ELECTROMAGNETIC DIRECTION FINDING EXPERIMENTS FOR LOCATION OF TRAPPED MINERS

R. G. Olsen and A. J. Farstad
Westinghouse Electric Corporation
Georesearch Laboratory
8401 Baseline Road
Boulder, Colorado 80303

The Coal Mine Health and Safety Act of 1969, passed by Congress in the wake of the disaster at Farmington, West Virginia, led to an extensive study by the National Academy of Engineering of the problems involved in coal mine safety.[1] One of the results of this report and subsequent research conducted by the U.S. Bureau of Mines has been the investigation of electromagnetic techniques for the location of trapped miners after a mine emergency. The Westinghouse Georesearch Laboratory has been involved in both the theoretical and field studies relating to this problem[2].

A compact personal beacon transmitter has been developed which can be attached to and powered by a miner's lamp battery. A compatible lightweight loop antenna package has also been developed which can be easily carried on a miner's belt. This antenna can be quickly deployed on the mine tunnel floor. For the purpose of calculating its electromagnetic fields on the earth's surface, the loop can be considered to be a magnetic dipole buried in the earth. (The earth is assumed to be homogeneous and to have a conductivity of σ mhos/m.) The surface of the earth is assumed to be uniformily sloping and the transmitter dipole oriented as in Figure 1. The fields on the earth's surface can be computed by using a superposition of the fields of a vertical magnetic dipole[3] and of a horizontal magnetic dipole[4] in proportions which depend on the slope of the terrain.

In the case of level terrain a null in the horizontal magnetic field occurs on the surface directly above the dipole[5]. This null is designated as the apparent source location and is the criterion by which the source is located. The criterion was tested at two hardrock mines and two coal mines in the fall of 1972. The apparent source locations were compared to actual locations determined by conventional surveying techniques. It was found that due to nonlevel terrain the apparent and actual source locations differed by up to 13 meters. This discrepancy can be resolved by an examination of the fields of a source beneath uniformly sloping terrain.

Figure 2 shows the experimental and theoretical results for a

case where the hill slope is 15° (H_ρ is the horizontal field, and H_z is the vertical field.) The null is displaced downhill by an amount which depends on the depth of the source, the ground conductivity, and the hill slope.

These results can be used to improve the location technique. If the apparent source location is known along with the ground conductivity, hill slope, and approximate source depth, the theoretical null offset can be used to obtain the actual source location.

References

1. G. Meloy, et al (1969 Mine Rescue and Survival, Nat. Acad. Eng.)

2. D. B. Large, L. Ball and A. J. Farstad (1973 IEEE Trans. Comm. Tech., vol. COM-21, No. 3, p. 194-202).

3. J. R. Wait (1971 Proc. IEEE, v. 59, n. 6, p. 1033-1035).

4. A. K. Sinha and P. K. Bhattacharya (1966 Radio Science, v. 1 (New Series), n. 3, p. 379-395).

5. J. R. Wait and L. L. Campbell (1953 Jour. Geophysics Res., v. 58, n. 2, p. 167-178).

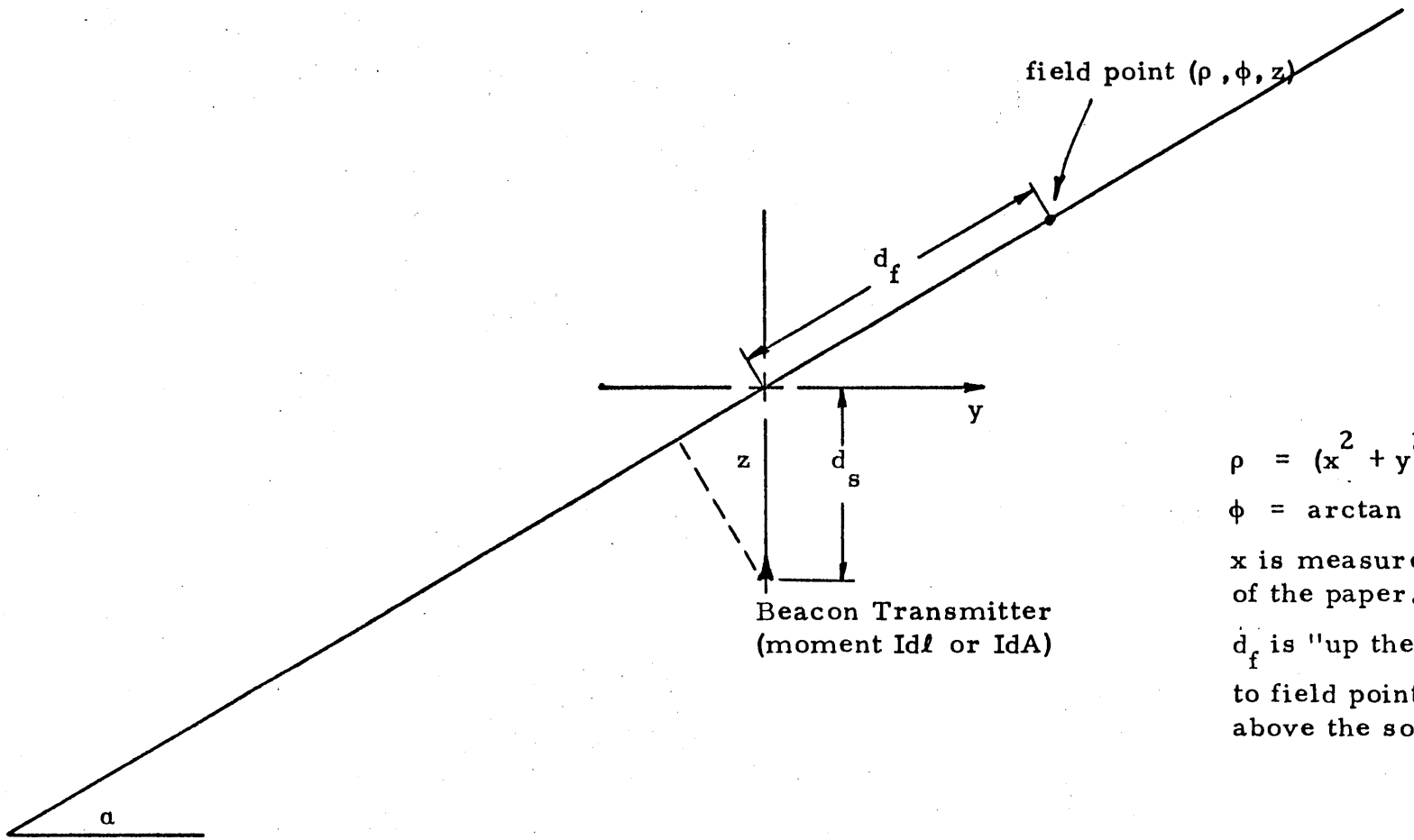

FIGURE 1 - DIPOLE LOCATED BENEATH A SLOPING INTERFACE AND COORDINATE SYSTEM IN WHICH FIELDS ARE TO BE REFERRED

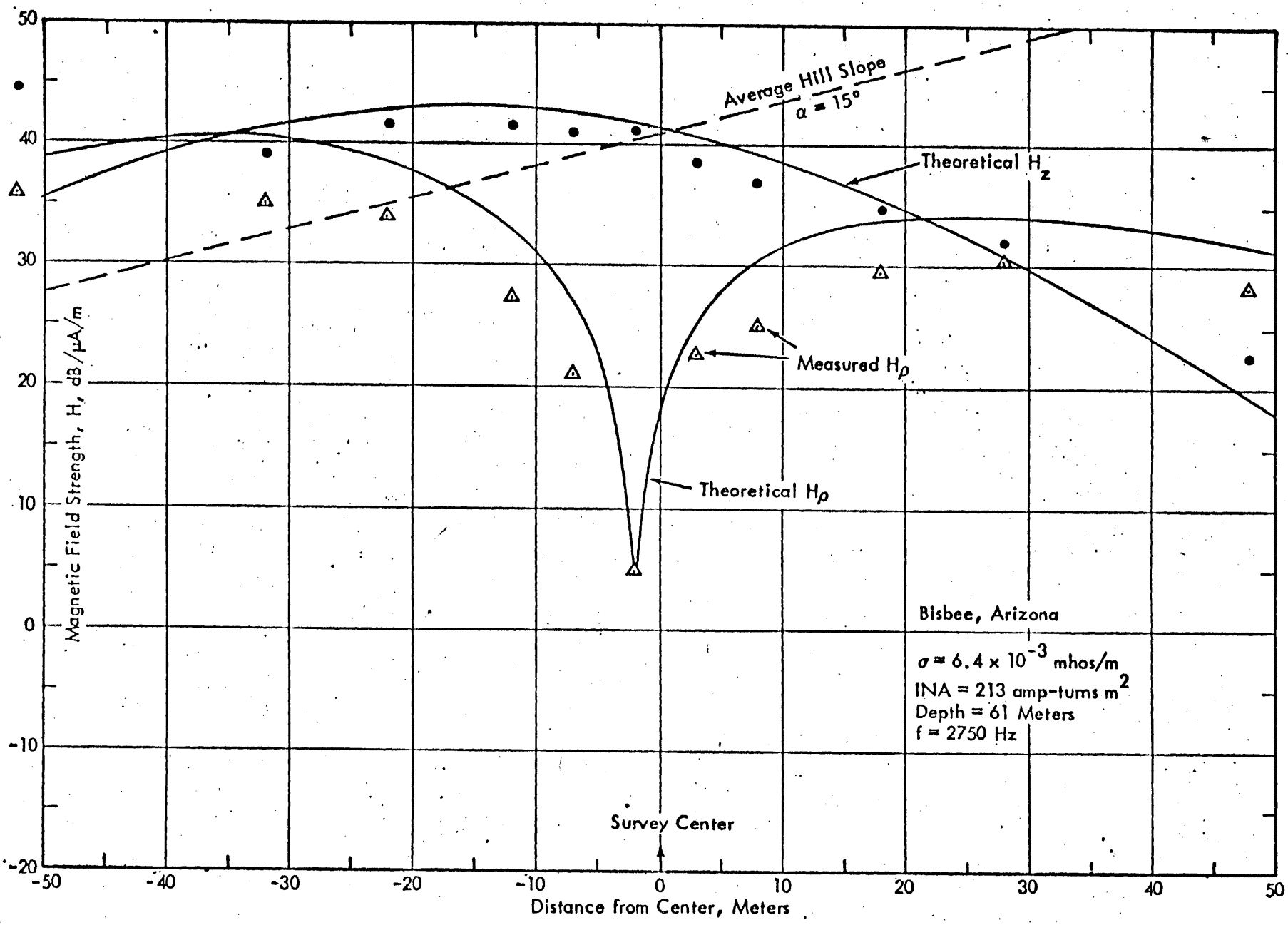

Figure 2. Electromagnetic Surface Pattern from Buried VMD (Along Hill Slope)