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TELLURIC CURRENT SOUNDING NEAR KILBOURNE AND HUNTS HOLES, NEW MEXICO

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The telluric content method utilizes natural electromagnetic phenomena known as geomagnetic micropulsations which are almost continuously present. The measurements consist of simultaneous recording of the horizontal component of the electric field at two sites, such as base and rover sites. If we know the subsurface configuration at the base site and the behavior of the electric fields at both the base and rover sites, we may deduce the subsurface configuration at the rover site. Telluric soundings can delineate anomalous low-resistivity areas, at depths greater than a few kilometres, which complements the shallower sounding methods such as AMT and D.C. soundings. The assumptions on which the telluric method is based and the properties of the relative ellipse area J, its geologic significance, and its dependence on frequency are stated by Berdichevskii (1960). For example, the assumptions usually made are that the earth consists of conductive layers over an insulating basement and that the thickness of the layers is much less than a wavelength in the earth. The J value is then equal to the ratio squared of the conductance at the base site to conductance at the rover site. Conductance, $S = \sum_i \frac{h_i}{e_i}$ where h_i and e_i are the thickness and resistivity of the ith layer.

The survey utilized a conventional L-shaped electrode and configuration with electrode spacings of 300 m. The data acquisition and reduction were done by means of the vectogram technique (Yungul, 1968). The data consist of hodographs, which approximate ellipses, of the telluric field drawn on X-Y recorders. Areas of closures measured from the ellipses are used to compute the J values. The band pass of the telluric system is between 0.1 and 0.014 Hz with the predominant activity at 0.04 Hz. A total of 22 sites were occupied with approximately 5-km spacing. Two stations were reoccupied and found to be with ±10% of the previous computed J value.

The J x 10 contoured values (Fig. 1), show two anomalous high-conductance areas, Kilbourne and Hunts Holes. A J x 10 value below 10 indicates a higher conductance than the base station. One-dimensional analytical models were generated for the base station and Kilbourne Hole location (Table 1). The model parameters are from interpreted Schlumberger soundings (Jackson and Bisdorf, this guidebook) with a high-resistivity basement layer (e = 10,000 ohm-m) added on a depth of 7 km. Apparent resistivities were computed from these models for 7.5 and .04 Hz, which are the AMT and telluric sounding frequencies. The apparent resistivity measured by AMT method (Hoover and Tippens, this guidebook) and the computed apparent resistivity for both sites agree quite well and give an approximate depth-of-penetration of 1 km, which is similar to the Schlumberger sounding depth. Assuming the conductance of the section at the base station to be accounted for by the Schlumberger sounding interpretation, the conductance at the Kilbourne Hole site was calculated from the telluric J value and is considered the observed conductance. But the differing model and observed conductance at Kilbourne Hole indicates low-resistivity material at a greater depth than the AMT or Schlumberger sounding penetrated. For example, increasing the thickness of layer 5 by 0.5 km would account for the higher conductance observed by the telluric method. In using one-dimensional models in interpretation, the model conductance at Kilbourne Hole is actually underestimated, since, for a feature such as Kilbourne Hole which has lateral dimensions of less than a skin depth, the J values are greater than the J values over a structure having the same vertical section with much larger horizontal dimensions. That is, there is actually a greater difference between observed and modeled conductance than shown in Table 1. Since we do not have a telluric site between the two holes, we do not know if the highly conductive layer is continuous between the holes.

REFERENCES

Berdichevskii, M. N., 1960, Electrical surveying by means of telluric currents [in Russian]: Gostoptekhizdat, Moscow, USSR; English translation by G. V. Keller, 1965, Colorado School Mines Quarterly, v. 60, no. 1, p. 1-216.

Yungul, S. H., 1968, Measurement of telluric relative ellipse area by means of vectograms: Geophysics, v. 33, p. 127-131.

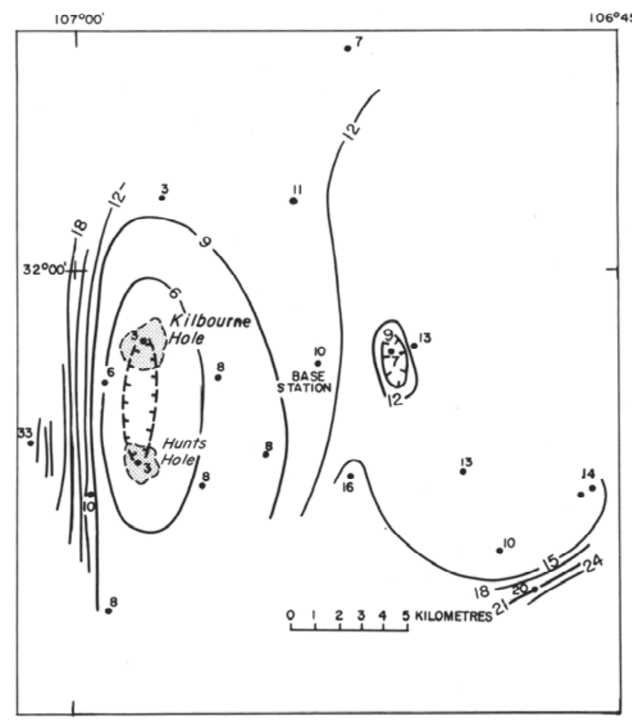

Figure 1. Telluric anomaly map showing contours and J x 10 values for stations (+), Kilbourne Hole and vicinity, New Mexico.

Layer	Resistivity (Ω-m)	Thickness (m)	Conductance (mhos)	Apparent Resistivity and Conductance	Field Observations
	Interpreted Resistivity Sections *Base Station*				
1	100	100	1.0	e_a (7.5)=15	e_a (7.5)=10
2	31	300	9.7	e_a (0.04)=29	------
3	2	500	250.00	S=321	S (Telluric assumed)=321
4	100	6,000	60.00		
5	10,000	---	---		
	Kilbourne Hole				
1	50	50	1.	e_a (7.5)=11	e_a (7.5)=8
2	4	50	12.5		
3	100	50	0.5	e_a (0.04)=22	------
4	10	500	50.0		
5	2	500	250.0	S=374	S=$\frac{321}{\sqrt{J}}$=586
6	100	6,000	60.0		
7	10,000	---	---		

Table 1. Models from Schlumberger soundings with insulating basement and apparent resistivity for 7.5, 0.04 Hz with conductances.