# Application of Self Potential (SP) Surveys and Shallow Temperature Gradient Measurements at a Warm Spring Area Near Hillsboro, New Mexico

**James C Witcher[1] and Howard P. Ross[2]**

[1]Witcher and Associates, PO Box 3142, Las Cruces, NM, 88003, jimwitcher@zianet.com
[2] Salt Lake City, UT, 84121

The self-potential (SP) method is most useful in early geothermal exploration. SP measures natural voltage differences at the surface and is inexpensive with two persons able to conduct a survey in a short-time frame. Required equipment includes: 1) 1,000 m of light-weight single conductor wire, 2) a high impedance digital voltmeter, and 3) copper-copper sulfate, porous-pot electrodes. One electrode provides a stationary base station, a second, a weather-elements protected and stand-alone electrode in the field is for drift corrections, and a third is a roving electrode. In practice, a radial survey allows many measurements at 60-m or less spacing and facilitates anomaly shape and magnitude characterization. Contrasts in subsurface electrical conductivity, high temperature gradients, and moving subsurface fluids can create SP anomalies. Cultural and telluric interference, electrode drift, infiltration from recent precipitation, and very dry soil with poor electrical subsurface connection can contribute to measurement noise. Typically, 2 millivolts (***m***V) data accuracy is possible with survey attention to soil moisture, drift, and brief telluric disturbance.

High-precision temperature logs of shallow small-diameter boreholes that are completed with water-filled, small-diameter pipe which is capped on the bottom and the annulus back-filled filled with grout can provide detailed subsurface formation temperature information and be cost effective. Measurement of thermal conductivity of drill core or cuttings allows detailed heat flow calculation.

The Hillsboro Warm Springs discharges 38°C, sodium-bicarbonate-sulfate water from a developed spring tank on top of a low mound with siliceous (opal ) deposits. Older opal deposits exist beneath thin colluvial cover in an apron surrounding the spring mound that extends laterally to a local and prominent jasperiod exposure of the Berrenda fault east of the springs. Spring aqueous Na-K-Ca and quartz geothermometers of 174 and 161°C and the presence of opal deposits infer potential for an intermediate-temperature geothermal system. The springs discharge is outboard 300 m to the west on the hanging wall of the exposed Berrenda fault on the Animas Mountains western margin.

Our SP survey, conducted during November, 1992 and November, 1997, consists of 8.3 line-km with 30 to 60 m spacing over approximately 2 km$^2$ centered on the warm springs. Positive SP, 0 to 25 ***m***V, is recorded adjacent the Berrenda fault at higher elevations. A positive closure of 34 ***m***V within this zone overlaps the Warm Spring. A small bipolar minimum anomaly of -10 to -23 ***m***V coincides with gradient hole SRC-1124-1 that shows formation up flow with gradients ranging from 400°C/km at 20 m depth to 175°C/km at 74 m depth and a bottom hole temperature of 80.3°C.

An area of approximately, 4 km$^2$ was explored with seven temperature gradient holes by NMSU and funded by Steam Reserve Corporation, Denver in the 1980's. Conductive temperature gradients ranged from 50-to-400°C/km. Using, an estimated thermal conductivity of 1.8 W/m°K, the total heat flux for the Hillsboro Warm Springs system is estimated to be about 8 MWt with a background 90 ***m***Wm$^2$ regional heat flow.

## Keywords:

aqueous geothermometry, heat flow, Hillsboro, SP, temperature gradient, warm springs

---