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October 2, 1978

SHALLOW 1-2 METER THERMAL SURVEYS

Shallow 1-2 meter thermal surveys have been done in several geothermal areas to delinate zones of anomalous temperature prior to the exploratory drilling or other geophysical surveys. Excellent results have been obtained where the anomalous heat was very near the surface and corrections for soil variability, albedo, diurnal effects etc. could be calculated or negated where the corrections or effects have much smaller magnitude than the thermal anomally.

Due to the inexpensive equipment and speed with which a shallow thermal survey may be performed, it is a best, first survey of a geothermal prospect where very shallow thermal waters are suspected. The survey would map near surface bodies of hot water. When used in conjunction with other geophysical and geochemical data, a map of near surface hot water could then be interpreted for zones of fractured rock and faults, or for shallow acquifers that are channeling hot water.

The equipment used in shallow thermal surveys is relatively unsophisticated, easily and inexpensively built. Equipment used in an actual survey consists of calibrated thermisters and a digital ohm-meter. The thermisters may be constructed out of 1 to 2 meter lengths of stereo speaker wire. The speaker wire is tipped with a high quality semi-conductor enclosed by silicon cement for protection. All of these materials may be purchased locally through stores such as Radio Shack. The digital ohm-meter in the Arizona Bureau of Geology's well temperature logging equipment may be used to calibrate thermisters and perform resistance readings during the survey. A temperature bath is used to calibrate each thermister. The resistance of each thermister is taken for two different temperatures. The following formula is used to determine the thermister constant of each thermister.

Equation 1:

$$\frac{Ro(T)}{Ro(To)} = e^{B\left[\frac{1}{T} - \frac{1}{To}\right]}$$

Where Ro(T) = resistance at absolute temperature T

Ro(To) = resistance at absolute temperature To

e = 2.718

B = a constant depending on construction and materials of each thermister

A temperature curve is then constructed for each thermister by plugging the thermister constant back into equation 1 and keeping T, Ro(T) constant and using different values for To to solve for Ro(To).

The shallow temperature survey has several problems which complicate interpretation. The considerations are:

(1) Diurnal solar heating variations

(2) Annual solar heating variations

(3) Aperiodic solar heating variations

(4) Albedo

(5) Surface roughness (important because heat may be more readily conducted away from soil by turbulent air flow over rough ground)

(6) Variation of soil heat conductivity

(7) Slope and exposure of terrain

(8) Elevation variations

(9) Variation of groundwater level and groundwater movement and recharge

(10) Vegetation

(11) Depth to bed rock

The solar heating variations 1, 2 and 3 may be mostly negated if the readings on the thermisters are taken over a few hours. A base station is established at the beginning of the survey and may be used to correct for solar heating variations during the survey. The thermisters should be implaced for 24 hours to allow for temperature equilibrium. Albedo, surface roughness, variation of soil heat conductivity, vegetation variations, slope and exposure of terrain may be minimal if care is taken in choosing sites with similar soil and mositure content, similar type vegetation, relatively flat or uniform slope, and similar exposure. The survey should be done in dry weather with low-speed winds. Corrections for elevation maybe necessary. The adiabatic change in temperature with elevation is used to make that correction. The variations caused by ground-water movement, level, and recharge may present interpretation problems. The depth to bed rock, when bed rock is covered by a thin cover of alluvium such as is found in the Southwestern bajada, may present similar interpretation problems. However, the shallow temperature survey is not intended to give unique solutions and is to be used with other geophysical data. Therefore, these problems may be recognized. Also, shallow heat sources of high temperature will probably give very high magnitude changes with steep-bounding gradients. For best results, 2 or 3 surveys over several months would correct for vegetation, exposure, surface roughness and diurnal effects that are the result of soil heat conductivity. Several base station thermistors would be established with readings taken at each site during the survey while leaving the base station thermisters in place. The data would then be corrected and compiled into a single map for interpretation along with other data.

Additional equipment for shallow temperature surveys would include a small two-man auger, a set of sieves for soil analyses, a balance for weight measurements on sieve separations, a small hot plate to dry soil samples, and a plane table and alidade with a stadia rod to facilitate rapid location of thermistor sites.

The shallow thermal survey is useful in Arizona's basin and range where very hot water has been observed at shallow depths. The technique would provide a rapid, inexpensive temperature map of such an area for interpretation of the source or conduit for the thermal waters.

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