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GEOLOGICAL AND CHEMICAL CHARACTERISTICS OF DIATOMACEOUS EARTH FROM THE DEPOSIT VESHJE NEAR NEGOTINO - R. MACEDONIA

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ABSTRACT

This paper presents the results of the geological and chemical research of Diatomaceous earth in the deposit Veshje near by Negotino.

The deposit - Veshje belongs to Tikvesh basin which is situated in the central part of Vardar zone. This rich and numerical representation of diatomaceous flora and conditions that were present in the upper lake basin during Pliocene are actually the major factors for the formation of productive layer of Diatomaceous earth. Productive diatomaceous horizon appears in a form of a layer, with a length of 1-2 km and a thickness of 0,6 - 1,25 m, tending to form a spike towards the peripheral parts of the basin. Immediate layers above and below of the productive horizon are the andesite tuffs and agglomerations.

Based on chemical analyzes made done on Diatomaceous earth from Veshje, it resulted in the following content: SiO_2 - 78.40 %, Al_2O_3 - 6.40 % CaO - 2.20% and Fe_2O_3 - 2.60 %. Under this structure, Diatomaceous earth is a quality mineral resource which can be applied for filtration, thermal insulation and many other uses in industry and construction.

KEYWORDS:

Diatomaceous flora, Diatomaceous earth, Tikvesh basin, Pliocene

1. INTRODUCTION

Diatomite represent siliceous, sedimentary rock consisting principally of the fossilized skeletal remains of diatom, a unicellular aquatic plant related to the algae, during the tertiary and quaternary periods ([1] [12]).

Diatomaceous earth (DE), or diatomite, typically consists of 86–91% silicon dioxide (SiO_2), with significant quantities of alumina (Al_2O_3) and ferric oxide (Fe_2O_3) [5].

Amorphous silica, is the main component of diatomite, although variable quantities of other materials (metal oxides, clays, salts - mainly carbonates and organic matter) may also be present, chemical precipitation and atmospheric contact, together with the prevailing environmental conditions, are determinant factors in the nature and importance of the impurity

content of a deposit [11]. Due to its specific properties (porous structure, high silica content, low density, low conductivity coefficient, etc.) [5], DE has extensively been applied in many ways, such as filter aid, adsorbent, insulating material, catalyst support or carrier [15]. Diatomaceous earth recently represents and effective natural inert powder that is used as an insecticide.

1.1. Geological structure of the wider surrounding area of the deposit Veshje

The deposit of Diatomaceous earth Veshje is located 2.5 km SW of the village Veshje, or about 14 km south of the city Negotino and at territory it lies on the northeastern slopes of the volcanic plateau Vitacevo. In geological terms the deposit Veshje belongs to Tikvesh basin situated in central Vardar zone on the territory of the Republic of Macedonia.
The wider surroundings of the site are characterized by heterogeneous lithological structure, dominated by tectonic elements of Vardar direction (Fig. 1).

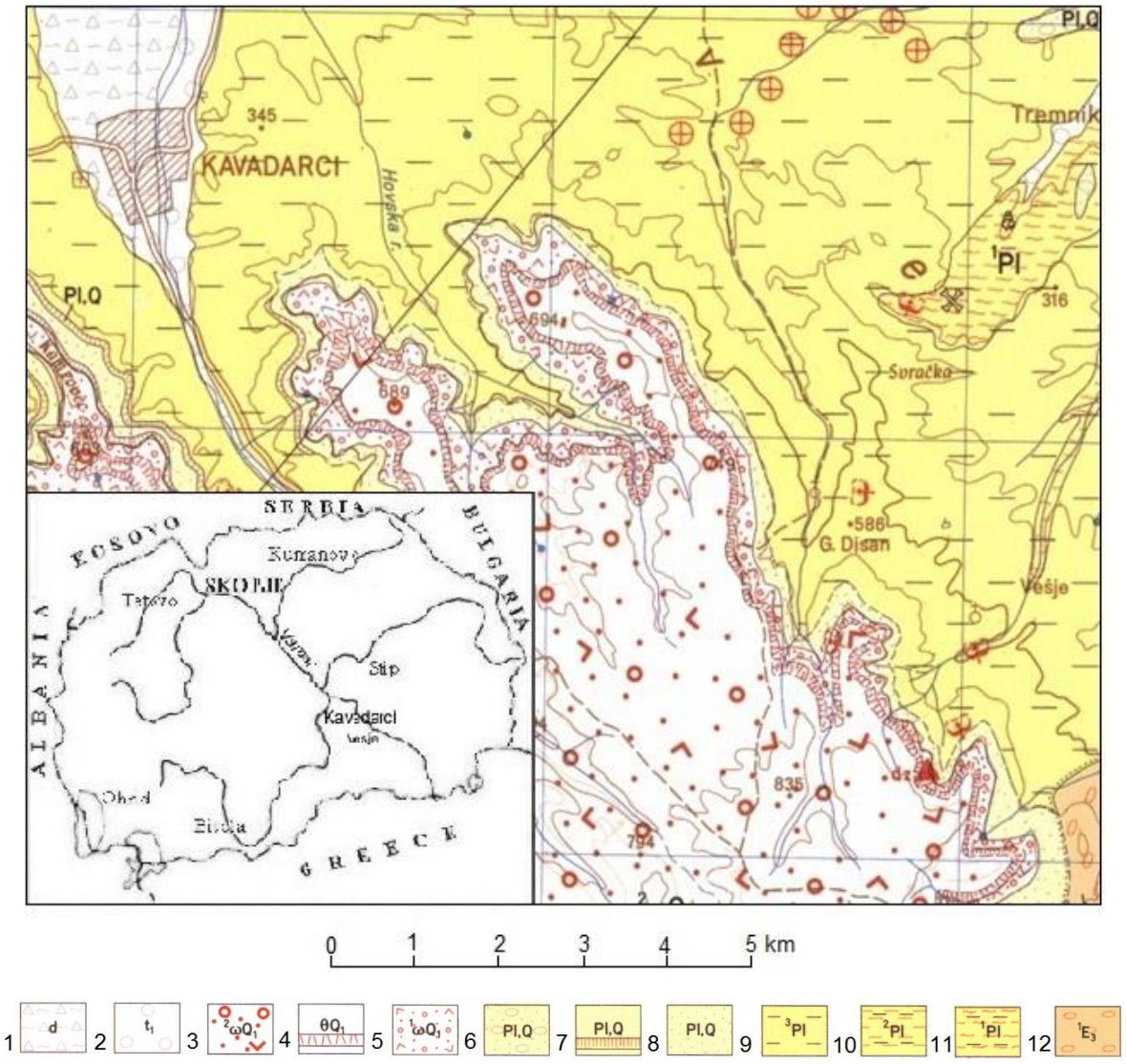

Fig. 1. Geological map of the vicinity of the deposit of Diatomaceous earth Veshje

1. Deluvium, 2. Lower river terrace, 3. Breccious tuff, 4. Stratified pelite tuff, 5. Aglomeratic and breccious tuff, 6. Sands and gravels, 7. Travertine limestones, 8. Sands, 9. Sandy series, 10. Series of marls and claystone with layers of coal, 11. Series of variegated clays, 12. Conglomeratic flysch

Heterogeneous lithological structure is represented by metamorphic rocks of Precambrian complex, rocks of Paleozoic complex, and Mesozoic rocks. The highest prevalence in the vicinity

of Veshje is at tertiary sedimentary rocks of the Paleogene (Upper Eocene) and Neogene (Pliocene) and quarterly sediments and volcanite.
Upper-Eocene sediments - are represented in the area of so-called basal lithozone ($_1E^3$), and they are found in the eastern regions of Veshje, specifically in the area of the village Vesvica. The basal lithozone is constructed of thick conglomerates around 600 m, built boulders of diabases, gabbro, and quartzite, and the upper part of Upper Jurassic limestone, rarely shale, diabases and gabbro.
Upper-Pliocene sediments - are represented by a sandy series Pl_3, which also have the highest prevalence in the basin. This series is made of sands and gravels with mostly yellowish color, and it is rarely seen and sub-layers of sandy clays, shales and poorly bonded sandstone. This series contains weak upper bound conglomerates, down to the southwest angle 3-5°. These sediments are found as containing fossil remains of *Mastodon arvernensis*, upon which the age of the sediments is defined as intermediate - Upper Pliocene [6].
Sediments of the Upper Pliocene-Pleistocene (Pl, Q) - are represented by limestone chalks and sand, and as the youngest occur at pyroclastic quaternary vulcanite constituting immediate construction of the site Veshje.

a) Travertine limestones (with sub-layers of gray sandstone) occurs in the form of two well layered plates south and southeast of Kavadarci (rare in the villages Disan and Veshje, which are most probably eroded). This series falls under the SW corner 3-5°, and the thickness of the plates is 3-8 m. Over the limestone chalks there are yellow sands lying, similar to those of the upper Pliocene.

b) Pyroclastic quaternary vulcanite – represent a part of the lake plateau Vitacevo and an end to the northern parts of Kozhuf quartzlatite massive volcanism [2]. They lie on older but different geological formations, and at the examined area they lie on Upper-Pliocene series. At the site of diatomaceous soil Veshje pyroclastic lie directly above the productive layer. Within these pyroclastites distinguished are: agglomerates, tuffs and stratified breccia.

1.2. Geological structure of the deposit Veshje

At the geological structure of the deposit Veshje there are lithological members volcanogenic-sedimentary complex of Pleistocene plateau Vitacevo or lower-quarterly age participating. The most represented pyroclastic creations presented with andesite agglomerates and volcanic andesite breccia, less stratified pelitic tuffs, diatomaceous earth, rarely limestone chalks and quaternary (diluvial) sediments.
The Upper Pliocene sediments (sand series) are presented in the northeastern and southeastern brim of the site (between Popovec- Pesokot and Osojot) and by stratigraphy they lie at the site shelf. Built from poorly clay bonded sands, rarely layered with marley and sandy clay, and rarely created as well of thin plates of grey-white limestone chalk. Generally these sediments have a NNW-SSE stretching and gently sink to the SW angle 2-3°.
Andesite pyroclastites lie directly on sandy series and are a product of quarterly Kozhuf volcanism. These creations lie at shelf and overlain the site, i.e. they occur in multiple stages of volcanic activity. For the most part, at the shelf of the locality there are andesite grainy gray tuffs lying with thickness of about 2 m, and below them almost everywhere there are andesite agglomerates or agglomerate tuffs occurring. The emergence of grain andesite tuffs can be considered as the beginning of a quieter phase, when freshwater lake where diatomite could be developed, which later on produced the material to create a layer of Diatomaceous earth.
Deposition of Diatomaceous earth is interrupted by starting a new volcanic activity, with more explosive nature, characterized by a series of andesite agglomerates, andesite agglomerative tuffs, rarely andesite breccia.
Andesite agglomerates almost everywhere lie directly over the layer of diatomaceous soil, and they occur in many of sub-layers of andesite agglomerative tuffs, and in some places and medium-grain andesite tuffs.
Visible signs of stratification of the series indicate that it was created (deposited) in the aquatic environment. Andesite agglomerates prevail with rounded fragments - volcanic bombs with diameters of 0.5 m. By contrast, in andesite agglomerative tuffs these fragments are no larger than 0.5 cm.

The total thickness of the pyroclastic complex of the examined locality is about 160 m, and probably the same in the vicinity (in higher areas) is not greater than 200 m.

2. MATERIALS AND METHODS

Material for studying the chemical composition of Diatomaceous earth represent 16 samples from the productive layer of the core 11 investigative drill-holes (D1, D2, D3, D4, D5, D8, D9, D10, D15, D16 and D19). Chemical characteristics of the mineral resource - Diatomaceous earth are determined by classical complete chemical analysis of 12 elements.

3. RESULTS AND DISCUSSION

The rich and numerical representation of diatomite flora and the conditions that were present at the lake basin during the Upper Pliocene, constitute major factors in the formation of the productive layer of diatomaceous earth at the deposit Veshje.
Diatomaceous productive horizon in the deposit Veshje has a shape of a layer that lies betweenthe andesite tuffs and agglomerates. The thickness of diatomaceous layer is variable, from 0.35 m in the peripheral parts up to 1-1.25 m at the central parts.
The color of the diatomaceous earth is different, depending on its composition or quality. There are varieties with white to gray-white, light gray and violet, and light beige etc. There are frequent sub-layers of clay-sandy sediments tuff–clay material of tufa and opal sub-layers and fossil flora at certain places in the productive layer. The thickness of these is 2-20 cm.
The layer of Diatomaceous earth is sub-horizontal with the general decline towards SW angle of 2-3°, which in many places has frequent wedging as a result of erosive action of waves in relatively shallow lake environment. This diatomaceous wedging is associated with a relatively short period of shallowness of the lake's basin, as well as explosive volcanism, which has probably put an end to the development of microorganisms - diatoms and other wildlife in the lake.
Determining the quality of mineral resource-diatomaceous earth is done by the method of classical chemical analysis of 12 elements of samples taken from the productive layer of the core of the drill-holes.
The data obtained by chemical analysis of diatomaceous earth of 16 samples of investigative drill-holes presented in Tables 1 and 2 show that the minimum content of SiO_2 in some blocks of the site Veshje in the drill D9 is 62.07% and the drill D8-2 65.70%. Maximum content of 87% was observed in the drill D19, and in the space of the old goldmine where the SiO_2 content is 90%.

Table 1. Chemical composition of Diatomaceous earth from the deposit Veshje – Negotino

	D1-1	D1-2	D2	D3-1	D3-2	D4	D5	D8-1
SiO_2	80.00	66.64	77.78	67.54	80.21	86.05	80.24	79.30
TiO_2	0.25	0.35	0.20	0.62	0.22	0.07	0.25	0.15
Al_2O_3	4.60	9.43	5.60	15.54	4.59	1.78	5.10	5.60
Fe_2O_3	1.43	3.77	2.14	6.86	1.72	0.86	2.14	2.08
MgO	0.93	3.35	0.72	2.02	0.77	0.34	0.74	0.81
CaO	1.40	2.36	2.05	2.60	1.41	2.00	1.70	1.66
Na_2O	0.70	1.65	0.65	2.25	0.70	0.28	0.80	0.80
K_2O	0.50	1.25	0.62	2.70	0.58	0.25	0.70	0.40
Loss of ignition	10.02	10.95	10.10	8.50	9.70	8.05	8.40	9.35
Total	99.83	99.75	99.86	100.13	99.90	99.78	100.06	100.15

Table 2. Chemical composition of Diatomaceous earth from the deposit Veshje - Negotino

	D8-2	D9-1	D9-2	D10-1	D10-2	D15	D16	D19
SiO_2	65.70	62.70	42.62	85.70	85.20	75.88	85.00	87.02
TiO_2	0.50	0.45	0.45	0.10	0.10	0.35	0.16	0.10
Al_2O_3	13.00	12.50	11.22	3.31	3.06	6.88	3.31	2.24
Fe_2O_3	4.29	3.72	3.86	1.43	1.14	3.00	2.19	3.07
MnO	-	-	-	-	-	0.12	0.06	0.05
MgO	1.98	3.30	1.86	0.50	0.52	1.61	0.65	0.88
CaO	2.73	5.04	19.04	1.68	1.46	3.36	4.40	3.70
Na_2O	2.10	3.30	2.70	0.80	1.10	0.90	0.64	0.37
K_2O	1.60	2.50	1.80	0.50	0.40	0.80	0.39	0.31
P_2O_5	-	-	-	-	-	1.48	0.40	1.18
SO_3	-	-	-	-	-	-	-	-
Loss of ignition	7.98	6.80	16.25	5.85	6.80	5.23	3.06	1.47
Total	99.88	99.60	99.80	99.87	99.78	99.61	100.26	100.39

Based on the analyses the average SiO_2 content of the entire site was 78.40%, Al_2O_3 6.40%, CaO 2.20%, Fe_2O_3 2.60% and loss during ignition 7.50% (Table 3).

Table 3. Chemical composition of the essential components of Diatomaceous earth in the deposit Veshje - Negotino

	SiO_2	Al_2O_3	Fe_2O_3	CaO	Loss of ignition	Thickness (m)
D1-1	80.00	4.60	1.43	1.40	10.0	0.25
D1-2	66.64	9.43	3.77	2.36	11.0	0.20
D2	77.78	5.60	2.14	2.05	10.0	0.40
D3-1	67.54	15.54	6.86	2.60	6.5	0.30
D3-2	80.21	4.59	1.72	1.41	9.7	0.50
D4	86.05	1.78	0.86	2.00	8.0	0.90
D5	80.24	5.10	2.14	1.70	8.4	0.40
D8-1	79.30	5.60	2.08	1.66	9.3	0.20
D8-2	65.70	13.00	4.29	2.70	8.0	0.30
D9	62.07	12.50	3.72	5.00	7.0	0.45
D10-1	85.70	3.31	1.43	1.68	5.8	0.85
D10-2	85.20	3.06	1.14	1.46	6.8	0.40
D15	76.00	6.90	3.00	3.30	5.2	0.50
D16	85.00	3.31	2.20	3.36	3.0	0.60
D19	87.00	2.24	3.07	3.70	1.5	0.50
Undermine	90.00	-	1.60	0.90	-	0.50
Total	78.40	6.40	2.59	2.20	7.50	0.58

Generally it could be claimed that the area with the best quality of Diatomaceous earth in the deposit Veshje running east-west on the section between the drills D4 and D10, i.e. in the central part of the investigated area. The quality gradually decreases to peripheral parts of the deposit.
Under this structure, the diatomaceous earth from the deposit Veshje a quality mineral resource that can be used for filtration, thermal insulation and many other uses in industry and construction.
Based on geological researches and chemical investigations the average content of useful substances (SiO_2) in Diatomaceous earth at the deposit Veshje is 78.40%, with an average thickness of the productive layer 0.60 m.
In future detailed geological surveys in this region that will define the continuity of the productive layer of the wider area, which will increase ore reserves, should continue. It will also answer the question in a former basin of sediment, where the space in which the productive layer thickness appears with its most thickness.

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