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DENSITY AND POLARIZABILITY COEFFICIENT OF THE RHYOLITES IN THE RHODOPE MASSIF

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ABSTRACT

The rhyolite formation in the Rhodope massif is presented by Tertiary extrusive and effusive lava in the Western and Central Rhodopes.

Data from measurements performed by the Department of Applied Geophysics, University of Mining and Geology, Sofia and other organizations are summarized. The values for the density and the polarizability coefficient are studied on samples from different areas of the Rodope massif – the Bratsigovo-Dospat depression, the Dospat anticline, the Southern Rhodope syncline, the Northern Rhodope syncline, the Smolyan depression and other more local structures as the Kovachevo syncline, the Batak syncline, the Vacha uplift, the Lyaskovo uplift and the Hvoina graben-syncline.

Statistical analysis is applied for estimating the characteristics of sample packs from one and the same region, as well as for estimating the characteristics of the total set of available data. The surface distribution of the analyzed parameters is also studied.

The compound analysis of the values for the density and the polarizability coefficient of the rhyolites in the Western and Central Rhodopes is proving that the detailed mapping according to these characteristics can efficiently enrich the information obtained by the traditional geological mapping.

INTRODUCTION

The rhyolite formation in the Rhodope massif is presented by Tertiary extrusive and effusive lava in the Western and Central Rhodopes and is most completely studied in the Bratsigovo-Dospat structure (Bahneva *et al.* 1978 ; Bojkov *et al.* 1978). It is composed by biotite and amphibole-containing rhyolites up to rhyodacites. In the northern part of the Bratsigovo-Dospat volcanogenic structure they form one elongated in subequatorial direction zone (Bahneva *et al.* 1978). In the rhyolite zone can be isolated several elementary volcano-structures. The authors state that each of these structures is built by several close in age, in structural-morphologic peculiarities and in magnetic characteristics extrusives, as well as by the connected to them effusive lava flows.

I.Bojkov *et al.* (1978) confirm that in the Bratsigovo-Dospat depression the rhyolite covers have frequent occurrence and are characterized by a well-expressed almost horizontal surface parallelism – angle of dip of about 12°. Extrusive rhyolite bodies intersecting the rhyolite covers are located in the western part of the depression. These extrusive bodies are normally determining the contrast in the relief.

The presented study is based upon data from measurements performed by the Department of Applied Geophysics, University of Mining and Geology, Sofia and other organizations. The values for the density and the polarizability coefficient are studied on samples from different areas of the Rodope massif – the Bratsigovo-Dospat depression, the Dospat anticline, the Southern Rhodope syncline, the Northern Rhodope syncline, the Smolyan depression and other more local structures as the Kovachevo syncline, the Batak syncline, the Vacha uplift, the Lyaskovo uplift and the Hvoina graben-syncline.

The values for the density and the polarizability coefficient are studied according to data from laboratory measurements on rock samples of outcrop and drill core. Statistical analysis is applied for estimating the characteristics of sample packs from one and the same region, as well as for estimating the characteristics of the total set of available data.

DENSITY CHARACTERISTICS OF THE RHYOLITES IN THE RHODOPE MASSIF

The measured on rock samples of outcrop or drill core 973 values for the density vary in a wide range.

In Table 1 are systematized the main statistical characteristics of the values distribution for the density and in figures from 1 to 6 are illustrated the histograms of the parameter distribution for the different regions and for the total set the studied samples.

The compound analysis of the histograms elaborated for the different regions is showing that one main group is well pronounced in the density distribution. This group is including samples having density within the limits of 2,30-2,50 g/cm^3. A second group is also well pronounced. It contains a considerably smaller number of samples (6-14% of the total set). These samples are having relatively low values for the density - within the limits of 2,05-2,30 g/cm^3. The second group is including samples affected by hydrothermal metamorphism. This group is causing the negative values for the skewness of the density distribution for the samples from the Western Rhodope block, the Bratsigovo-Dospat depression, the Dospat anticline and the Smolyan depression, as well as for the total set of samples. Another group is well pronounced for the samples from the Southern Rhodope syncline. It contains about 20% of the samples and is characterized by relatively high values for the density - within the limits of 2,50-2,68 g/cm^3. This group is causing the positive value for the skewness of

the density distribution. In the other regions relatively high values for the density are measured only for separate samples.

The density distribution for the total set of samples is characterized by an average value of 2,38 g/cm^3, a standard deviation of 0,092 g/cm^3, and a wide range of parameter changes – from 2,04 g/cm^3 up to 2,68 g/cm^3.

Table 1. Main statistical characteristics of the density ρ [g/cm^3] of the rhyolites in the Rhodope massif

Region	Count	ρ^{min} / ρ^{max}	Average value	Standard deviation	Skewness	Kurtosis
Western Rhodope Block	174	2,17 / 2,48	2.35	0,072	-2,092	0,008
Bratsigovo-Dospat Depression	416	2,13 / 2,57	2,39	0,074	-6,12	6,6
Dospat Anticline	92	2,04 / 2,64	2,34	0,12	-2,24	2,3
Southern Rhodope Syncline	106	2,15 / 2,68	2,40	0,12	1,23	-0,29
Northern Rhodope Syncline	48	2,23 / 2,53	2,36	0,093	0,83	0,75
Smolyan Structural Depression	79	2,28 / 2,64	2,45	0,071	-1,01	2,11
Total	973	2,04 / 2,68	2,38	0,092	-4,94	7,67

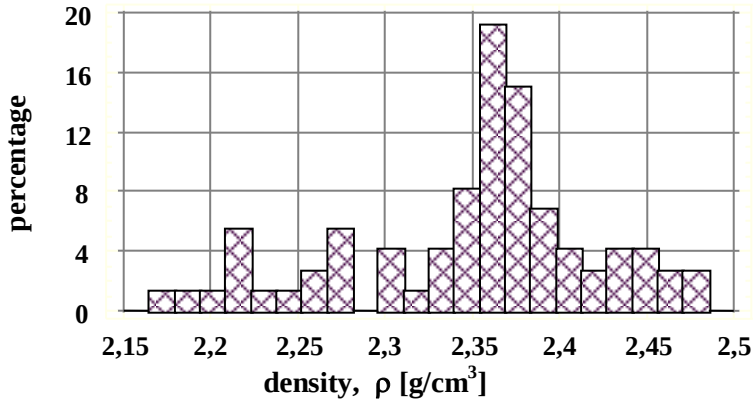

Figure 1. Histogram of the density distribution of the rhyolites in the Western Rhodope block

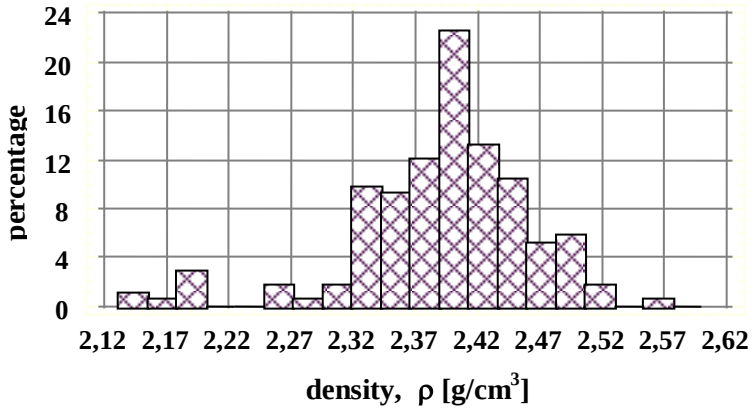

Figure 2. Histogram of the density distribution of the rhyolites in the Bratsigovo-Dospat depression

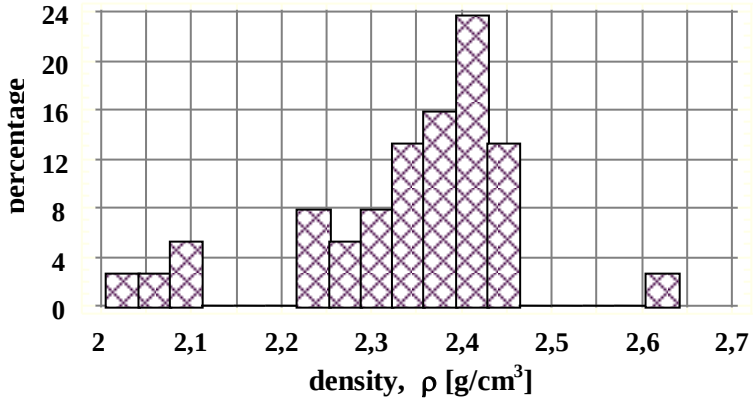

Figure 3. Histogram of the density distribution of the rhyolites in the Dospat anticline

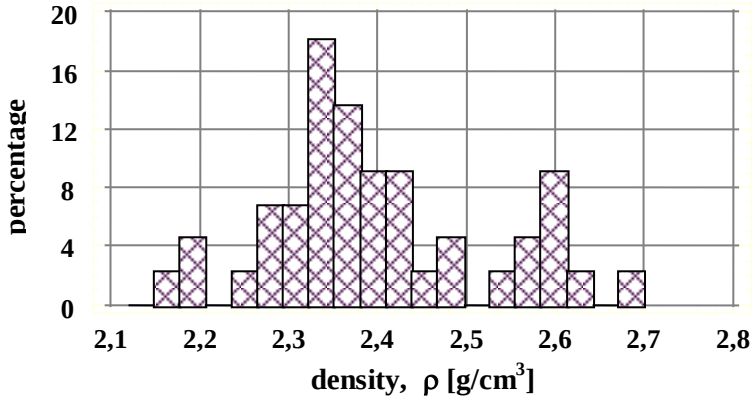

Figure 4. Histogram of the density distribution of the rhyolites in the Southern Rhodope syncline

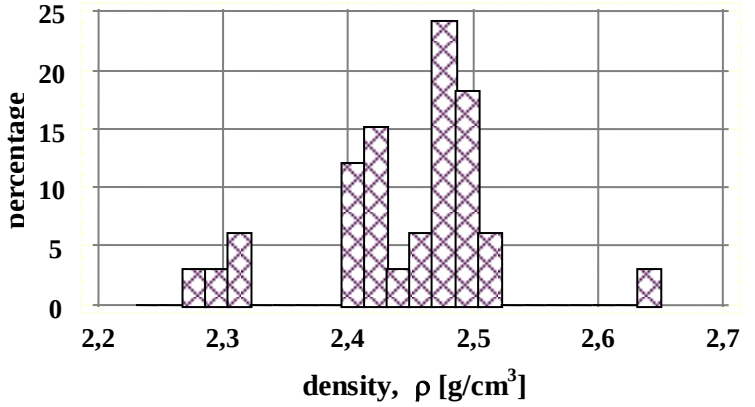

Figure 5. Histogram of the density distribution of the rhyolites in the Smolyan structural depression

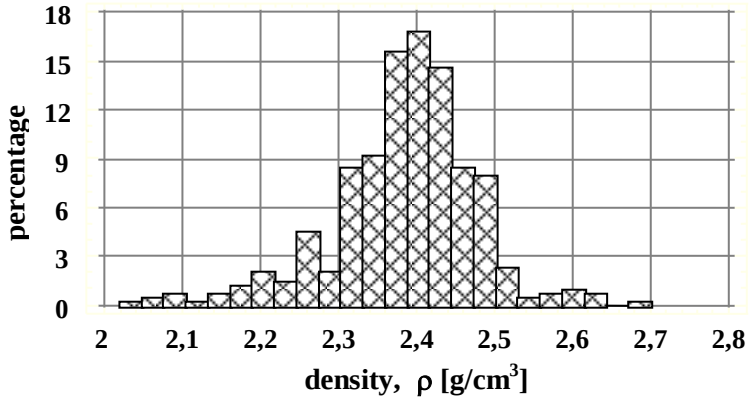

Figure 6. Histogram of the density distribution for the total set of rhyolite samples from the Rhodope massif

Different cluster analysis methods have been tried. The best results were obtained using the Ward's method, City-Block distance metric and classifying the data into 4 subgroups. The first one is including the samples affected highly by the hydrothermal changes. The second and third subgroups are containing about 76% of the total set of samples. The forth subgroup is characterized by relatively high density.

In Table 2 are presented the average values for the density of the separated subgroups and in Fig.7 is illustrated the dendrogram of the performed grouping.

Table 2. Average values for the density of the separated four subgroups after applying cluster analysis using the Ward's method, City-Block distance metric

Subgroup number	Samples		Average values for the density, ρ [g/cm3]
	Count	%	
1	68	7	2,16
2	350	36	2,33
3	389	40	2,41
4	166	17	2,51

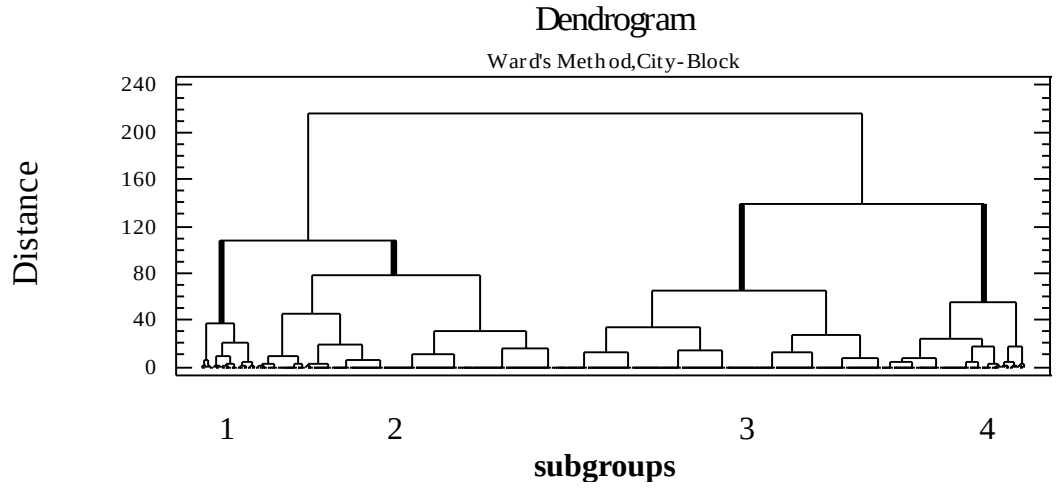

Figure 7. Dendogram of the performed grouping according to the density of the rhyolite samples from the Rhodope massif (four subgroups classified)

The surface distribution of the density of the rhyolites in the Western and Central Rhodopes region is presented in Fig.8. The Bratsigovo-Dospat depression is generally characterized by decreased values for the density. The Southern Rhodope syncline and the Smolyan structural depression are characterized by increased parameter values. The presented rose-diagram is showing no predominant direction of the isolines orientation.

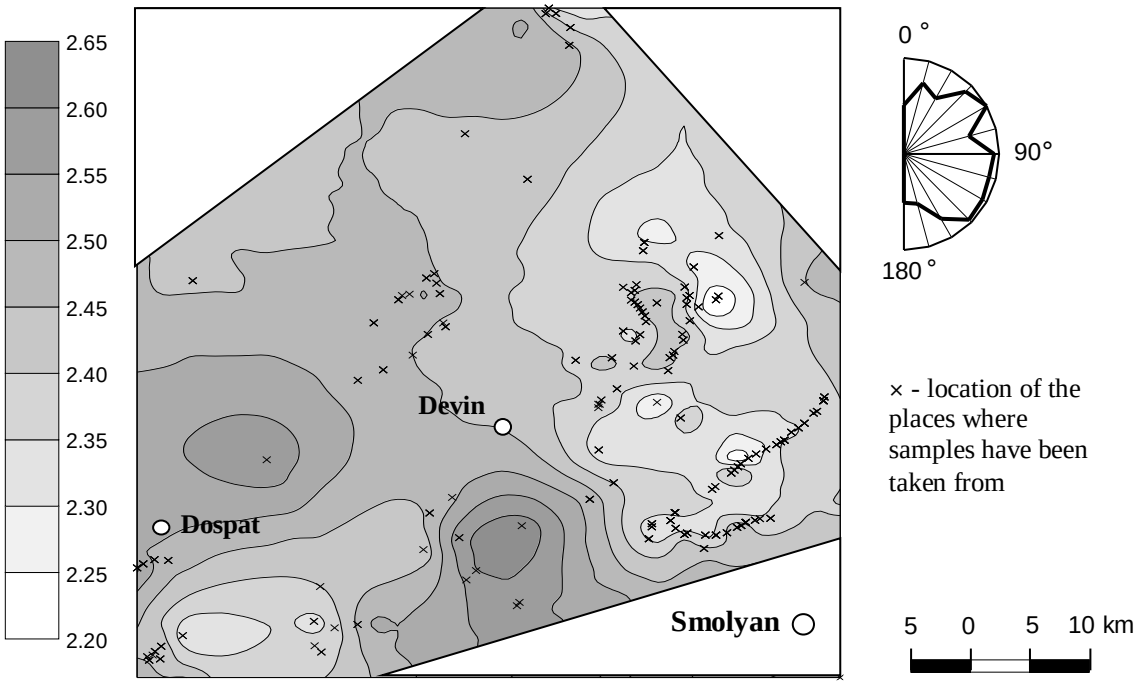

Figure 8. Scheme of the density surface distribution of the rhyolites in the Western and Central Rhodopes region and a rose-diagram of the isolines orientation.
The zoning is performed in g/cm^3

POLARIZABILITY COEFFICIENT OF THE RHYOLITES IN THE RHODOPE MASSIF

The measured on rock samples of outcrop or drill core 423 values for the polarizability coefficient vary in a wide range – from 0,22 up to 6,51% with an average value of 1,51%. In Fig.9 is illustrated the histograms of the parameter distribution for the main set of rhyolite samples – excluded are only about 2% of the samples characterized by relatively high polarizability coefficient (η >4,5%). The well-pronounced positive value for the skewness of the parameter distribution is connected to the presence of samples taken from the periphery of ore-bearing zones.

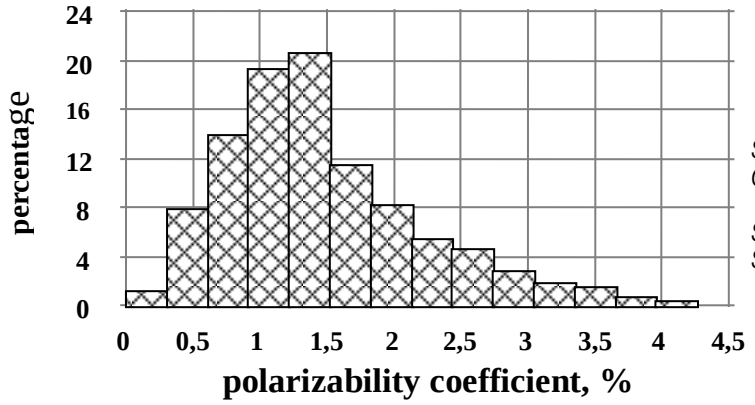

Figure 9. Histogram of the polarizability coefficient for the main set of rhyolite samples from the Rhodope massif

Summary statistics of the total set :
Count = 423; Min / Max = 0,22 / 6,51 %;
Average = 1,51 %;
Standard deviation = 0,85 %;
Skewness = 12,4; Kurtosis = 22.1

Different cluster analysis methods have been tried. The best results were obtained using the Ward's method, City-Block distance metric and classifying the data into 4 subgroups. In Table 3 are presented the average values for the polarizability coefficient of the separated subgroups and in Fig.10 is illustrated the dendrogram of the performed grouping. Very well pronounced is the first subgroup including about 39% of the samples characterized by an average value for the polarizability coefficient of 0,81%. The second and third subgroups are composed on the next level of grouping. They have average parameter values 1,40 and 1,96% respectively and comprise about half of the samples (48%). The forth subgroup has an average value for the polarizability coefficient of 3,14% and is containing about 13% of the total set of samples. It includes samples taken from the periphery of ore-bearing zones. These are the rhyolite samples causing the well-pronounced positive asymmetry of the presented in Fig.9 histogram.

Table 3. Average values for the polarizability coefficient of the separated four subgroups after applying cluster analysis using the Ward's method, City-Block distance metric.

Subgroup number	Samples		Average values for the polarizability coefficient, %
	Брой	%	
1	165	39	0,81
2	114	27	1,40
3	89	21	1,95
4	55	13	3,17

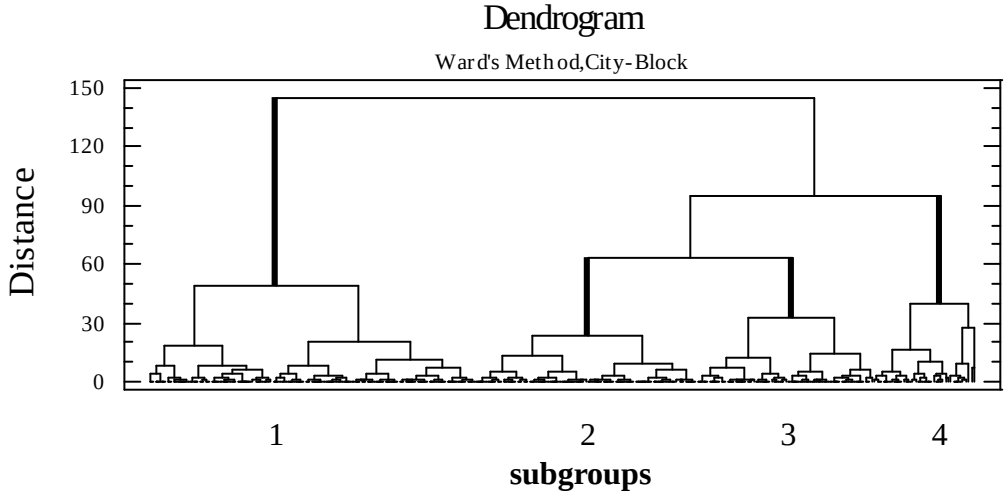

Figure 10. Dendogram of the performed grouping according to the polarizability coefficient of the rhyolite samples from the Rhodope massif (four subgroups classified)

CONCLUSIONS

- The density of the rhyolites in the Rhodope massif varies in a wide range - from 2,05 up to about 2,50 g/cm^3. One main group is well pronounced in the density distribution. This group is including samples having density within the limits of 2,30-2,50 g/cm^3. A second group is also well pronounced. It contains a considerably smaller number of samples (6-14% of the total set). These samples are having relatively low values for the density - within the limits of 2,05-2,30 g/cm^3. The second group is including samples affected by hydrothermal metamorphism. This group is causing the negative values for the skewness of the density distribution for the samples from the Western Rhodope block, the Bratsigovo-Dospat depression, the Dospat anticline and the Smolyan depression, as well as for the total set of samples.
- On the scheme of the surface distribution of the density of the rhyolites in the Western and Central Rhodopes region the Bratsigovo-Dospat depression is mapped by decreased values for the density and the Southern Rhodope syncline and the Smolyan structural depression are located by increased parameter values.
- The polarizability coefficient varies in a wide range – from 0,22 up to 6,51% with an average value of 1,51%. The well-pronounced positive asymmetry in the parameter distribution is connected to the presence of samples taken from the periphery of ore-bearing zones.
- The performed study of the density and the polarizability coefficient of the rhyolites in the Western and Central Rhodopes is enriching the possibilities for effective analysis of geophysical data and more precisely - for interpretation of gravity anomalies and results from the induced polarization method.

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