P9-7	ESTIMATION OF FREQUENCY DISPERSION PARAMETERS BY INDUCTIVE TRANSIENT METHOD

I. YELTSOV, M. EPOV and E. ANTONOV
Institute of Geophysics pr. Ak Koptuga, 3,Novosibirsk, 630090 Russia.
E-mail:yeltsow@uiggm.nsc.ru

Introduction

Numerous experiments, executed by the method of induction transient electromagnetic field, are contained with obvious attributes of influence of induced polarization on process of a transient field. Theoretical researches directed on study of the phenomenon frequency dispersion of electrical resistivity have resulted in creation of a new method - high resolution electromagnetic sounding (Svetov et al, 1996) . The idea of this direction is reduced to an opportunity of detailed study of the earth in conditions of polarization of the rocks. Availability of additional medium polarization parameters (besides traditionally used resistivity) results in increase of information and reliability of the geological medium properties estimation.

Solving Method

The physical phenomenon of induced polarization is a little investigated and has not while of advanced theoretical base. However it is possible to represent the polarization as dispersion of electrical resistivity of the rocks, that is dependence of resistivity on frequency. Such approach is sufficient for given research, because it is enough to explain numerous natural experiments. At the same time it is possible to take advantage of known empirical dependencies of resistivity on frequency, not take into account the electrochemical details, leaving for framework electromagnetic approach. Here as empirical dependence the formula Cole-Cole is used.

$$r(iw) = r_{\infty} / (1 - h / (1 - (iwt)^{c})$$

For mathematical modeling of the transient electromagnetic fields in polarization horizontally - layered medium rather effective algorithms are developed (Epov et al, 1993). It permit to investigate main laws of behavior of the response from polarization medium. The main feature of this problem - using of complex resistivity, dependent on frequency, solving in frequency - domain and transition in the time - domain.

Analysis of the results

As the first example we shall consider a problem of polarization intrusive body influence estimation. Object is locate on a small depth. The model parameters are the following. Resistivities (Ohm.m): ρ_1=100, ρ_2 =10, ρ_3 = 100. Boundary depths (m): z_1 = 100, z_2 = 10. An array of observation is coincide loops 100 x 100 m^2.

On fig. 1 the curves of apparent resistivity (ρ_τ) are shown. We have change of polarization parameter (η) on second layer at a fixed characteristic time of relaxation (τ). On fig. 2 - apparent resistivity at change of a characteristic time of relaxation and fixed parameter of polarization (η = 0.15) are shown. Parameter c = 1. Thin line corresponds to normal model without polarization. So we have, that the increase of polarization parameter results in increase of abnormal response amplitude, and growth of a characteristic time of relaxation - in displacement of apparent resistivity maximum in the area of late times.

So significant changes of amplitude and form of the response, as well as very simple correspondence between frequency dispersion parameters and behavior of apparent resistivity provide sure inversion of parameters η and τ with usual optimization algorithms. By use of little noised (1%) synthetic data and initial model not far than 50%, 2-parameters inverse problem is confidently solved by minimization of the residual function with the help of simplex algorithm.

The second example is estimation of ore body, under intrusive body. The model parameters are following. Resistivities (Ohm.m): ρ_1=50, ρ_2 =1, ρ_3 = 50, ρ_4 = 2, ρ_5 = 2000. Boundary depths (m): z_1 = 100, z_2 = 110, z_3 = 510, z_4 = 520. An array of observation is the same - coincide loops 1000 x 1000 m^2.

On fig. 3 the curves of apparent resistivity for case, when the second layer (intrusive body) is polarized are indicated. And on fig. 4 - for polarization second (intrusive body) and fourth (ore body) layers with parameter c = 0.65 are indicated. Appreciably, that influence of resistivity frequency dispersion from ore body is observed only on reasonably late times. Change of character of response recession on late times unequivocally communicates with polarization of ore body, that provides solving of inverse optimization problem. The sure inversion of frequency dispersion parameters is possible only at reasonably large ($\eta > 0.4$) values of polarization parameter. The characteristic time of relaxation is $\tau \sim 5$ ms. This parameter for above problem is not determined.

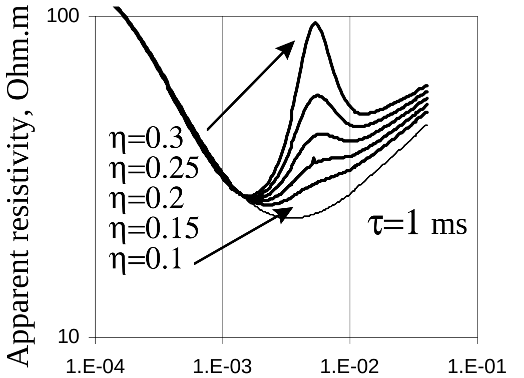

Figure 1

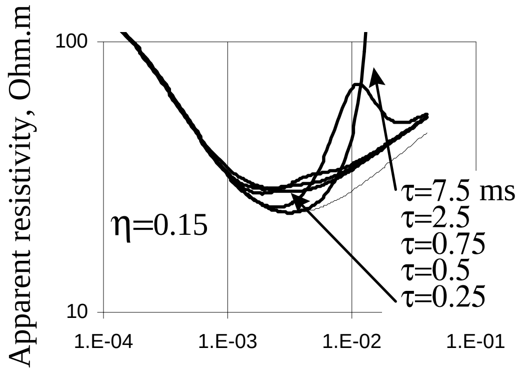

Figure 2

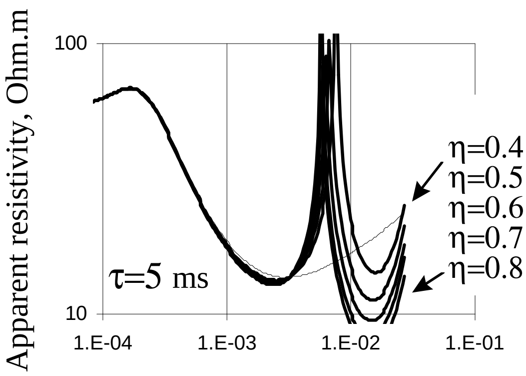

Figure 3

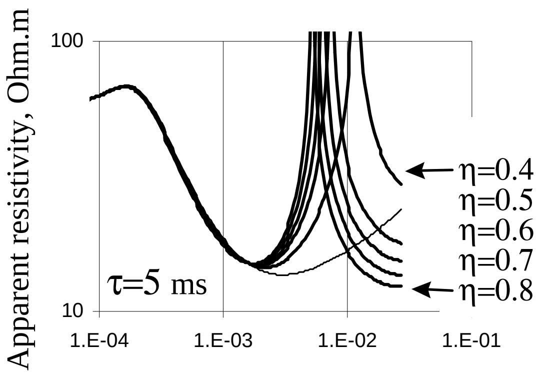

Figure 4

Conclusion

Our studies permit to generalize the significant influence of electrical resistivity frequency dispersion on the response of geological medium in induction transmitter / receiver systems. For many cases the effect of electromagnetic method resolution increase is observed. In studies models the frequency dispersion parameters yield quantitative estimation on the basis of residual function minimization by simplex method.

References

Svetov B.S., Ageev V.V., Lebedeva N.A, 1996. Polarization of rocks and phenomena of high resolution electrical prospecting: Geofizika, , ¹ 4, 42-52.

Epov M.I., Antonov E.Yu., Sokolov V.P. 1993. Modeling of transient responses in finite arrays above quasi layered polarizable semispace: Abstracts of International Geophysical conference «Moscow'93», , P. 1.10.