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CHARACTERISTICS OF THE GEOLOGICAL AND GEOPHYSICAL STRUCTURE OF THE PANAGYURISHTE ORE REGION ACCORDING TO GEOMAGNETIC DATA

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ABSTRACT. Analysis and interpretation of magnetic field in scale 1:100000 are performed for the investigation of the geological and geophysical structure of the Panagyurishte ore region.
The magnetic susceptibility of the rocks that are composing the Panagyurishte ore region changes in a large interval – from practically non-magnetic members of the gneisses and the granodiorites, up to the high-magnetic gabbro that has a magnetic susceptibility of 7500.10^{-6} SI. This good differentiation is a precondition for the effective utilization of data connected to the geomagnetic field distribution.
The observed geomagnetic field in the territory under study is highly differentiated. This is reflecting the non-uniform according to magnetic properties near-surface geological section. The anomalies have relatively small range and high amplitudes. In order to perform quantitative interpretation, upward continuations of the geomagnetic field are computed at heights of 1, 2, 3, 4, 5 and 6 km.
The calculated upward continuations are showing that most of the anomalies are quickly diminishing. The rocks characterized by increased magnetic susceptibility, presented by the volcanic complex and the gabbro, are mapped without ambiguity by positive anomalies on the distribution schemes for levels up to about 2 km. The granitoids and the metamorphic complex rocks are outlined by low values for the geomagnetic field.
The results from the quantitative interpretation of the well-pronounced relatively local anomalies show that the average depths toward the centers of the magnetic masses causing the respective anomalies have values varying in the range from 0.2 km down to about 1.0 km.

ХАРАКТЕРИСТИКА НА ГЕОЛОГО-ГЕОФИЗИЧНИЯ СТРОЕЖ НА ПАНАГЮРСКИ РУДЕН РАЙОН ПО ГЕОМАГНИТНИ ДАННИ

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РЕЗЮМЕ. За изследване на геолого-геофизичния строеж на Панагюрския руден район е извършен анализ и интерпретация на магнитното поле в мащаб 1:100000.
Магнитната възприемчивост на скалите, изграждащи Централното Средногорие варира в широки граници – от практически немагнитни представители на гнайсите и гранодиоритите до високомагнитно габро, за което магнитната възприемчивост достига 7500.10^{-6} SI. Тази добра диференциация е предпоставка за ефективно използване на данните за разпределението на геомагнитното поле.
Наблюдаваното геомагнитно поле за изследваната територия е силно диференцирано Това отразява нееднородния по магнитни свойства приповърхностен геоложки разрез. Аномалиите имат сравнително малък обхват и големи амплитуди. За целите на количествената интерпретация е извършено аналитично продължение на геомагнитното поле в горното полупространство на височини 1, 2, 3, 4, 5 и 6 км. За нивата до около 2 km еднозначно се отделят с позитивни аномалии скалите с повишена магнитна възприемчивост, представени от вулканогенния комплекс и габро. Гранитоидите и скалите на метаморфния комплекс се картират с ниски стойности на геомагнитното поле.
Резултатите от количествената интерпретация на добре оформените относително локални аномалии показват, че са средните дълбочини до центъра на магнитоактивните маси, формиращи съответните аномалии са в границите от 0.2 до около 1.0 km.

Introduction

Analysis and interpretation of the geomagnetic field in scale 1:100000 are performed for the investigation of the geological-geophysical structure of the Panagyurishte ore region. The territory under study includes 5427 km^2. It is aligned in N-S direction and has a rectangular shape with dimensions 67 x 81 km.

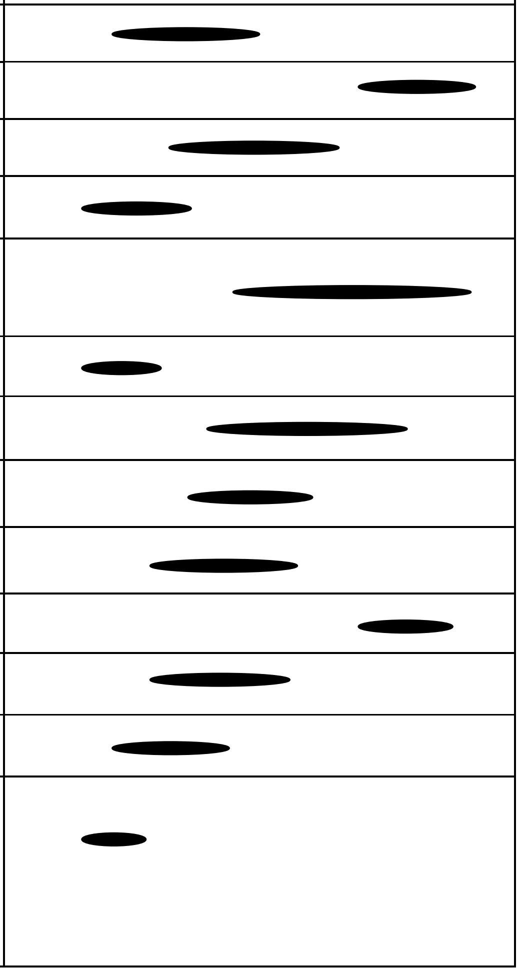
The compound analysis and the component distinction of the magnetic field are performed by the utilization of selected transforms. For the recalculation are applied traditional methods (Baranov, 1975; Telford et al., 1990; *Магниторазведка*, 1980, etc.). The quantitative interpretation is performed along selected profiles by the application of the selection and regularization method (Ставрев, Радичев, 1990). The obtained results are presented as schemes and as sections along selected profiles.

The summarized data (Raditchev et al., 1999; 2002, etc.) for the magnetic susceptibility of the rocks that are composing the Panagyurishte ore region are presented in Table 1.

The magnetic susceptibility of the rocks that are composing the Panagyurishte ore region changes in a large interval - from practically non-magnetic members of the gneisses and the granodiorites, up to the high-magnetic gabbro that has a magnetic susceptibility of 7500.10^{-6} SI.

Table 1. *Summarized data for the magnetic susceptibility æ (in units SI) of the rocks, composing the Panagyurishte ore region*

Age	Facies	Type of rocks	æ [10^{-6} SI] 0 1000 2000 3000 4000 5000
Upper Cretaceous	Intrusive (abyssal)	Diorites	
		Gabbro	
		Monazites	
	Hypoabyssal	Granodiorites	
		Diorite - , quartz-diorites - and granodiorite - porphyrites	
		Quartz-monazite-diorites	
	Volcanic	Andesites	
		Andesite tuffs	
		Andesite tufaceous breccia	
		Basaltic andesites	
		Dacites	
		Dacite tufaceous breccia	
Palaeozoic	Intrusive	Granitoids	



A low magnetic susceptibility is characteristic for the granodiorites of the hypoabyssal complex – $æ_{av}$ = 240.10^{-6} SI. Low to middle values for the average magnetic susceptibility have the dacites of the volcanic facies – $æ_{av}$ = 1900.10^{-6} SI and the diorites of the intrusive facies – $æ_{av}$ = 1300.10^{-6} SI. In the three facieses one can observe rock types characterized by relatively high magnetic susceptibility: the porphyrites of the hypoabyssal complex – $æ_{av}$ = 4800.10^{-6} SI, the andesites of the volcanic facies – $æ_{av}$ = 3200.10^{-6} SI, and the gabbro of the intrusive facies – $æ_{av}$ = 5600.10^{-6} SI. The basaltic andesites are characterized by increased magnetic susceptibility – $æ_{av}$ = 4600.10^{-6} SI.

The practically non-magnetic members of the metamorphic complex and the granodiorites, as well as the relatively increased magnetic susceptibility values of the rocks belonging to the volcanogenic complex have dominant influence in the formation of the geomagnetic field in the Panagyurishte ore region.

Estimating the magnetic susceptibility of the ore deposits, one should take into account the fact that beside the preliminary conditions for the formation of the magmatic rocks, a considerable influence over the changes of the magnetic susceptibility have also the secondary hydrothermal processes. They lead to the formation of new ferromagnetic minerals or to the destruction of existing ferromagnetic minerals and respectively to the formation of less magnetic ones. The analysis shows that for the conditions of the Panagyurishte ore region the dominating process is the destruction of existing ferromagnetic minerals and respectively the formation of less magnetic ones.

Analysis and interpretation of the geomagnetic field

As it is well known, if compared to the observed gravitational field, the observed geomagnetic field has the physical-mathematical sense of a first derivative and respectively is reflecting smaller depths of the geologic-geophysical section. The performed upward continuation is suppressing the local anomalies and is revealing in a slightly deformed shape the relatively regional components. It has to be mentioned that the idea of "local" and "regional" components is in a high degree relative. In this sense it is useful to utilize a set of different upward continuation schemes and like this to be able to follow the magnetic field distribution changes and the character of the reflected peculiarities of the geologic-geophysical structure.

For the geomagnetic field are performed upward continuations at heights 1, 2, 3, 4, 5 and 6 km.

The observed geomagnetic field in the territory under study (Fig. 1) is highly differentiated. This is reflecting the non-uniform according to magnetic properties near-surface geological section. The anomalies have relatively small range and high amplitudes.

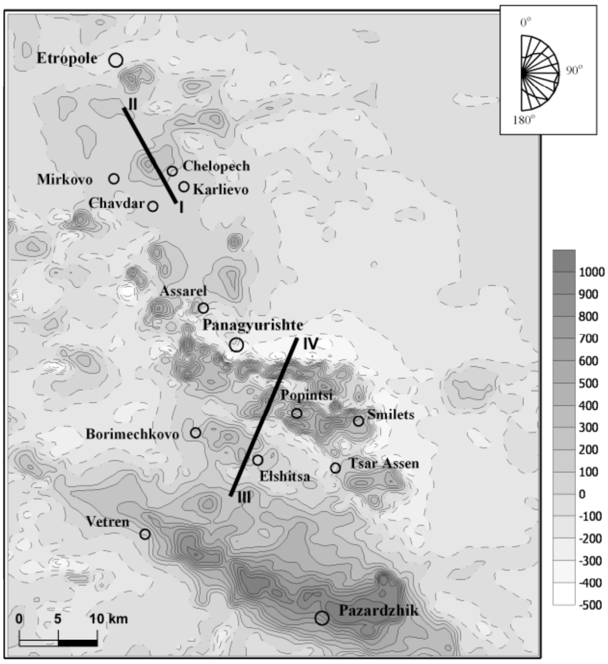


Fig. 1. Scheme of the geomagnetic field vertical component ΔZ distribution (in nT), the position of the studied lines and a rose-diagram of the field isolines orientation

The calculated upward continuations are showing that most of the anomalies are quickly diminishing. This is well illustrated by the presented field distribution schemes compiled from the upward continuations at heights H=1 km (Fig. 2) and H=3 km (Fig. 4).

The analysis of the geomagnetic field distribution, taking into account the geologic map and the rocks magnetic susceptibility (Table 1), is showing that the positive magnetic anomalies are mapping the predominant presence of rocks of the volcanogenic complex in the geological section.

In Figure 3 are illustrated the main positive and negative anomalies pronounced on the geomagnetic field distribution scheme compiled from the upward continuation at height H=1 km.

The expansive negative anomaly 1n and the occupying a limited area negative anomaly 2n are mapping the Srednogorie anticlinorium granitoids. In the western part of the studied territory the negative anomalies 3n and 4n are connected to the metamorphic complex.

Fig. 2. Scheme of the geomagnetic field vertical component ΔZ upward continuation at height H=1 km (in nT) and location of the main ore deposits and ore mineralizations

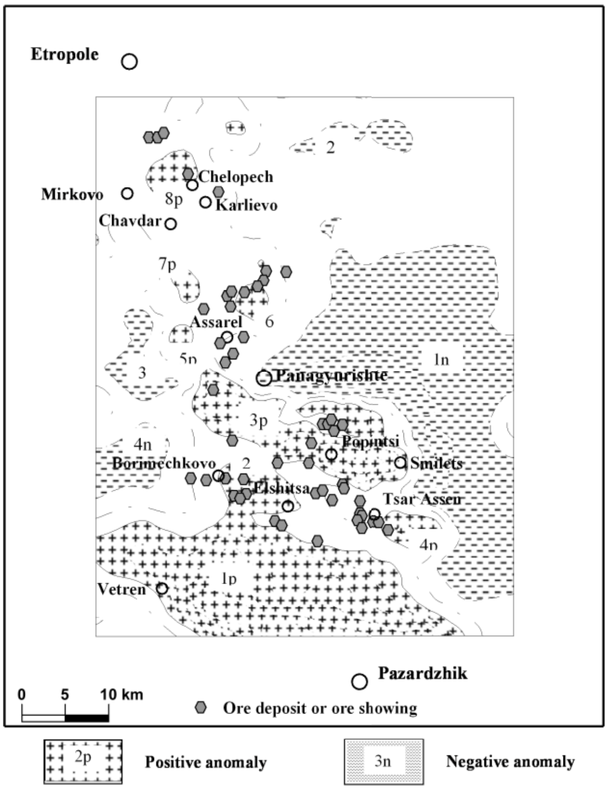


Fig. 3. Zoning of the geomagnetic field vertical component ΔZ distribution, compiled from the upward continuation at height H=1 km and location of the main ore deposits and ore mrienalizations

The vast positive anomaly 1p in the southern portion of the area (outside the boundaries of the Panagyurishte ore region) is caused by the Srednogorie neointrusions. The set of positive anomalies 2p, 3p, 4p, 5p, 6p, 7p and 8p is reflecting without ambiguity the influence of the volcanogenic complex rocks characterized by an increased magnetic susceptibility.

In Figure 5 are illustrated the results from the quantitative interpretation of the well-pronounced relatively local anomalies. Presented are the average depths toward the centers of the magnetic masses causing the respective anomalies. These depths have values varying in the range from 0,2 km down to about 1,0 km.

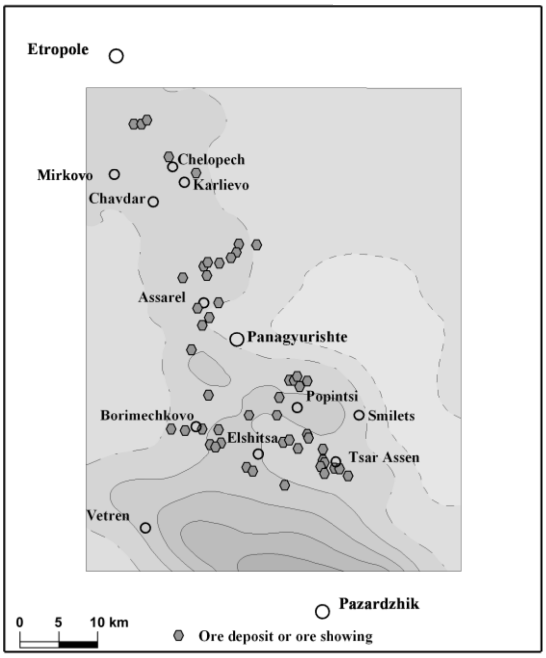


Fig. 4. Scheme of the geomagnetic field vertical component ΔZ upward continuation at height H = 3 km (in nT) and location of the main ore deposits and ore mineralizations

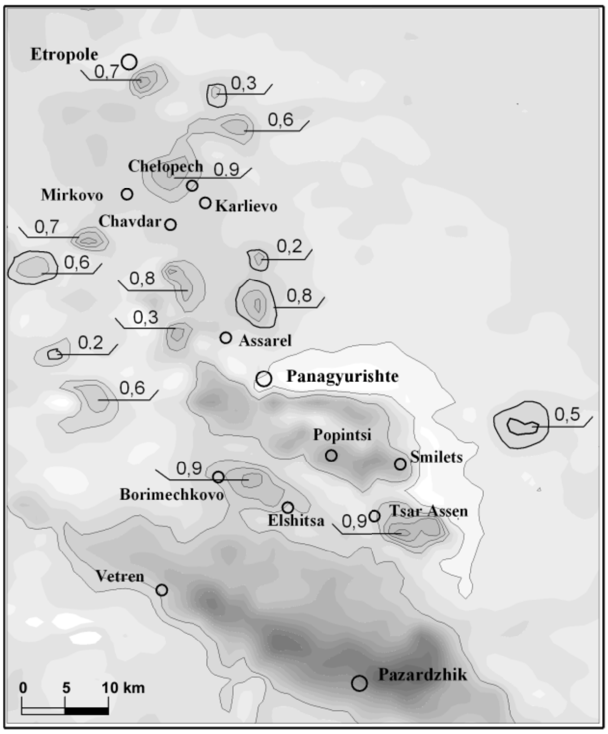


Fig. 5. Scheme of the main local geomagnetic anomalies in the Panagyurishte ore region and depths (in kilometers) toward the centers of the anomaly-forming magnetic masses

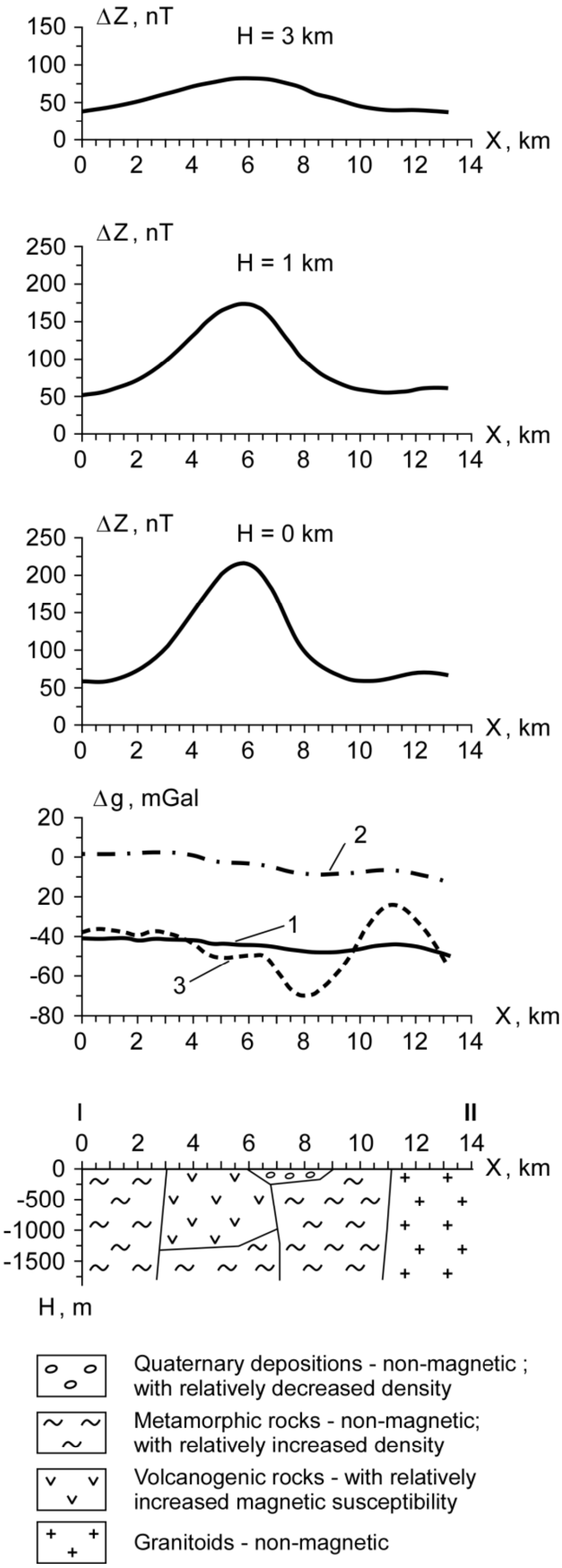


Fig. 6. Geomagnetic field distributions along profile I-II (see Fig. 1) compiled from the upward continuations at heights 0, 1, and 3 km; distribution of the observed gravitational field (1), variation anomalies compiled from the centre-point and ring method of Griffin using circle of radius R=10 km (2) and downward continuation to depth H=1 km (3); geologic-geophysical model along the profile

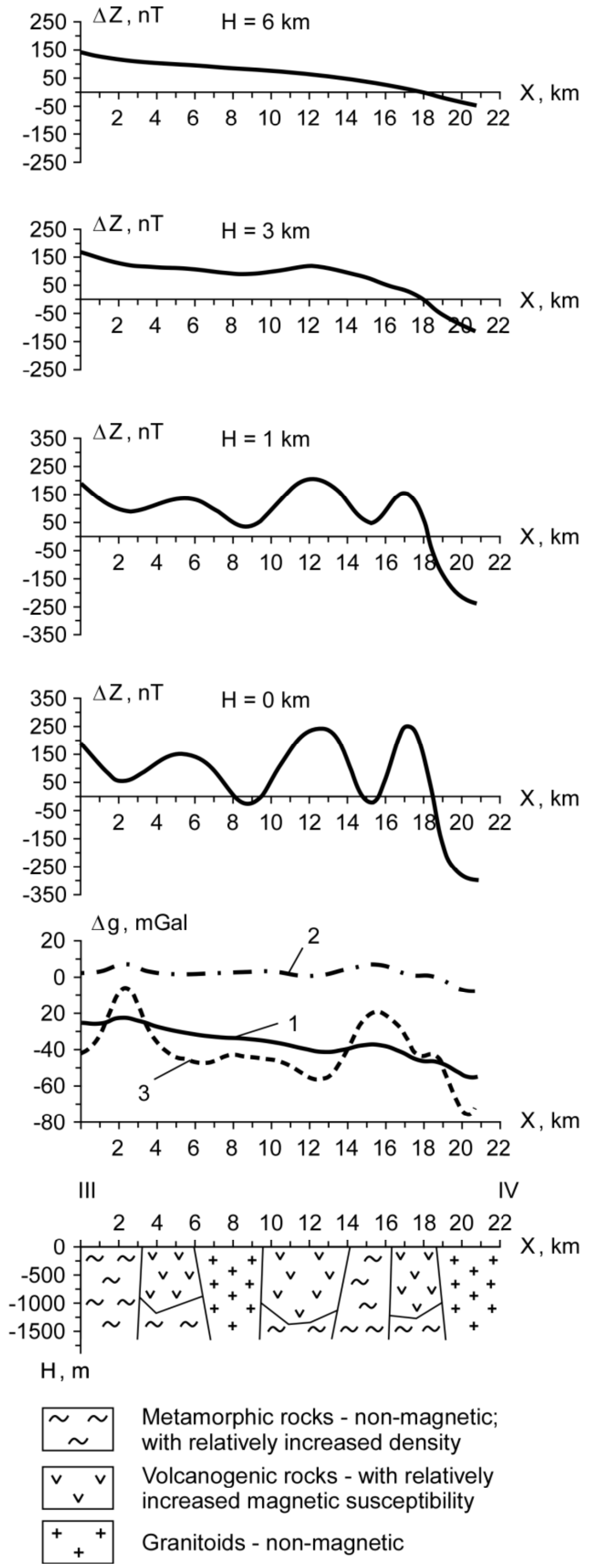


Fig. 7. Magnetic field distributions along profile III-IV (see Fig. 1) compiled from the upward continuations at heights 0, 1, 3 and 6 km; distribution of the observed gravitational field (1), variation anomalies compiled from the centre-point and ring method of Griffin using circle of radius R=10 km (2) and downward continuation to depth H=1 km (3) ; geologic-geophysical model along the profile

Along the profiles I-II and III-IV (see Fig. 1) is illustrated the distribution of the geomagnetic field vertical component ΔZ on different levels and the distribution of selected gravitational fields. Quantitative interpretation is performed, according to average residual values for the magnetic susceptibility. The obtained geologic-geophysical models of the sections along the lines are illustrated in Figure 6 and Figure 7.

Only one anomaly is registered along profile I-II (Fig. 6). It diminishes relatively slowly. The anomaly amplitude decreases from 175 nT for the observed geomagnetic field down to 25 nT for the upward continuation at height H = 6 km. This fact is revealing the considerable depth of the anomaly-forming masses presented by the rocks of the volcanic complex.

The analyzed geomagnetic field distribution along profile III-IV (Fig. 7) is highly differentiated on levels up to about 2 km and flattens quickly on higher levels. On levels above 3 km it reflects only the regional gradient of the Srednogorie magnetic minimum that is mapping the Srednogorie anticlinorium granitoids. The rocks characterized by increased magnetic susceptibility, presented by the volcanic complex, are mapped without ambiguity by positive anomalies on the distribution schemes for levels up to about 2 km. The granitoids and the metamorphic complex rocks are outlined by low values for the geomagnetic field.

The compound analysis of the obtained results shows that the studied area is situated over a highly differentiated geomagnetic field. Only in the north-eastern part of the region is well-distinguished a vast area of relatively undisturbed field, characterized by negative values for the geomagnetic field vertical component ΔZ. This zone is reflecting the granitoids of the Srednogorie anticlinorium. In the periphery of this territory is well-expressed the metallogenic complex, having increased magnetic susceptibility. The complex fault tectonics and the processes of hydrothermal metamorphism also have substantial influence over the composite mosaic picture of the geomagnetic field distribution in the studied region.

The results, obtained from the performed qualitative and quantitative analysis and interpretation of the geomagnetic field in the Panagyurishte ore region prove the prospects for the application of geophysical methods for mapping in a horizontal plane. When the geophysical field reveals a complex morphology, it is befitting to utilize proper transforms. It is also possible to perform a correct estimation of the depth distribution of geological formations, i.e. mapping in a vertical plane. That is very important for the geological mapping, and especially for the goals of the exploration studies.

Conclusions

The analysis and interpretation of the Panagyurishte ore region geomagnetic field in scale 1:100000 gives reason for the following conclusions:

- The magnetic susceptibility of the rocks that are composing the Panagyurishte ore region changes in a large interval. The practically non-magnetic members of the metamorphic complex and the granodiorites, as well as the relatively increased magnetic susceptibility values of the rocks belonging to the volcanogenic complex have dominant influence in the formation of the geomagnetic field in the studied area.

- The observed geomagnetic field in the territory under study is highly differentiated. This is reflecting the non-uniform according to magnetic properties near-surface geological section. The anomalies have relatively small range and high amplitudes.
- In order to perform quantitative interpretation, upward continuations of the geomagnetic field are computed at heights of 1, 2, 3, 4, 5 and 6 km. The rocks characterized by increased magnetic susceptibility, presented by the volcanic complex, are mapped without ambiguity by positive anomalies on the distribution schemes for levels up to about 2 km.
- The results from the quantitative interpretation of the well-pronounced relatively local anomalies show that the average depths toward the centers of the magnetic masses causing the respective anomalies have values varying in the range from 0,2 km down to about 1,0 km..

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