as indicated by:

1. Its location within the Battle Mountain "heatflow high".
2. Favorable water geochemistry which suggests equilibrium temperatures in the range deemed necessary for electrical generation.
3. A significant heatflow anomaly not related to mountain front faults.
4. Coincidence, at least in part, between the aeromagnetic, gravity, thermal and electrical anomalies.
5. If a viable resource is found, the newly constructed transmission line from the Valmy power plant to southern Idaho passes within 30 km of the property.

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