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Investigation of Raw Material Properties of Türkoğlu (Kahramanmaraş) Region Dolomites

Türkoğlu (Kahramanmaraş) Yöresi Dolomitlerinin Hammadde Özelliklerinin İncelenmesi

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ABSTRACT

This study was carried out with the aim of determining the raw material properties of the dolomites of the Türkoğlu (Kahramanmaraş) region. In this study, samples were taken from the dolomites of occur widely area in Turkoglu (Kahramanmaraş) and the chemical composition, mineralogical structure, petrographic properties, physico-mechanical and thermal properties of the dolomite samples were determined. Thermal characterization experiments (TG-DTA) were carried out to determine the thermal behavior of dolomites under high temperature conditions. As a result of the experiments, it was understood that the properties of the examined dolomite samples were suitable for use in various sectors (lime, glass and refractory production, etc.).

Keywords: Dolomite, MgO, CaO, TG-DTA, Turkoglu (Kahramanmaraş)

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ÖZ

Bu çalışma, Türkoğlu (Kahramanmaraş) yöresi dolomitlerinin hammadde özelliklerini belirlemek amacı ile gerçekleştirilmiştir. Çalışma kapsamında, Türkoğlu yöresinde oldukça geniş bir bölgede oluşmuş dolomitlerinden örnekler alınmış ve dolomit örneklerinin kimyasal bileşimi, mineralojik yapısı ve petrografik özellikleri, fizikomekanik ve termal özellikleri belirlenmiştir. Termal özellik belirleme deneyleri (TG-DTA) dolomitlerin yüksek sıcaklık şartları altındaki ısıl davranışlarını belirlemek amacı ile gerçekleştirilmiştir.
Deneyler sonucunda, incelenen dolomit örneklerinin özelliklerinin çeşitli sektörlerin (kireç, cam ve refrakter üretimi vb) kullanımı için uygun olduğu anlaşılmıştır.

Anahtar Kelimeler: Dolomit, MgO, CaO, TG-DTA, Türkoğlu (Kahramanmaraş)

INTRODUCTION

Dolomite, the rock, contains a large proportion of dolomite the mineral. Dolomite typically occurs as the major constituent of sedimentary formations in association with calcite. Carbonate rocks tend to be composed either mostly of calcite or mostly of dolomite. Ideal dolomite has a crystal lattice consisting of alternating layers of Ca and Mg, separated by layers of CO_3 and is typically represented by a stoichiometric chemical composition of $CaMg(CO_3)_2$ where calcium and magnesium are present in equal proportions. The layer-type structure of dolomite is responsible for the strong anisotropy of the physical properties, including the thermal expansion. Theoretical composition of the dolomite is 21.86% MgO, 30.42% CaO and 47.73% CO_2. Varying amounts of impurities including SiO_2, Al_2O_3 and Fe_2O_3 are present in dolomite. The amounts and types of these impurities may have a large effect on the extent of densification. Dolomite occurs widely scattered in nature and is an important material for the metallurgical (as flux, as fettling material for the hearth of furnaces), pharmaceutical, paper and fertilizer industries (Leighton and Pendexter, 1962).
Thermal analysis might offer the means of defining the fraction of each mineral lattice in such mixtures and the concentration of each cation in each lattice. The correlation of the thermal data with the structural pattern should provide a broader understanding of these minerals in their natural occurrence. A general review of the literature on the decomposition of carbonates indicates that a great deal of variability exists in the reported values of the decomposition temperatures, activation energies and rates of decomposition. The decomposition of dolomite has been studied extensively because of its mineralogical interest and industrial importance (Warren, 2000).

This study was carried out with the aim of determining the raw material properties of the dolomites of the Turkoglu (Kahramanmaraş) region. The sampled area is located approximately 1 km to the west of Türkoğlu District and approximately 25 km to the southwest of Kahramanmaraş Province (Demirkol, 1988).

MATERIAL AND METHOD

The dolomite samples were taken from Turkoglu region (Kahramanmaraş) in Turkey (Figure 1). During sampling, rock types having no bedding planes were selected to eliminate any anisotropic effects in the measurements of the samples. The dolomite samples present macroscopically light and dark grey coloured comprising discrete and tiny crystals. Microcracks were not present throughout the mass of dolomite samples.

Analyses were performed on dolomite samples, specifically on portions obtained from samples collected in a manner and quantity representative of the field, using the following analytical procedure. In the chemical analysis and thermal experiments (TG, DTA analysis) ground -0.5 mm size dolomites were used. Specimens of ~5-10 cm mean edges were for the physical experiments. The compressive strength of the dolomites was determined by the Schmidt hammer in situ (field).

- XRF (Siemens SRS 300 X-ray Flouresans Spectrometer) was used to determine the chemical compositions of dolomite samples.
- Physical properties (the bulk density, effective porosity, water absorption rate) of the limestones were determined using saturation and buoyancy techniques, as recomended by ISRM and TSE (TS 699, 2009; TS EN 12407, 2019).
- Transmitted light microscopy (Olympus BH-2) was carried out on polished thin sections of the limestone in order to identify the texture, shape, and size of the grains.
- The compressive strength of the dolomite was determined by the Schmidt hammer. Schmidt hammer tests were carried out on in situ (field). The tests were performed with an N-type hammer having impact energy of 2.207 Nm. All tests were conducted with the hammer held vertically downwards and at right angles to the horizontal rock surface. In the tests, the ISRM method was applied for each rock type. ISRM suggested that 20 rebound values from single impacts separated by at least a plunger diameter should be recorded and the upper 10 values averaged. The test was repeated at least three times on each rock type and the average value was recorded as the Schmidt hammer value.

- Differential thermal and thermogravimetric analyses (simultaneous TG/DTA, SII Exstar 6000 DTA-TG) were carried out to determine quantitatively and qualitatively the various compounds presented in samples. Analysis was performed in sample of dolomite at a temperature range of 25-900ºC and gradient of 10ºC/min.

Figure 1. The dolomite area, Turkoglu region (Kahramanmaraş)
Şekil 1. Dolomit sahası, Türkoğlu bölgesi (Kahramanmaraş)

RESULTS AND DISCUSSION

Dolomite Characteristics

The chemical analyses results of dolomite sample is presented in Table 1. It was found that the studied dolomite sample is MgO higher than 20%, the impurities (Fe_2O_3, Al_2O_3, SiO_2 and MnO) are very low. Since the $MgCO_3$/$CaCO_3$ ratio varies with the type of dolomitic limestone, the decomposition temperature does not remain constant.

Table 1. Chemical composition of dolomite sample

Tablo 1. Dolomit örneğinin kimyasal içeriği

Fe_2O_3 (%)	Al_2O_3 (%)	SiO_2 (%)	MnO (%)	CaO (%)	MgO (%)	LOI (%)
0.82	0.79	1.57	0.027	29.50	21.10	46.193

In details, following the standard procedure outlined by ISRM (1979), physical properties (unit weight, water absorption ratio, porosity) were determined. The analysis results of physical properties of the dolomite sample are shown Table 2. Dolomite sample indicated medium void volume values in porosity (2.5-5%) (Tarhan, 1989). The value of unit weight (2.8-2.9 g/cm^3) was found to be characteristic for a dolomite.

Table 2. Physical properties of the dolomites

Tablo, Dolomit örneğinin fiziksel özellikleri

Unit weight (g/cm^3)	Water absorption ratio (%)	Porosity (%)
2.78	1.45	1.1

In petrographic investigation, in thin section, dolomite shows very high relief and it is colorless at PPL, displaying strong birefringence with characteristic very high five order colors at CPL. Petrographic property shows that most of the dolomite crystals are of medium to coarse crystal size, light to dark brown in colour. It shows a perfect rhombohedral cleavage and very commonly shows lamellar twinning. The main component proved to be calcite ($CaCO_3$) and dolomite ($CaMgCO_3$) for dolomite sample, although this does not preclude the possibility of the presence of small quantity (SiO_2) (Figure 2).

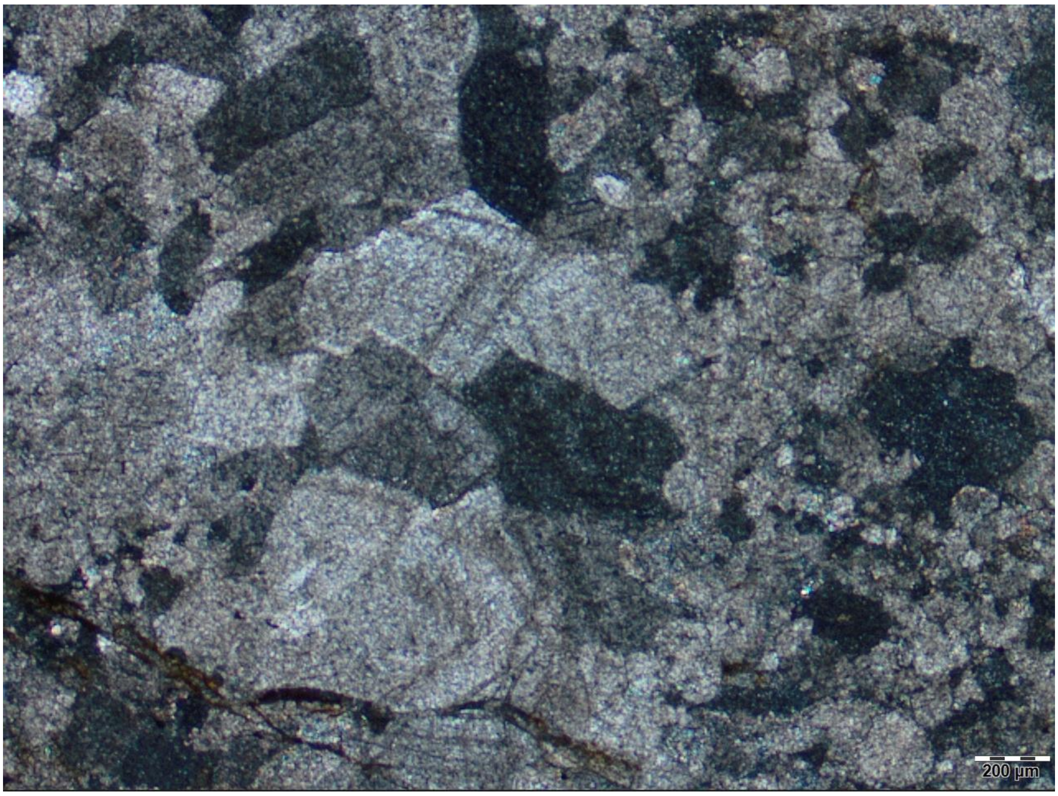

Figure 2. Thin Section Image of Dolomite

Şekil 2. Dolomit İnce Kesit Görüntüsü

Uniaxial compressive strength was indirectly determined with the Schmidt hammer test using a Schmidt hammer instrument according to ISRM. Schmidt hammer test is considered as a famous testing for rock strength and deformability characterization owing to its quickness, portability, low cost and non-destructiveness. Schmidt hammer was originally developed for measuring the strength of hardened concrete (Schmidt 1951). It correlates with rock compressive strength (Barton and Choubey, 1977). Schmidt hammer can be used easily in the field. Its indirect test is simpler, faster, and cheaper (Kilic, 2006).

In the present work, the uniaxial compressive strength (UCS) (MPa) of the studied Turkoglu region dolomite determined with the Schmidt hammer test using an Schmidt hammer, has been calculated according to Deere and Miller (1966). According to Deere and Miller, (1966), the rebound numbers are used to estimate uniaxial compressive strength of the Turkoglu region dolomite in vertical direction (normal to bedding plane). The obtained values of UCS range from 29.7 to 51.8 MPa for the vertical direction (Figure 3).

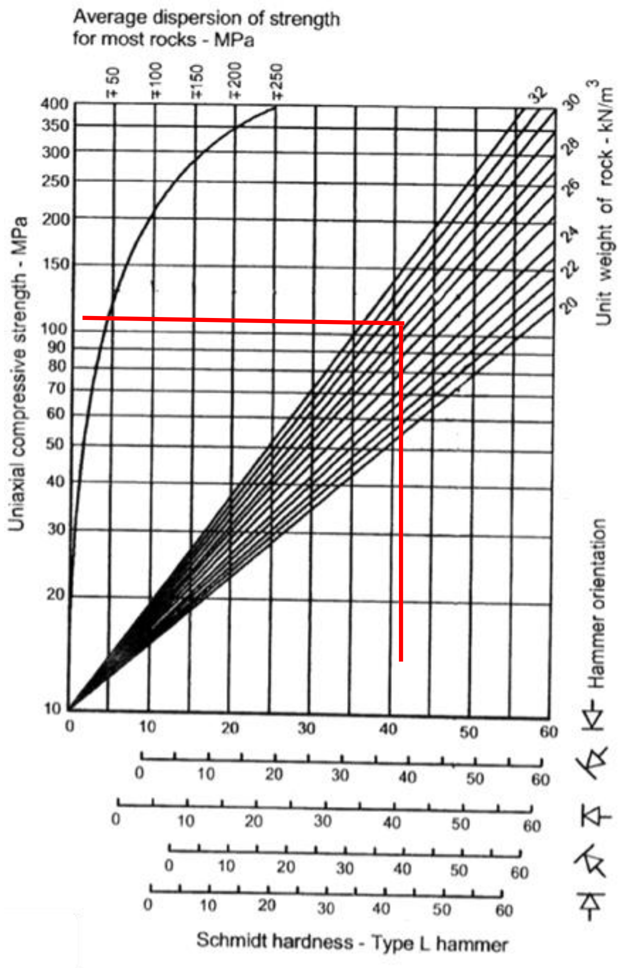

Figure 3. The estimated UCS of dolomite (Deere ve Miller, 1966)

Şekil 3. Dolomit UCS (Tek Eksenli Basma Dayanımı) Tahmini

Thermal analysis was performed in a simultaneous TG–DTA. The experimental conditions were: (i) continuous heating from room temperature to 900°C at a heating rate of 10ºC /min, TG and DTA curves were obtained. The following data was obtained by thermal analysis: (i) reaction peak temperature and main effect (endothermic or exothermic) and (ii) content of bound water, which is the weight loss in the temperature range 450–800±3°C and content of CO_2 released during the decomposition of magnesium carbonate phase (Figure 4, Figure 5).

The internal structure of a rock having open and closed pores in its texture affects its heat transfer. The changes in pore structure also play a significant role on the calcination mechanism and the reactivity of a calcined dolomite is strongly dependent on its physical and structural properties, which in turn are highly dependent on calcination conditions (Boynton, 1980). Pure dolomite decomposes in two separate stages (eq. 1-2).

$MgCa(CO_3)_2 \rightarrow CaCO_3 + MgO + CO_2\uparrow$ (1)

$CaCO_3 \rightarrow CaO + CO_2\uparrow$ (2)

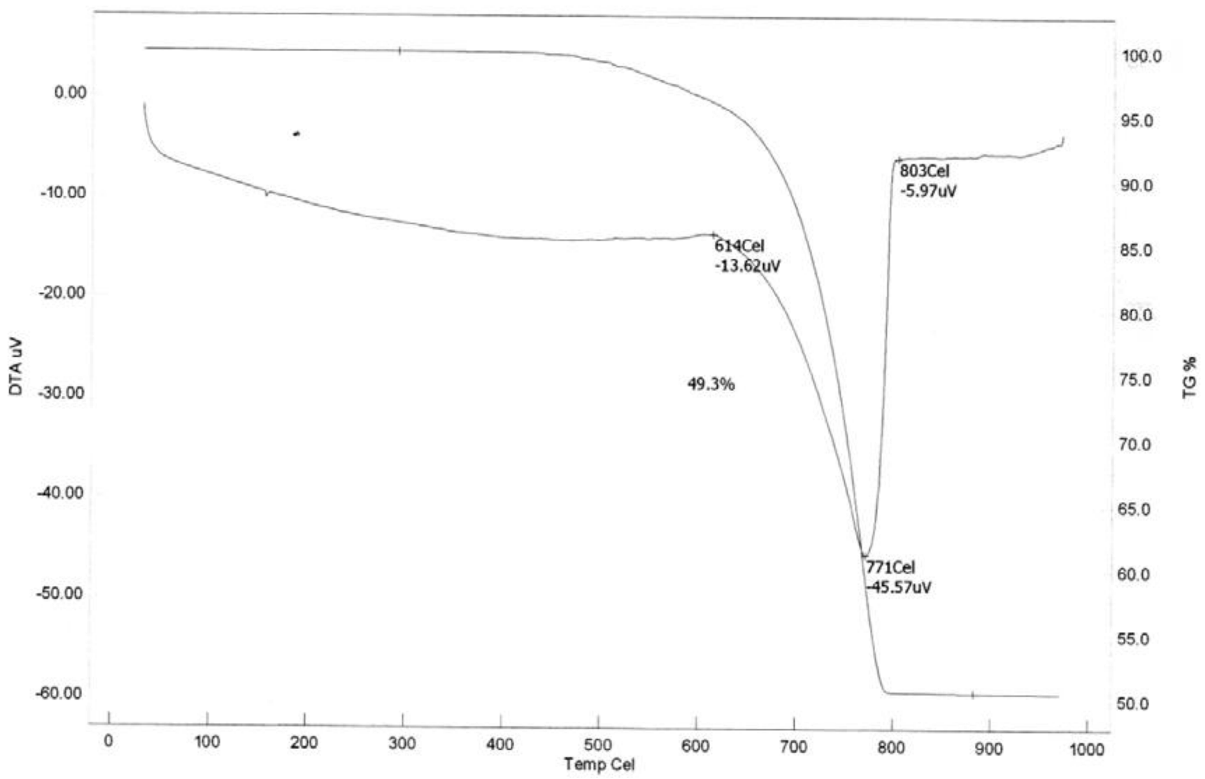

Figure 4. The Result of TG-DTA Analysis

Şekil 4. Örneğin TG-DTA Analiz Sonucu

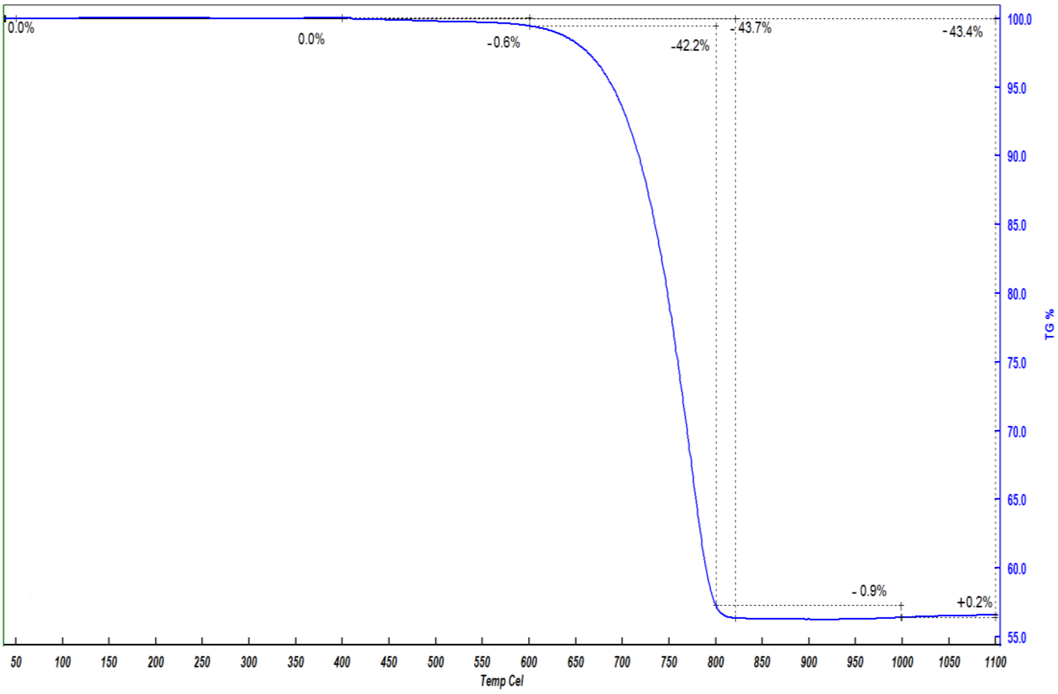

Figure 5. The Result of TG Analysis (% Loss of Weight)

Şekil 5. Örneğin TG Analiz Sonucu (Ağırlık Kayıpları %)

CONCLUSIONS

In this study, dolomites of the Turkoglu (Kahramanmaraş) region, raw material properties, chemical composition, mineralogical structure, petrographic properties and physical properties; such as unit weight, water absorption ratio, porosity, mechanical property; uniaxial compressive strength (UCS) and thermal behavior were determined.

Based on the experimental results obtained in this work, the conclusions can be summarized in the following points:

According to chemical analyses results, the studied dolomite sample is MgO higher than 20%, the impurities (Fe_2O_3, Al_2O_3, SiO_2 and MnO) are very low. Since the $MgCO_3$/$CaCO_3$ ratio varies with the type of dolomitic limestone, the decomposition temperature does not remain constant. Mineralogical and petrographic analyses results show that the main component proved to be calcite ($CaCO_3$) and dolomite ($CaMgCO_3$) for samples, although this does not preclude the possibility of the presence of small quantity (SiO_2).

According to ISRM (1981), carbonate (dolomite) was classified into medium to strong rocks. Physical, mechanical and thermal properties indicated that the changes in pore structure also play a significant role on the calcination mechanism and the reactivity of a calcined dolomite is strongly dependent on its physical and structural properties.

As a result of the experiments, it was understood that the properties of the examined dolomite samples were suitable for use in various sectors (lime, glass and refractory production, etc.).

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