PHYSICAL PROPERTIES OF CHROMITE ORES AND ULTRABASIC ROCKS IN THE ALBANIDES

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A B S T R A C T

This paper presents the results of a petrophysic study on the induced polarization, resistivity, density and magnetic properties of ultrabasic rocks and chrome iron ores in Albanides. The density is the most stable and typical physical property of chrome ores. The magnetism and induced polarizability of chromite ores and ultrabasic rocks varies in broad bands.

ΦΥΣΙΚΕΣ ΙΔΙΟΤΗΤΕΣ ΤΩΝ ΧΡΩΜΙΤΙΚΩΝ ΚΟΙΤΑΣΜΑΤΩΝ ΚΑΙ ΤΩΝ ΥΠΕΡΒΑΣΙΚΩΝ ΠΕΤΡΩΜΑΤΩΝ ΣΤΙΣ ΑΛΒΑΝΙΔΕΣ

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Π Ε Ρ Ι Λ Η Ψ Η

Η εργασία αυτή παρουσιάζει τα αποτελέσματα μιας γεωφυσικής μελέτης των υπερβασικών πετρωμάτων και των κοιτασμάτων σιδηροχρωμίου στις Αλβανίδες. Για τον σκοπό αυτό μετρήθηκαν η επαγώμενη πόλωση, η ειδική αντίσταση, η πυκνότητα και οι μαγνητικές ιδιότητες των πετρωμάτων. Βρέθηκε ότι η τιμή της πυκνότητας, είναι η πιό σταθερή και τυπική ιδιότητα των χρωμιτικών κοιτασμάτων. Η μαγνήτιση και η επαγώμενη πόλωση των χρωμιτών και των υπερβασικών πετρωμάτων κυμαίνεται σε μεγάλο εύρος.

INTRODUCTION

Ultrabasic rocks form an important complex of Inner Albanides. The big and the well known deposits of chromite are linked with these rocks. A variety of geological, geophysical and geochemical methods is used for chrome deposits prospecting in Albania. The details of petro-physical studies on the density magnetism, resistivity and induced polarization of ultrabasic rocks and chromite iron ores are presented elsewere (Frasheri 1974, 1989). The representative samples of different kinds of rocks and ores with the same properties and characteristics have been subject to mineralogical petrographical studies. Chemical analyses were performed in chromite ore samples to determine their Cr_2O_3 and FeO content.

DENSITY

Density of ores.

Chromite ores have a high density from 2550 to 4380 kg/m^3. It depends mainly from the content of Cr_2O_3 in the magnesiochromite (fig. 1):

$$\delta = 40C + 2000$$

δ - density of chrome ore, in kg/m^3

C - content of Cr_2O_3 in ore in percentage
The correlation coefficient is 0.92

This relation is not the same for different deposits (Fig. 1-a, 1-b). The degree of metamorphism of chromites and especially of serpentinization of its olivine, is another factor which affects the density of the ore. These factors make the distribution functions of chromite to be different for different deposits or the same deposits, even for the same kind of ore (Fig. 2,3). Generally the data for the density of chrome spinel ores for the studied massif differentiate them into three categories.
1. Chromite rich ores with 30 % Cr_2O_3 and mode density 3730 kg/m^3.
2. Intermediate ores with 20-30 % Cr_2O_3 and mode density 3040 kg/m^3.
3. Chromite poor chromite with 12.5-20 % Cr_2O_3 and low mode density 2700 kg/m^3.

Density of rocks.

The dunites are compact, massive and when fresh they have a high density which reaches up to 3340 kg/m^3 (Fig. 4). The dunites group includes, besides the fresh kind (0-5 % serpentine minerals) also the less serpentinized kind (10-15 % serpentines), which have density mode of 2910 kg/m^3. Clearly differentiated from these rocks there is another set of dunites which belong to the serpentinized group and has a mode density of 2680 kg/m^3 (Fig. 4). This density reduction is connected with the increase of serpentine content from 15 - 20 % to 50 % (Bushati 1988).

Another phenomenon which influences the density reduction is the presence of fissures. Petrographics studies have revealed that the dunite rock fissures constitute 10 to 20 % of rock volume and have a density value of 3000kg/m^3, though they may be unserpentinized.

The density of hartzburgites and serpentinized hartzburgites varies within the above mentioned limits.

Though the density of hartzburgites varies within the same limits as the density of dunites we notice that the maximun in the distribution curve of hartzburgites density shifts on the right, i.e. they have a density mode of 3000 kg/m^3, which is greater than that of dunites. Serpentinites have low densities. The distribution curves (Fig. 4) show that though they may be serpentinites from dunites or hartzburgites, the density varies within the same limits and the density mode is 2570 kg/m^3. In some cases the reduction of density up to 2200 kg/m^3 is conditioned by the great increase of serpentinite fissures especially in the serpentinites which are formed during the process of dynamometamorphism.

Pyroxenites and gabbro-pegmatites have a high density mode of 3080 and 3070 kg/m^3 respectively.

MAGNETISM

Magnetism of chrome spinel ores and ultrabasic rocks is unstable and depends on their mineral content, on the presence of ferromagnetic minerals and on the form in which the ferromagnetic minerals enter in the composition of the ores or rocks. Besides, the chemical transformations, recrystallizations,

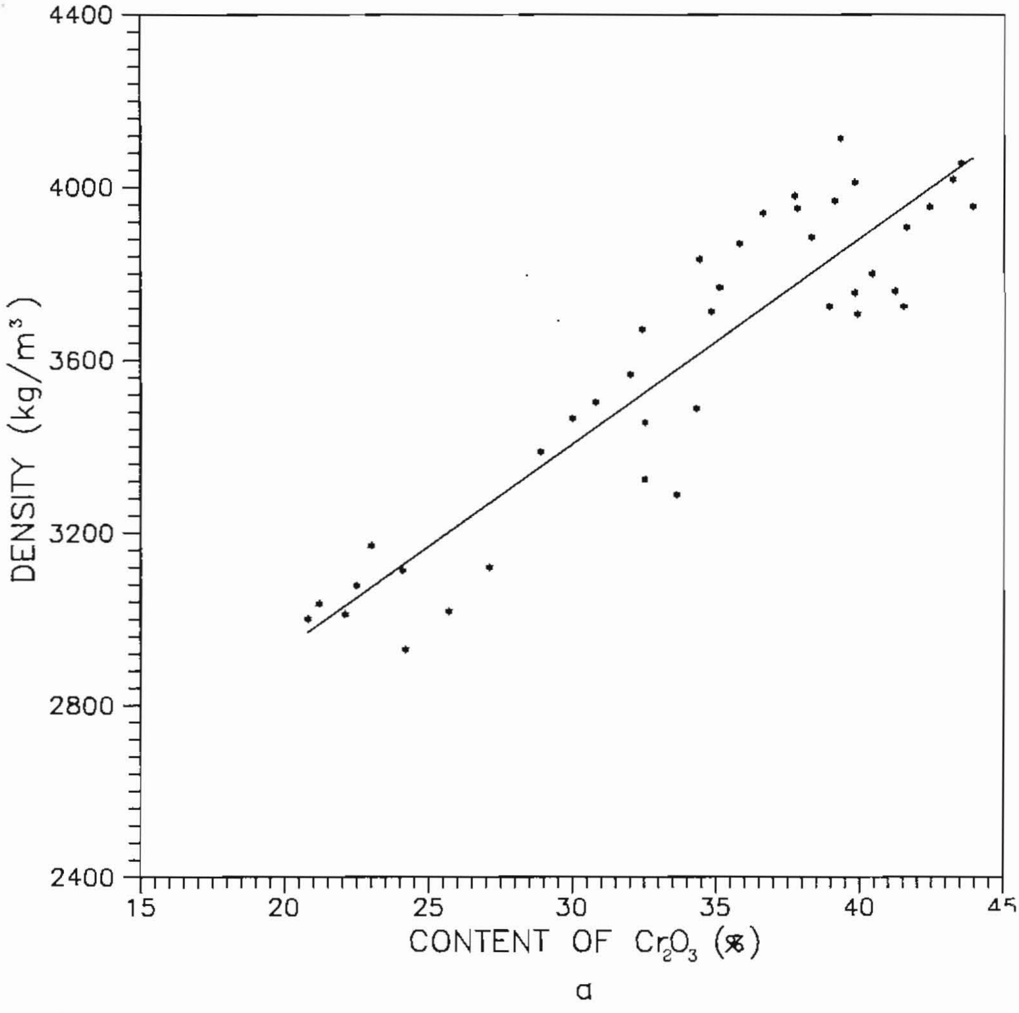

Fig.1. Density variation with Cr_2O_3 content of chrome iron ores Kami (a) and Vlahna (b) deposit in Tropoja Masif.

redistributions of the dislocation of the mechanical stresses have most probably changed the magnetic properties.

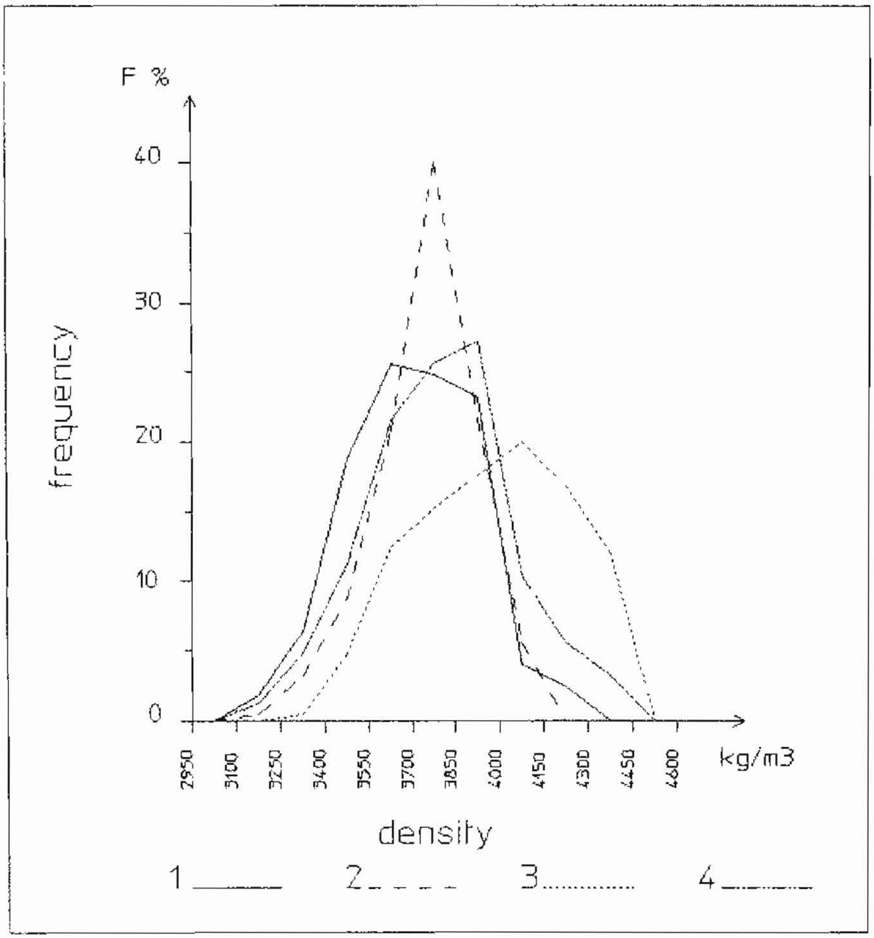

Fig.2. The distribution curves of the density in a chrome iron ore. 1. Northern part of the ore body; 2. Central part of the ore body; 3. Southern part of the ore body; 4. The generalized curve.

Magnetism of ores.

The massive type ore in the fresh ultrabasic rock has an induced magnetism (I_i) mode (500 ± 150)$\cdot 10^{-5}$ units SI (Fig. 5). Remanent magnetization (I_r) varies from $100\cdot 10^{-5}$ to $8100\cdot 10^{-5}$ units SI. There are found strong magnetic ores (with induced magnetization $3700\cdot 10^{-5}$ units SI and remanent magnetization with the highest mode $5300\cdot 10^{-5}$ units SI), and nonmagnetic ores. The disseminated ore type has an induced magnetization smaller than the massive ore type, while the remanent magnetization has almost equal values. The ores in serpentinized rocks differ from the others. Unlike the ores that are in fresh rocks, those in serpentinized ones are generally not magnetic.

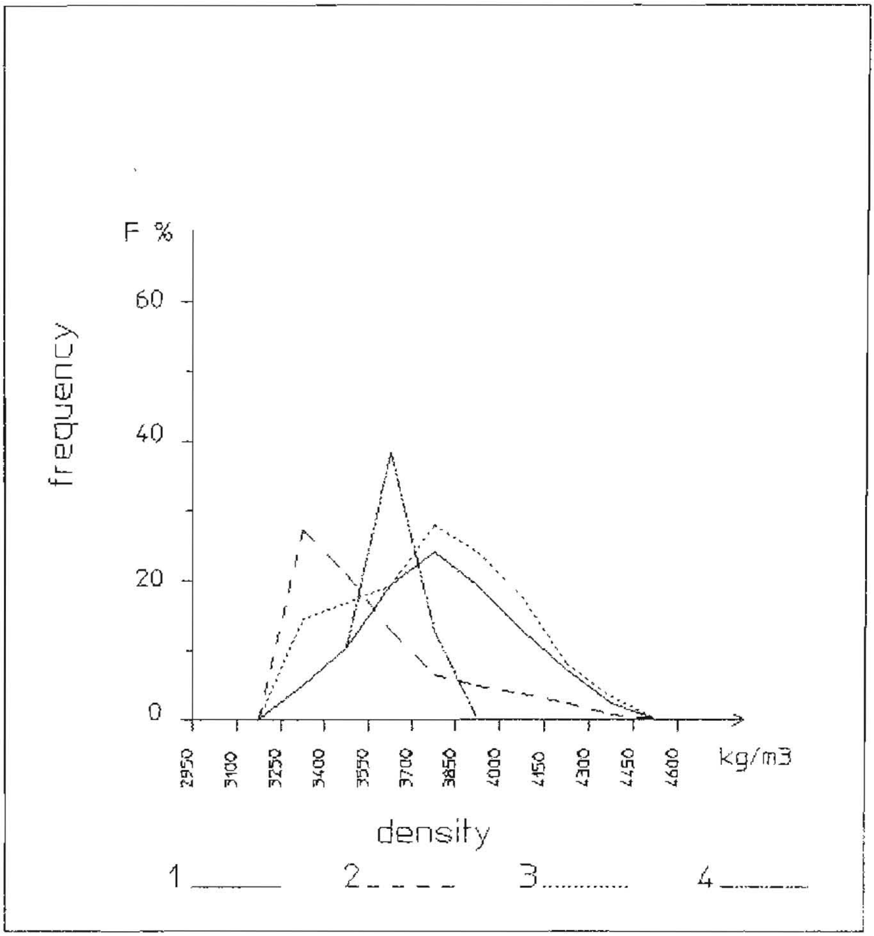

Fig.3. Distribution curves of the density from different chrom spinel rich ores. 1. Tplani; 2. Rragami; 3. Kami and 4. Kepenek deposit.

Mineralogical studies reveal that induced magnetization is determined by the content of the ferromagnetic minerals, in general, and the secondary magnetite in particular (Frasheri 1974, 1984, Sumer 1978).

The Cr_2O_3 has an unconsiderable magnetism and it is typically antiferromagnetic. Chrome spinel ores, because of their typical spinel crystal structure and the chemical formula $(Mg,Fe^{2+})(Cr,Al,Fe^{3+})_2O_4$, are part of the ferrites and the magnetic moment of the molecule is formed mainly by the bivalent atom of iron Fe^{2+}. This is clearely revealed in the results of two chrome spinel samples with a structure of intermediate and dense disseminations (Frasheri 1974, 1989):

Sample nr. 1: Content of FeO 11.31 %
$I_r = 3517 \cdot 10^{-5}$ units SI, $I_i = 140 \cdot 10^{-5}$ units SI

Sample nr. 2: Content of Feo 16.07 %
$I_r = 3553 \cdot 10^{-5}$ units SI, $I_i = 270 \cdot 10^{-5}$ units SI

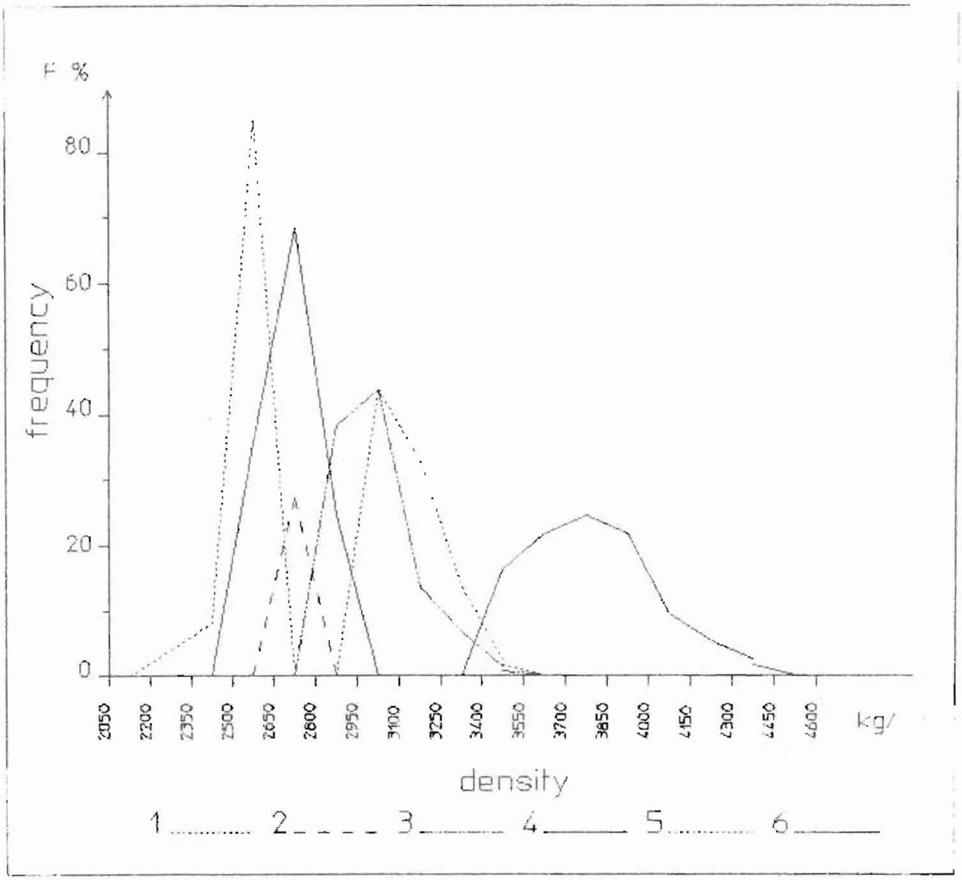

Fig.4. Density variation curves of chrome spinel ores and ultrabasic rocks. 1. Serpentinites; 2. Serpentinized rocks; 3. Fresh dunites and hartzburgites; 4. Chromite poor ore; 5. Intermediate chromite ore; 6. Chromite rich ore.

Besides the induced magnetization in the chromite spinels, it exist the phenomenon of hysteresis, as the result of which there might appear remanent magnetization. The values of the remanent magnetism have given broad limits as expected, but with maximal values smaller than the remnent magnetization of the magnetic minerals and especially of magnetite. The remanent magnetization showed values down to $100 \cdot 10^{-5}$ units SI, and the induced magnetization down to $300 \cdot 10^{-5}$ units SI for the ores in the serpentinized rock was accompained by a Q_n ratio change from $Q_n>1$ to $Q_n \leq 1$ as well.

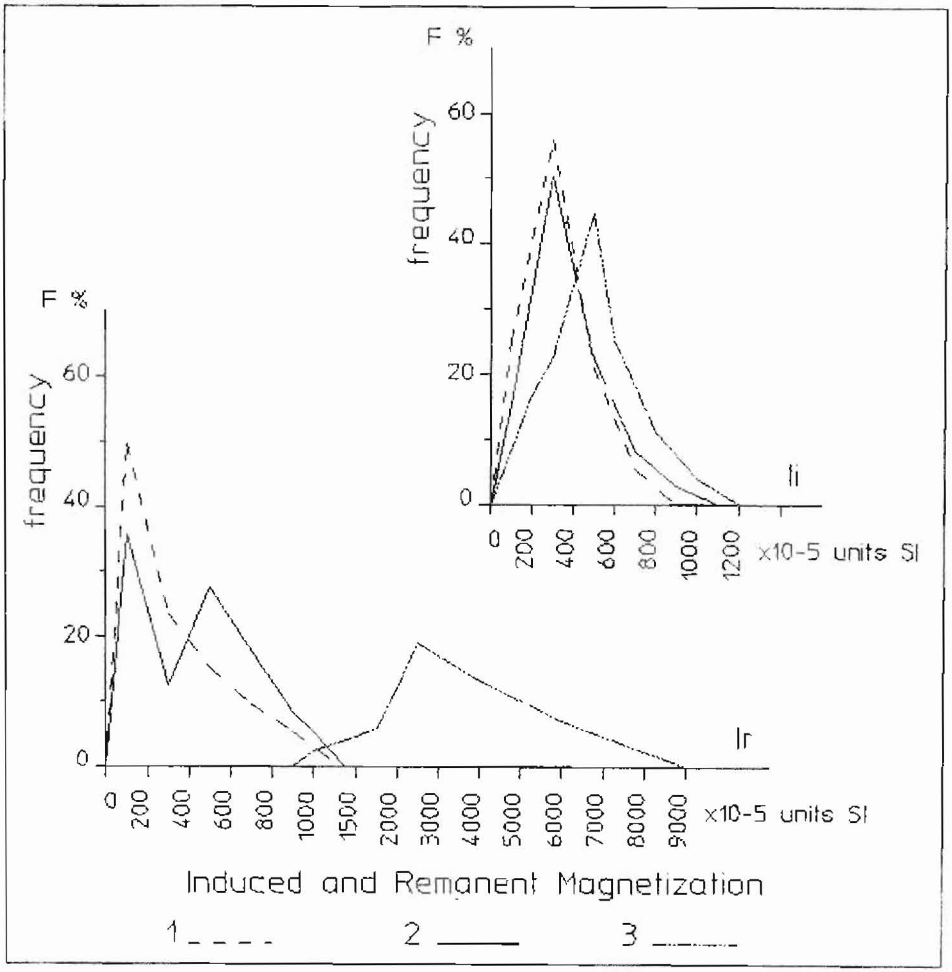

Fig.5. The distribution curve of the induced and remanent magnetization of the chrome spinel ore and ultrabasic rocks. 1. Dunites; 2. Hartzburgites; 3. Chromespinel ores.

Remanent magnetization oscillates in broader limits than the induced magnetization, especially for particular samples reaching values up to $97000 \cdot 10^{-5}$ units SI. Mineralogical studies indicate that magnetism is strengthened along side with increasing of the chromite grains in the ores (Cina, 1987).

Magnetism of rocks.

The ultrabasic rocks have a magnetism which changes in a broad band, conditioned by the presence of ferromagnetic minerals, mainly by the secondary magnetite and less by magnetized accessory chrome spinel (Frasheri, 1974; Saad, 1969; Wegun, 1983). Apart from this, being ferromagnetic these rocks might have a large natural remanent magnetization (I_r). In this way the ultrabasic rocks can be considered from particulary nonmagnetic to high magnetic. Dunites and fresh hartzburgites have the lowest degree of magnetism (Fig. 5). The magnetic properties of this two kinds of rocks vary within almost the same limits. In 48 % of the cases in this rocks $Q_n>1$, with intermediate value 2.3 for dunites and 1.9 for hartzburgites. That reveals the influence of the thermal nature of the remanent magnetization.

Serpentinites, though they may be from dunites or hartzburgites that contain secondary magnetite, have a higher magnetism. The main characteristic of the magnetism of serpentinites is the variability: from particulary nonmagnetic to high magnetic (with $I_r = 70000 \cdot 10^{-5}$ units SI and $I_i = 3700 \cdot 10^{-5}$ units SI). This phenomenon can be explained by the degree of serpentinization because the quantity of serpentine minerals in the rock does not always determine the quantity of the secondary magnetite. Nevertheless concerning to this problem there are also different opinions. Veined rocks like pyroxenites in the majority of the cases are made up of medium coarse grained enstatite. The magnetic properties of the pyroxenites vary in narrow band, though the majority of them are slightly magnetic with the most frequent values of $I_i=350 \cdot 10^{-5}$ units SI and $I_r = 150 \cdot 10^{-5}$ units SI (table 4). Gabro-pegmatites in general are weak magnetic rocks. Another phenomenon observed in the study of the magnetism of chrome spinel and the surrounding rocks is the inversion of the vector of the remanent magnetization. Chrome spinel of ore body has its vector of remanent magnetization with an intermediate azimuth of declination $\Phi = 356°$ and inclination angle $\Theta = -70°$ (Fig. 6). In the surrounding dunites the angle of inclination of the I_r vector is on average $\Theta = 60°$, while the azimuth $\Phi = 42°$. The inclination angle of the I_r vector in the surrounding rocks is in accordance with the angle of the magnetization vector for the latitude in the northen hemisphere, in our country. The sample from dunitic envelope with I_r vector, preserving the azimuth of direction $\Phi=46°$ (as in the rocks that are far from the body), has a negative inclination angle, as in the ore $\Theta = 11°$. The negative direction of the inclination of the remanent magnetization vector of the ore could be explained, if we accept the latter formation of the ore body in comparison with the time of crystallization of the surrounding rocks. These rocks were already magnetized and the ore was magnetized under the action of the demagnetizing field of the surrounding rocks. Under the thermic influence of the ore matter, in the dunitic envelope of the ore body the direction of the I_r inclination has changed.

There are same geological facts which are in favour of this idea: Among the ultrabasic rocks there is also met chrome spinel ore with a surface surrounded by 2-3 mm dunite salbande of yellow color unlike for the dunites, which are more or less green. The microscopic study of the polished section has shown thatthe part near chromite intercalations in the olivine is more serpentinized than the other part. This phenomenon shows the thermic influence of chrome spinel in the surrounding olivine. Apart from this phenomenon there is also the ore which has cemented irregular pieces of olivine. The mineralogical study showed that the order of the minerals' formation is olivine- chromite. Olivine had been crystallized before the chrome spinel ore. The negative inclination of the I_r vector of the chrome spinel ore, observed in some deposits, shows that there is not a special or local one but it has a broad extension (Frasheri, 1974; Vontetakis, 1979).

INDUCED POLARIZATION

Chrome spinel ore and the studied ultrabasic rocks have a polarizability which varies in board limits of IP coefficient from 0.2 to 51 %.

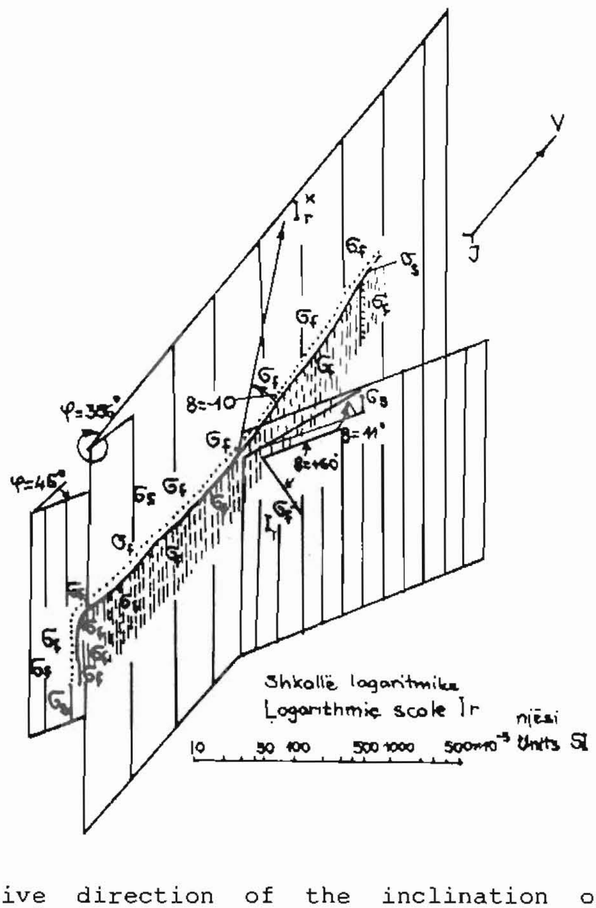

Fig.6. Negative direction of the inclination of remanent magnetization I_r of chrome ore.

Polarizability of the ores.

The rich chrome spinel ore has an IP coefficient which varies from 0.7 to 30 %. The polarizability is divided in three groups: Low polarization (0.7-3 %), intermediate polarization (3-18%) and strong polarization (18-30%) (Fig.7). The distribution curve of IP coefficient of the rich chromite has a right asymmetry, whereas that of the poor ore and that of the ore with intermediate content has a left asymmetry.

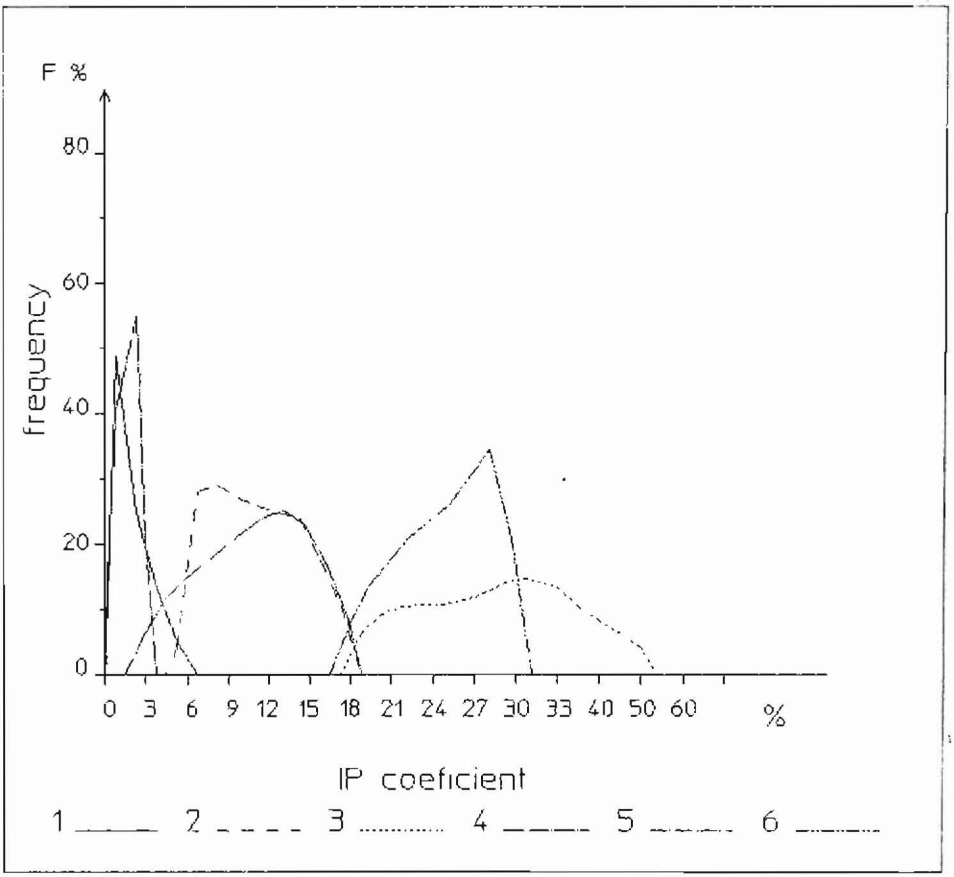

Fig.7. The distribution curve of the induced polarizability of the chrome spinel ores and ultrabasic rocks. 1,2,3 Rocks are respectively weak, intermediate and strongly polarized; 4,5,6 Ore with massive type that is weakly, intermediate and strongly polarized.

Polarizability of the rocks.

The coefficient of IP in the ultrabasic rocks varies in broader limits than in the chromites. If the maximal value of this IP coefficient reaches up to 30 % (for the chromites) in the surrounding rocks reaches up to 51 %.

According to the polarizability, it is possible to distinguish up to three kinds of rocks which are weakly, intermediate and strongly polarized. The limits of the IP coefficient for these three kinds of rocks are almost the same with those of the three classes of the ores, only that the maximum limit of the rocks with strong polarization has a value of 21% more. Dunites, hartzburgites and fresh pyroxenites as well as a category of serpentinites assume the lowest level of polarizability. Their polarizability rarely amounts to 5 %. Dunites and hartzburgites are both of them serpentinized and serpentinites have an intermediate and strong polarization.

No difference is noticed between the serpentinites from dunites and serpentinites from hartzburgites.

The fresh rocks and the serpentinized ones which do not contain secondary magnetite, are not practicaly polarized (<0.2%). With the increase of the quantity of magnetitie the IP coefficient is also increased. With the appearance of the magnetite in the form of fine chains and veinlets, the coefficient of IP is increased.

Based on the data related with the nature of the polarizability of the chrome spinel ore and the ultrabasic rocks, it can be concluded that their intermediate and strong polarization is a volumous polarization developed in the metal (Magnetite) -electrolyte interface. The absence of distinctions between the anodic and cathodic polarization speaks of the volumous nature of polarization, too.

CONCLUSIONS

1. The density is the most stable and typical physical property which can be used for the differentation of the chromites from the surrounding rocks. Therefore the gravity is the basic geophysical method for the prospecting of chromite deposits.

2. The gravity survey, as the main geophysical method of the prospecting, cannot substitute the magnetic and both of them cannot substitute the electrical prospecting (IP method).

There are magnetic ores which can be strongly polarized but which cannot be or are poorly differentiated from the host rocks by the density values.

3. There are chromite ores with similar features to the surrounding rocks. These ore bodies cannot create local anomalies of physical fields.

4. Physical properties of ultramaphic rocks show a great variation and sometimes a group of rocks can be differentiated by its physical properties from surrounding rocks.

5. The study of the orientation of the vector of remanent magnetization for the ores and surrounding rocks can be used as a suplementary information about their conditions of the formation and their consecutive changes.

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