CAPACITIVE COUPLED ARRAY-THE NEW TYPE OF SENSOR FOR RECEIVING RESISTIVITY VALUES IN GEOPHYSIC TECHNIQUE

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Abstract: Ground resistivity conditions in a variety of geological environments were measured using a technique that does not rely on galvanic contact between the sensors and the terrain. The capacitive-coupling method converts a current applied through one pair of antenna and a voltage potential received though another. By the way, we have received the apparent resistivity value corresponding to every particular constant K which is also dependent upon the geometry of the antenna arrays (called nongrounded dipole). Thus this way allows taking apparent resistivity values of a survey. Because contact resistance problems are obviated, surveys in very resistive conditions (>10000 ohm-m) can be conducted [1]. However, it is good to use the method in the difficult area (for example, a boggy ground area, a frozen ground area or concreted area...). Because of that, to find a good form for the antenna arrays using in this method is needful. This paper want to introduce this method (CCR: capacitive-coupling apparent resistivity method) and some our experimental results with the new forms of capacitive coupling arrays.

1. Electromagnetic fields of currents

The electromagnetic field associated with the current in the ground is not so easily understood intuitively. If the ground is made up of uniform layers the resulting fields measured on the surface are independent of the ground conductivity and so depend on the magnitude of the current and the geometry of the source current line and the location of the sensor used. If the ground is inhomogeneous the symmetry of the result is broken and anomalous fields appear which depend on the variations in the conductivity. The apparent resistivity is a function of the frequency of the applied current. The way, the switched DC current and the alternating voltage is applied can represent by the equivalent circuit across the sample or between the field electrodes which has the form as figure 1. At DC the capacitor is an open circuit and all the current passes through the sum of R1 and R2, developing a voltage Vp = I (R1 + R2). As the frequency increases, current can flow through the capacitor. At high frequency the current is effectively short circuited by the capacitor and the voltage developed is simply IR1 (R1 >> R2). Between the DC and high frequency limits the voltage across the capacitor is phase shifted from the current and so adds an imaginary component to the total voltage measured across the circuit. Thus *we see that this circuit faithfully reproduces the key features observed in measurements.* It is important to note that the interface impedance acts like a gate or valve for the current. Both Z_W (total impedance) and the impedance of C (= $1/\omega C$) become large at low frequency.

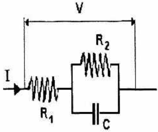

Fig.1. The equivalent circuit for alternating current

2. The apparent resistivity values

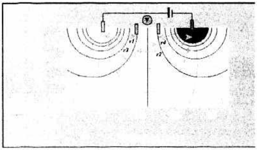

Fig.2. The simple way of measuring resistivity by a direct contact

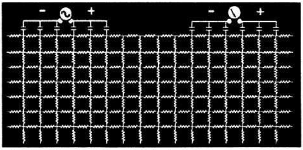

Fig.3. The simple model for the substance reactions at the current from CCR method

We can estimate the resistivity of the gound in one geological environment by measurement as figure 2. The electrode array for this experiment is four electrodes. The distances between these electrodes are given by r_1, r_2, r_3 and r_4. The apparent resistivity value (ρ) of this measurement is $\rho = K\ (\Delta V/I)$ with K depend on the geometry (r_1, r_2, r_3, r_4) of the transmitte dipole (current line) and the receive dipole (voltage line).

In this method we have given a microscopic model of the interface (*fig.3*). The model with many modifications to accurately reflects some of the substance reactions at the interface of the current from CCR dipoles. The apparent resistivity value (ρ) of the measurement with the capacitive-coupling array is given by the same formula $\rho = K\ (\Delta V/I)$. Here K also depend on the geometry of CCR dipoles.

3. Experiments and results

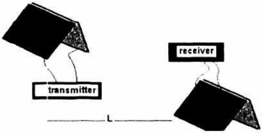

Fig.4a Flat capacitor dipole-dipole

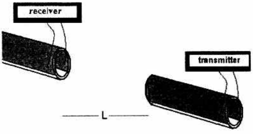

Fig.4b Cylinder capacitor dipole-dipole

Some forms of capacitors used for transmitte dipole and receive dipole in our experiments are shown in Fig.4. In Fig. 4a, an angle of flats of the capacitor is named Δ. The dependence of sensitive of measurement on the values Δ is estimated. The curve 5.a shows the dependance on Δ of flats of the receive dipole. The curve 5.b shows the dependance on Δ of flats of the transmitte dipole. A selective microvolmeter SE90VLF (made by SCINTREX Co.) and an alternating voltage generator (20 kHz) are used for CCR method in these measurements.

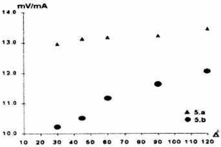

Fig.5. The dependence of sensitive of measurement on the values Δ

Taking the measurements with dipole-dipole array (L= 60 cm, see Fig. 6) we obtain the effect of soil to V/I value. Using measurements with box of soil (dimentions of box: 7cm, 30cm, 50cm) the values V/I depend on the distance r as follow:

r = 2 cm V/I = 8.8 mV/mA
r = 5 cm V/I = 6.72 mV/mA
r = 10 cm V/I = 6.55 mV/mA
without the box: V/I = 5.54 mV/mA

These measurements are in the same surrounding and then the effect of soil to V/I value is very clearly.

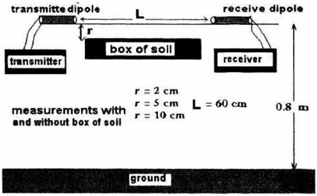

Fig.6. The model of the measurements with dipole-dipole array

The experiment results on some resistivity conditions in real geological environments are show in Fig.7 and Fig.8. In Fig. 7 the object buried underground is a concreted tunnel with air and water. In Fig.8 two objects buried underground are a concreted box with air and water (dimensions: 0.8m x 1.2m x 0.8m) and a long tunnel of air (dimensions 0.4mx0.4m).

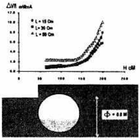

Fig.7. The experiment on tube with air

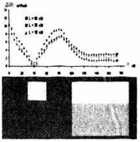

Fig.8. The experiment on concreted boxes with air

An anomalous fields appear as the dielectric changes strongly from the soil environment to the air environment. These figures show that the values V/I depend on the effect of a dielectrically change of geological environment is very clearly. It is very good for us to connect the values V/I of the mesurements to the ground resistivity conditions in a variety of geological environment.

Conclusions

The results of our experiments show that the effect of a dielectrically change of geological environment is very clearly. That is conditions for CCR method. The obtainable of the effect is very good for researching and making a model of equipment used for a mesure in CCR method. Next time our study will be continued on these subject and on researching the method constructing geophysical image from CCR data.

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References

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2. V.M. Timofeev, A.W. Rogozinski, J.A. Hunter, and M. Douma, *A new ground resistivity method for engineering and environmental geophysics*; in Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems, (1994).