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Structural, petrographic and geochemical features of the calcite quarry in the Biga Peninsula (Çanakkale, Türkiye)

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Abstract

Calcite is a significant industrial raw material used in many fields owing to its properties. For this reason, determining the calcite quarry's geological and geochemical characteristics promotes the sector. This study was carried out to explain the geological and geochemical properties of the marble blocks of Paleozoic metamorphics located in the Biga peninsula. The length of this area, operated as a calcite quarry, is 350 meters, and its width is around 50 meters. Although alterations are partially observed due to the effect of faulting, the alteration is quite low in the main production area. Secondary minerals are rarely seen in fractures and cracks in marbles that display texturally granular texture. In geochemical analyzes, CaO values are around 55%, and MgO values are quite low. Structural elements in the region show that the region has gone through two separate deformation phases. These are NW-SE direction compression and NW-SE direction tension, respectively. Rose and point-contour diagrams obtained from the joint values measured in the calcite field confirm these deformation phases. The structural condition of the calcite quarry in terms of operation is compatible with its other characteristics. These data show that the calcite quarry suggests remarkably useful properties in terms of industrial raw materials.

1. Introduction

Limestone consists of calcite, whose chemical formula is $CaCO_3$ (calcium carbonate). It is largely used in many sectors in aggregate, powder, block, etc., owing to its physical and chemical properties [1]. The most important sectors are metal, paper, ceramics, chemistry and construction. For this reason, it is inevitable to research limestone, an extremely remarkable industrial raw material, and determine its physical and chemical properties.

The quality of the calcite mineral is determined by its grain diameter, color and chemical purity [2-3]. The hardness of pure calcite is three according to Moh's scale, and its specific gravity is around 2.6-2.7 g/cm^3 at 20°C [3]. Carbonate rocks consisting of calcite with these properties are generally used as aggregates. To satisfy this need, the geological and geochemical characteristics of the calcite quarries should be explained.

When the geological framework of Turkey is reviewed, significant carbonate belts stand out. While some belts spread in relatively long and continual areas, a block or lenticular structure occurs in some areas for tectonic reasons. This study explained the geological and geochemical properties of the limestones in the Biga (Çanakkale) peninsula in Western Anatolia.

Western Anatolia has led to much research due to its complex geological structure. The stratigraphic base of the Biga peninsula consists of units belonging to the Sakarya continent. Sakarya Zone [4] consists of Kazdağ group metamorphics and the Karakaya complex [5]. The Kazdağ group comprises pre-Permian amphibolite facies metamorphic rocks that have undergone metamorphism [6]. Metamorphic rocks are still cut by Upper Paleozoic granitoids (Çamlık meta granitoid [5], Söğüt granite [7], Kavsarali unit [8] and Yolindi metagranite [5]). In the region, which has a remarkably complex geological structure, there are large carbonate blocks in metamorphic rocks. These blocks are used as calcite quarries, and the geological and geochemical data of this quarry are exceedingly limited. For this reason, it will be very beneficial for the industry in the region to explain the geological features of the calcite quarry.

2. Material and Method

A 1/10,000-scaled geological map of the study area was drawn up. The contact relations of the units were completed in the field and redrawn in the Corel Draw program. In supplement, thin sections of the samples collected from the calcite quarry were made in ITU-JAL and examined under a polarizing microscope. Eventually, the geochemical analyzes of the samples were carried out with the X-ray fluorescence (XRF) spectrometer method. The X-ray diffraction analysis (XRD) method was preferred for mineralogical identification.

In addition to these basic analyses, joint measurements were carried out in the calcite field. In addition to the regional structural evaluations, point-contour and rose diagrams were prepared, and the states of the effective force regimes in the region were determined. For this study, the Stereo-net program was used.

The data gathered were described in the office.

2.1. Geological Background

Pre-Tertiary rocks in the district crop out in tectonic belts, which spread in a NE-SW direction [5]. These tectonic zones consist of the İzmir-Ankara zone, Sakarya zone, Çetmi mélange, and Ezine zones from east to west, respectively.

The study area is located in the Sakarya zone defined by Şengör and Yılmaz [9]. Kazdağ metamorphics and the Karakaya complex come together with tectonic contact. According to the Turkish Tectonic Units [10], the study area is located within the Paleozoic-Early Mesozoic subduction-subduction complex (Figure 1).

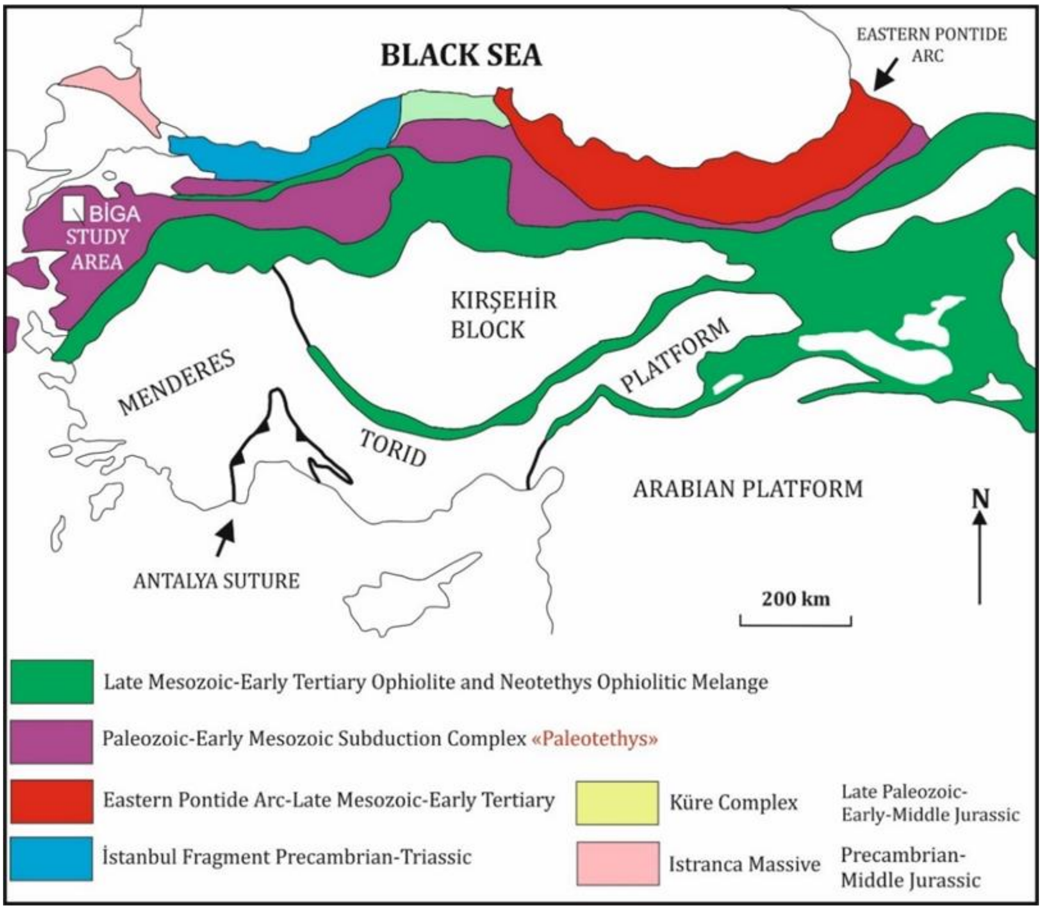


Figure 1. Tectonic location map of the study area (Modified from Şengör et al. [10])

The base of the study area is the Kalabak Unit. Within this unit, there are Torasan formations and Çamlık Metagranodiorites are observed. The Torasan formation, which mainly includes phyllites, schists, metarhyolite, marble blocks and metaserpentinite blocks, is cut by the Çamlık Metagranodiorites. As a result of the deformations that occurred in the province, these two units belonging to the Kalabak Unit came together in some areas with a tectonic contact. The Karakaya formation of the Karakaya complex overlies this basement unit with angular unconformity. The contact of this unit, which consists of metamorphic rocks, with the basic units is generally tectonic (Figure 2).

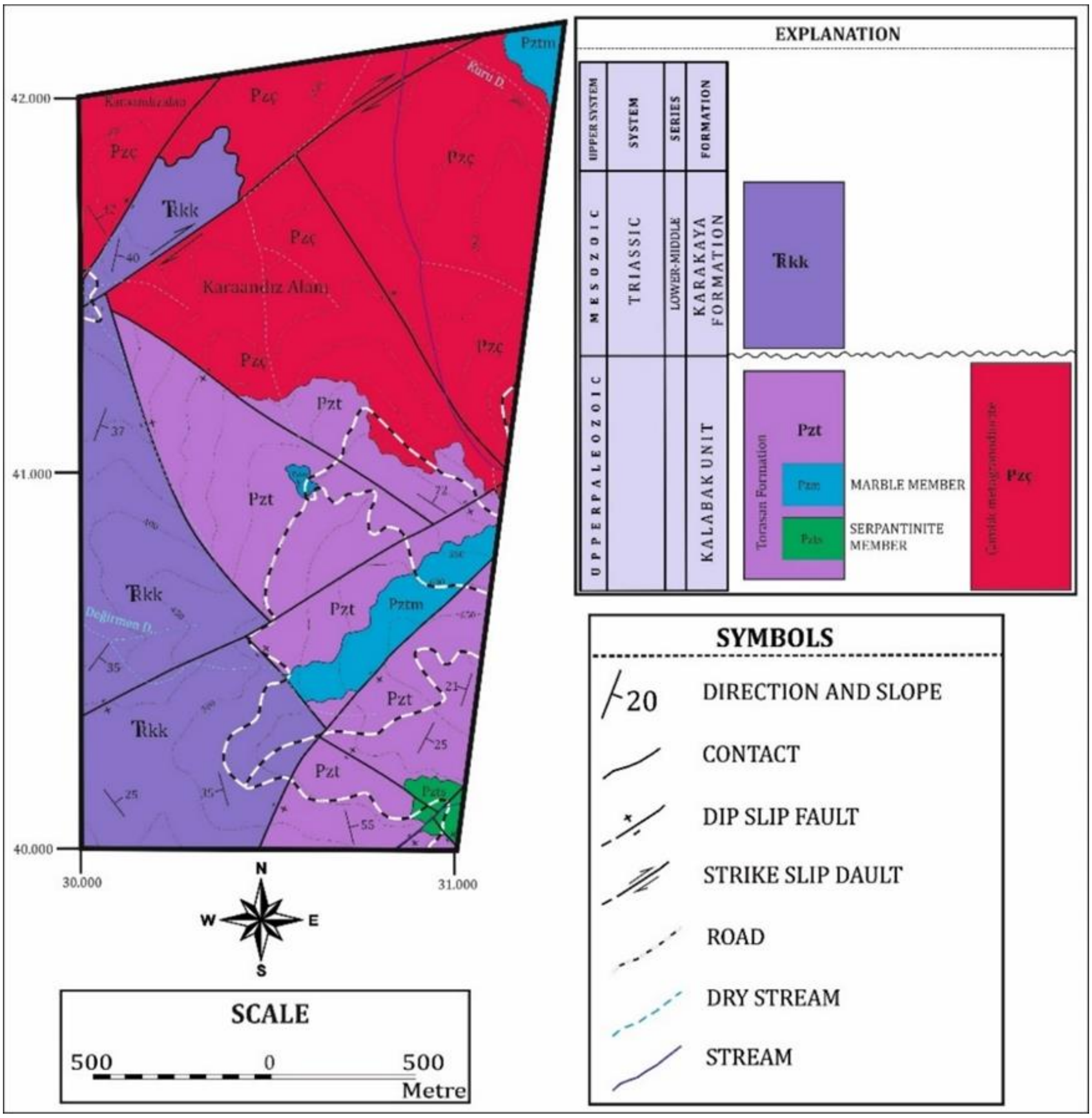


Figure 2. Geological map of the study area

Detailed investigations were implemented in the calcite quarry area, which is included in these lithologies and defined as the Marble member. The mineralogy, petrography and geochemistry of the rock, along with the structural relationship of the marble contact, are explained.

2.2. Characteristics of Calcite Quarry

The study area has an already operated calcite quarry east of Değirmen creek. This quarry operated using the calcite mineral belonging to the Marble blocks in the Torasan formation. Located on the site in a northwest-southeast direction, this marble block is approximately 350 meters long and 50 meters wide. This unit is cut by two NE-SW and NW-SE direction faults.

In the enterprise opened at 540 m elevations of the unit, it is observed that it is bordered by a fault along the dry stream and is in the form of a lens in the Torasan formation (Figure 3). The field easily recognizes its weathering color and morphological features (Figure 4a). In the continuation of the unit towards the northeast, it is observed that the alteration color turns dark grey-blackish grey (Figure 4b).

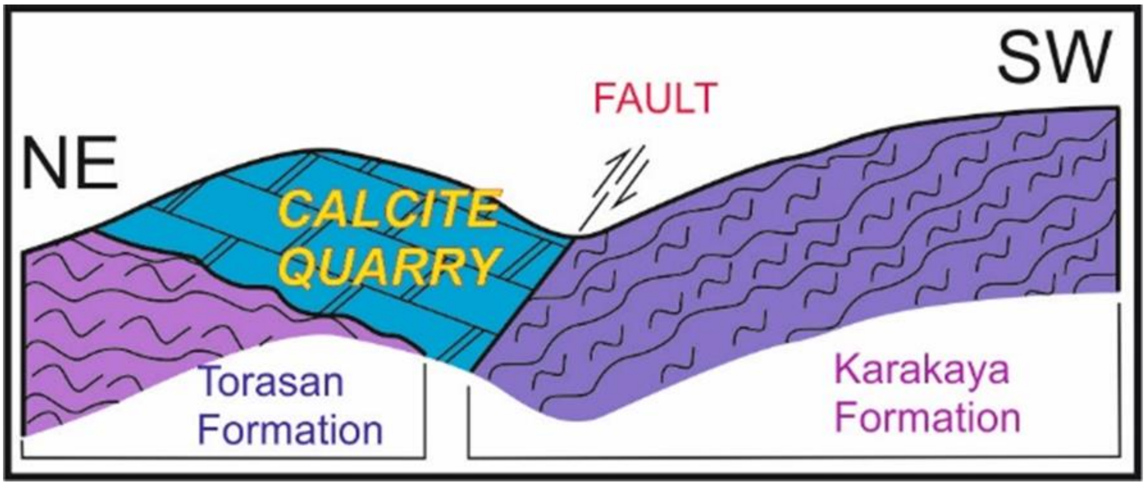


Figure 3. Geological cross-section of the calcite quarry district (without scale)

Figure 4. General view of a. calcite quarry; b. Marble

2.3. Petrography

When the macroscopic properties of the samples collected from the field were examined, it was determined that the color was white-grey, heterogeneous color distribution and medium-coarse grained. It reacts when treated with 10% HCl acid, and no decomposition is observed in the hand samples.

Thin sections of the same samples were examined under a polarizing microscope. The examination determined that the rock has a crystalline mosaic texture (Figure 5). The rock is monomineralic and consists entirely of calcite crystals. Opaque minerals and quartz-type silicate minerals are remarkably rare. No alteration-decomposition is observed except for the iron oxide yield. The frequency of fissures and cracks is low in micro terms of the rock. It is seen as very plain and homogeneous regarding mineral content and structural elements (Figure 5).

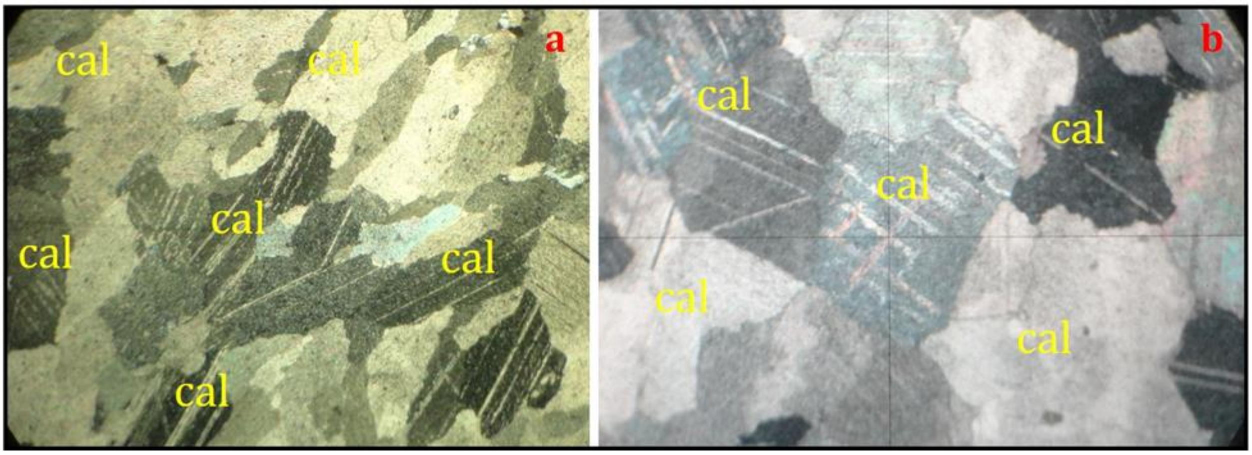
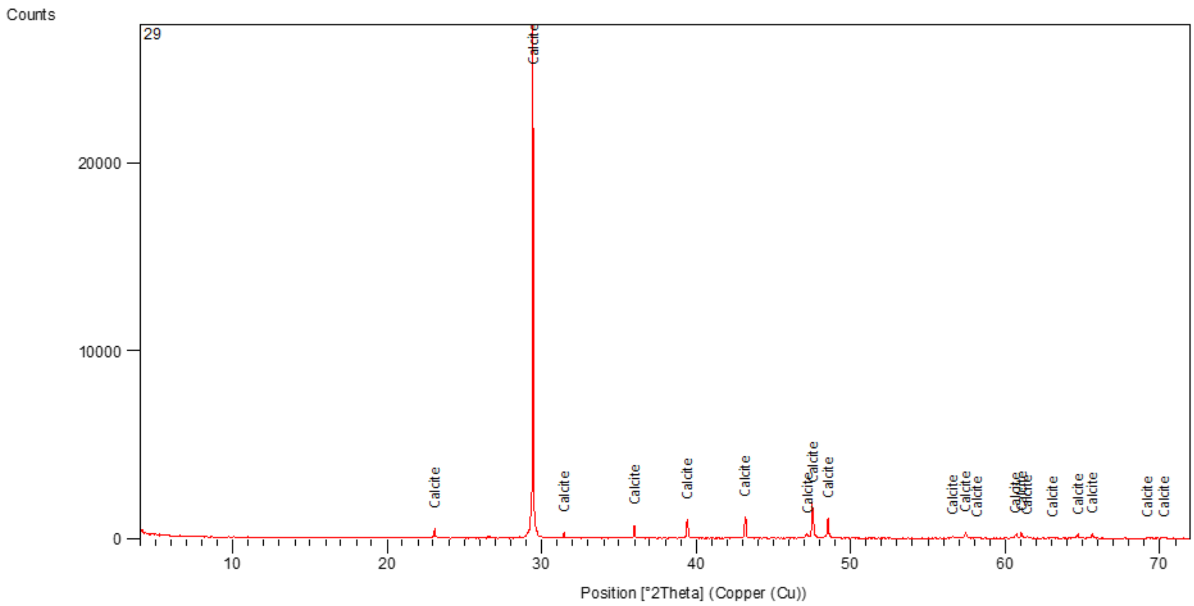


Figure 5. Microphotograph of marble (Abr: cal, calcite)

X-ray diffraction (XRD) analysis of the sample collected from the field was performed, and calcite mineral was detected (Figure 6).



Semi Quant [%]	Ref. Code	Compound Name	Chemical Formula
100	98-006-0995	Calcite	C1 Ca1 O3

Figure 6. XRD analysis of the calcite sample

3. Geochemistry

In the calcite field, three drillings were made before. Samples representing the field were compiled from the cores of these drillings. Samples from 12, 15, 30, 82, 162, and 212 meters were selected in the sounding, where the calcite lens is the thickest. Detailed geochemical analyzes of the samples obtained from different meters were made.

The major oxide (%) values of the samples taken from the field are given in Table 1. It is recognized that the SiO_2 concentration in the samples is between 0.1-1%, the MgO concentration is between 0.27-0.66%, and the CaO concentration is around 55%, respectively.

Table 1. Major oxide concentration (%) of the calcite specimens

SAMPLE (%)	BC-1 (12m)	BC-2 (15 m)	BC-3 (30 m)	BC-4 (82 m)	BC-5 (162 m)	BC-6 (212 m)
SiO_2	0,05	0,99	0,20	0,11	0,04	0,11
Al_2O_3	0,03	0,10	0,03	0,05	0,00	0,04
Fe_2O_3	0,01	0,03	0,05	0,05	0,02	0,02
MgO	**0,66**	**0,48**	**0,27**	**0,57**	**0,62**	**0,60**
CaO	**55,73**	**55,91**	**55,66**	**55,75**	**55,25**	**55,82**
K_2O	0,00	0,00	0,00	0,00	0,00	0,01
TiO_2	0,00	0,00	0,00	0,00	0,00	0,00
P_2O_5	0,01	0,01	0,01	0,02	0,01	0,00
MnO	0,00	0,01	0,01	0,00	0,00	0,00
LOI	**43,47**	**42,42**	**43,74**	**43,41**	**44,01**	**43,35**
TOTAL	**99,95**	**99,95**	**99,97**	**99,96**	**99,95**	**99,95**

4. Structural Geology

Metamorphic rocks constitute the dominant lithology in the study area. These rocks have lost their original position due to deformations in the region. Considering the structural elements in the region, it is possible to say that the region has undergone two separate deformation phases. When the types and directions of the faults are examined:

It can be said that NW-SE is trending dip-slip faults (Figure 7) and NE-SW trending strike-slip faults developed as a result of NW-SE trending compression in Phase 1 (Figure 8).

In Phase 2, due to an NW-SE trending tension, NE-SW trending dip-slip faults are observed to develop and cut the NW-SE trending dip-slip faults (Figure 2).

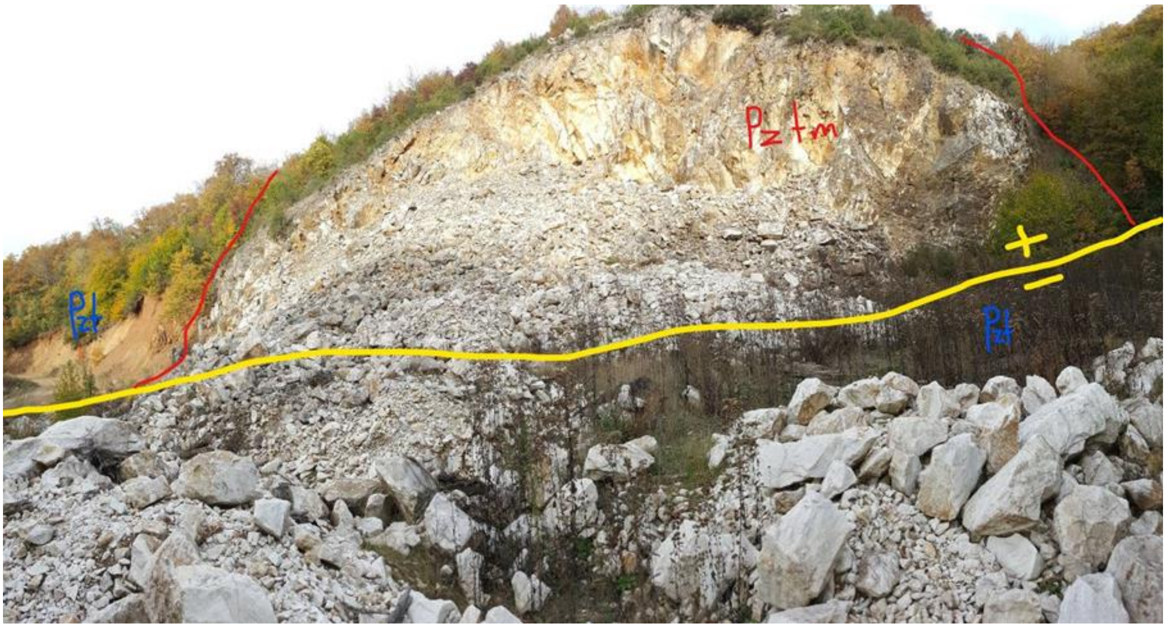


Figure 7. The general view of the NW-SE trending dip-slip fault cutting the Calcite Quarry (Looking from the Southwest to the Northeast). Abbreviations: Pzt; Torasan formation, Pztm; Marble Member

Figure 8. General view of the right-lateral strike-slip fault observed in the Karakaya formation west of the Karaandız district (looking from the southeast to the northwest)

The study area has undergone intense deformation, and the units have faulted within themselves. The contact relationship of the lithostratigraphic units is generally tectonic. It is seen that it is difficult to determine the contact relationships due to the dense vegetation. However, these faults can be detected, especially along eroded streams.

Joint measurements were carried out for the deformation analysis of the calcite quarry located in the study area. Fifty joint measurements and kinematic analyzes were made at two different locations.

For the kinematic analysis of the measured joints, point-contour and rose diagrams were prepared (Figure 9-10-11).

According to the rose diagrams (Figure 9), N50E tension and N40W compression were detected at Location 1, and N20E tension and N40W compression at Location 2.

In addition, the prepared point-contour diagrams (Figure 10-11) give a result that supports the rose diagrams.

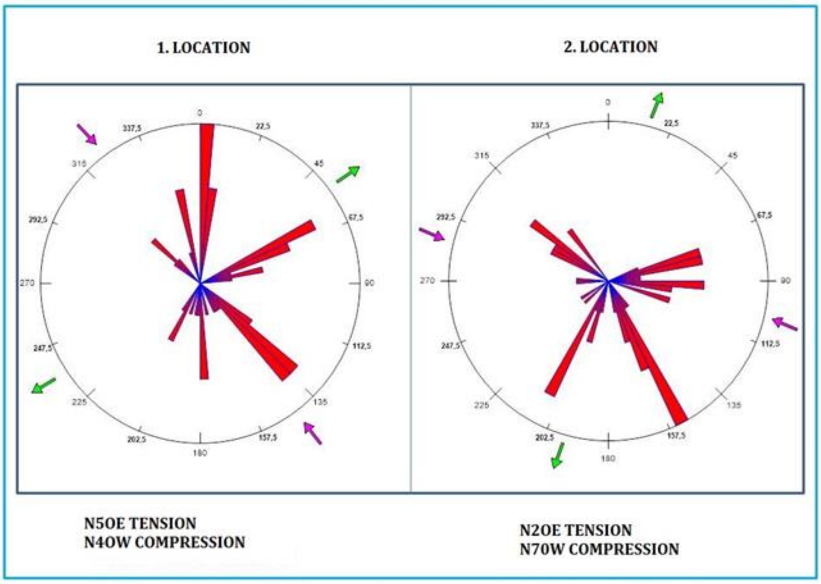


Figure 9. Rose diagram of the joints

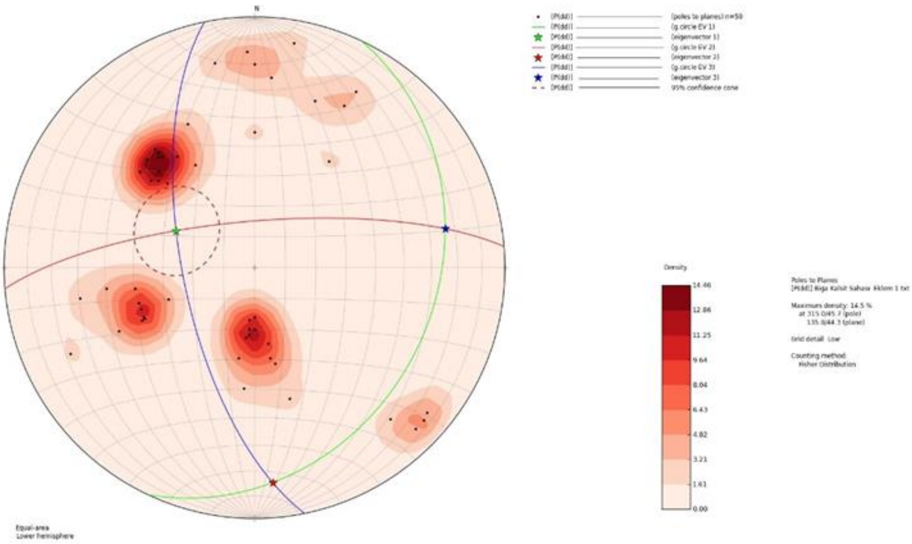


Figure 10. Point-contour diagram of the 1. Location's joints

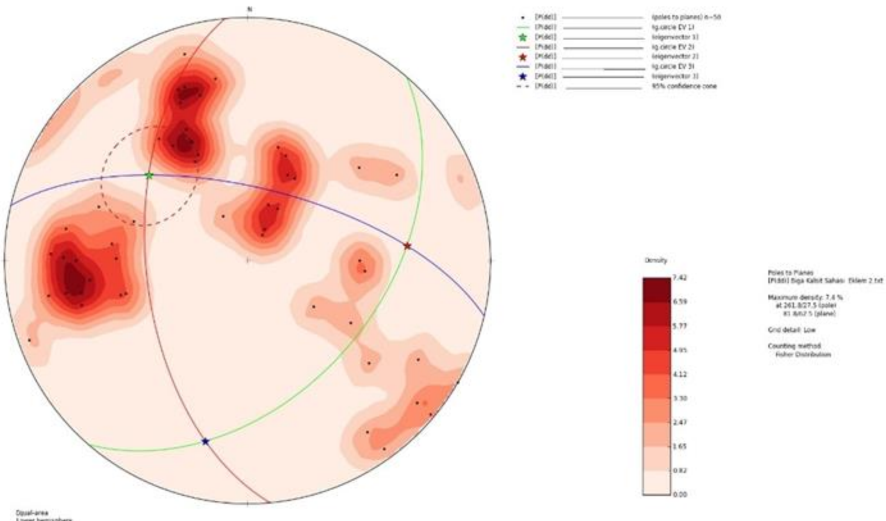


Figure 11. Point-contour diagram of the 2nd Location's joints

5. Conclusion

The geological and geochemical characteristics of the Marble member of the Torasan formation located on the Biga peninsula were explained. The contact relationships of the Marble member, considered a calcite quarry, were determined. This unit, which extends approximately NE-SW, has a length of approximately 350 meters and a width of approximately 50 meters. Petrographic and geochemical explanations of calcite, a useful mineral in the marble member, were carried out. As a result of the study, it was determined that the calcite in the quarry, which was observed as a block, was medium-coarse crystalline, was less affected by deformations in terms of fractures and cracks, the alteration was at low levels, the CaO value was around 55%, and the MgO content was quite low. The variation of CaO and MgO values according to the drilling points is given in Figure 12.

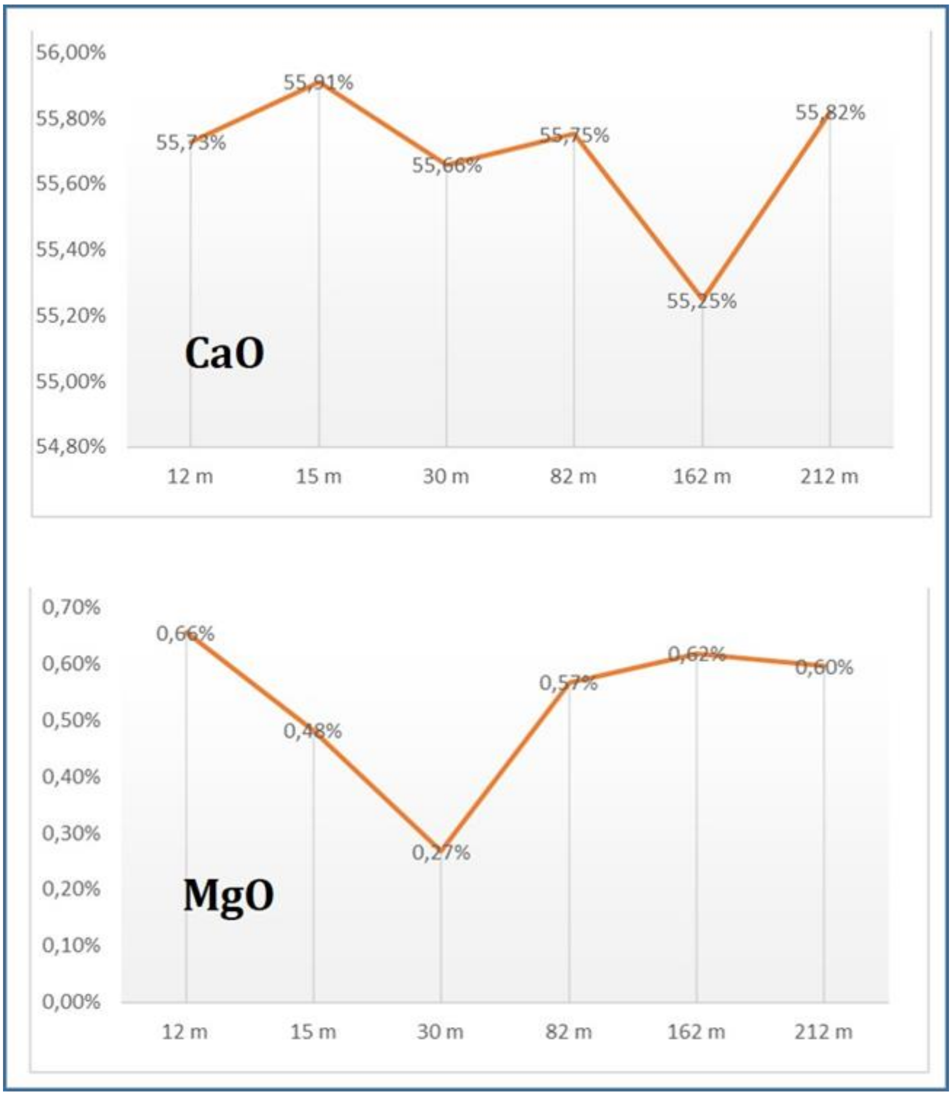


Figure 12. CaO and MgO concentrations (%) of the samples

When the region's structural elements and joint measurements were evaluated together, it was determined that there were similar compression and tension regimes. In terms of business, it is very important to reveal the deformation structures of the region and the calcite quarry.

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Author contributions

Mustafa Kaya: Petrography, Geochemistry. **Cihan Yalçin:** Data curation, Methodology, Writing-Original draft preparation, Editing. **Mustafa Kumral:** Software, Visualization, Investigation.

Conflicts of interest

The authors declare no conflicts of interest.

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