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COMPARISON BETWEEN EASTERN RHODOPES BLOCKS BY HEAVY MINERALS CONCENTRATE DATA

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Introduction

The concepts on the geological structure of the Rhodopes and in particular on the East Rhodopes changed many times: median massif of superimposed tectono-magmatic activization; mosaic of exotic and accretion collage blocks; a chain of high-grade metamorphic core complexes with superimposed depressions between them.

According to present-day concepts, the Rhodopes were affected during the Late Alpine tectonic cycle by extensional processes resulting in the formation of high-grade metamorphic core complexes (domes). The following domes can be divided: Central Rhodopian, Kesebir and Biala Reka domes. The Sakar high-grade metamorphic block, located in the NE part of the studied area, was not affected by extension.

Depressions filled mainly with terrigenous sediments and intermediate and acid volcanics were superimposed in the areas between the domes as well between them and the Sakar Block They all are denoted as East Rhodopian Depression.

The individual blocks are characterized by specific metallogeny. The studied part of the Central Rhodopian Dome hosts ores of the quartz-galena-spalerite formation exclusively (Central Rhodopian ore region). Typical for the East Rhodopian Depression, Biala Reka Dome and Kesebir Dome (East Rhodopian ore region) are the quartz-gold-base metals ore formation as well as quartz-gold-adularia mineralizations. For the time being, significant ore mineralizations are not known in the studied part of Sakar Block.

Method

The preliminary studies carried out on the minerals distribution in heavy minerals concentrate samples from Momchilgrad Depression and the consequent prognoses for gold prospecting in the East Rhodopes have shown a contrast between the mineral composition of the samples from the Paleogene depressions and those from their metamorphic framework. This result provoked us to compare the blocks divided according to geological considerations (Central Rhodopian Dome, Kesebir Dome, Biala Reka Dome, Sakar Block and East Rhodopian Depression) based on the composition of heavy mineral concentrates samples taken from the stream sediments in these structures.

This comparison was made using the bilateral criteria of Kolmogorov-Smirnov (after Cheeney, 1986). The blocks were indexed in color in the virtual plain on the monitor screen and then the samples from the database, plotting in the colored areas, were separated and standardized to the total number of mineral discoveries in the total area (Table 1). The maximum difference (sup) between the distributions of discovered minerals for every two blocks was compared with Ksm – the admissible difference at a 99.99% confidence interval

$$Ksm = 1.63\sqrt{\frac{n_1 + n_2}{n_1 n_2}}$$

where: n_1 – number of discoveries of a mineral in the first sampling, n_2 – number of discoveries of the same mineral in the second sampling. When sup<Ksm it is assumed that both samplings appear to be part of one general population, whereas when sup>Ksm – both samplings come from different general populations at probability 99.99%.

For clarity, a coefficient of distinction K is introduced. It indicates how many times every two objects differ from the critical value:

$$K = \frac{\sup}{Ksm}$$

For the purpose of mineralogical zonation, the Poison test was used by comparison of the mineral composition within basic squares at expected number of identical minerals Ma (Vitov, 1994):

$$Ma = \frac{(a+b)(a+c)}{a+b+c+d}$$

where: a – number of identical minerals; b – number of minerals in the first sample only; c – number of minerals in the second sample only; d - number of minerals, which were looked for but were not discovered in both samples. The probability distribution P for discovery of m identical minerals in both samples is given by Tonkov (1984):

$$Pm = \frac{Ma^m}{m!}e^{-Ma}$$

where: m=0, 1, 2…; e=2.71 – base of natural logarithms. At

$$\sum_{m=0}^{m=a} Pm > (1-\alpha)$$

it is assumed that both mineral compositions belong to one population. In this case groups of samples of close mineral composition are defined which is illustrated by coloring of the basic square on the map in the group color. In this case α is the boundary of a critical field (probability for error), as well as a factor of subdivision of the area into smaller domains.

Data from heavy mineral concentrates mapping of Bulgaria carried out in 1945-2000 by geological parties of KGMR were used for comparison of the tectonic blocks. These data were stored in a database and up-dated up to 2004. For solving that problem, 20872 heavy minerals concentrate samples were used with data for 46 different minerals (Table 1).

Results

The comparison of tectonic blocks was made by distribution analyses of discovered minerals in the samples (Table 1, Table 2). It was established that the blocks differ significantly in their heavy mineral concentrates composition.

The subdivision into regions based on mineral composition using heavy mineral concentrates data within basic squares has shown that changing of α determines the degree of detailed subdivision of the region as follows:

α	0.50	0.25	0.10	0.05	0.025	0.01
N	2	4	8	11	13	17

Conclusion

The study carried out has shown contrasting composition of heavy mineral concentrates samples from different East Rhodopes blocks that is a consequence of their different geological structure as well as of their specific metallogeny.: **Central Rhodopian Dome – 6075 samples** with monazite, galena, xenotime, pyromorphite, scheelite, orthite, cerussite, kyanite, sphalerite; **Kesebir Dome** – **956 samples** with kyanite, gold, scheelite, monazite and Chromite; **Biala Reka Dome – 1987 samples** with gold, chromite, scheelite, monazite, kyanite and bismuthite; **Sakar Block** – **2098 samples** with ilmenite, rutile, scheelite, monazite, bismuthite, barite and gold; **East Rhodopian Depression – 9746 samples** with barite, chromite, monazite, gold, kyanite, galena. The minerals arranged by frequency of meeting characterize the composition of the regions and the metallogenic prospective for ore prospecting.

Table 1. Probability distribution of minerals to be discovered in heavy minerals concentrates from Eastern Rhodopes totally and from individual tectonic blocks.

Block		East Rhodopes (totally)	East Rhodopian Depression	Central Rhodopian Dome	Kesebir Dome	Biala Reka Dome	Sakar Block
Number of samples		20872	9746	6075	956	1987	2098
Number of discoveries		48212	24393	12992	1851	3266	5710
N	Mineral	Probability for discovery					
1	Monazite	0.1497	0.0838	0.3147	0.1696	0.0756	0.0912
2	Chromite	0.0958	0.1407	0.0140	0.0918	0.1987	0.0322
3	Barite	0.0941	0.1539	0.0153	0.0048	0.0551	0.0686
4	Gold	0.0766	0.0750	0.0290	0.1934	0.2801	0.0562
5	Scheelite	0.0705	0.0300	0.0608	0.2020	0.2026	0.1474
6	Kyanite	0.0751	0.0683	0.0431	0.2928	0.0719	0.0402
7	Galena	0.0555	0.0381	0.1189	0.0145	0.0428	0.0063
8	Rutile	0.0468	0.0474	0.0106	0	0	0.1681
9	Ilmenite	0.0395	0.0347	0.0013	0	0	0.1816
10	Orthite	0.0361	0.0402	0.0457	0	0	0.0288
11	Zircon	0.0310	0.0484	0.0108	0	0	0.0302
12	Cerussite	0.0239	0.0188	0.0454	0.0048	0.0079	0.0120
13	Xenotime	0.0227	0.0065	0.070	0.0005	0.0009	0.0038
14	Pyromorphite	0.0225	0.0062	0.0677	0.0081	0.0122	0
15	Titanite	0.0194	0.0290	0.0109	0	0	0.0152
16	Sphalerite	0.0168	0.0124	0.0384	0	0.0030	0
17	Thorite	0.0163	0.0196	0.0026	0.0010	0.0039	0.0455
18	Pyrite	0.0164	0.0259	0.0013	0	0	0.0159
19	Martite	0.0084	0.0159	0.0012	0	0	0.0007
20	Apatite	0.0083	0.0156	0.0013	0	0	0.0007
21	Arsenopyrite	0.0080	0.0017	0.0220	0.0108	0.0116	0.0005
22	Limonite	0.0074	0.0138	0.0012	0	0	0.0003
23	Spinel	0.0072	0.0048	0	0	0.0003	0.0399
24	Leucoxene	0.0070	0.0133	0.0010	0	0	0.0007
25	Wulfenite	0.0070	0.0010	0.0240	0	0	0.0001
26	Anatase	0.0065	0.0121	0.0012	0	0	0.0005
27	Corundum	0.0062	0.0077	0.0059	0	0.0006	0.0056
28	Marcasite	0.0061	0.0114	0.0009	0	0	0.0007
29	Lead	0.0058	0.0068	00.0030	00.0021	0.0183	0.0017
30	Hematite	0.0051	0.0097	0.0006	0	0	0.0001
31	Anglesite	0.0045	0.0025	0.0122	0	0	0
32	Malachite	0.0043	0.0032	0.0090	0	0.0036	0.0001
33	Chalcopyrite	0.0021	0.0012	0.0055	0	0.0003	0
34	Molybdenite	0.0015	0.0005	0.0038	0.0010	0.0024	0.0001
35	Cinabar	0.0010	0.0009	0.0002	0.0010	0.0030	0.0024
36	Coper	0.0006	0	0.0022	0	0	0

37	Vanadinite	0.0004	0.0007	0.0004	0	0	0
38	Cuprite	0.0003	0	0.0006	0	0	0.0012
39	Columbite	0.0002	0	0.0010	0	0	0
40	Silver	0.0002	0.0004	0	0	0	0
41	Stibnite	0.0001	0	0	0	0.0027	0
42	Cassiterite	0.0001	0.0001	0	0.0010	0.0009	0
43	Massicot	0.0001	0.0001	0	0	0	0.0001
44	Azurite	<0.0001	0	00.0003	0	0	0
45	Minium	<0.0001	0.0001	0	0	0	0
46	Volframite	<0.0001	0	0	0	0.0003	0

Table 2. Comparison between Eastern Rhodopes blocks by mineral composition of heavy mineral Concentrates samples (Kolmogorov-Smirnov, $\alpha<1\%$, Cheeney, 1976)

Object A	Number N_1	Object B	Number N_2	sup	Ksm	K
East Rhodopian Depression	19546	Central Rhodopian Dome	12970	0.218	0,018	11.86
		Kesebir Dome	1891	0.205	0.039	5.23
		Biala Reka Dome	3460	0.179	0.030	5.98
		Sakar Block	6198	0.141	0.023	5.93
Central Rhodopian Dome	12970	Kesebir Dome	1891	0.243	0.040	6.07
		Biala Reka Dome	3460	0.243	0.031	7.80
		Sakar Block	6198	0.231	0.025	9.18
Kesebir Dome	1891	Biala Reka Dome	3460	0.218	0.046	4.69
		Sakar Block	6198	0.250	0.042	5.84
Biala Reka Dome	3460	Sakar Block	6198	0.212	0.034	6.14

The Central Rhodopian Dome is characterized with the highest coefficient of distinction K in comparison with all other blocks, what is a reflection of its specific metallogeny. The East Rhodopian Depression, Biala Reka Dome and Kesebir Dome have the lowest coefficient of distinction, what is explained by their close metallogeny – they together build up the East Rhodopian gold-base metals region. It is difficult to explain the low coefficient of distinction of Sakar Block (sterile) from the structures of the East Rhodopian ore region. Having in mind the features of the relief and the direction of flow of the rivers a contamination of Sakar Block with minerals typical for the EastRhodopian ore region is quite possible.

The heavy minerals concentrates data have shown a potential for more detailed subdivision of the region and have confirmed the specific features in its geological structure.

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