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PROCEEDINGS

Edited by

Saša Stojadinović

and

Dejan Petrović

November 29th – 30th 2021

Bor, Serbia

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FORECAST RESOURCES OF ZEOLITHIC TUFFS OF SERBIA

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Abstract

*Our zeolite tuff deposits (Zlatokop, Igroš, Jablanica 1, Beočin, Toponica and Slanci), which were the subject of detailed research, spatially and genetically are connected to volcanic*volcaniclastic*rocks of marine environment of Senonian and Neogene age, as well as lake sediments of Neogene age. Zeolitic tuff deposits were formed as a product of devitrification of volcanic glass. More will be said here about the prognostic resources of our zeolite tuffs, both in relation to the registered phenomena so far, and to possible areas in terms of finding new quantities of this economically very interesting mineral raw material.*

***Keywords**: zeolitic tuff, clinoptilolite-heulandite group, Serbia deposit.*

1. INTRODUCTION

During the geological development of the earth's crust, favorable geological conditions for the creation of higher concentrations of zeolite minerals and the formation of zeolite mineral deposits have been renewed several times. In Serbia, this occurred during the Upper Cretaceous, Paleogene and Neogene, and are related to the effusive activities of Dacite, Dacito-andesitic and andesitic magmas. The most economically significant deposits of zeolite tuffs in our country were created during the Neogene by intensive Young Alpine tectonic-magmatic multiphase activity. Potentially the most promising are: the Vranje, Toplica, Kruševac, Krivorec, Sokobanj, Bogovina, West Moravian and Ibar basins, the eastern part of the Great Moravian trench as well as the Fruška Gora area.

2. MINERAGENETIC SKETCH OF SERBIA

The following regional geotectonic units face each other on the territory of today's Serbia: theDinarides, the Carpatho-Balkanids and the Serbian-Macedonian mass, and the Pannonian and Dacian basins are also present. In addition to the mentioned geotectonic units, geological processes that took place during the Cenozoic era - in the zone of neo-Alpine (Cenozoic) tectonic-magmatic activation (TMA) are of special importance in the formation and spatial distribution of many important non-metallic raw materials in Serbia.

The zone of the Cenozoic TMA extends in the middle of the Balkan Peninsula and diagonally intersects all its main geotectonic units. According to Grubić (1974) [2], it is characterized by Tertiary minerageny - intrusive and volcanic igneous activity, specific molasses Neogene lake basins and intense neotectonic movements, which caused significant ups and downs (up to 2 km) of large blocks limited by renewed old and new faults. Since this zone is young, formed in the final stages of the alpine geotectonic cycle, it cannot genetically be included in any of the older geotectonic units it intersects, but represents a separate mineragenetic unit of Serbia [1]. Numerous and economically very important deposits of non-metallic mineral raw materials are

located in the Cenozoic TMA zone. Their formation is conditioned by tectonic-magmatic activity, which began at the end of the Oligocene and was renewed with varying intensity throughout the Neogene. Simultaneously with this activity, many sedimentation basins were formed in which there are economically very interesting volcanogenic-sedimentary formations.

Volcanogenic-sedimentary (and hydrothermal-sedimentary) processes that were manifested in many Neogene basins have enabled the formation of numerous deposits of useful raw materials (bentonites, diatomites, magnesite, dolomites), among which vitroclastic tuffs (pozzolans) and zeolites (zeolites) occupy a significant place. In most cases, volcanic pyroclastic material is interstratified in the form of layers of different thickness among the sediments of Neogene lake basins. In addition, our Neogene tuffs have Dacite, Dacite-andesitic and andesitic composition of their equivalent magmas. They mainly belong to vitroclastic and vitrocrystalloclastic types with a volcanic glass content of 60-90% - all of which were very favorable preconditions for their later zeolitization [4].

The area of Fruška Gora belongs to the Pannonian Basin, the formation of which was conditioned by intense neo-alpine tectonic movements, and from the beginning of the Neogene it was covered by the Paratethys Sea, from which only the Horst Mountains protruded [6]. Along the southern rim of Paratethys, in connection with the same tectonic movements, smaller or larger intermountain depressions were created, which in the form of individual bays of the Pannonian Sea or separate lakes, stretched over the sunken parts of older geotectonic units. Within the Neogene (Miocene and Pliocene) sediments, which are spread on the surface around the Horst mountains, along the southern periphery of the basin and in the surrounding intermountain depressions, there are numerous economically very important deposits of non-metallic minerals: rock salt (Tuzla), cement marls, expanding, ceramic, refractory and brick clays, limestones, etc. On the northern slopes of Fruška Gora, zeolite tuffs (Općište-Beočin deposit) of Dacite composition are present, which appear as interstratified parties in the Middle Miocene series. Also, in the north of Vojvodina, in northern Bačka, deep drilling as part of the exploration of oil deposits, the presence of zeolite tuffs was ascertained. However, considering the great depth (950 to 980 m) at which the presence of zeolite minerals within the Neogene volcaniclastic deposits on the territory of Vojvodina was stated, it can be said that these phenomena of zeolitized pyroclastics cannot have any greater economic significance.

Lake Miocene formations are also located east of Belgrade in DunavskiKljuc, in the area of VelikoSelo and Slanci, where lake pelites represent typical lake formations consisting of well-layered marly clays and marls, laminated bituminous shales, with frequent occurrences of dacite tuffs and tuff. According to the manner of occurrence (exclusively interlayers) and chemical composition, tuffs from Slanci coincide with synchronous Dacite tuffs on Fruškagora and Posavo-Tamnava, central Šumadija and Pomoravlje.

In addition to the Neogene basins (valleys) that territorially belong to the southern edges of the Pannonian Basin, potentially promising areas in terms of the existence and finding of deposits and occurrences of zeolite tuffs are ore-bearing formations of our Neogene volcanic-sedimentary lake basins within the Serbian-Macedonian province. In the first place, it is the area of the Vranje valley with already known deposits and phenomena (Zlatokop, Katalenac, Mečkovac, etc.).In addition to the Vranje basin, the Toplica, Kruševac (Igroš, Jablanica I), Krivareka(Toponica), Sokobanja, Bogovina, West Moravian and Jarandol basins, as well as the eastern part of the Great Moravian trench (Sokobanja and Bogovina basin) are potentially the most interesting and significant.

3. FORECAST RESOURCES OF ZEOLITE TUFFS IN SERBIA

The most important parameters of the zeolite tuff deposits of Serbia explored so far (Table 1) [5] show us that, in terms of proven reserves, they are relatively small deposits on a global scale. The predominant zeolite mineral in our zeolite tuff deposits is clinoptilolite, while only in some cases it is mordenite. Geological and technological knowledge about some phenomena of zeolite tuffs (Katalenac, DugeNjive and Mečkovac-Vranjskakotlina) are insufficiently known, primarily because they have been considered as tuffs (raw materials for the cement industry), while their zeolite characteristics have remained only indicative. and insufficiently examined. Figure 1 [3]shows a prognostic mineragenetic map of Serbia with potentially the most important Neogene basins for finding deposits and occurrences of zeolite tuffs.

Table 1. Basic parameters of zeolite deposits in Serbia (according to Simić et al., 2014)

Tray	Depth zeolite (m)	Zeolite layer thickness (m)	Potential reserve (mil t)	Reserves (mil t)	CEC (meq / 100g)	Method of exploitation
Općište-Beočin	2-28	14.2	2	0.26 0.15	157 108	Surface mine
Igroš	5-20	1.5	0.1	0.05	145	Surface mine
Jablanica 1	0-15	18.5	2.2	0.20	168	Surface mine
Toponica	2-25	2.4	0.5	0.50	140	Pit exploitation
Zlatokop	20-30	2	1.3	0.67	164	Pit exploitation
Katalenac	On the surface	110	3.4		70	Surface mine
Duge njive	On the surface	> 50	1.1			Surface mine
Mečkovac	On the surface	38	1.0			Surface mine

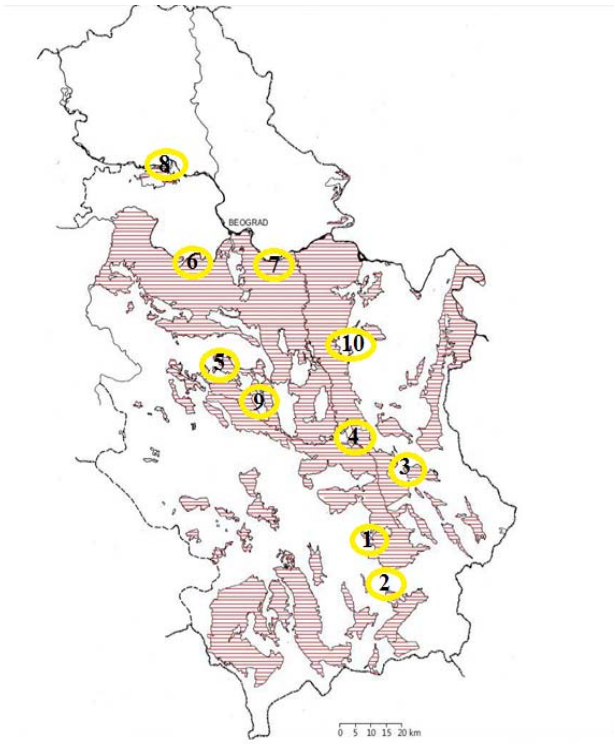

Figure 1. Forecast mineragenetic map of Serbia with potentially the most important Neogene basins for finding deposits and occurrences of zeolite tuffs (1. Vranje basin; 2. Krivorec basin; 3. Toplica basin; 4. Krusevac basin; 5. Valjevo-Mionica basin; 6. Posavina region -Tamnava basin, 7. Slanci basin, 8. Fruška Gora area, 9. West Moravian basin, 10. Eastern part of the Great Moravian trench (Sokobanja and Bogovina basin))

4. CONCLUSION

Based on all the above, it can be said that Serbia is a potential country in terms of the existence and discovery of zeolite tuffs, and thus the further development of the zeolite industry, ie their application in various fields. For that, it is necessary to continue detailed monitoring and study of geological and technological properties of our zeolite tuffs and their more complete characterization. Future research in the coming period in the aforementioned areas will almost certainly reveal some new sites with zeolite tuffs as the predominant and economically very interesting mineral raw material.

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