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Telluric profiling studies in the Penrose Area, Colorado

by

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During 1980, the U.S. Geological Survey conducted geophysical studies east of Canon City, Colorado, as part of a geothermal evaluation program. The work was done in cooperation with the Colorado Geological Survey.

Three E-field-ratio telluric profiles were made approximately 13 kilometers east of Canon City, and 3 kilometers southwest of Penrose, Colorado (see Fig. 1). The traverses were between 5 and 13 kilometers in length and trended west-northwest to west. The purpose of the traverses was to locate major north-trending faults that displace the Precambrian bedrock but have little or no surficial expression. These faults could provide channels for the upflow of geothermal waters. Warm water (25°C) has been found in several wells drilled in the region.

The geology of the area has been mapped regionally (Scott and others, 1978) and some detailed work has been done by Weimer (1980). The study area lies within the Canon City embayment, just south of the southern terminus of the Front Range. The sedimentary section has been folded resulting in thickening of the Mesozoic and Paleozoic sedimentary rocks above the Precambrian bedrock. No major faults have been mapped, but well data suggest that north-trending faults associated with anticlines and synclines create horst and graben structures in the subsurface (Weimer, 1980). A few kilometers south of the study area (east of Florence), the sedimentary section thickens from 1100 meters (4.5 kilometers south of station 4E, line 3) to 2700 meters (6 kilometers south of station 14W, line 3) over a horizontal distance of 4500 meters (see figure 2 for station locations). Weimer has attributed the thickening to a zone of "steep dip" associated with faulting in the basement on the flanks of the Brush Hollow anticline (Fig. 2). This zone has created a deep (2500-meter) basin between the Brush Hollow anticline and Canon City.

None of the faulting has obvious surficial expression; the local terrain is fairly flat, dipping slightly to the east. The surface exposures are mostly Quaternary alluvium and the Cretaceous Pierre and Niobrara Shales.

The locations of telluric traverses are shown in figure 2. The profiles, which show the relative telluric voltage at a period of 30 seconds referenced to dipole 0-1 on each line, are given in figures 3 through 5. These figures plot the relative voltage changes (proportional to the square root of resistivity) along the traverses.

The telluric instrumentation and method have been described by Beyer (1977). For this survey the bandwidth of the recording system was 20-40 seconds (0.025-0.05 hertz) which results in a maximum depth of exploration (skin depth) of many kilometers in normal earth material. As a rule of thumb, changes in resistivity can be detected at about 1/2 a skin depth. In 20 ohm-meter material the skin depth is 13 kilometers.

Along traverse 1 (fig. 3) there is an increase in voltage (resistivity) westward from station 7 as the contact between the Niobrara and Pierre is approached. This increase could be caused by either a lithology change or an upfaulted basement block to the west. East of station 7 the profile is quite flat, although two lows with an approximate 10% decrease in voltage occur between stations 3 and 4 and near station 6. These could be expressions of faulting. There appears to be no reflection of the Brush Hollow anticline in the data at its inferred location near station 2, although there is an increase in voltage eastward from station 3, which may be attributed to it.

Traverse 2 (fig. 4) shows two low-voltage zones, one between stations 2 and 6 and another west of station 8. These again could be indicative of faulting with upthrown blocks between stations 6 and 8 and east of station 2. The eastern low may also be an expression of the syncline shown on figure 2.

Traverse 3 was located south of lines 1 and 2 and extended west into the zone of steep dip proposed by Weimer. The changes in voltage along the profile (fig. 5) are large, varying by almost one order of magnitude. The voltage drops indicate three low-resistivity zones: one west of station 8W, one between stations 4W and 1E, and one east of station 4E. These zones probably represent downthrown and tilted fault blocks, with the largest displacement occurring in the eastern and western lows. These possible faults could be located approximately at stations 4E, 0, 4W, and 8W with downthrown sides toward the telluric lows. The voltage changes could also be the result of folding and thickening in the sedimentary section. The low centered between stations 6 and 8 east coincides with the inferred mapped syncline axis, and the shallower high between stations 2E and 4E coincides with the Brush Hollow anticline. The zone of steep dip extends west from station 8W and may reflect thickening of the Pierre.

Combining the results from the three profiles, locations of inferred major faults are plotted on figure 2. The faults can be projected from line to line, revealing the northward trends shown. The major faults lie on the flanks of the anticline and on the edge of the zone of steep dip. Extensions of the two westernmost inferred faults aline with faults located by two seismic lines to the south (Zacharakis, 1980). The two faults between the Brush Hollow anticline and the syncline are probably part of a complex structure. At station 3E on line 3, the axis of the telluric ellipse was rotated 90^{o} from its normal trend, signifying 3-dimensional structure at depth.

It should be noted that these interpretations are speculative and based on geophysical data alone, since the geology of the area is not well mapped and all structures and contacts are approximate.

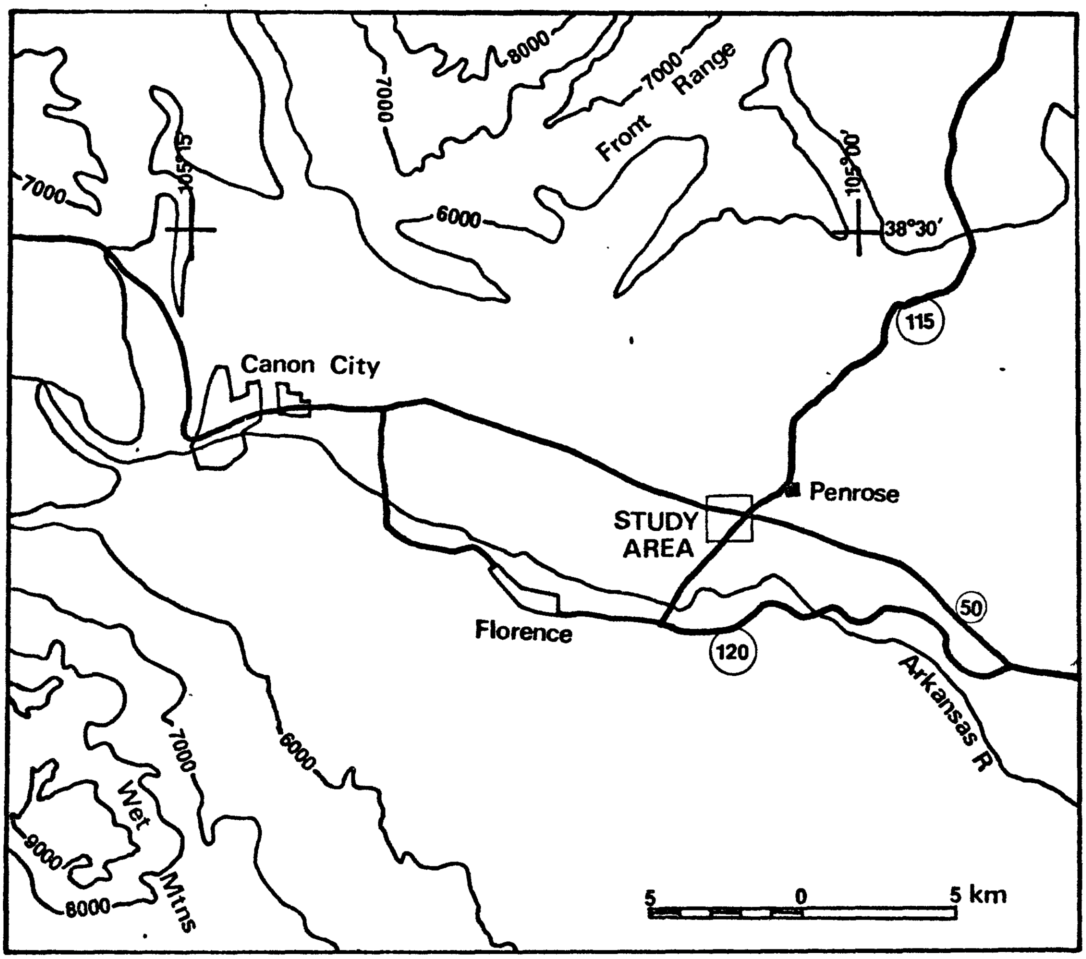
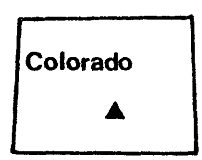


Figure 1. Location of study area.

Contour interval 1000 feet (305 m).



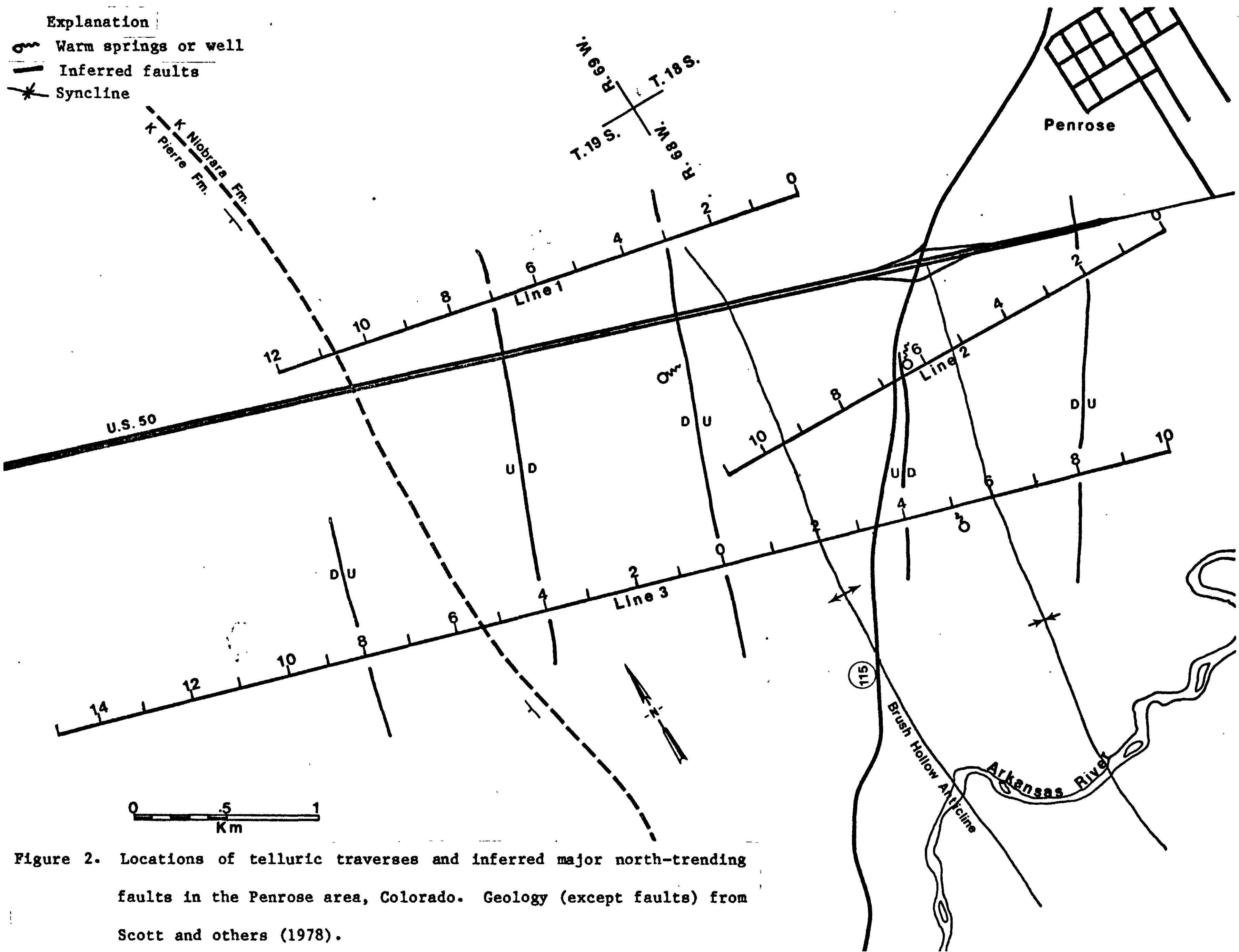


Figure 2. Locations of telluric traverses and inferred major north-trending faults in the Penrose area, Colorado. Geology (except faults) from Scott and others (1978).

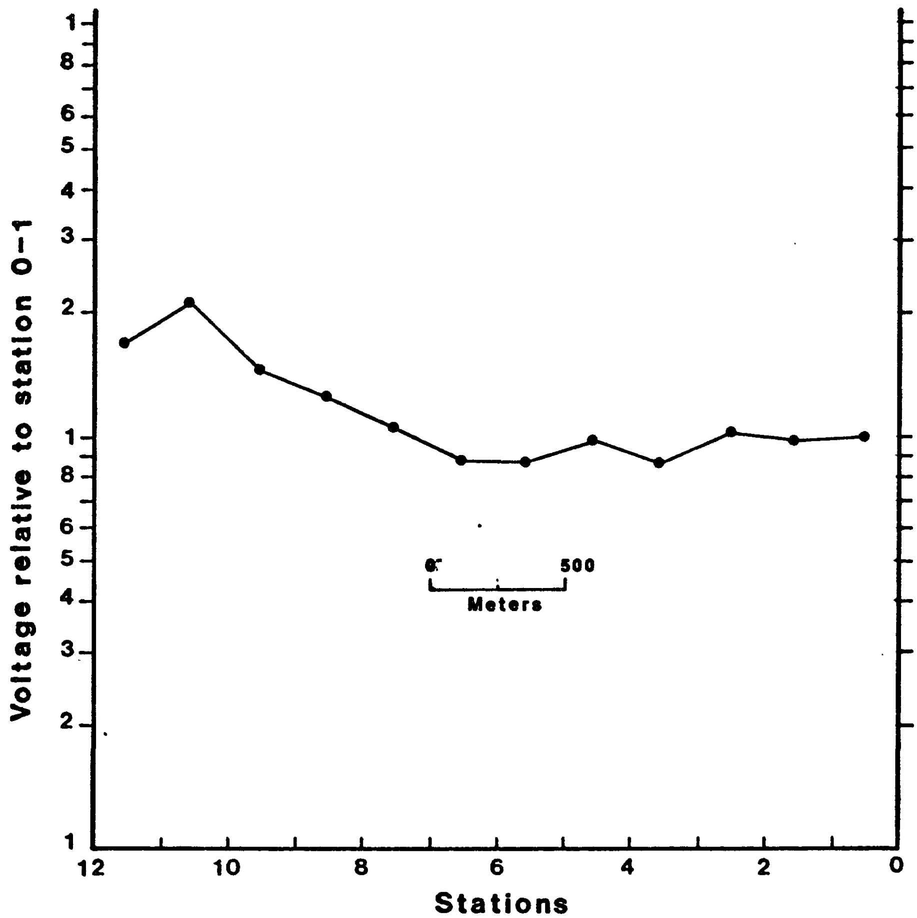


Figure 3. Penrose area, Telluric traverse 1

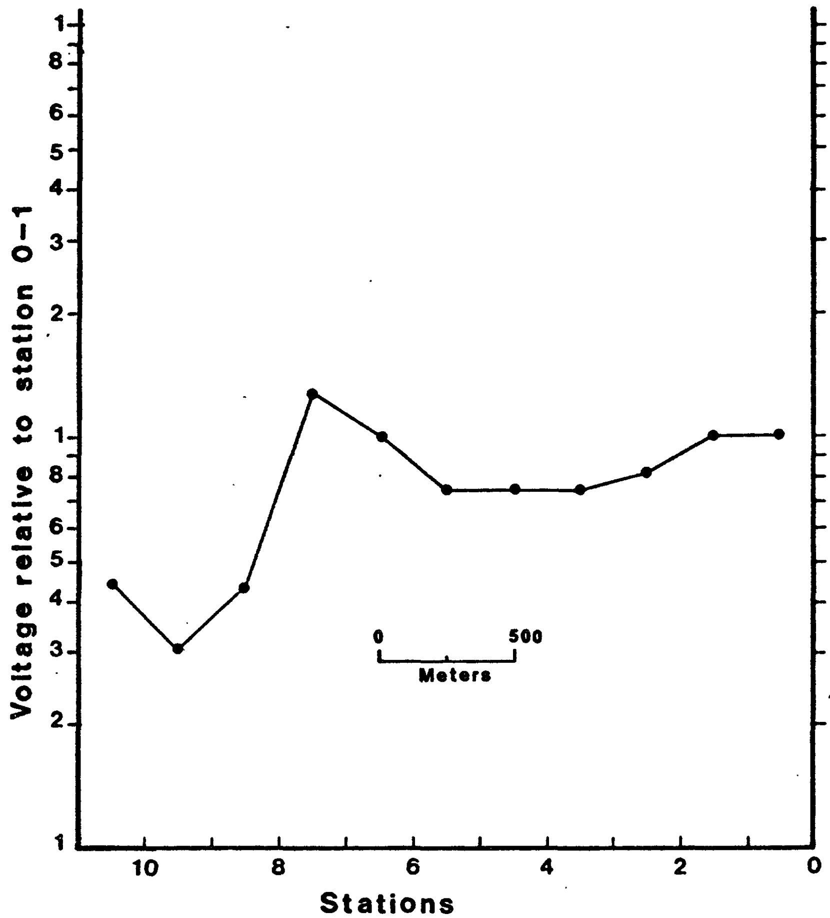


Figure 4. Penrose area, Telluric traverse 2

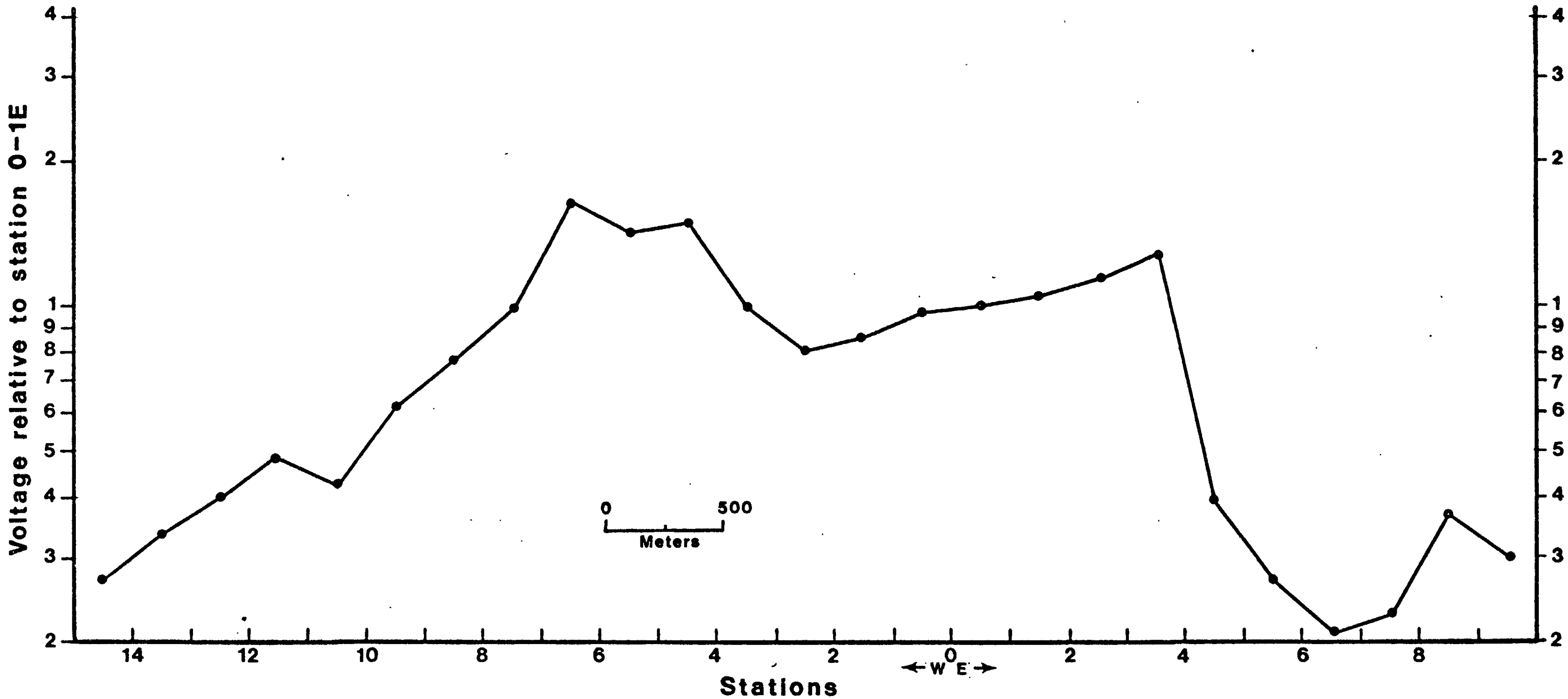


Figure 5. Penrose area, Telluric traverse 3

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