THE ADVANTAGES OF THE NEW PROPOSALS IN THE IMPROVED SYMMETRIC INDUCED POLARIZATION SOUNDING METHOD

Vu Duc Minh
College of Science, VNU

Abstract. The higher resolution, greater investigating depth, increasing reliability of geology forecasting results and possibility of expanding the application of the improved symmetric induced polarization sounding method have been illustrated by theoretical and field medium are the advantages of the new proposals presented in this article.

I. Introduction

In the article [2], the our new proposals, especially the Petrovski induced polarization (IP) parameter η_p, have been introduced for data processing in the induced polarization sounding method; as a result, their advantages in comparison to the previous conventional parameters have been illustrated by calculating for the theoretical medium. However, the Petrovski transforming formula contains derivation which is not stable, so desired results are not always obtained. With purpose to overcome these disadvantages, we have proposed the improved symmetric electrode array and the corresponding measurement procedure, the simple algebraic transformations (without the derivation) to apply to the resistively sounding method [1]. Those improved symmetric electrode array and transformations are of scientific and practical significance. Basing on those researches, we also have proposed the improved symmetric IP sounding method (ISIPS) and it has been tested effectively as the article [3].

In this article, we will illustrate the correctness and advantages of the new proposals in the ISIPS by theoretical and practical medium; proposing possibility of expanding and achieve better geological effective of the new proposals to the application of the ISIPS in fact for data processing obtained by using the previous conventional IP sounding method.

II. Basics of the new proposals in the improved symmetric induced polarization sounding method

II.1 The new induced polarization parameters

As known , the apparent polarization is calculated by the following formula:

$$\eta_k = \rho_k^* - \rho_k/\rho_k^*, \tag{1}$$

where ρ_k^* and ρ_k are the apparent resistivities of the polarized and non- polarized medium, respectively, corresponding to the resistivity parameters ρ_k^* and ρ_i which are related by: $\rho_i^* = \rho_i/(1-\eta_i)$ where i is the medium model index.

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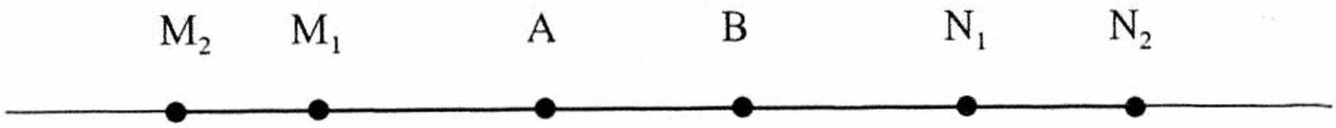
Basing on the above definitions, we have also definite the new IP parameters [2] similarly:

- The polarization of the symmetric Induced Polarization sounding method: η_s.
- The polarization of the dipole-axis Induced Polarization sounding method: η_r.
- The Petrovski polarization: η_p

II.2 The new transformations

According to [3], the improved symmetric Induced Polarization sounding electrode array is allocated as the following:



where, with one current-electrode separation AB, from the measurement we may obtain $\rho_{s1}(r_1), \eta_{s1}(r_1)$ and $\rho_{s2}(r_2), \eta_{s2}(r_2)$, corresponding to r_1 and r_2. In such a way 4 curve ρ_{s1}, ρ_{s2} and η_{s1}, η_{s2} are obtained.

Then:

$$\rho_{sr} = \frac{1}{2} K_r \left(\frac{\rho_{s2}}{K_{s2}} - \frac{\rho_{s1}}{K_{s1}} \right), \tag{2}$$

where ρ_{sr} - the dipole-axis resistively sounding curve obtained by transforming from the symmetric resistively sounding curve ρ_s.

The values of Petrovski resistively sounding curve ρ_{psr} are calculated by the following formula:

$$\rho_{psr} = \rho_s/(2\rho_{sr}/\rho_s - 1). \tag{3}$$

Then all the necessary information will be calculated according to the schema shown on figure 1.

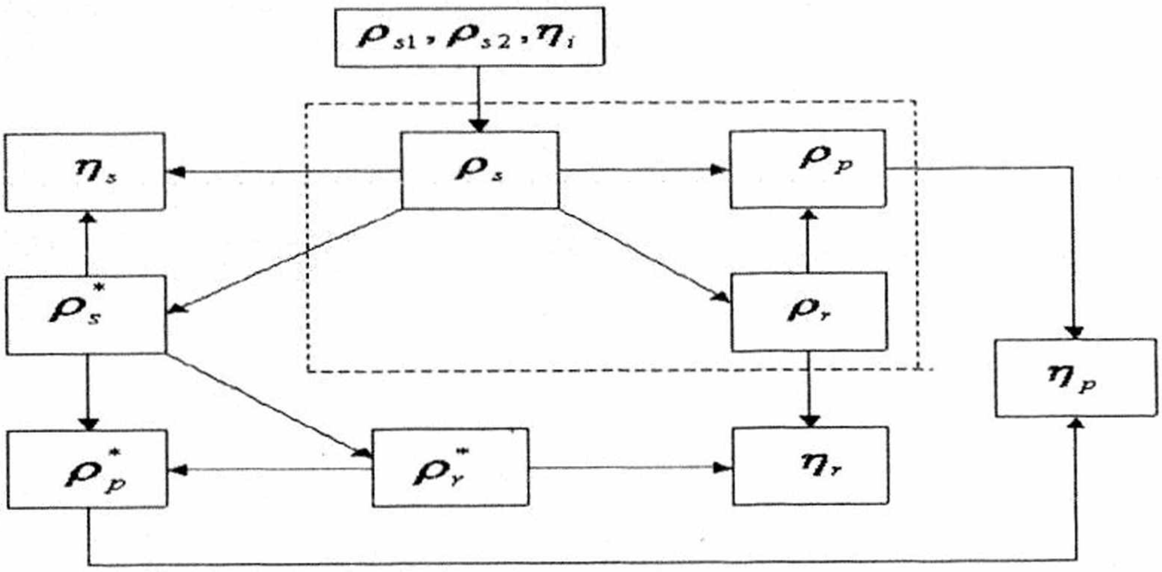


Figure 1. Schema calculating parameters by using ISIPS array

III. Checking the mutual principle

We have measured and calculated experimentally the mutual principle on the field medium. Below we present only the example result in Tan Dan - Hoanh Bo - Quang Ninh.

Figure 2 shows the apparent resistively curves ρ_{rstr} (rorstr) practically measured by the improved symmetric sounding array MABN, ρ_{rsng} (rorsng) practically measured by the improved symmetric sounding array AMNB and the corresponding Petrovski resistively sounding curves.

Figure 3 shows the Petrovski resistively curves ρ_{prstr} (roprstr) for array MABN and ρ_{prsng} (roprsng) for array AMNB; the Petrovski resistively curves ρ_{prsxd} (roprsxd) derived from the transformation of the values ρ_r practically measured by the IDAIPS array and one value $\rho_{rsxd}(r_{\max})$ measured by the equatorial dipole array at final size $\rho_{\max}$ of the IDAIPS array.

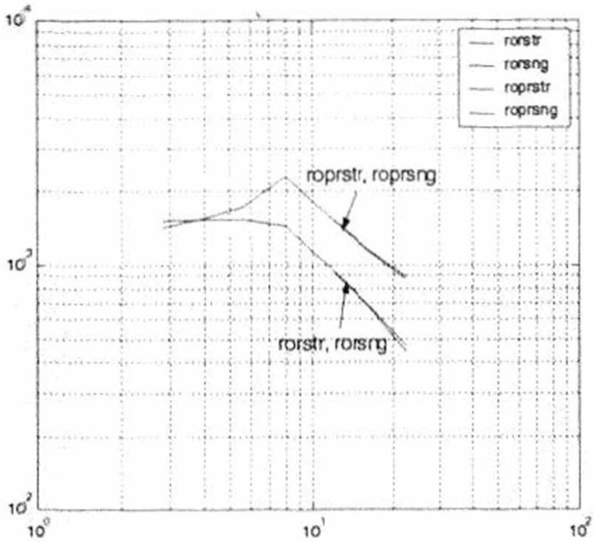


Figure 2. Curves ρ_{rstr} (rorstr), ρ_{rsng} (rorsng) and corresponding Petrovski curves

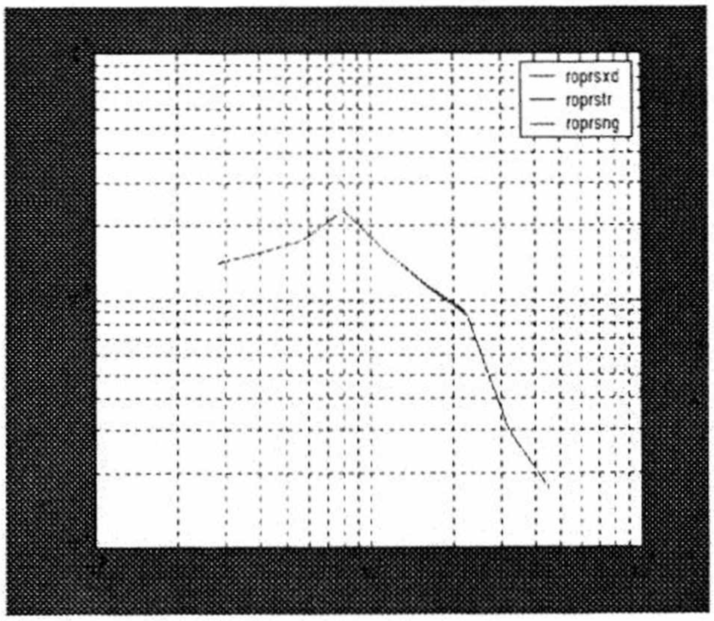


Figure 3. Petrovski resistively sounding curves

We realize that curves are fitted. This proves that the mutual principle is right for all the arrays, the electrode spacing, the measurements as well as the transformations that have been used to confirm the method.

IV. Confirming the correctness and advantages of the new proposals

IV.1 Calculating values of the polarization sounding curves

★ *The three-layered geo-electrical model*

By simulation method in PC, we have built the programs of calculating the polarization sounding curves on layered geo-electrical models for different electrode array by Matlab language. We only give a specific example of the three-layered geo-electrical model as following: $\rho_i = [14.51]$; $\eta_i = [241]$; $h_i = [15]$; with $i = 1, 2, 3$

Figure 4 shows the theoretical IDAIPS curve η_r (etar) and the curve corresponding to the IDAIPS curves η_{sr} (etasr) obtained by transformation.

Figure 5 shows the theoretical Petrovski curve η_p (etap) and the Petrovski curve η_{psr} (etapsr) obtained by transformation.

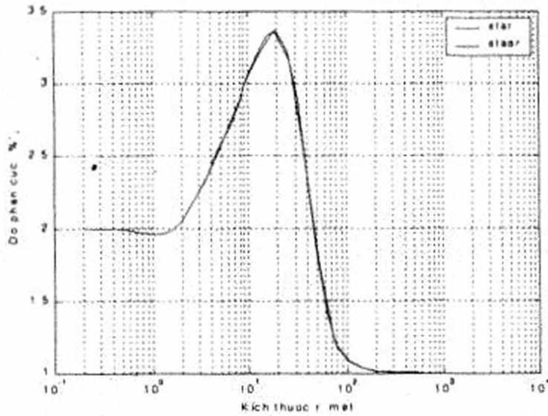


Figure 4. The theoretical curve η_r (etar) and curve η_{sr} (etasr) obtained by transformation

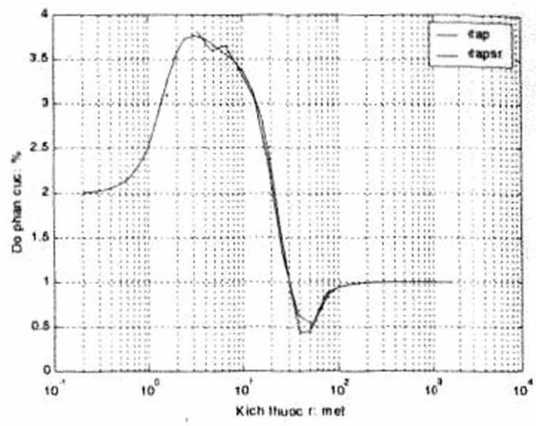


Figure 5. The theoretical curve η_p (etap) and η_{psr} (etapsr) obtained by transformation

★ *The field medium*

The testing calculations have been performed in Tan Dan - Hoanh Bo - Quang Ninh and Daksong - Gia Lai. Below we only present the example curves measured at point 22 of the profile S11 in Daksong - Gia Lai.

Figure 6 shows curve η_r (etar) practically measured by the IDAIPS array; the IDAIPS curves η_{sr} (etasr) and η_{psr} (etapsr) obtained by transformation of curves ρ_s, η_s practically measured by the ISIPS array and ρ_{sr}.

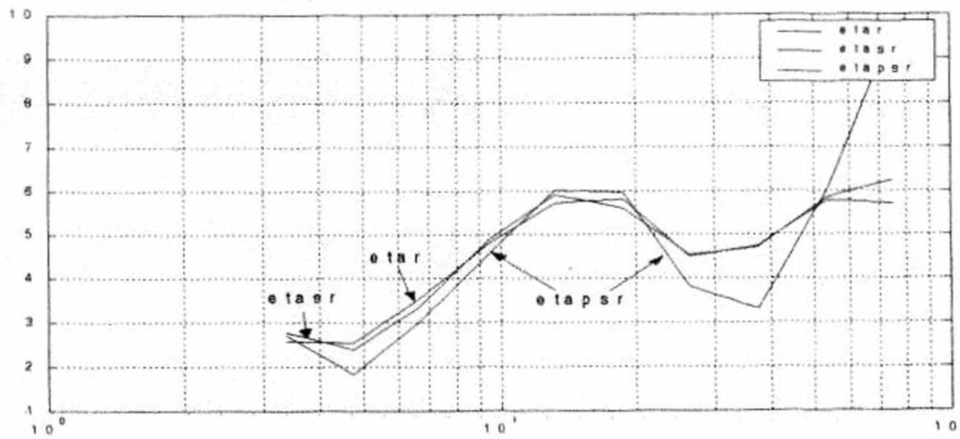


Figure 6. The practical curve η_r (etar) and curve η_{sr} (etasr), η_{psr} (etapsr) obtained by transformation

In comparing, practical measured curves and corresponding curves obtained by transformation are nearly fitted, only the values at some final sizes is not the same. This proves the correctness of the algebraic transformations mentioned above. Besides, Petrovski curve also has reflected clearly resolution ability - that is its advantages.

IV.2 Processing data on the profile

The new proposals have been applied in two directions:

1. Processing and analyzing data obtained previously by the normal IP sounding

method in order to exploit and add other useful information in two ways:

+ Interpolating values of curves η_k and ρ_k obtained previously by the normal IP sounding method to values of the improved IP curves with the corresponding sizes of electrode spacing and coefficients.

+ From the sizes of normal electrode array, calculating corresponding coefficients of the improved electrode array.

2. Processing and analyzing data obtained by the ISIPS method.

Below we present only the results of applying the new proposals to exploit data obtained previously by the normal SIPS method on profile 20 in Song Giang - Quang Nam, which were measured by Union of Physic-Geology in 1999.

★ *The results of processing and analyzing data obtained previously by the normal SIPS method on profile 20* (see figures 7, 8)

• Line 20 was formed in the Northeast - Southwest direction perpendicularly to the folding structure with Northwest - Southeast direction in the Southeast of Giang River.

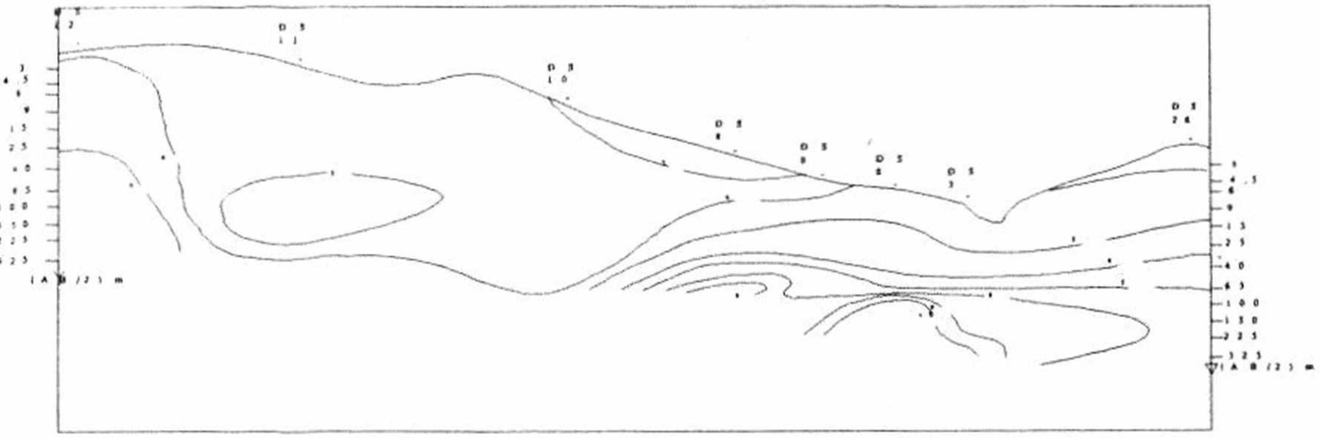


Figure 7. Contour section η on the profile 20 (%)
(Source: Union of Physic-Geology)

• Along the profile, the following main geological formations are identified:

+ Ben giang - Que son magma complex:

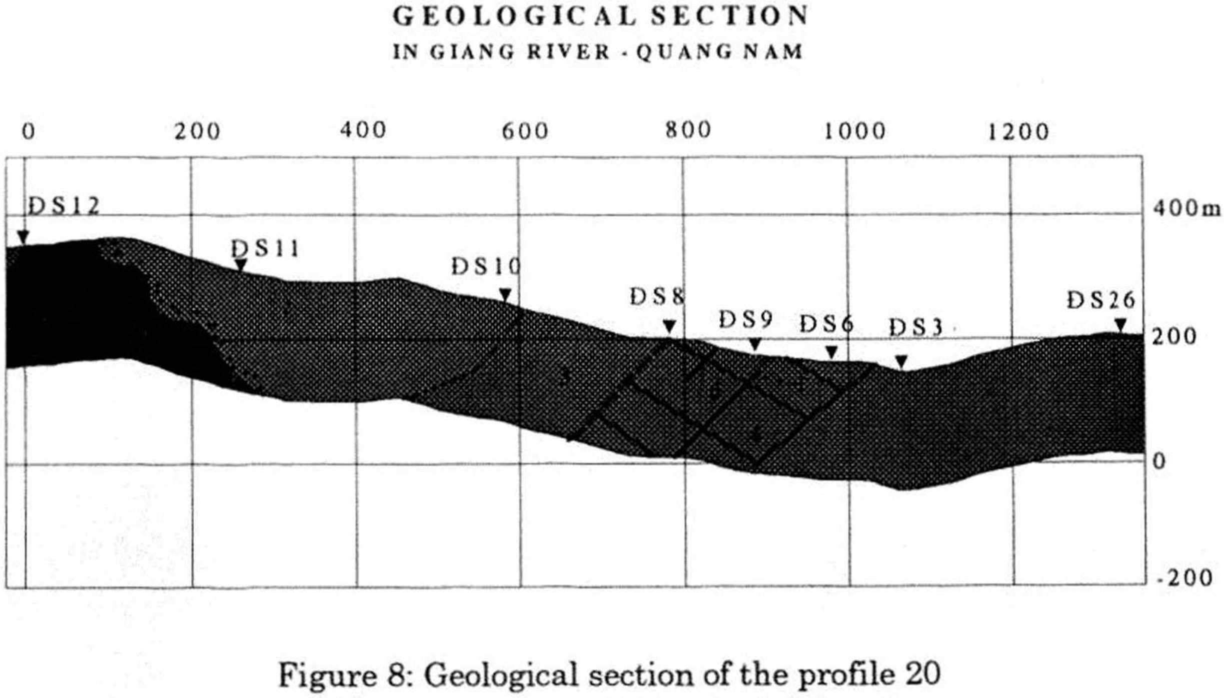


Figure 8: Geological section of the profile 20
(Source: Union of Physic-Geology)

Main components: granodiorite, biotite hornblende, and toranite biotite hornblende. Specific physical features are resistivity with $\rho = 2,000 - 3,000$ ohms.m, polarization $\eta_k = 3 - 5\%$

Directions:

1. Granodiorite of Ben Giang - Que son complex, phase 2;
2. Schist of Kham duc formation, layer 3;
3. Schist of Kham Duc formation, layer 2;
4. Altered zones;
5. Faults;
6. Vents of gold-sulfuric quartz.

+ The metamorphic sedimentary rocks of Kham Duc formation consist of:

- Upper layer: biotite - granite quartz shale, mica quartz, and plagioclase - biotite quartz. Specific physical features are resistivity with $\rho = 1,000 - 2,000$ ohms.m, polarization with $\eta_k = 2 - 4\%$.

- Lower layer: Bimica gneis, bimica quartz, biotite gneis, schist, and biotite quartz. Specific physical features are resistivity with $\rho = 500 - 1,000$ ohms.m, stimulated polarization with $\eta_k = 2 - 4\%$.

Metamorphic sedimentary formations were strongly folded and divided by deep faults perpendicularly with the surveyed profile. Along the faults, rocks are strongly destroyed and infiltrated by sulfuric ores. Destroyed zone has small resistivity $\rho = 200 - 500$ ohms.m and high polarization $\eta_k = 3 - 5\%$.

Gold bearing polymetal surphide - quartz zones have the resistivity relevant to altered zones and high polarization $\eta_k = 5 - 10\%$.

• The aim of the IP sounding method is to solve the following tasks:

+ To study folded structures along the surveyed profile;

+ To define gold bearing surphide - quartz zones.

★ *The results of applying the new proposals to exploit data*

With applying the new proposals to exploit data obtained previously by the normal SIPS method on profile 20 in Song Giang - Quang Nam then contour sections of polarization have been calculated and reported. Below we only present the example contour sections η_{sr} and η_{psr} on figures 9, 10.

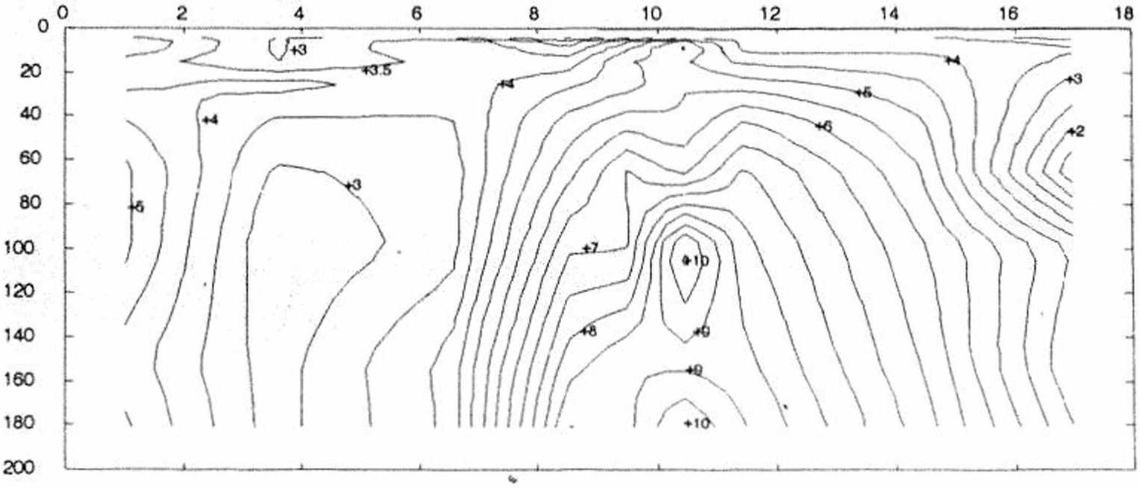


Figure 9. Contour section η_{sr} (%)

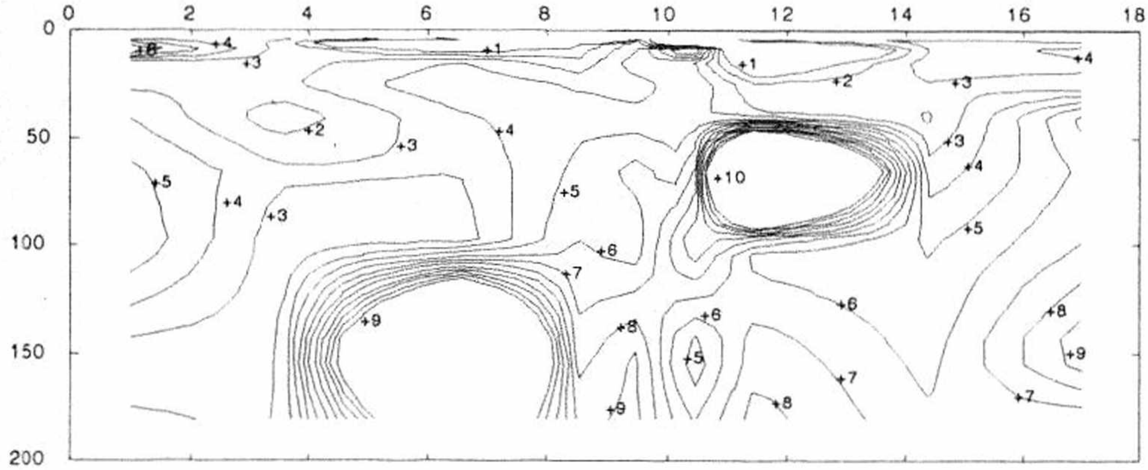


Figure 10. Contour section η_{prsxd} (%)

The results of applying the new proposals in the ISIPS to exploit data obtained on profile 20 in Song Giang - Quang Nam can be seen that:

+ Detail division of geological components in the section;

- Magmatic granodiorite formation is characterized by resistivity 2,000 - 3,000 ohms.m, polarization 4 - 5%;

- Metamorphic sedimentary rocks of Kham Duc formations are characterized by resistivity 1,000 - 2,000 ohms.m, polarization 3 - 5%.

+ The broken zone, destructed along the faults is clearly defined. This zone is characterized by low resistivity 200 - 800 ohms.m, polarization 6 - 8%; defining in more detail the gold bearing surphide - quartz zones with the polarization from 8 to 10%. The contour section η_{psr}, severally, defined clearly and in detail the vent bodies with the polarization from 8 to 10%.

We see clearly that applying the new proposals in the ISIPS to calculate the apparent resistivity and polarization values permits defining research objects in more detail and locating more clearly.

V. Conclusions

1. For the first time, the Petrovski IP parameters (especially η_p) have been proposed and their scientifically theoretical base built and advantages that they exhibit higher resolution and greater investigating depth than the conventional parameters ρ_k, η_k have been confirmed by us.

2. The new proposals in the ISIPS have high scientific reliance, really usefulness, and scientific and practical significance. They eliminated the fundamental disadvantage that the transformation between curves through the unstable derivation existed for a long time. One of the advantages of our proposal is only using the simple and reliable algebraic formulas to transform curves. Creating algorithms of processing and analyzing the data using the new proposals in the ISIPS basing on selecting reliable information with comprehensiveness. They also have made the geology forecasting results clearer and

more reliable, reflected the nearly real IP effect of study objects, increased resolution of weak anomalies. All of those have illustrated the distinguished advantages of the new proposals.

3. Expanding and increasing possibility of the application of IP sounding method, not only for new measurement project, but also for exploiting and adding other useful information to support the processing and analyzing old obtained previous IP data. This is quite a new problem and very necessary for the IP sounding method.

We continue to develop and complete this direction of processing and analyzing the IP sounding data basing on exploiting the above new proposals have made by the author, as well as continue to develop this new direction for 2D - 3D algorithms.

References

1. Lê Viết Dư Khương, Vũ Đức Minh, Các phương pháp mới trong đo sâu điện trở dùng tổ hợp hệ cực đo hợp lý, *Tạp chí Các Khoa học về Trái đất*, 23 **3**(2001), tr. 217-224.
2. Vu Duc Minh, Le Viet Du Khuong, Some Induced-Polarization sounding methods and their ability in investigating geological medium, *VNU. Journal of Science, Natural Sciences*, t XVII **4**(2001), pp. 28-34.
3. Vu Duc Minh, Induced-Polarization Sounding methods in a new manner, *Journal of Geology*, Seri B, No. **17, 18**(2001), pp. 94-101.