LIMESTONE, CLAY RESERVES AND THEIR UTILIZATION IN THE FIELD OF CONSTRUCTION

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ABSTRACT

Limestones and clays are non-metallic minerals, are classified in the sub-group of the non-renewable natural resources and are of significant importance particularly in the field of construction. As far as constructors are concerned limestone rocks and clays continue to be categorized as the main materials, which are at a large scale used in low and high construction. These construction materials are primarily used in wall molding, filling, production of various fractions for the preparation of concrete, production of various types of facades, adhesives, production of bricks, blocks, tiles and other products. The underlying purpose of thispaper is to carry out a subtle analysis of the reserves, utilization and some of the main features of limestone and clay in the Republic of Kosovo. Limestones and clays are industrial minerals (non-metallic minerals) which bear peculiar characteristics such as; textural, structural, physico-mechanical, geological etc. The territory of Kosovo is relatively rich in limestone and clay reserves. Estimated geological reserves in 1978 were 128 million ("M"-million [m^3] limestone and 15 "M" [ton] clays, while in 2014 were 361 ("M") [m^3] limestone and 27 "M" [ton] clays. According to the physico-mechanical properties limestone belongs to the type of moderately hard and very hard rocks. They have specific average weights of 2.71 [g/cm^3], compressive strength of a water-saturated shaft ranging from 107.3 to 152 MPa, CaO, MgO and SiO_2 contents of 54.06%, 0.97% and 1.28%. The mineral limestone contituent is mainly made of calcite which varies from 86.04 % to 97.6 %.

Key words: Kosovo, rocks, limestone, clay, construction, construction permission.

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INTRODUCTION

Limestone is a rock that originally formed under the ocean. It is made of the bones and shells of tiny sea creatures that died millions of years ago. Clay is a sticky, poor-draining soil. When fired in a kiln it becomes extremely hard. Bricks, tiles and pots are made this way, as well as ceramics-from fine porcelain to sewer pipes. Construction has always been considered as one of the most noteworthy human activities. During the last 16 years in Kosovo, the construction sector has been subject to a rapid grown at a faster pace compared to other sectors of the economy, and has fulfilled the increasingly high demands of the population for more housing, road infrastructure etc. Consequently, this has led to an increasing trend in the utilization of limestone and clay. In 2011 the urban population was estimated to approximately 38% (versus 32.5% in 1981 and 9.7% in 1948), while the rural population was 61.9%. Along with the growth of urban population, the area of settlements has expanded, so from 2002 to 2012 it is assessed that the area of settlements has increased by about 8000 ha *(KEPA, 2015)*. In the country, limestone and clay rocks are mainly used as natural raw materials for construction because they have good physico-mechanical properties and durability. Moreover they are extracted and processed at a lower cost than other rocks. In addition, it is worth emphasizing that they are characterized by a diversity, both in quantity and quality and comprise a priceless asset regarding country's economic development. Despite that, limestones have a wide spatial distribution throughout the territory of Kosovo *(Fig. 1)* and cover 13.1% of the territory *(Ahmetaj I., 1981).* They mainly build the mountain massifs on the west side (Mokna, Bjeshket e Nemuna, Pashtriku, Koritniku, etc.), in other areas of the country they appear in the form of mountain greens with more limited spread (Shkoza, Gllama, Baja etc.). From a techtonic point of view, limestones that are located in the western part of the country, pertaining to the region of Mirdita, which in the territory of Kosovo includes Pashtrik, Koritnik and Shkoza mountains *(Andelkovic J, 1976)*. The geological reserves of limestone in 1978 were 128 million [m^3] *(Jakupi A., 1978)*, while in 2015 these reserves are 361 [m^3] *(ICMM, 2015)*, whereas the geological reserves of clay in 1978 were 15 thousand [ton] *(Jakupi A.,1978)*. In 2015 these reserves are 22 thousand [tonnes] *(ICMM, 2015)*. They are unmixed, bound rock bottom rocks dominated by clay minerals *(Shkupi N. D., 1984)*. The most important clay sources in Kosovo are found in: Podujevo, Zveçan, Skenderaj, Peja, Gjakova, Klina, Rahovec, Prizren, Hani i Elezit, Ferizaj, Prishtina and Kamenica.

STUDY AREA

The Republic of Kosovo is located in Southeast Europe (Western Balkan Country), in the center of the Balkan Peninsula *(Fig.1)*, between the coordinates 41°50'58" to 43°15'42" north latitude, 20°01'02" to 21°48'02"and the eastern geographic length *(PHK, 2010-2020+)*. It has an area of 10.905,25 km2, with 1469 settlements with a population of 1.782.115 inhabitant *(ask.rks-gov.net, 2020)*. The population density is 163 inhabitants per km^2, whereas the average age is approximately 25 years. The climate is continental medium *(Pllana, 2015)*, average annual temperature 10ºC (min., -27ºC and max., 39ºC), average annual precipitation in the eastern part on average fall over the year 600 mm, while in the western part above 700 mm *(KEPA, 2015)*. As far asthe morphological point of view is concerned, the peripheral part is interspersed with mountainous massifs, whereas the plain part consists of: Dukagjini basin and Kosovo plain. Minimum altitude of 252 m (Drini i Bardhe-Vermica), at maximum 2565 m (Gjeravica peak).

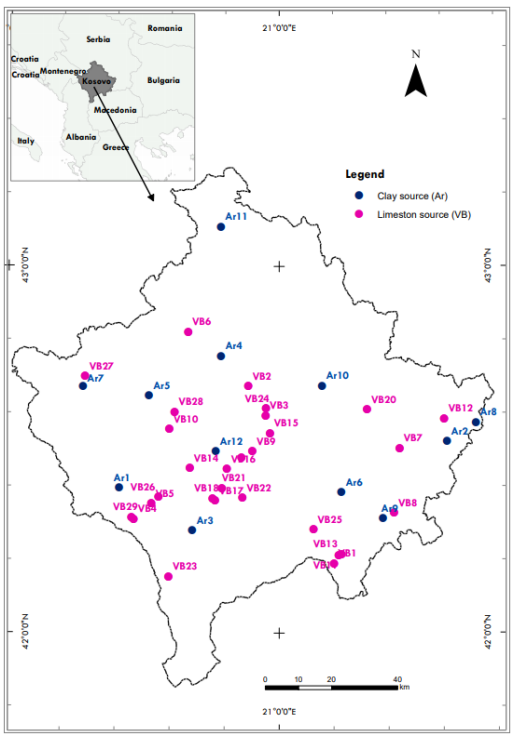


Fig.1. The study area

Geology-Geological construction is quite complex and involves rocks of all geological ages from the Paleozoic to the Quaternary *(Elezaj Z., Kodra A., 2008)*. Due to the fact it is necessary to carry out a fully-fledged analysis of rocks pertaining to all geological ages from the Paleozoic to the Quaternary participate. Carbonate rocks (limestone, dolomite, marbles, etc.). The massive Paleozoic limestones are mainly located at low altitudes. They have the highest prevalence in the lidar (Drenica Mountains). Mesozoic limestones (Triassic, Cretaceous) are far more widespread in the western part and partially in the central part. They are comprised of massive limestone blocks. The Triassic limestones are widespread in the mountains; Mokna, Sharri, in the Central Mountains, in the Koritnik Mountains. The Cretaceous limestones are spread in the mountains of Pashtrik, Drenica and Caraleva.

METHODOLOGY AND MATERIALS

There has been carried out a development strategy, which represents a systematic work supported by field observations as well as utilizing analogous experience and practices. The method of analysis is mainly quantitative, utilizing accurate qualitative data. The type of research for this paper enters the research group relying on the collection of institutional and scientific materials *(Jakupi A., 2005)*. To achieve the purpose of this research it was necessary to browse an extensive literature on the geology of Kosovo. The first phase of the work was the collection of archival materials, written and published by researchers and public institutions related to the management of natural resources, namely carbonate rocks and clays. The second phase was related to the selection, processing, analysis and interpretation of data and the third phase was the writing of the paper. Indeed, there has been depicted a wide range of archival documents, strategic documents, development plans, normative acts, reports, reports, as well as relevant data produced by state and academic institutions, professions and designers in the field of geology and mining. The materials used in this research work have been; topographic maps at a scale of 1:25000 *(https://www.topografskakarta.com/)*, geological maps at a scale of 1:100 000 *(Vojnogeografski institut. 1984)* and 1: 200 000 (*ICMM, 2006)*, clarifiers of geological maps at a scale of 1:100 000. Official reports published by the Independent Commission for Mines and Minerals, Elaborate for the calculation of geological reserves for limestone and clays and books published in connection with the mineral resources of Kosovo as

referred to in this paper. For technical work the Excel program was used for the construction of tables and graphs, while for the georeferencing, digitalization and preparation of the source map for limestone and clay the ArcMap program was used.10.1.

RESULTS AND DISSCUSSION

In the Republic of Kosovo, limestone clays and clays are widely used in the field of construction, owing to the fact that they are spread throughout its structural-facial areas. to the newer ones.In terms of mineralogical composition the limestones are mainly composed of calcite ranging from 86.04% to 97.6%.They are white, gray, gray to dark, often with yellowish hues and reddish veins. Among others, it's worth pointing out that they consist of pure, compact, good quality limestone, and also meet medium dolomitized breccia limestones that have undergone this process. In some sources metamorphosed limestones of varying degrees, turning to marble. Limestones generally show good geological-engineering properties during opening and exploitation, in which exploitation troughs of 15 m to 20 m can be formed *(Bytyqi B, 2010)*. The VB20 source limestones have shown low to moderate metamorphism rates giving the limestone a recrystallized crystallocrystalline appearance with shell fractures. The physico-mechanical properties of this rock are of satisfactory value for its use as a cornerstone; ballast for all layers of road; saturation; substrates, stabilizers and coatings for asphaltbetone *(Konomi N & Mesh A, 2006)*. Limestone at the source VB22 is dolomitized marble limestone characterized by good physico-mechanical properties *(Civil Engeniering Institute "Macedonia" Skopje, 2010)*. The source limestone VB23 is reddishand represents biomycritic facies, from fossils to rudistite found, the size of calcite crystals is from 0.5 to 1 mm *(Qorri N, 2005*). At source VB 17-18 are silicified, massive textured silica limestone, the main mass (over 95%) being carbonate *(Konomi N & Mesh A, 2010)*. During the period 2005-2015, 29 "M" [m^3] of limestone were exploited, with an average amount of 2,664,417.12 "M" [m^3] per year or 8% of the total limestone reserves known so far, while 859,363.85 tons of clay were exploited, or only 3.2% of the total amount of geological reserves known so far.
Table 1 dhe 2., shows the geological reserves of limestone and clay in some of the most popular sources, while figure 3 and 4., shows the progress of limestone and clay use in the period (2005-2015).

Table.1. Reserves of limestone

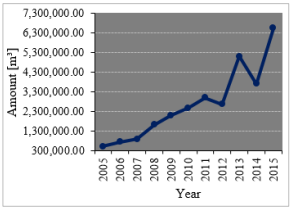
Table.2. Reserves of clay

ID	Reserves [m³]	ID	Reserves [m³]	ID	Reserves [m³]	ID	Reserves [m³]
VB1	10.734.000	VB15	1.828.360	VB8	735.000	VB22	218.169
VB2	50.386.000	VB16	1.127.057	VB9	4.028.399	VB23	188.854
VB3	15.411.000	VB17	1.200.348	VB10	1.588.000	VB24	1.738.098
VB4	12.000.000	VB18	548.677	VB11	517.159	VB25	4.554.108
VB5	15.376.000	VB19	1.759.892	VB12	104.399	VB26	754.581
VB6	4.446.000	VB20	689.360	VB13	6.711.207	VB27	375.734
VB7	4.033.000	VB21	853.044	VB14	3.822.648	VB28	3.000.000
						VB29	14.103.903

*VB-for Limeston source

ID	Reserves [m³]	ID	Reserves [m³]
Ar1	3.856.905	Ar7	1.000.000
Ar2	2.543.551	Ar8	1.000.000
Ar3	2.598.072	Ar9	10.000.000
Ar4	3.000.000	Ar10	500.000
Ar5	2.242.353	Ar11	600.000
Ar6	2.500.000	Ar12	250.000

*Ar-for Clay source



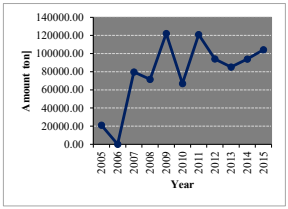


Fig.3. The scale of utilizing limestone ***Fig.4.*** The scale of utilizing clay

The physical-mechanical components of limestone in Kosovo, are at a large scale comprisedof good mechanical properties which are shown below; specific weight fluctuates in the range of 2.67 g/cm³ to 2.75 g/cm³, natural weight volume fluctuates from 2.65 g/cm³ to 2.72 g/cm³, dry volume weight fluctuates from 2.62 g/cm³ to 2.68 g/cm³. The degree of porosity varies from 0.01% to 2.2%. Meanwhile, water absorption ranges from 0.052% to 0.51%. The similarity ranges from 0.97 to 0.99. The resistance to compression of a water-saturated shaft varies from 107.3 to 152 MPa. The resistance to compression of a dry shaft fluctuates from 104.5 to 144 MPa. Shear/sanding resistance ranges from 14.5 to 26.6 cm³/50cm². Frost Resistance/stable/. Sustainability in Na_2SO_4 /stable/. The LA (Los Angeles abrasion test) coefficient fluctuates from 22.85% to 30.0%. The speed or velocity of longitudinal waves fluctuates from 1.45 km/s to 5.02 km/s. On the basis of physico-mechanical parameters the limestone rocks are basically categorized as; relatively strong and very strong rocks. Clay quality-the best clays for bricks and tiles are those that have this content as in table 3.

Table.3. Clay quality

Component	[%]
SiO_2	65 to 72
Al_2O_3	12 to 18
Fe_2O_3	to 6
CaO	around 5

Sufficient quality to see more clays in the Ar1, Ar.4, Ar.11 source. Source clays Ar.10 cannot be uniformly desired, so they seek to be handled more successfully when choosing case choices. Characteristics are the possibility of having clays in the Ar.12 source. The Ar.7 source clays are not a good option. For the optimal clays the required ratio: SiO_2/Al_2O_3 to last less. Likes clays that have a more or less uniform content, withplastic properties, without excellent interference (limestone, sandstone, and in light sulfur).

The wide utilization of limestone and clays has come as a result of the growing demand for more infrastructure and housing facilities. Generally speaking, Limestone and clays were mainly used primarily as a natural raw material for construction, and along with for other industry processes. Limestone rocks in our country have been primarily utilized for the profileration of inerts, cement and lime. The widespread use proves that these rocks have good physico-mechanical features and durability, are extracted and processed at a lower cost than other rocks. In 2011 the urban population comprised 38% (32.5% 1981 and 9.7% 1948), while the rural population was 61.9%. Along with the increase of urban population, the area of settlements has increased, so from 2002 to 2012 it is estimated that the areas of settlements have increased about 8000 ha *(KEPA, 2015)*. Some of the clay products: semi-Mediterranean tiles, covering surface 20x30 cm; chimney blocks (250x190x190) mm; thermo blocks-5 (250x190x190) mm; partition blocks-12 (250x120x190) mm; fert monte M-14 (280x140x250) mm; Duct. Within the 11 year period this amount of limestone was exploited: 517 "M". [m³] in 2005, whereas in 2015 were used 6.531 "M". [m³], an average of 2.665 "M". [m³] ("M"-million). The geological reserves of clays are 27 "M" [tons], (estimated to be even larger). Within the 11-year period, this amount of clays was used: 20,936.29 [tons] in 2005, while in 2015, 104, 170.00 [tons] were used, with an average value of 78,123.99 [tons];

Table.3. Chemical composition and some statistical indicators of limestone in Kosovo

Chemical Compostion	Samples												Min	Ave.	Max
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12			
CaO	54.01	58.95	53.39	52.3	54.15	54.19	16.44	55	51.96	54.12	54.02	55.3	16.44	51.15	58.95
MgO	0.32	0.56	0.31	0.76	0.76	2.27	28.62	Nil	1.41	0.36	0.33	0.45	0.31	3.29	28.62
Fe_2O_3	0.41	0.14	0.41	0.56	0.19	0.17	0.49	Nil	0.45	0.4	0.4	0.018	0.018	0.33	0.56
Al_2O_3	0.02	0.4	0.02	0.56	1.38	0.12	Nil	Nil	0.15	0.05	0.19	0.05	0.02	0.29	1.38
SiO_2	2.63	0.63	2.53	1.66	0.84	0.87	10.0	0.55	3.44	2.52	2.64	0.36	0.36	2.39	10
L.O.I	42.52	38.23	41.96	42.4	42.59	42.38	44.07	43.2	42.29	42.44	42.44	43.44	38.23	42.33	44.07

*L.O.I.-Loss on Ignition

CONCLUSIONS

Raw materials such as limestone and clays have been explored and are still being explored concerning their quantity, quality and use. Besides that, it is still indispensable taking into consideration the market demand, as well as forcarrying out geological and technological research. Lime and clay reserves are actually large in the territory of Kosovo and represent potential for economic development of the country. Based on the analysis of depicted data of this research, it is indicated that a large number of limestone and clay deposits are in the process of being exploited, while there are also waste resources that have potential and are promising for future. Limestone and clays are widely used in the construction material industry. The construction industry is continuously asking for products made of limestone and clay. Limestone is widely used as a non-metallic material, owing to the fact that it possesses very good technical characteristics and properties so that it can produce good aggregates for concrete and generally stones for construction. The physico-mechanical features of this rock are of satisfactory value for its use as a cornerstone; ballast for all layers of road; saturation; substrates, stabilizers and coatings for asphaltbetone. Clays with good quality are shown at the source: Ar1, Ar.4, Ar.11, while some clay sources require additional assessment measures. The geological reserves of the limestone rock are 361 "M" [m³], (estimated to be even more). Within the 11 year period this amount of limestone was exploited: 517 "M" [m³] in 2005, while in 2015 were used 6.531"M" [m³], an average of 2.665 "M" [m³]. Clay geological reserves are 22 "M" [ton], (estimated to be even more). During the 11 year period this amount of clays was used: 28 thousand [ton] in 2007, while in 2015, 104 thousand [ton], with an average of 63 thousand [ton].

REFERENCES

1. Ahmetaj, I., (1981).Terrenet Krastike në KSA të Kosovës, (faqe 175-206), Bul. i pun. shkenc. i FSHN-Prishtinë.
2. Agjencioni për Mbrojtjen e Mjedisit të Kosovës (KEPA), (2015). Raporti për Gjendjen e Ajrit në Kosovës 2013-2014, faqe 7., Prishtinë.
3. Agjencioni për Mbrojtjen e Mjedisit të Kosovës, (2015). Raporti për Gjendjen e Ujërave në Republikën e Kosovës 2013-2014, faqe 10-11., Prishtinë.
4. Agjencioni i Statistikave të Kosovës, (2020). Vjetari Statistikor i Republikës së Kosovës, faqe 13., Prishtinë, https://ask.rks-gov.net/en/kosovo-agency-of-statistics.
5. Bytyqi, B., (2010). Elaborati gjeologjik mbi karakteristikat e gurit gëlqerorë dhe llogaritja e rezervave në lokacionin "Shume-Groblje" Malishevë.

6. Civil Engeniering Institute "Makedonija" Skopje, departament for materials and roads, (2010), Analizat fiziko mekanike dhe mineralogjike të shkëmbit gëlqerorë në Biraq.
7. Elezaj, Z., Kodra, A., (2008). Gjeologjia e Kosovës, Prishtinë.
8. Instituti i Planifikimit Hapësinor, (2010). Plani Hapësinor i Kosovës, Strategjia e Zhvillimit Hapësinor 2010-2020+, Prishtinë.
9. Jakupi, A., (2005). Metodologjia e Punës Shkencore Kërkimore, Prishtinë (faqe 9-15).
10. KPMM, (ICMM)., (2015). Raporte vjetore 2005-2015, Prishtinë.
11. Konomi, N., Meshi, A., (2007). Raporti i Analizave kimike dhe fiziko-meknike për shkëmbin gëlqerorë në Rainoc, FGJM, Tiranë.
12. Qorri, N., (2005). Elaborati gjeologjik mbi kategorizimin e rezervave të gurit gëlqerorë dhe llogaritja e tyre në "Lugi i Keq"-Vërmicë-Prizren.
13. Shkupi, N.D., (1984). Fjalor i Gjeologjisë, Tiranë, faqe 38.
14. Çadraku, H., Bytyqi, A., (2014). Elaborati për rezervat dhe kualitetin e gëlqerorëve në vendburimin "Udha Drome" në Kaçanik.
15. Çadraku, H., Rexhepaj, B., (2012). Elaborati për rezervat dhe kualitetin e gëlqerorëve në vendburimin "Ngucat" në Ngucat-Malishevë.
16. Çadraku, H., Rexhepaj, B., (2012). Elaborati për rezervat dhe kualitetin e gëlqerorëve në vendburimin "Kleçkë" në Kleçkë-Lipjan.
17. Çadraku, H., et.al.,(2010). Plani i menaxhimit të resurseve minerale të Kosovës, KPMM-Prishtinë.
18. Dushi, M., (2008). Pasuritë minerale të Kosovës-vëllimi i parë, Prishtinë.
19. Fejza, I., Çadraku, H., Sahiti F., (2010). Elaborati për rezervat dhe kualitetin e gëlqerorëve në vendburimin "Qafa e Goleshit" në Minernë-Lipjan.
20. Fejza, I., Çadraku, H., Sahiti F., (2006). Elaborati për rezervat dhe kualitetin e gëlqerorëve në vendburimin "Grab-Semetishtë"-Suharekë.
21. Fejza, I., Çadraku, H., Sahiti F., (2005). Elaborati për rezervat dhe kualitetin e gëlqerorëve në vendburimin "Biraqë"-Suharekë.
22. Fejza, I., Çadraku, H., Sahiti F., (2009). Elaborati për rezervat dhe kualitetin e gëlqerorëve në vendburimin "Grab-Samadragjë"-Suharekë.
23. Gashi, H., (2008). Raporti i analizave kimike për shkëmbin gëlqerorë në Kleçkë.
24. Halilaj, B., Osmanaj I, (2004). Raporti i analizave kimike për shkëmbin gëlqerorë "Lugi i Keq" "INKOS" Obiliq.
25. Tusar, B., (2001). Kamenolomi i okolis, UDK 622.25:581.
26. Vojnogeografski institut. 1984. Osnovne geološke karte Srbije (1:000 000), hartat gjeologjike, planshetet 100 000 për Kosovë, http://geoliss.mre.gov.rs/OGK/
27. Harta topografike për territorin e Kosovës https://www.topografskakarta.com