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Geochemical Evaluation of Dolostone Deposits in Montenegro: Implications for Potential Industrial Applications

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Abstract: *Dolomite is a valuable mineral commodity with numerous industrial applications. Dolostones are mineral resources with significant growth potential. The study area encompasses south and central Montenegro. Mineralogical, petrographic, geochemical, and technological properties were investigated. Upper Cretaceous dolostones are compact and contain organic matter, whereas Triassic dolostones are weathered dolomites without organic matter. Both of formations displayed varying dolostone quality, prompting the geological and technological classification of Montenegrin dolostones. Upper Cretaceous dolostones are utilized in the building industry as aggregate, dimension stone, and filler, whereas Triassic dolomites are not suitable as dimension stone and have limited potential as aggregate. Both dolostones can be utilized in the steel industry and agriculture, but not as high-quality fillers when whiteness is a limitation, or for lime production where chemical composition and grain size are regulated. This is the first comprehensive study of geochemical evaluations of dolostone deposits in the Balkans and their potential industrial use.*

Keywords: *primary raw materials; mineralogy; physical-mechanical properties; technological properties; materials science.*

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1. Introduction

Due to its dual use in referring to the mineral ($Ca,Mg(CO_3)_2$) and to the sedimentary carbonate rock formed mostly of dolomite (mineral), the name ‘dolomite’ can be ambiguous [1]. Specifically, rocks with 10–50 % dolomite mineral are called dolomitic [2, 3]. Dolomitization, or limestone replacement, produced the great majority of dolomite [4]. Because this process is not always complete, rocks that are commonly referred to as dolomite include dolomitic limestone, pure dolomite, calcareous dolomite, and even dolomitic marlstone. For this reason, rocks containing the mineral dolomite are frequently referred to as dolostones. The primary impurities found in dolostone include silica, sulfur, alumina, iron hydroxides and oxides, and increased concentrations of calcium.

Dolomite is a mineral commodity that is comparable to limestone but less versatile; after crushing and screening, it is mostly utilized as aggregate in the building industry [5–7]. Another prominent application of dolostone in the construction industry is dimension stone, which is typical in Montenegro [8–10]. Since chemical composition is not as important, any type of dolostone with beneficial mechanical and physical features can be used for the aforementioned applications.

Chemical composition and technological characteristics, such as degree of whiteness, sorptivity, or refractoriness, are crucial for the industrial (chemical) use of dolomites. Examples of these applications include the manufacturing of cement and dolomitic lime, the metallurgy of iron and steel, refractories, ceramics, animal feed, agriculture, etc. [2, 11-17] Dolomite is utilized as a flux in metallurgy and is a valuable source of calcium and magnesium metals in industry [18]. Recently, dolostones have also been researched as possible materials for energy storage, which is highly important in regard to the Green Agenda and the preservation of energy [19, 20]. As it is prevalent in Northern Montenegro and Western Serbia, dolostones can sporadically hold mineralization of lead, zinc, copper, barite, and fluorite [21]. Because of the silica and sulfur dioxide minerals, in this case, they are not acceptable as usable mineral commodities. The scope of dolomite's application is exceedingly broad. There have been numerous studies published in recent decades. However, new information on this highly utilizable and cost-effective primary raw material is always advantageous in terms of conserving natural resources and lowering end-product costs.

Dolostones account for at least 15% of all carbonate rocks in Montenegro. Dolostones are found in many stratigraphic units of the Triassic, Jurassic, and Cretaceous ages, alongside the dominant limestones of the Mesozoic succession [9]. Dolostones can be early-diagenetic or late-diagenetic, with the latter being more common. As a result, dolostones are one of Montenegro's most important mineral commodities, with significant growth potential. Dolostones were extensively examined in this region during the development of the former Yugoslavia's main geological map. Thus, only Triassic dolomites at Virpazar and Nikšić were investigated as mineral deposits [22, 23]. Dolomite from the Balkan region (particularly Montenegro) has been researched as a potential filler in paper manufacturing [24]. The systematic geological exploration of dolostones in Montenegro began in 2017 [25], with a focus on the Triassic and Upper Cretaceous dolostones of southern and central Montenegro. This study intends to characterize and further validate the quality of the investigated dolostones as potential mineral raw materials for a variety of industrial applications while also addressing environmental challenges and reducing carbon footprints.

2. Experimental

2.1. Material: geological background

In the Montenegro region, dolostones can be found in Jurassic, Cretaceous, and Triassic formations [26]. In the Triassic carbonate sequence, dolostones occur in the Anisian, Ladinian, and, predominantly, Upper Triassic stages of the Visoki Krš zone; however, they are much less represented in the Durmitor tectonic unit. These are epigenetic dolomites in the Anisian and Ladinian, but in the Upper Triassic, particularly in the Lofer Formation, both genetic kinds coexist in the same cyclothems. In some locations, however, Upper Triassic sequences with thicknesses greater than 500 m are represented solely by dolostones. Geological exploration of Triassic dolomites as a chemical mineral commodity was conducted in the Virpazar and

Vranjina deposits south of Podgorica, near Virpazar town, and in the Šuma and Brno deposits near Nikšić. Table I displays their grade and tonnage. However, Virpazar and Vranjina are reasonably well-explored deposits that are situated inside Skadar Lake National Park.

Tab. I Reserves and grade of explored dolomite deposits.

	Reserves by category (10^3 t)				Average content (%)						
Deposit	**A**	**B**	**C_1**	**Total**	**CaO**	**MgO**	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**R_2O_3**	**LOI**
Virpazar	3252	20230	36877	60359	32.10	20.73	0.15	0.09	0.13		46.01
Vranjina	3247	6720	14294	24261	33.70	19.40	0.44	0.16	0.21		
Šume	179	786		965	33.00	18.52	0.74			1.52	45.62
Bršno	-	-	3225	3225		17.30	0.68			1.31	
			Total reserves:	*88810*							

Jurassic dolostones predominantly occur in the High Karst tectonic unit, mainly within Liassic and younger Malm carbonates, and considerably less within Dogger and older Malm. They often come from late diagenetic dolomites, which are found in irregular zones that can stretch up to 5 km. Jurassic dolomites were not explored as a mineral commodity; however, in the course of studying bauxite in central Montenegro (Figure 1), late diagenetic dolomites of the Upper Kimmeridgian and Tithonian were identified and separated over a considerable area. These dolomites had a medium- and coarse-grained structure, were almost white in color, and unquestionably belonged to the class of high-quality dolomites. Late diagenetic, medium- and coarse-grained dolomites of Kimmeridgian-Titonian age are widely distributed throughout the terrain of the Kuči thrust sheet, with thicknesses ranging from 50 m to 250 m. Those dolomites will be the primary target for further exploration.

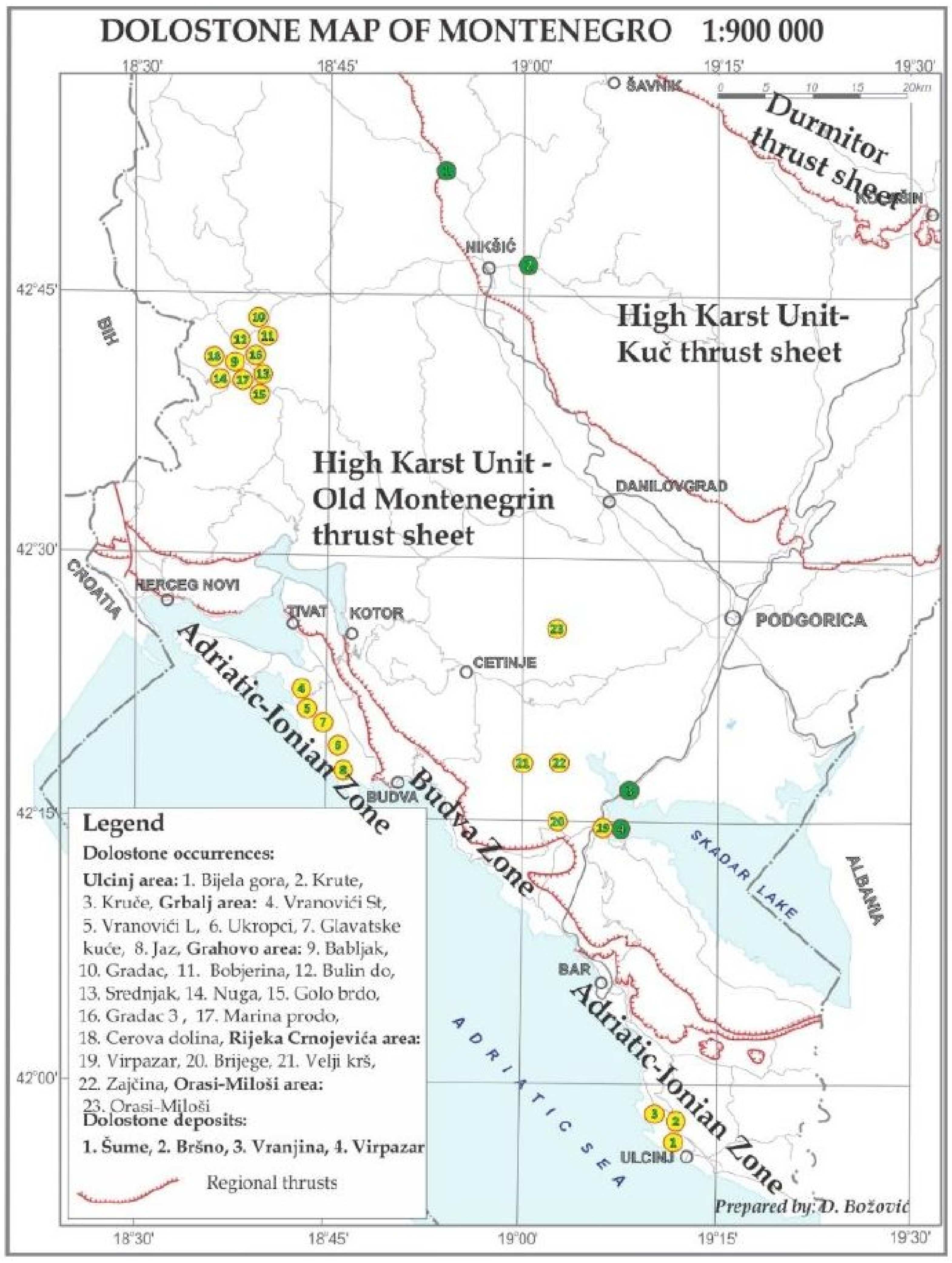

Fig. 1. Schematic map of Southern and Central Montenegro with the most important deposits and occurrences of dolostone.

In the Old Montenegrin and Kuči thrust sheet terrains, dolomites are widely distributed and have a substantial presence within the Lower Cretaceous carbonate formations of the High Karst tectonic unit. They are particularly found in the older Lower Cretaceous, where they alternate irregularly with dolomitic and limestones both laterally and vertically. In the Upper Cretaceous formations of the same tectonic unit, late diagenetic dolomites have a significant distribution, especially in the Cenomanian and Turonian of Western Montenegro. Dolomites can be found at various levels in the Upper Cretaceous carbonate platform of the synclinal structure of the Zeta River. Similarly, in the Adriatic-Ionian Zone carbonate platform, they originated in the Turonian and the youngest Maastrichtian portions of the geological column.

Triassic dolostones are often huge, but they are also quite worn and devoid of bituminous material. On the other hand, bituminous matter makes up the majority of the huge and compact Upper Cretaceous dolostone.

2.2. Methodology

From each deposit or occurrence, samples were taken for mineralogical, geochemical, and technical analysis, taking into account the variations in the macroscopic composition of stone to ensure full representativeness. Each deposit yielded samples weighing between 80 kg and 100 kg. Representative rock pieces were taken to prepare thin sections for optical microscopy and scanning electron microscopy, and the remaining material of each sample was crushed in a laboratory jaw crusher, a Denver Model Colo 4" x 6". After splitting, 5 kg of material was taken for laboratory analyses, pulverized in the agate stone pulverizer KHD Humboldt Wedag, packed in plastic bags, and properly marked. A duplicate of each sample has been kept at the Geological Survey in Podgorica.

Mineralogical and technological studies, either on rock pieces or powder, included optical microscopy, X-ray powder diffraction (XRD), differential scanning calorimetry and thermogravimetric analysis (DSC and TGA), determination of moisture, whiteness, specific weight, oil absorption, water absorption, and pH determination. For XRD and DTA-TGA analyses, three samples were taken from Vranovići, Krute, and Zajčina localities. Samples were marked with labels Vl, Kt, and Za, respectively.

XRD analyses were performed on a PHILIPS X-ray diffractometer, model PW-1710, with a curved graphite monochromator and a scintillation counter. The intensities of diffracted CuKa X-ray radiation (l = 1.54178 Å) were measured at room temperature in intervals of 0.02°2q and a time span of 1 s and in the range of 4° to 65°2q. The X-ray tube was loaded with a voltage of 40 kV and a current of 30 mA, while the slits for directing the primary and diffracted beams were 1° and 0.1 mm.

DSC and TGA analyses were done on three samples using Netzsch simultaneous thermal analysis STA 449F5 Jupiter with a heating speed of ΔT = 10°C/min in a temperature interval of 20 to 1000°C. The sample mass for analyses was 100 mg.

The degree of whiteness was determined on a spectrophotometer, Datacolor ELREPHO, which uses a diffuse/0° optical geometry and an automated, adjustable UV filter in accordance with ISO 2469. Determination of whiteness was done on 20 g of each sample previously pulverized to 100 % below 63 µm and compared to standard whiteness, MgO = 99 %. Oil absorption was analyzed on dried 5 g samples with flaxseed oil with a specific mass of 0.928 g/cm^3, while water absorption was done on dried 20 g samples with distilled water.

Geochemical analyses were done at Bureau Veritas, Metals, Minerals & Environmental, Geoanalytical Services, Canada [27]. Whole rock major oxides were analyzed either by X-ray fluorescence analysis on fused discs (XF700 Standard Package) or by lithium borate fusion ICP-MS (LF200 Package). Carbon and sulfur analysis were done by Leco

(TC000 Package). Refractory and rare earth elements were analyzed by lithium-borate fusion ICP-MS (LF100 Package). Other trace elements have been analyzed by ICP-ES/MS using a modified (1:1:1 = HNO_3 : HCl : H_2O) aqua regia digestion (AQ200 Package). 2.250 g of rock samples were previously crushed, split, and pulverized to 200 mesh. Detection and upper limits are given in Tab. II and III.

Tab. II Detection and upper limits of analytical methods for macro elements.

Element	Package	Detection limit	Upper limit	Package	Detection limit	Upper limit
SiO_2	*XF700*	0.01%	100%	*LF200*	0.01%	100%
Al_2O_3	*XF700*	0.01%	100%	*LF200*	0.01%	100%
Fe_2O_3	*XF700*	0.01%	100%	*LF200*	0.04%	100%
MgO	*XF700*	0.01%	100%	*LF200*	0.01%	100%
CaO	*XF700*	0.01%	100%	*LF200*	0.01%	100%
Na_2O	*XF700*	0.01%	15%	*LF200*	0.01%	100%
K_2O	*XF700*	0.01%	15%	*LF200*	0.01%	100%
MnO	*XF700*	0.01%	50%	*LF200*	0.01%	30%
TiO_2	*XF700*	0.01%	20%	*LF200*	0.01%	10%
P_2O_5	*XF700*	0.01%	40%	*LF200*	0.01%	100%
LOI	*XF700*	0.10%	100%	*LF200*	0.10%	100%
TOT/C	*TC000*	0.02%	50%	*TC000*	0.02%	20%

Tab. III Detection and upper limits of analytical methods for trace elements and REE.

Element	Detection limit (mg/kg)	Upper limit (mg/kg)	Element	Detection limit (mg/kg)	Upper limit (mg/kg)
V	8	10,000	**Dy**	0.05	10,000
Ba	1	50,000	**Yb**	0.05	10,000
Sn	1	10,000	**Gd**	0.05	10,000
Zn	1	10,000	**Sm**	0.05	10,000
Sr	0.5	50,000	**Er**	0.03	10,000
W	0.5	10,000	**Eu**	0.02	10,000
As	0.5	10,000	**Ho**	0.02	10,000
Nd	0.3	10,000	**Pr**	0.02	10,000
Co	0.2	10,000	**Lu**	0.01	10,000
Th	0.2	10,000	**Tm**	0.01	10,000
Ce	0.1	50,000	**Tb**	0.01	10,000
Y	0.1	50,000	**Hg**	0.01	50
Zr	0.1	50,000			
U	0.1	10,000			
Cu	0.1	10,000			
Ni	0.1	10,000			
Pb	0.1	10,000			
Cd	0.1	2,000			
Mo	0.1	2,000			
Sb	0.1	2,000			
Rb	0.1	1,000			

A total of 16 samples from outcrops (cubes with minimal dimensions of 25x25x25 cm) from 16 occurrences were tested for physical (bulk and apparent density, porosity, water absorption) and mechanical properties (uniaxial compressive strength and abrasive resistance) according to the SRPS standards. The bulk density is given as mass per unit of apparent volume. The volume was determined by hydrostatic weighing of specimens soaked and suspended in water under atmospheric pressure. On powdery samples, the real densities were determined using a pycnometer with water as the displacement fluid. From the values for specific and bulk density, total porosity was calculated. The specimens for determination of bulk density were also used for determination of water absorption by measuring the mass of water absorbed by the sample after immersion for 48 h at atmospheric pressure and expressed as a percentage of the initial mass of the sample previously dried at 105ºC to a constant weight. The uniaxial compressive strength (UCS) tests were performed on dry and water-saturated dolostone samples (cubes size 5x5x5 cm), and the samples underwent freeze-thaw cycles. Böhme abrasion resistance was determined using 7-cm cube samples.

3. Results and discussion

Calcite and dolomite were found to be the only minerals in all of the dolostones tested. Triassic samples are dolomite, whereas Upper Cretaceous dolostones are a mix of calcite and dolomite (Fig. 2). The content of all other components is quite low. DTA-TGA curves with mass losses of the investigated dolomite samples are shown in Fig. 3.

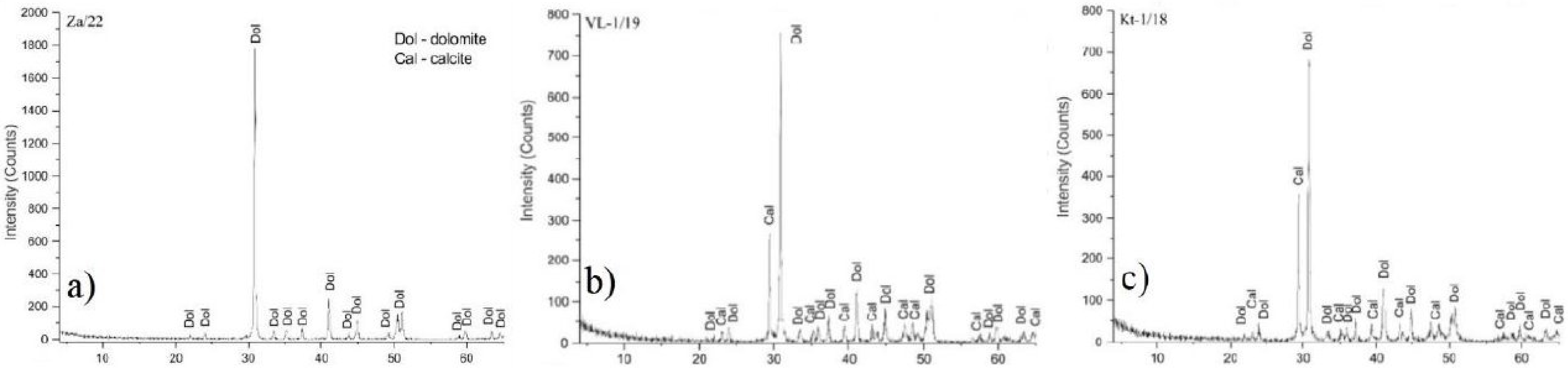

Fig. 2. XRD mineral composition of three typical dolostone samples.

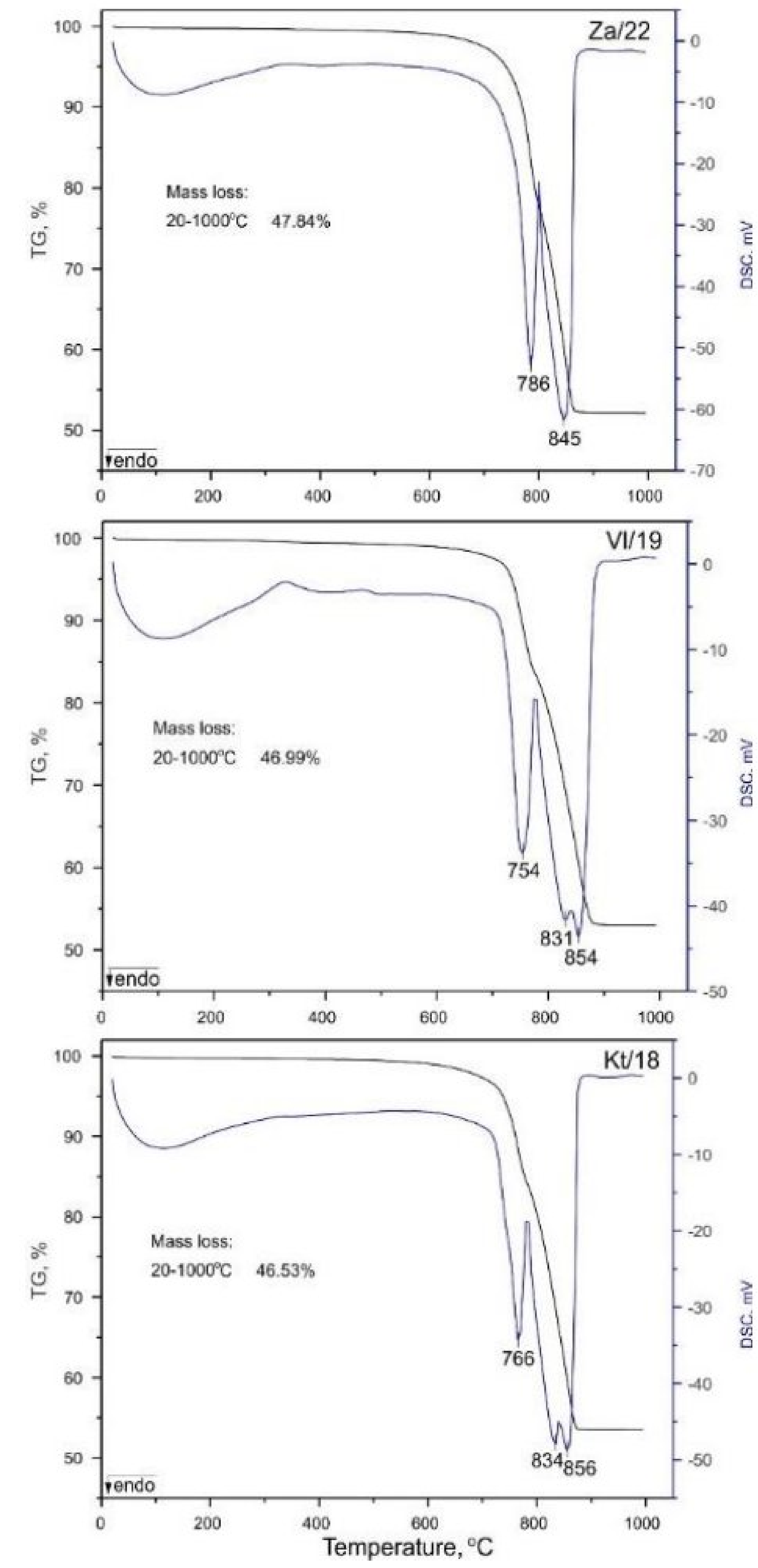

Fig. 3. DSC-TGA curves with mass losses of three typical dolostone samples.

The chemical analysis of dolostones (Tab. IV and Fig. 4) revealed that Triassic samples belong to dolomites, while Upper Cretaceous samples may be classified either as calcareous dolomite (Ulcinj and Orasi-Miloši area) or dolomitic limestone (Grbalj area). However, chemical analyses of single samples (Fig. 5) show that calcareous dolomites are inhomogeneous and, therefore, generally unsuitable for use as dolomite resources in the chemical industry. In Fig. 5, values of pure dolomite chemistry correspond to marked lines.

Table IV. Chemical analysis of studied dolostones classified by area.

Area	*Ulcinj*	*Grbalj*	*Orasi-Miloši*	*Grahovo*	*Rijeka Crnojevića*
Age	*Upper Cretaceous*	*Upper Cretaceous*	*Upper Cretaceous*	*Upper Triassic*	*Upper Triassic*
Rock type	*Calcareous dolomite*	*Dolomitic limestone*	*Calcareous dolomite*	*Dolomite*	*Dolomite*
SiO_2 (%)	0.08	0.05	0.54	0.14	0.67
TiO_2 (%)	<0.01	<0.01	0.01	<0.01	0.02
Al_2O_3 (%)	0.03	0.03	0.25	0.08	0.28
Fe_2O_3 (%)	0.05	0.02	0.12	0.07	0.14
MgO (%)	16.47	7.47	18.69	20.54	20.67
CaO (%)	36.50	46.65	34.39	31.81	31.29
Na_2O (%)	<0.01	0.04	0.04	0.06	0.03
K_2O (%)	0.02	0.01	0.04	0.03	0.04
MnO (%)	<0.01	<0.01	<0.01	<0.01	<0.01
P_2O_5 (%)	<0.01	<0.01	0.01	<0.01	0.02
LOI (%)	46.12	44.95	45.50	47.04	46.50
SO_3 (%)	0.14	0.05		<0.002	
TOT/C (%)	13.29	12.59	12.53	12.66	12.41
TOT/S (%)	0.05	0.04	<0.02	<0.02	<0.02

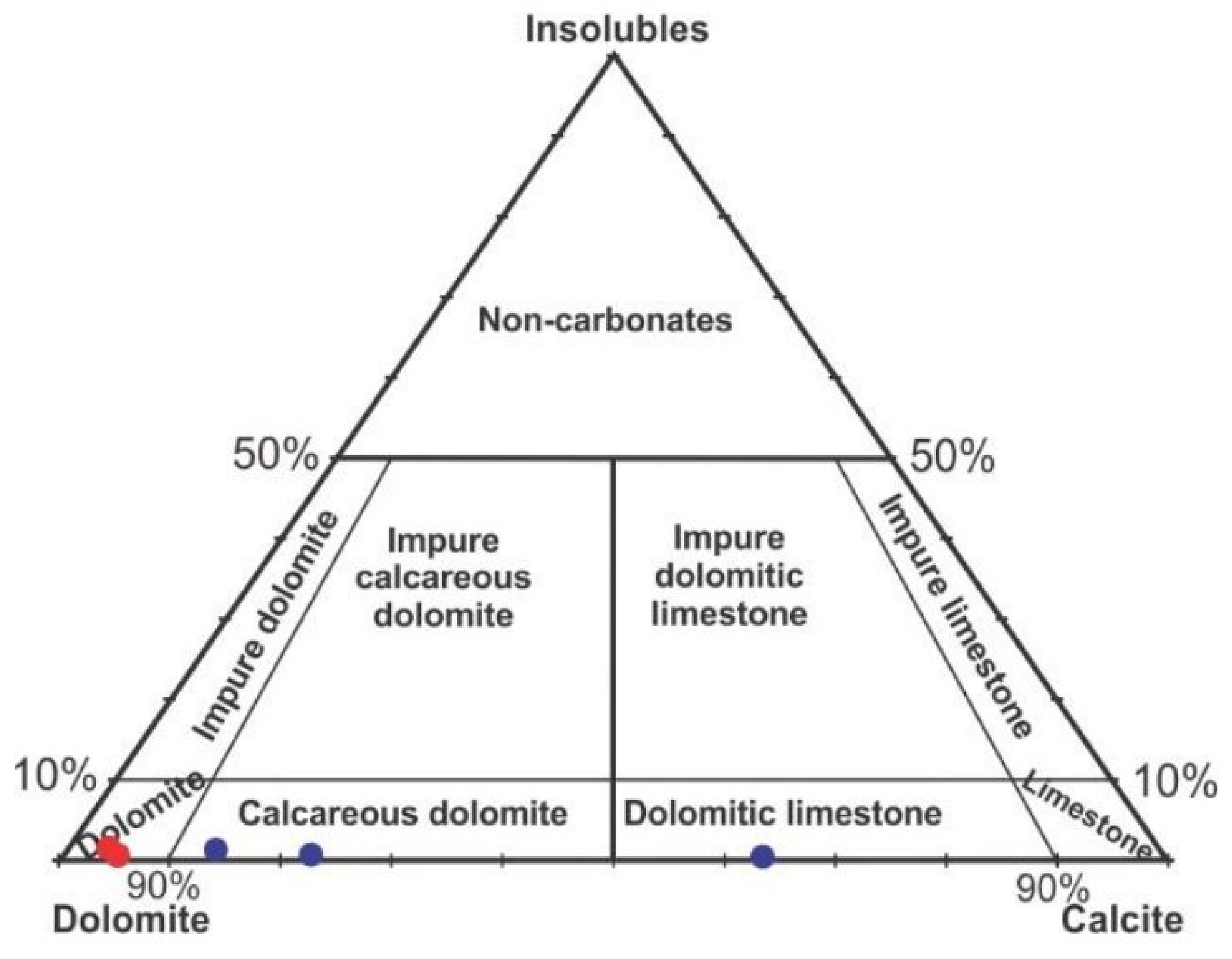

Fig. 4. Classification of studied dolostones by area and age:
(Full red circles: Triassic dolomites; blue circles: Upper Cretaceous dolostones).

The content of selected, largely potentially toxic trace elements (Tab. V) revealed certain differences, such as a lower Sr concentration in Triassic dolomites than in Upper Cretaceous dolostones, which is connected to the CaO content of the examined rocks. A much higher content of Cu, as well as a higher content of Pb and Zn, could be attributed to the deposition of a tiny amount of material from Anisian to lower Ladinian volcanic rocks, which occasionally host mineralization in the Dinaric metallogenetic province [21].

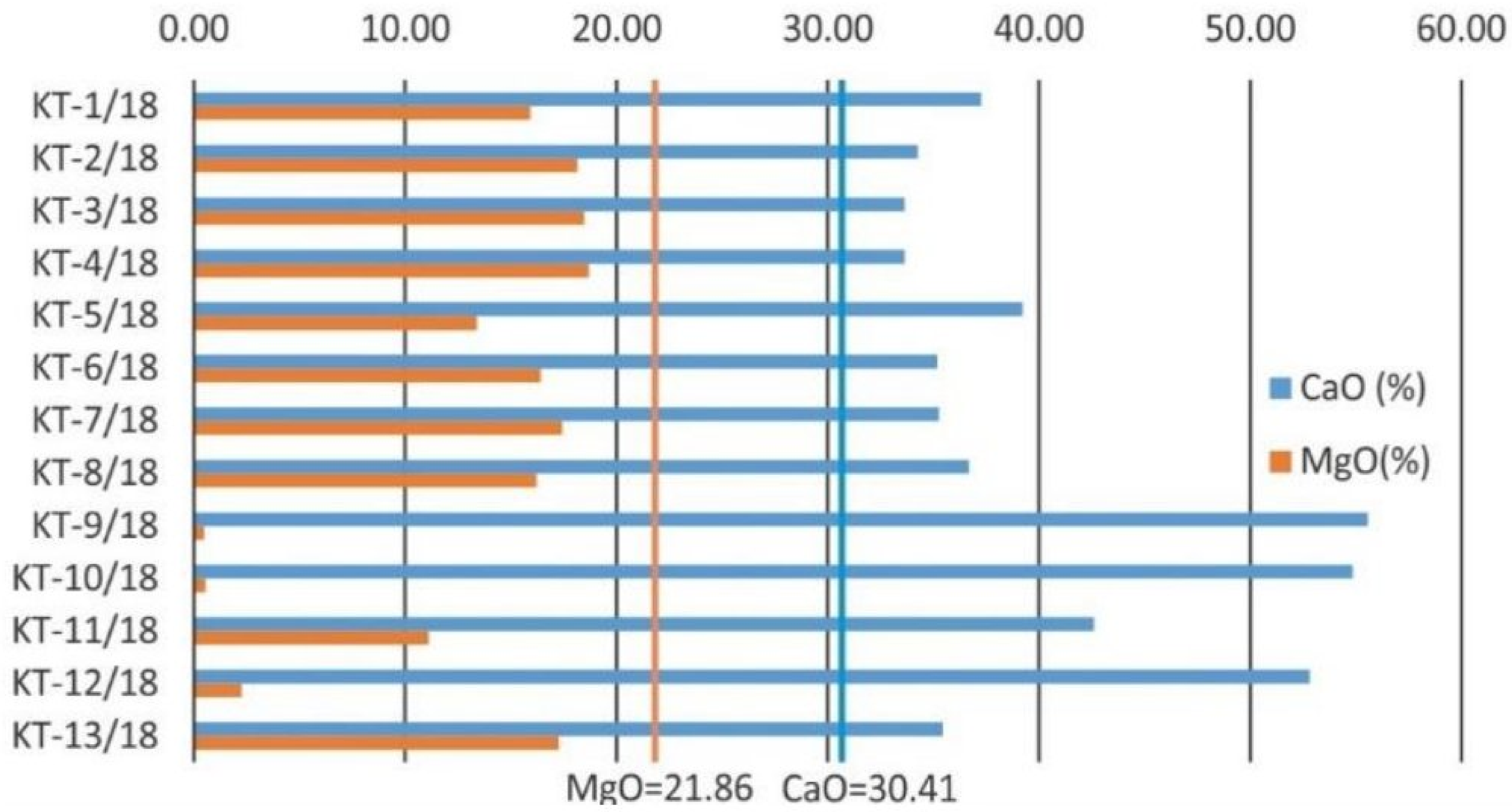

Fig. 5. Chemical analysis of Ulcinj area calcareous dolomite (Krute deposit).

Tab.V Content of selected trace elements (in ppm) in studied dolostones by area.

Area	*Ulcinj*	*Grbalj*	*Orasi-Miloši*	*Grahovo*	*Rijeka Crnojevića*
Age	*Upper Cretaceous*	*Upper Cretaceous*	*Upper Cretaceous*	*Upper Triassic*	*Upper Triassic*
Ba	2	2	4	3	8
Co	<0.2	<0.2	0.3	0.2	0.5
Rb	0.2	0.3	1.9	0.6	1.3
Sn	<1	<1	23	<1	30
Sr	139	336	135	91	56
Th	<0.2	<0.2	0.2	0.2	0.3
U	5.8	4.2	3.8	3.0	0.8
V	14	17	16	12	14
Zr	2.9	0.9	4.4	2.2	6.1
Mo	1.3	1.4	3.6	1	0.3
Cu	1.8	1.8	199.3	2.3	252.2
Pb	0.5	0.4	25.6	0.5	32.4
Zn	3	2	13	5	9
Ni	1.9	1.2	12.6	0.8	3.5
As	0.7	0.8	2.4	1.8	0.7
Cd	0.2	0.2	0.6	0.1	0.2
Sb	<0.1	<0.1	1.9	<0.1	0.6
Hg	<0.01	<0.01	0.03	<0.01	0.03

The content of rare earth elements in studied samples is very low (Tab. VI), typical for carbonate rocks. REE is slightly increased in the Rijeka Crnojevića Triassic dolomites deposit, indicating traces of redeposited material. Extremely low amounts of potentially hazardous trace elements, including As, Cd, and Hg, are also evident, allowing dolomite to be used in a high-quality filler product. On the other hand, elevated levels of Cu, Pb, Zn, and Ni in specific areas suggest that constant sampling is required when doing exploration.

Tab. VI Content of rare earth elements (in ppm) in studied dolostones by area.

Area	*Ulcinj*	*Grbalj*	*Orasi-Miloši*	*Grahovo*	*Rijeka Crnojevića*
Age	*Upper Cretaceous*	*Upper Cretaceous*	*Upper Cretaceous*	*Triassic*	*Triassic*
La	0.4	0.5	0.7	0.6	1.4
Ce	0.5	0.6	1.4	0.9	2.1
Pr	0.06	0.08	0.18	0.10	0.28
Nd	0.3	0.3	0.5	0.4	1.1
Sm	0.09	0.05	0.10	0.09	0.22
Eu	0.02	0.02	0.02	0.03	0.06
Gd	0.09	0.08	0.10	0.10	0.23
Tb	0.01	0.01	0.02	0.02	0.04
Dy	0.06	0.08	0.07	0.10	0.23
Ho	0.02	0.02	0.02	0.02	0.05
Er	0.04	0.04	0.04	0.06	0.18
Tm	0.01	0.01	<0.01	0.01	0.03
Yb	0.05	0.05	<0.05	0.05	0.13
Lu	0.01	0.01	<0.01	0.02	0.02
Y	0.5	0.3	0.6	0.5	2.7
ΣREE	1.66	1.90	3.15	2.44	5.97
ΣREEY	2.12	2.22	3.75	2.91	8.62

Tab. VII provides the fundamental parameters that should be assessed on the examined samples when utilizing dolostone as a filler. While all numbers are comparable, those from the Grbalj area show the poorest values. In all the locations under study, whiteness and yellowness are rather low. Dolostones should not be considered a prospective resource for high-quality filler goods, as the results show that all of them are of lesser quality for high-purity filler applications when compared to the limestone of the Bjelopavlići area in Montenegro [27].

Tab. VII Basic technological parameters of dolostone by the area.

Area	**Oil absorption (%)**	**Water absorption (%)**	**Whiteness (%)**	**Yellow-ness***	**Bulk density (g/cm^3)**	**Specific density, (g/cm^3)**	**Specific area, (m^2/g)**
Ulcinj	15.10	18.80	82.77	n/a	1.11	2.79	1.68
Grbalj	10.76	13.90	69.06	n/a	1.19	2.79	0.48
Orasi-Miloši	15.96	18.60	59.71	15.74	0.97	2.88	
Grahovo	15.50	18.23	75.61	8.53	0.90	2.78	1.59
Rijeka Crnojevića	14.97	19.05	80.86	6.42	0.78	2.86	

*n/a – not analysed

Stone for aggregates has a fairly good and uniform quality, according to its physical and mechanical characteristics (Tab. VIII). It must be stated, nonetheless, that the weathering and fragmentation of the stone made sampling the Triassic dolomites from the Grahovo and Rijeka Crnojevića localities difficult. After careful handpicking, samples might be obtained from a number of locations.

Tab.VIII Basic parameters of physical-mechanical properties of Montenegro dolostone.

Parameter	SRPS Method	Unit	Ulcinj	Grbalj	Orasi-Miloši	Grahovo	Rijeka Crnojevića
Bulk density	*B.B8.032*	kg/m^3	2654	2660	2688	2709	2670
Specific density	*B.B8.032*	kg/m^3	2671	2675	2715	2731	2707
Total porosity	*B.B8.032*	m/m%	0.75	1.01	0.56	1.00	0.69
Water absorption	*B.B8.010*	m/m%	0.45	0.51	0.23	0.57	0.27
UCS*:							
- Dry	*B.B8.012*	MPa	117.7	111.3	122.4	124.0	119.2
- Water saturated	*B.B8.012*	MPa	109.6	101.8	117.7	114.7	110.8
- After freezing	*B.B8.012*	MPa	102.7	256.9	109.2	106.1	102.2
Flexural Strength	*B.B8.017*	MPa	12.2	9.9	13.1	11.6	15.1
Treton impact test	*B.B8.019*	m/m%	15.1	17.2	17.4	17.1	17.5
Böhme abrasion test	*B.B8.015*	$cm^3/50cm^2$	19.3	20.9	19.0	19.0	19.4
LA test	*B.B8.045*	m/m%	20.1	22.1	20.0	21.1	20.9
Resistance to Na_2SO_4	*B.B8.002*	R/NR**	R	R	R	R	R
Freeze-thaw resistance	*B.B8.001*	R/NR	R	R	R	R	R
Total chloride (Cl)	*B.B8.042*	%	0.0019	0.0015	0.0007	0.0007	0.0010
Sulphide (S)	*B.B8.042*	%	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Sulphates (SO_3)	*B.B8.042*	%	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

* The uniaxial compressive strength; ** Resistant/Not resistant

The geological and technological classification of Montenegro dolostones, including four previously explored deposits of pure dolomite, is presented in Tab. IX. The analyses showed that Upper Cretaceous dolostones are compact, usually with a small content of organic matter, and represent a good resource for construction applications like aggregate rock, dimension stone, and construction filler. Upper Cretaceous dolostones can be used in industry as filler (0 – 4 mm stone fraction) for agriculture, iron and steel manufacture, and other uses. However, the use of high-quality filler is constrained by its whiteness, and the chemistry of lime limits its use.

On the other hand, Triassic dolomites are generally weathered without organic matter. Their application as aggregate is limited due to the grain size and is impossible for dimension stone. However, Triassic dolomites are a good resource for lower-quality construction fillers where whiteness is not important. Industrial application of Triassic dolomites is possible as filler for iron and steel production and agriculture, but not for filler in paints and other demanding products due to their low whiteness. From a chemical point of view, Triassic dolomites would be of great interest for dolomitic lime production, but the limiting factor is grain size with too many small fractions.

Tab. IX Geological and technological classification of Montenegro dolostones.

Area	Ulcinj	Grbalj	Orasi-Miloši	Grahovo	Rijeka Crnojevića	Nikšić
Age	Upper Cretaceous	Upper Cretaceous	Upper Cretaceous	Triassic	Triassic	Triassic
Tectonic unit	Adriatic-Ionian	Adriatic-Ionian	High Karst	High Karst	High Karst	High Karst
Rock type	Calcareous dolomite	Dolomitic limestone	Calcareous dolomite	Dolomite	Dolomite	Dolomite
Fabric	Massive Compact	Massive Compact	Massive Compact	Massive Weathered	Massive Weathered	Massive Weathered
Organic matter	Yes	Yes	Yes	No	No	No
Construction Application						
Aggregate stone	Yes	Yes	Yes	Limited (grain size)	Limited (grain size)	Limited (grain size)
Dimension stone	Yes	Yes	Yes	No	No	No
Filler	Yes	Yes	Yes	Yes	Yes	Yes
Industrial Application						
Filler (iron & steel)	Yes	Yes	Yes	Yes	Yes	Yes
Filler (paints, etc.)	Limited (whiteness)	Limited (whiteness)	Limited (whiteness)	Limited (whiteness)	Limited (whiteness)	Limited (whiteness)
Agriculture	Yes	Yes	Yes	Yes	Yes	Yes
Lime	Limited (chemistry)	No	Limited (chemical composition)	Limited (grain size)	Limited (grain size)	Limited (grain size)

4. Conclusion

Like limestone, dolomite is a mineral resource that has a lot of potential but has not been exploited much in the past. The limitless deposits of this mineral resource, however, suggest that a suitable method of monetizing it across a range of industries must be found while also addressing environmental challenges and reducing carbon footprints.

The majority of dolomites are weathered and devoid of any organic content. When whiteness is not a concern, dolomites are an excellent source for lower-quality construction fillers. Dolomites can be used industrially as a filler for agricultural, iron, and steel manufacture, but not as a filler for paints or other high-quality products because of their low whiteness. Dolomites would be very interesting from a chemical standpoint for the synthesis of dolomitic lime, but the size of the grains with too many small fractions is a limiting problem.

Dolomite was previously the subject of very small-scale regional geological exploration, primarily aimed at demonstrating the quality and reserves of this mineral raw material in four registered deposits and the potential for use as refractory material (Virpazar and Vranjina deposits) and for metallurgy, i.e., a steel plant in Nikšić (Šume and Bršno deposits). Based on the findings of this study, further geological exploration of dolomite should be carried out in accordance with specific phases and stages of the research process, which would be detailed in detail in the research idea and methodology. This allows for a more accurate assessment of the outlook for geological dolostone formations and occurrences as well as an appraisal of the potential for dolostones as a raw material for the mineral industry that might be used for eventual export or regional consumption.

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Геохемијска процена лежишта долостона у Црној Гори: могућност потенцијалне индустријске примене

Резиме: *Доломит је вредна минерална сировина са бројним индустријским применама. Долостони су минерални ресурси са значајним потенцијалом раста. Подручје истраживања обухватило је јужну и централну Црну Гору. Испитивана су минералошка, петрографска, геохемијска и технолошка својства. Горњокредни долостони су компактни и садрже органску материју, док су долостони из тријаса истрошени доломити без органске материје. Обе формације су показивале различит квалитет долостона, што је довело до геолошке и технолошке класификације црногорских долостона. Долостон горње креде се користи у грађевинској индустрији као агрегат, грађевински камен и пунило, док тријаски доломити нису погодни као грађевински камен и имају ограничен потенцијал као агрегат. Оба долостона могу да се користе у индустрији челика и у пољопривреди, али не и као висококвалитетна пунила када је белина ограничење, или за производњу креча где су хемијски састав и величина зрна регулисани. Ово је прва свеобухватна студија геохемијских процена лежишта долостона на Балкану и њихове потенцијалне индустријске употребе.*

Кључне речи: *примарне сировине; минералогија; физичко-механичка својства; технолошка својства; наука о материјалима.*