SOME ASPECTS OF MAGNETOTELLURIC FIELD PROCEDURES

LAUST BÖRSTING PEDERSEN

Department of Solid Earth Physics, University of Uppsala, Box 556, S-751 22 Uppsala, Sweden

Abstract. Progress in magnetotelluric field procedures that has taken place over the past few years is reported upon. These include calibration procedure of equipment, misorientation effects, recording characteristics, in-field processing and trend towards future developments.

1. Introduction

The improvements in the quality of magnetotelluric data has taken place since the pioneering years in the fifties and sixties can be attributed both to better electronic amplifiers and hence better signal to noise ratios of the magnetic and electric sensors as well as to the introduction of digital data acquisition systems, which compared with analogue systems have a much better dynamic range.

Fischer (1982) in his review also emphasizes the improvements obtained by using SQUID magnetometers with their superior noise figures and the remote reference technique to reduce bias from impedance estimates. The papers by Gamble et al. (1978), Gamble et al. (1979a, 1979b) have now become classical papers on these subjects.

Since the publication of Fischer's review it can perhaps be said, that no major steps forward have been taken in improving measurement techniques and instrumentation. Probably the most important step is that it has now become common use to perform some kind of in-field processing to ensure good data quality before the measurement site is abandoned and a new site is occupied.

I feel that time has come to discuss some effects that will always be problematic irrespective of the sophistication in equipment and processing techniques. A list of questions were sent out to 50 groups around the world dealing with MT-studies. The questions included such topics as calibration, noise characteristics, recording parameters, controlled source/natural source, in-field processing, in-field interpretation and future trends.

10 MT-groups gave their comments and answers to some of the above points, and I shall in the next paragraphs discuss some of these. Unavoidably my presentation is biased from my own experiences gained from using a rather conventional system with induction coil magnetometers and digital acquisition with in-field processing with the possibility of local as well as of remote referencing.

2. Calibration Procedures

Most groups use fixed bands for recording data. 2 decades seem to be a typical bandwidth. Calibration is done for all channels at a number of frequencies distributed sufficiently close that the transfer functions are adequately sampled. Our group employs a special technique in which the output current of a sine generator coupled in logarithmic sweep mode is monitored via electric sensor input amplifiers. This signal and the corresponding outputs from input amplifiers are regarded as input and output, respectively, to a filter whose transfer function has to be determined. To avoid bias problems we determine transfer functions in narrow frequency bands, typically 20 points per decade, and calibration is usually done over a total bandwidth of 2 decades in one run. Truncation effects of FFT are reduced by using very long time series, typically 32 k points.

The normal procedure for calibrating induction coils is to place them in long cylindrical coils laid out horizontally on the ground. An interesting procedure, reported by the Hungarian group (Varga and Verő (1986)), applies a big horizontal circular loop as magnetic field generator. In the middle of the loop the antenna to be calibrated is placed vertically into the ground. The advantage is that the ambient magnetic field variations in the vertical direction can be made much smaller than the horizontal variations if the calibration site is properly selected. The Hungarian group performs such an absolute calibration once every year, but in addition they also perform a relative calibration in the center of each frequency band at each new site to test the stability of each channel. Secondary fields due to induced currents in the ground as well as capacitive leakage between the loop and the ground puts a limit to the use of this configuration at higher frequencies as pointed out by Vozoff (1961) and Wait (1961).

3. Representation of Transfer Functions of Electric and Magnetic Channels

The point values of transfer functions are either interpolated to any frequency of interest by interpolation or by fitting in each frequency band a polynomial of higher order. If transfer functions vary close to linear as a function of frequency the polynomial fitting procedure will work satisfactorily, but if the transfer functions include effects of bandpass or notch filters it is better to use some interpolation scheme to represent transfer functions between measured frequencies.

4. Noise characteristics

a. INSTRUMENTAL NOISE

The best way to measure instrumental noise is theoretically to place magnetic