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Usability value of the Yenicekale formation exposure around the Pazarcık (Kahramanmaraş) as a cement raw material

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Research Article

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ABSTRACT

The study area is located around Pazarcık - Narlı, Kahramanmaraş province. The aim of the study is to investigate the value of units belonging to the Yenicekale Formation Kışla Marl Member as cement raw material. As a result of XRD studies, it was determined that Yenicekale formation Kışla Marn Member which is exposed to large areas in the region is composed of illite, quartz, dolomite, calcite and chlorite minerals by rock analyzed. By geochemical analysis, SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, K_2O, Na_2O, SO_3 contents of the units were determined and these values were compared with the limit values used in cement raw materials. When the results were evaluated, it was determined that the total alkali elements (Na_2O + K_2O) were within the limit values, but others were below or above these limit values. In addition, with geochemical analyses, it was calculated Silicate and Aluminium Modules. The most suitable values for Silicate Modules in Turkish Cement Factories are 2.2 - 2.6. In this study, Silicate Modulus values are in the range of 1.94 - 5.22. Standard values for Aluminum are between 1.5 and 2.5. The values of Aluminum Modules determined in this study are in the range of 0.43 - 1.38. For Hydrolic Module, the standard values are in the range of 1.8 - 2.2. The values determined in this study are in the range of 0.24 - 5.

1. Introduction

The study area is located in the Söğütlü-Şahintepe, around the Pazarcık, Kahramanmaraş province (Figure 1). The survey area is in the southeastern part of the Kahramanmaraş basin, on a scale of 1/25.000 the sheet of M38. Until now, numerous studies were presented in order to reveal the geological features of the region. (Arpat and Şaroğlu, 1972, 1975; Gözübol and Gürpınar, 1980; Önalan, 1986; Yılmaz et al., 1988; Dizer, 1991; İmamoğlu, 1993; Baydar and Yergök, 1996; Derman, 1999; Gül, 2000; 2004 ; Robertson and Ünlügenç, 2001; Gül et al., 2005; Darbaş and Gül, 2006; Varol et al., 2012; Kop et al., 2014)

The aim of the study is to reveal the availability of the claystone - siltstone - marl units that exposure around the Pazarcık - Narlı for the cement industry. Clays, hydrous aluminum silicates, are abundant in the sedimentary, igneous, and metamorphic units. Due to the wide range of using the field of the clay minerals, it should be investigated in which type of application it will take place. In terms of clay studies in Turkey, the number of studies has increased in recent years (Orhun, 1965; Seyhan, 1967; Özkan, 1977; Gündoğdu and Yılmaz, 1983; Erdoğan, 1994; Çelik and Karakaya, 1997; Abdioğlu, 2002; Yalçın, 2004; Özpınar et al., 2006; Çelik Karakaya, 2006; Bor, 2008).

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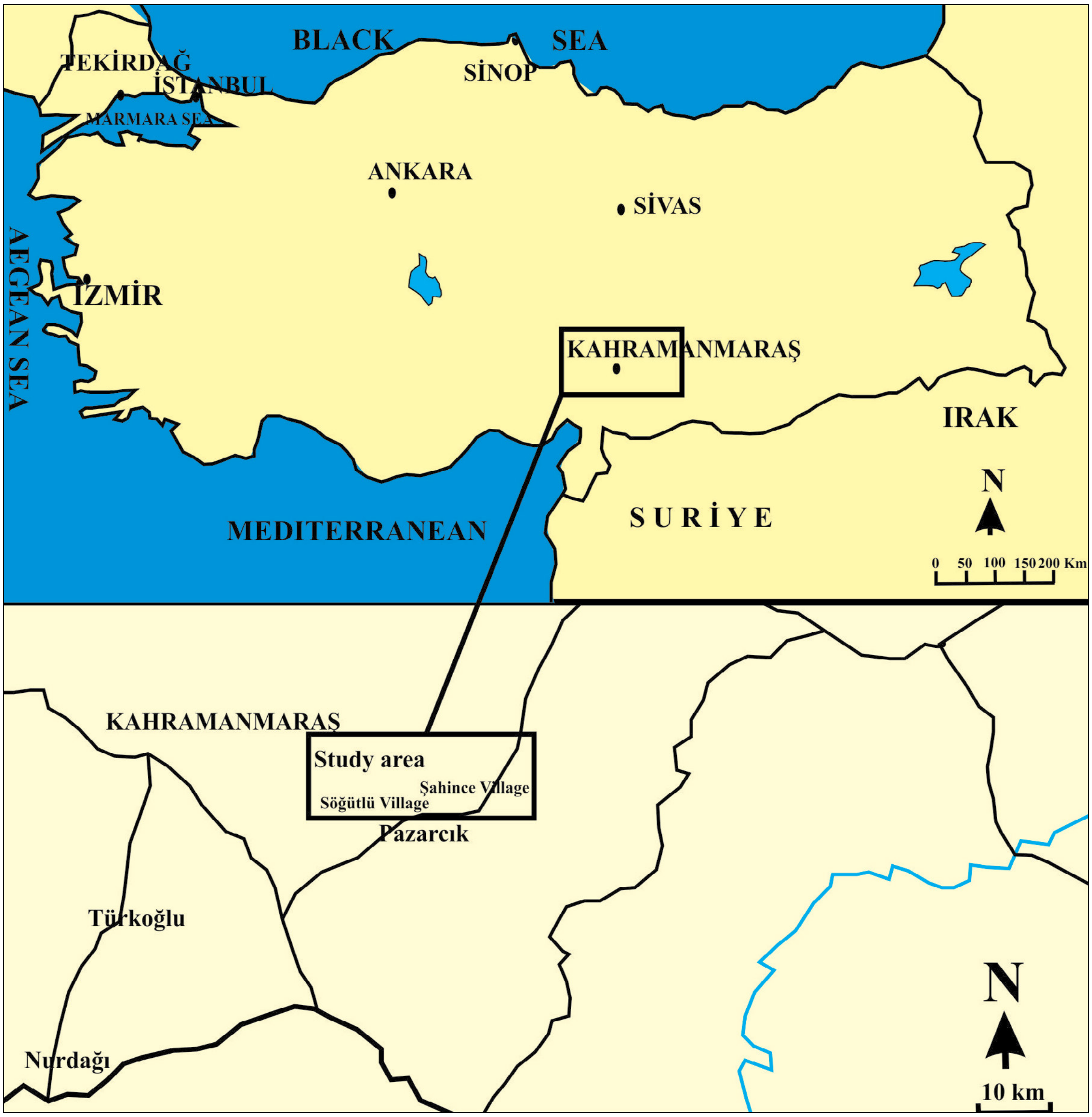

Figure 1- Location of the study area.

According to the study purpose, firstly, sections were taken within the well-exposed outcrops of the Yenicekale formation, and samples were collected. The rock analysis of the collected samples was run by using the XRD method, moreover, detailed clay analysis was done on the clay-rich samples. While the major oxide contents such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, K_2O, Na_2O, SO_3 were measured by using the geochemical analysis, our findings were compared with the standard values.

2. Method

2.1. X-Ray Diffraction (XRD) Analysis

28 samples were collected from the 3 different sections (Section 1, 2 and 4) and those samples were prepared for the XRD analysis. The jaw crusher and rod mills were used for mineralogical (XRD) analysis. Initially, the grain size of the samples was reduced to smaller than 1 centimeter by using the jaw crusher. After that, the broken samples were pulverized in a ball mill at a certain period and time. Totally the powdered 28 samples were individually extracted by XRD - WR (3 - 70º) and XRD - CF (2 - 20º) were

performed by separating the clay fraction by physical and chemical methods in the two samples.

The XRD - WR and XRD - CF were done at the faculty of engineering of the geology department laboratory of Ankara University.

The XRD patterns were obtained with an Inel Equinox 1000 diffractometer operating at tube voltage and current 30 kV and 20 mA, respectively using monochromatic CoKα1 radiation (λ= 1.788970 Ǻ). Diffraction patterns were recorded between 0^o - 116.455^o with a scanning rate of 0.03.

For the XRD - CF analysis, the two samples from the different levels taken from the clay beds were used. After the pulverization, the washing, decantation, pickling, centrifugation, and sedimentation (holding for 3 hours and 40 minutes) and plaquing processes were performed one by one. The plaquing process was run to obtain a more clear 001 plane reflections of the clays. According to Çelik Karakaya (2006), if platy clay minerals are parallel to the plane surface of the diffractometer, the intensities of the basal reflection increase. After this stage, those 2 samples performed 3 separate processes. At first, these samples were dried in the air for the real image, and then waited at ethylene glycol steam (hold in a desiccator around 16 hours about 60 ^oC) and the heating treatments were applied (in the oven about 550 ^oC for 2 hours) at the end.

2.2. Geochemical Analysis

The 28 samples were taken from three different sections, and the analyses were performed in the Aksaray University Scientific Technological Application and Research Center of Geochemical Analysis Laboratory. The soil samples were powdered in a ball mill carbide mortar to pass through a 20-micron size. The 5.000 gr of the pulverized sample was mixed with the 1.000 gr of Micropulver Wachs C homogeneously. After that, the obtained pellets from a heterogeneous mixture by using a die attachment under the 13 kg/N conditions by pressing. The pressed pellets obtained were analyzed by Pananalytical Axios Max model wavelength diffraction XRF. For instance, the values of the loss of ignition were determined by keeping the ash oven at 950 ^oC for 12 hours.

2.3. Used Modules in Cement Industry

Hydraulic module: HM = CaO / SiO_2+Al_2O_3+Fe_2O_3

If the HM < 1.7; the strength of cement is usually insufficient.

If the HM > 2.4; the strength of volumetric cement is absent.

Silicate module: SM = SiO_2 / Al_2O_3 / Fe_2O_3

If the SM > 4; the heating could be harder.

Aluminum module: AM = Al_2O / Fe_2O_3

If the AM < 1.3; it causes problems at the pulverisation stage.

3. Regional Geology

Although numerous studies were presented about the geological features of the region, this study is based on Sümengen (2014). According to Sümengen (2014), the general characteristics of regional geology are presented in the following paragraphs (Figure 2).

The Neogene units in the studied area accounted for autochthon sequence and overlie the basement unconformably (Figure 2 and 3). The bottom of the Neogene sequence of the study area occurs the Maastrihctyen Besni formation, composed of Keklikpınarı conglomerate, Sıraca marl and Elmalı limestone members. The Besni formation is underlie conformably by marl - limestone - sandstone units of the Maastrihtiyen - Early Eocene Germav formation. The Early Eocene Gercüş formation units such as sandstone, siltstone, and limestone are disconformably overlied the Germav formation. The Middle - Late Eocene sedimentary sequence in the study area is represented by the limestone units of the Midyat formation and Hoya formation, respectively. The Gaziantep formation conformably overlies this sequence. The Gaziantep formation consists of late Eocene -Early Oligocene chert and clay - rich limestone. The Miocene units of the sequence are represented by cherty and fossiliferous limestone rocks of the Late Oligocene - Early Miocene Fırat formation.

In the study area, the Early Miocene Zeytin Formation (sandstone - mudstone), Lice formation (limestone), and Beşenli formation (sandstone - marl - conglomerate) are exposed conformably.

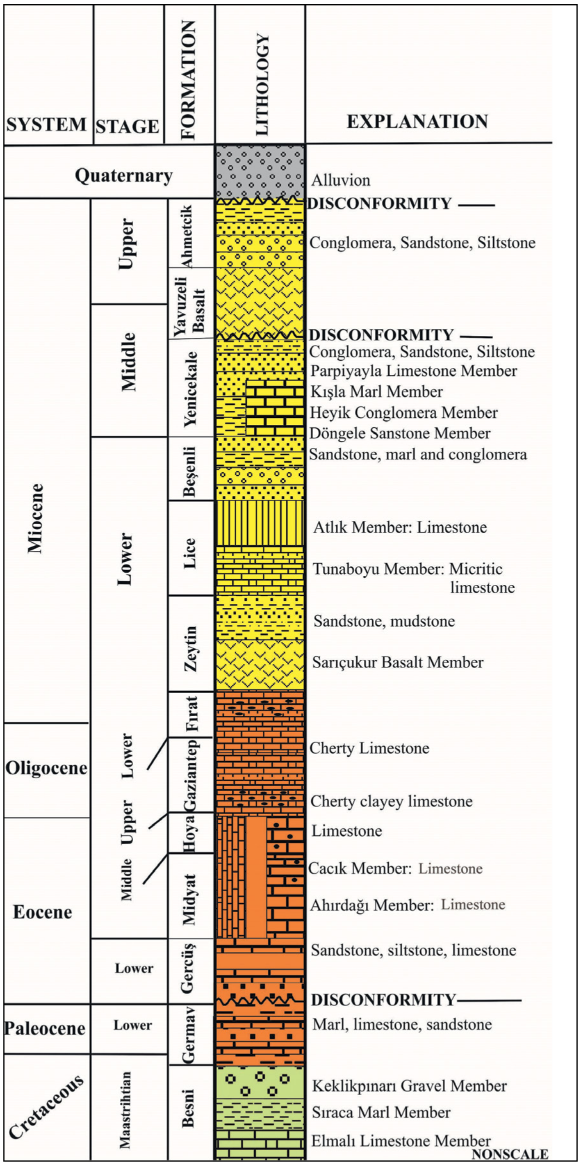

Figure 2- General stratigraphy section of study area (Sümengen, 2014).

The Middle Miocene units in the survey area are represented by Yenicekale formation which is the main unit of this study. The Yenicekale formation consists of conglomerate, sandstone, and siltstone. This unit is divided into 4 different members by Baydar and Yergök (1996) as Parpiyayla Limestone Member, Kışla Marl Member, Heyik Conglomerate Member, and Döngele Sandstone Member.

The main material of this study is Kışla Marl Member of Yenicekale formation that mainly includes claystone and marl units and these units will be summarized below. The Yenicekale formation in the Middle - Late Miocene is overlained disconformably by Yavuzeli basalts. Moreover, the Late Miocene Ahmetçik formation that consists of conglomerate, sandstone, and siltstone, is unconformably overlaid by the Yavuzeli basalts.

The Pliocene period is represented by the Gölbaşı formation in the study area. The Gölbaşı formation mainly contains conglomerate, sandstone, marl, and tuff units. The Quaternary alluvial units are found on the top.

4. Stratigraphy of the Study Area

The clay units that accounted for this study belonged to the Yenicekale formation Kışla Marl Member that exposed around the Pazarcık, Şahintepe. The general features of these units were given in the following chapter (Figure 4).

4.1. Yenicekale formation, Kışla Marl Member

Definition: firstly, it is described by Baydar and Yergök (1996).

Stratotype: Kışla district which is the south of Zeytin (Süleymanlı).

Thickness: 300 - 350 m (Baydar and Yergök, 1996).

Base - top - lateral Relations: according to Baydar and Yergök (1996), the Yenicekale Kışla Marl Member show gradual transition with lower level of the Miocene Zeytin formation and it was reported that the Sazak Member of the Saraycık formation, overlies the Yenicekale Kışla Marl Member, is gradually transitive.

Lithology: The member consists of greyish-whitish marl units. There are claystone layers in some places.

Depositional environment and dating: Baydar and Yergök (1996) reported that the age of Kışla Marl Member is the Middle - Miocene.

5. Measured Stratigraphic Sections

5.1. Section 1

Section 1 was measured at the entrance of the Şahintepe village. The altitude of the section is 847 m. The starting and ending points in the coordinates

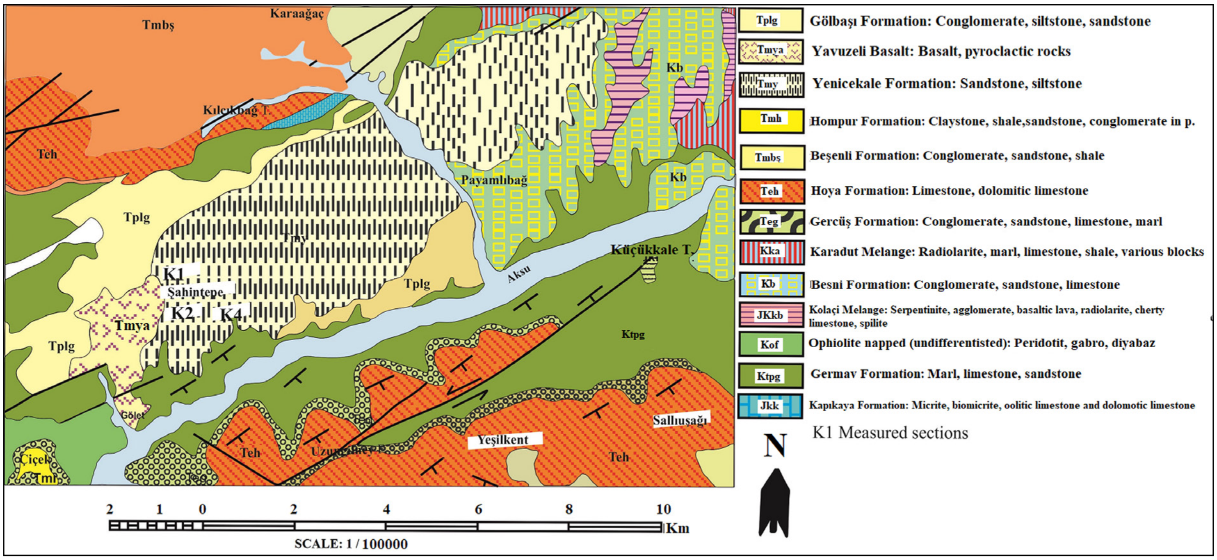

Figure 3- General geology map of study area (Sümengen, 2014).

Figure 4- General view of marl units belonging to Yenicekale formation Kışla Marl Member in the study area.

of the section are 37S 0351431, 4156872, and 37S 0351386, 4156932, respectively. The bottom of the sequence starts with marl units. It rarely occurs in clay laminates (Figure 5) and the thickness of the sequence is 660 cm. The XRD and geochemical analysis were done on 10 samples and 3 samples were collected for the petrographic analyses from section 1.

Section 1 continues with a sequence dominated by plant remains and clay nodules within the marl units exposed at the upper levels. At the higher level of the section, there is a layer where yellowish and brownish claystone units are intercalated.

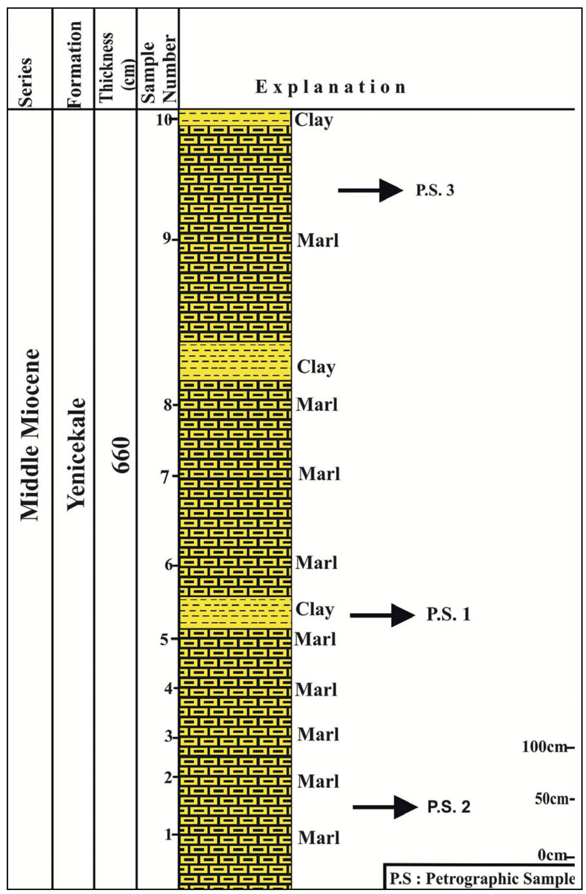

Figure 5- Time-stratigrafic section for section 1.

5.2. Section 2

The starting and ending point in the coordinates of the section are 37S 035202, 4156089, and 37S 0352085, 4156061, respectively. The thickness of the sequence is 753 m. The section is composed of light-colored marl units and also contains claystone layers (Figure 6). For section 2, 8 samples were collected for

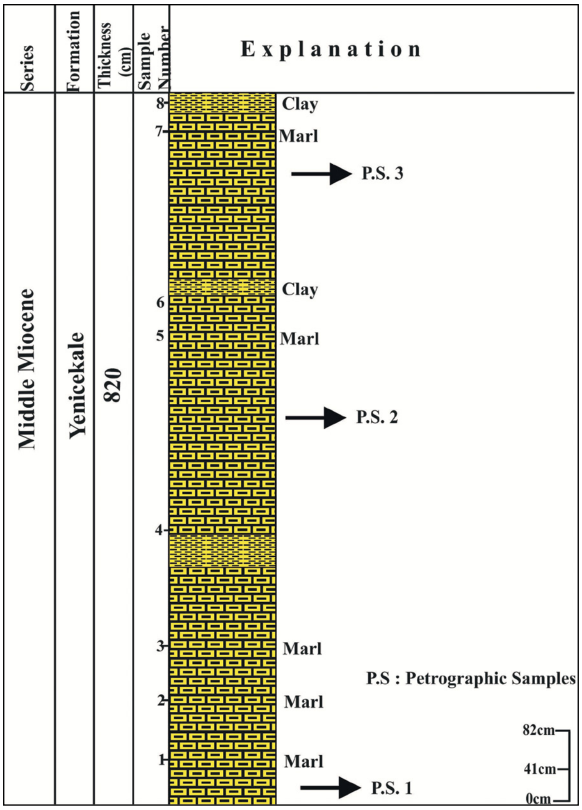

Figure 6- Time-stratigrafic section for section 2.

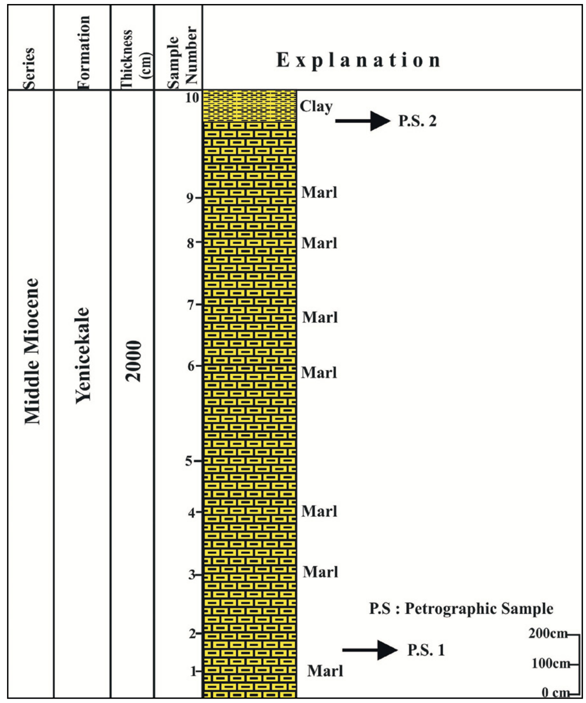

Figure 7- Time-stratigraphic section for section 4.

the XRD and geochemical analysis, while 3 samples were selected for the petrographic analysis.

The sandstone units, the thickness changes 5 - 20 cm, are found at the higher level of section 2. Those sandstone units are overlaid by greenish colored and 10 cm thick clay layers. The intercalation of sandstone and claystone continues through approximately 2 m. Generally, the sandstone units are thinner than the claystone units.

5.3. Section 4

The thickness of section 4 is 827 m (Figure 7). The coordinates of the section are 37S 0354136, 415666, and 37S 0354154, 4157803, respectively. The sequence completely consists of light whitish-beige marl layers. The marl units can be seen at the higher level of the section. 10 samples were used for the XRD and geochemical analysis and 2 samples for the petrographic analysis.

6. Petrographic Investigation

6.1. Section 1

In total 3 samples were collected from section 1. The locations of the samples on section 1 were given in Figure 5. The detailed petrographic features of those samples for this section are presented below.

Section 1, petrographic sample 1: it can be defined as mudstone according to Dunham (1962) and as intramicrite according to Folk (1965). The desiccation cracks are limited in this sample (Figure 8).

The section 1, petrographic sample 2: likewise, this sample is named mudstone according to Dunham (1962), and intramicrite by the Folk classification system (1965). The parts of rock can be examined as extraclast and lithoclast. Also, sample 2 includes quartz minerals. The secondary rock disintegration occurred and those fragments were recemented. All these pores were filled by the desiccation cracks. The shells that formed at the edges of the desiccation cracks by the microorganisms and the dissolved materials with fragmental structures such as the quartz minerals were recemented. The increased pores were filled by dog-tooth cement during the exhumation (Figure 9).

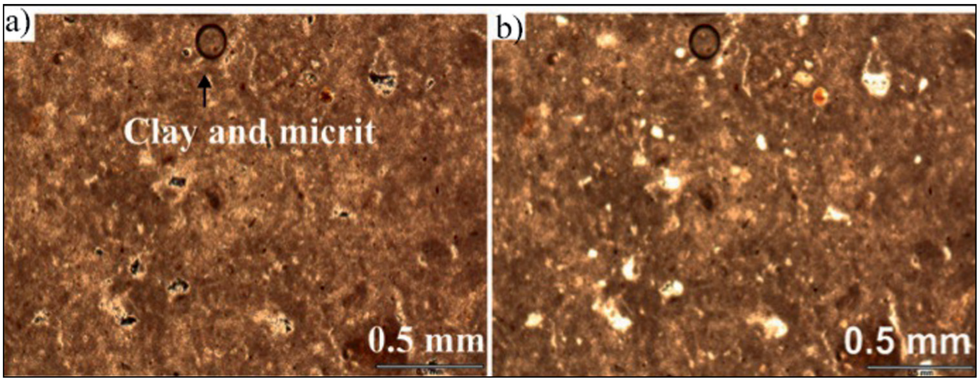

Figure 8- Section 1, petrographic sample 1: intramicrite (Folk, 1965), mudstone (Dunham, 1962); a) double nicol view, b) one nicol view.

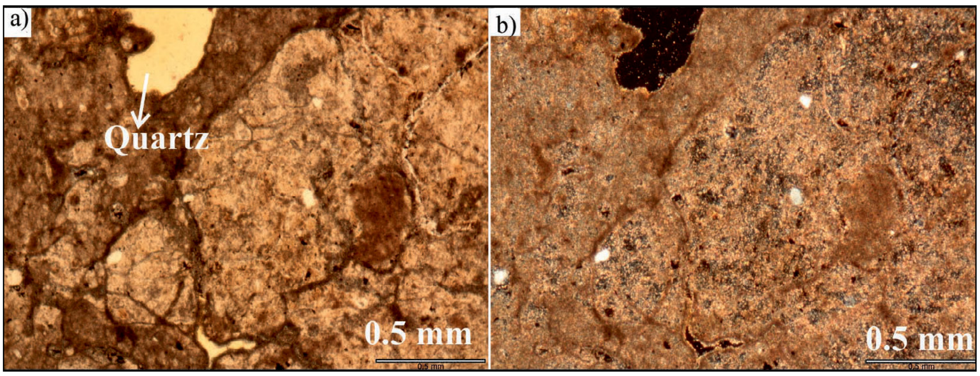

Figure 9- Section 1, petrographic sample 2: intramicrite (Folk, 1965), mudstone (Dunham, 1962); a) double nicol view, b) one nicol view.

Section 1, petrographic sample 3: The sample is named as mudstone based on the Dunham (1962), and intramicrite by Folk classification system (1965). Due to the differences in the grain sizes within the same sample, the gradation can be interpreted as poor. The pores between the grains were filled with transparent calcite crystals. In addition, the sample contains quartz and feldspar fragments (Figure 10).

6.2. Section 2

3 samples were collected from section 2 for the purpose of petrography**.** The locations of the samples within section 2 were illustrated in Figure 6.

Section 2, petrographic sample 1: Under the Dunham classification (Dunham, 1962) system, the

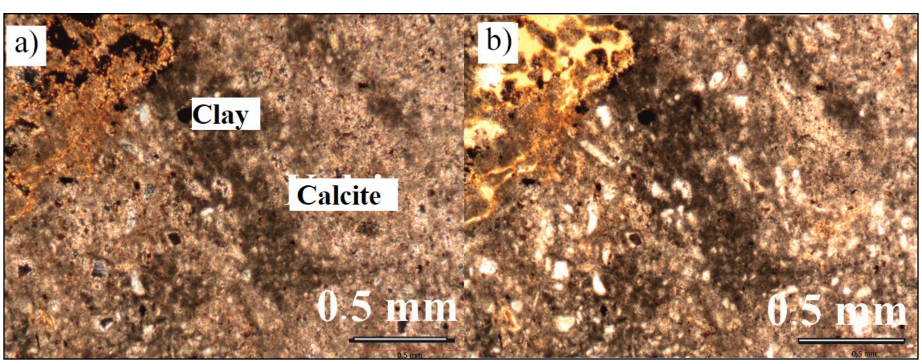

Figure 10- Section 1, petrographic sample 3: intramicrite (Folk, 1965), mudstone (Dunham, 1962); a) double nicol view, b) one nicol view.

sample is called wackestone, and extra litho micrite based on the Folk classification (1965) system. Some levels of the sample contain fossils. Because of this, the sample points out the shallow marine environment. Also, the sample includes abundant quartz - feldspar - lots of rock fragments. For this reason, it is indicated that the depositional area was affected by terrestrial transportation. Additionally, the sample contains plant branches (Figure 11).

Section 2, petrographic sample 2: The sample was named as mudstone according to the Dunham classification (Dunham, 1962) system and bio-micrite based on the Folk classification system (Folk, 1965). The sample contains planktonic foraminifera valves with a Globigerinid structure (Figure 12).

Section 2, petrographic sample 3: According to the Dunham (1962) classification system, the sample was called as grainstone and biosparite based on the Folk (1965) classification system (Figure 13).

6.3. Section 4

2 samples were collected for the petrographic investigation from this section. It can be seen in Figure 7 for the location of the samples of section 4.

Section 4, petrographic sample 1: According to Dunham (1962), the sample is called a mudstone and litho-micrite based on the Folk (1965) classification (Figure 14). The sample rarely includes the plant branches (Figure 14).

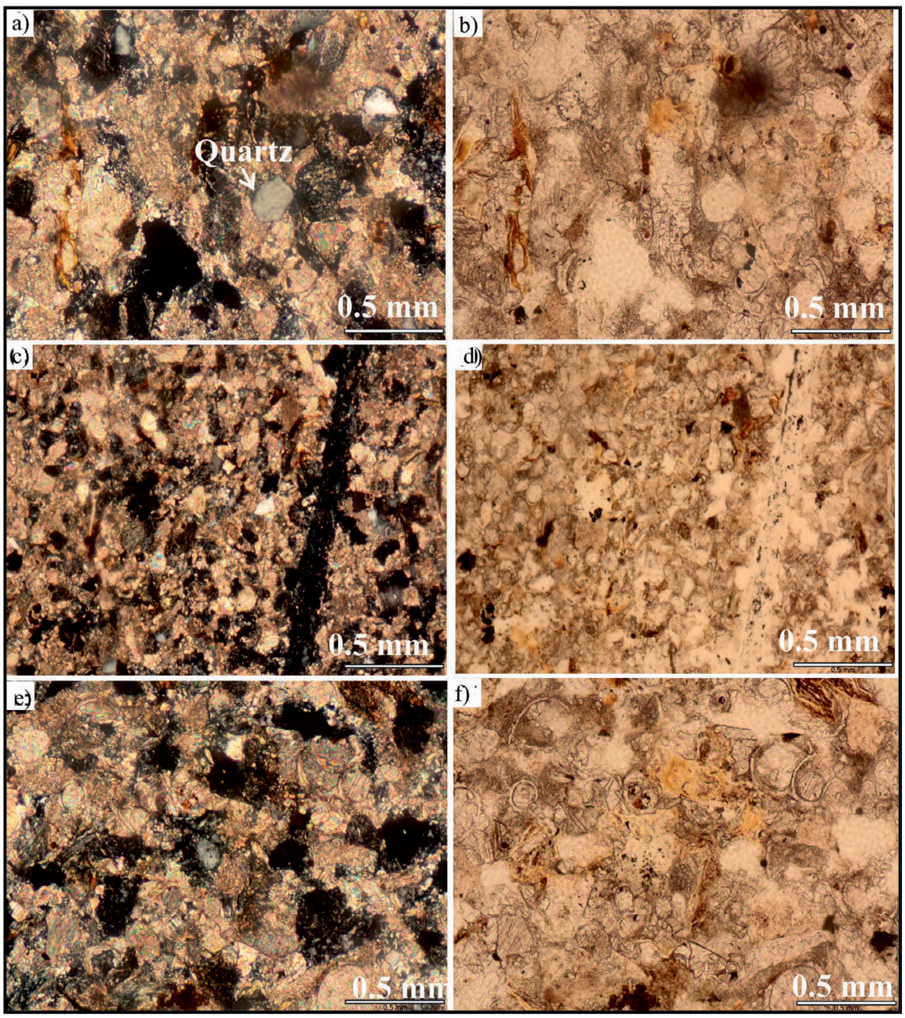

Figure 11- Section 2, petrographic sample 1; a) wackestone, and extra litho micrite (Folk, 1965) (double nikol), b) wackestone (Dunham, 1962), extra litho micrite (Folk, 1965) (one nikol), c) plant branches in section (double nikol view), d) plant branches in section (one nikol view), e) fossils in layers (double nikol view) , f) fossils in layers (one nikol view).

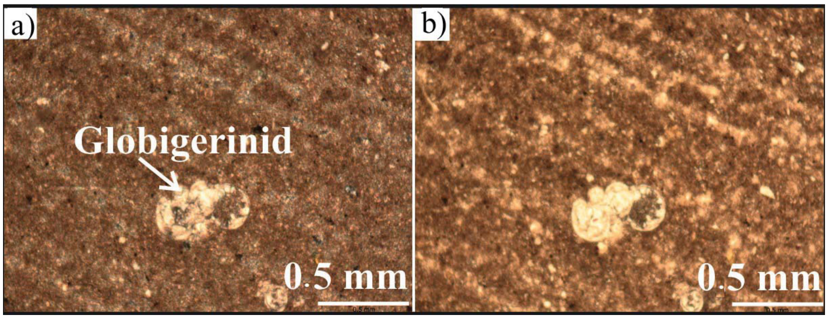

Figure 12- Section 2, petrographic sample 2: Mudstone (Dunham,1962), biomicrite (Folk,1965); a) double nicol view, b) one nicol view.

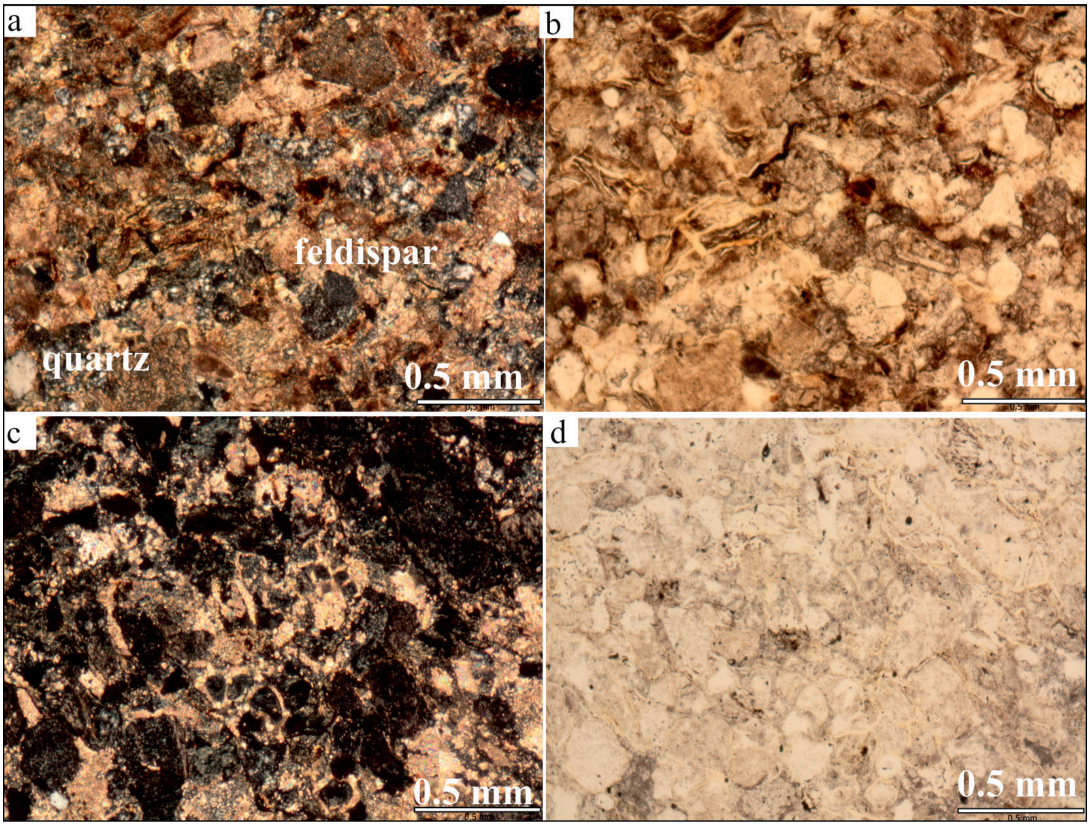

Figure 13- Section 2, petrographic sample 3: Grainstone (Dunham, 1962), biosparite (Folk, 1965); a) double nicol view, b) one nicol view, c) double nicol view of fossils – rich parts, d) c) one nicol view of fossils - rich parts.

Section 4, petrographic sample 2: likewise, the sample was named as mudstone by the Dunham (1962) classification system, and litho-micrite according to the Folk (1965) (Figure 15) classification system. The sample occasionally contains aventurine coarse quartz crystals.

7. Clay Mineralogy of the Study Area

In order to investigate the value of marl - claystone units exposed in the study area as cement raw material, 3 sections were taken, and all the rock properties of 28 samples belonging to these sections, which were determined by the XRD, are given in detail below.

7.1. XRD Whole Rock Analysis (XRD - WR)

The clay samples pulverised after the crushing and grinding processes. After this step, the quartering method is applied for the pulverized samples, and then the XRD - WR scans were taken without any processing (Figure 16).

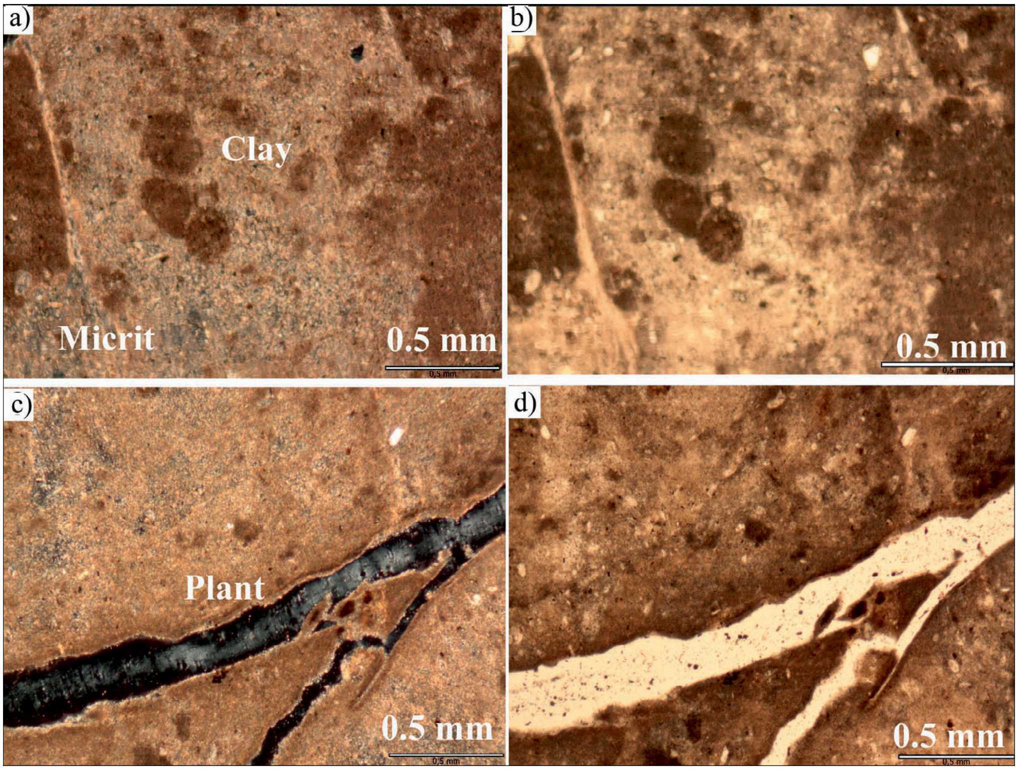

Figure 14- Section 4, petrographic sample 1: Mudstone (Dunham,1962), litho-micrite (Folk,1965); a) double nicol view, b) one nicol view, c) double nicol view of the section with plant branches in the section, d) one nicol view of the section with plant branches in the section.

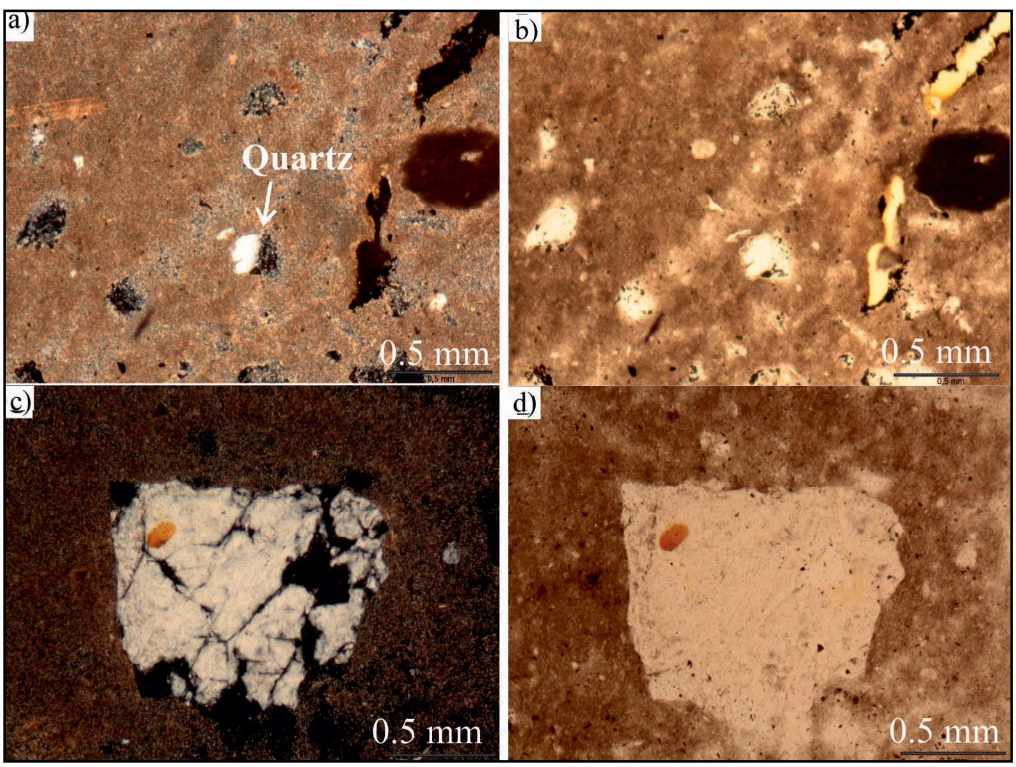

Figure 15- Section 4, petrographic sample 2: Mudstone (Dunham, 1962), litho-micrite (Folk, 1965); a) double nicol view, b) one nicol view, c) double nicol view of the section with calcite crystal in the section, d) one nicol view of the section with calcite crystal in the section.

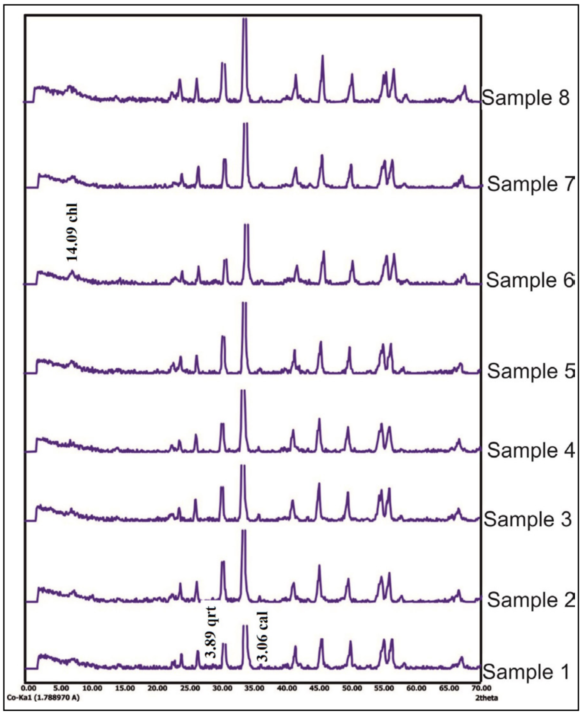

Figure 16- XRD - WR and XRD - CF diffractomes of section 1 (chl: chlorite; ill: illite; cal: calcite; qtz: quartz).

The clay units that constitute the subject of the study and exposed around the Pazarcık - Şahintepe Yenicekale formation, and generally, calcite, quartz, dolomite, chlorite were determined by the samples, collected from clay beds belongs to Kışla Marl member. Moreover, the type and amount of these minerals show variety.

7.1.1. Section 1

10 samples collected from section 1, consist of 8 claystone and 2 marl units (Figure 16). For this analysis, 2θ: 3° to 70° were used and the XRD diffractions were obtained (Table 1). Those diffractions are pointed out the dolomite, illite, quartz, and opaque minerals, respectively.

7.1.2. Section 2

All of the 8 samples taken from this section consist of calcite minerals (Figure 17). To obtain the suitable diffraction for the determination of the minerals, 2θ, from 3° to 70°, were applied (Table 2).

Table 1- Minerals belonging to section 1 for which XRD - WR and XRD - CF analyzes were made.

SAMPLE NUMBER	XRD - WR	XRD - CF
SECTION 1 - SAMPLE 1	Dolomite, Illite, Quartz	
SECTION 1 - SAMPLE 2	Dolomite, Illite, Quartz	
SECTION 1 - SAMPLE 3	Dolomite, Illite, Quartz	
SECTION 1 - SAMPLE 4	Dolomite, Illite, Quartz	
SECTION 1 - SAMPLE 5	Dolomite, Illite, Quartz	Illite
SECTION 1 - SAMPLE 6	Dolomite, Illite, Quartz	
SECTION 1 - SAMPLE 7	Calcite, Dolomite, Illite, Quartz	
SECTION 1 - SAMPLE 8	Calcite, Dolomite, Illite, Quartz	Illite
SECTION 1 - SAMPLE 9	Calcite, Dolomite, Illite, Quartz	
SECTION 1 - SAMPLE 10	Calcite, Dolomite, Illite, Quartz	

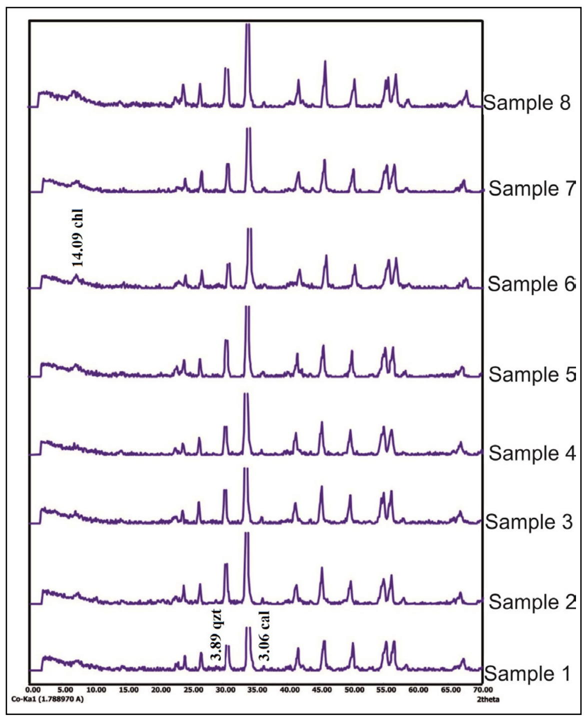

Figure 17- XRD - WR diffractoms of section 2 (chl: chlorite; cal: calcite; qtz: quartz).

Table 2- Minerals belonging to section 2 for which XRD - WR and XRD - CF analyzes were made.

SAMPLE NUMBER	XRD - WR	XRD - CF
SECTION 2 - SAMPLE 1	Quartz, Calcite	
SECTION 2 - SAMPLE 2	Quartz, Calcite	
SECTION 2 - SAMPLE 3	Quartz, Calcite	
SECTION 2 - SAMPLE 4	Quartz, Calcite	
SECTION 2 - SAMPLE 5	Quartz, Calcite	
SECTION 2 - SAMPLE 6	Quartz, Calcite, Chlorite	
SECTION 2 - SAMPLE 7	Quartz, Calcite	
SECTION 2 - SAMPLE 8	Quartz, Calcite	

7.1.3. Section 4

All of the 10 samples taken from this section consist of the dolomite units. The samples were scanned by using 2θ, from 3° to 70° (Table 3).

7.2. XRD Clay Fraction Analysis (XRD - CF)

The clay fraction analysis was applied to sample 5 and sample 8 in section 1 from 28 samples taken from 3 different sections. These samples were scanned under normal conditions, ethylene glycol, and plus by heating up to 550 °C. As a result of the XRD diffraction, the most dominant primary mineral in these samples is illite (Figures 16, 17, and 18; Tables 1, 2 and 3).

Table 3- Minerals belonging to section 4 for which XRD - WR was made.

SAMPLE NUMBER	XRD - WR
SECTION 4 - SAMPLE 1	Dolomite, Calcite
SECTION 4 - SAMPLE 2	Dolomite
SECTION 4 - SAMPLE 3	Dolomite
SECTION 4 - SAMPLE 4	Dolomite
SECTION 4 - SAMPLE 5	Dolomite
SECTION 4 - SAMPLE 6	Dolomite
SECTION 4 - SAMPLE 7	Dolomite
SECTION 4 - SAMPLE 8	Dolomite
SECTION 4 - SAMPLE 9	
SECTION 4 - SAMPLE 10	

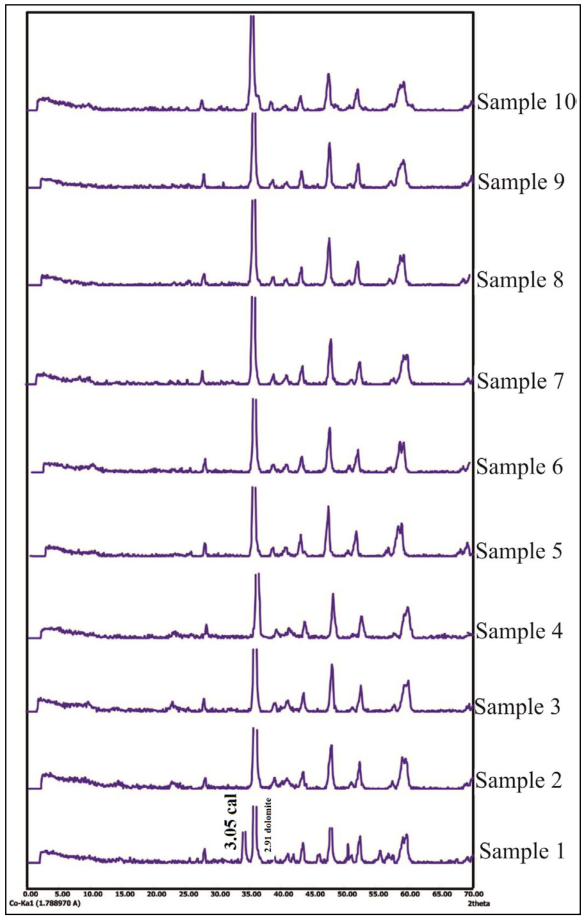

Figure 18- XRD - WR diffractoms of section 4 (cal: calcite).

8. Geochemistry

SiO_2, CaO, MgO, Al_2O_3, Fe_2O_3, TiO_2, Na_2O, K_2O, MnO, P_2O_5, and values of LOI at a total of 28 samples were determined for the geochemical analysis (Table 4).

The CaO oxide concentrations of 10 samples collected from section 1, changes between 5.17% and 24.26%. The CaO contents of the samples stem from the presence of calcite or dolomite. Besides, the XRD results of sample 8, sample 9, and sample 10 confirm the presence of calcite and dolomite (Table 1). Likewise, in section 2, 8 samples show the CaO values in a range of 26.99% and 41.74%. Moreover, all samples in section 2 contain the calcite minerals and this case was approved by the XRD results (Table 2) . On the other hand, the CaO values in the total 10 samples of section 4 are between 18.66% and 37.19%. The calcite mineral only was observed in sample 1 of section 4. These analyses were approved by the XRD results (Table 3).

Table 4- Chemical analysis results of clay samples in sections 1 - 2 and 4 (SM: Silicate modulus, AM: Aluminum modulus, HM: Hydraulic modulus).

Section Name	Element Sample Number	SiO_2%	TiO_2%	Al_2O_3%	Fe_2O_3%	MnO%	MgO%	CaO%	Na_2O%	K_2O%	P_2O_5%	LOI	TOTAL%	SM	AM	HM
Section I	SectionI-Sample 1	27.86	0.48	4.709	4.302	0.06	12.92	18.16	0.028	0.419	0.034	32.35	101.31	3.09	1.09	0.49
	SectionI-Sample 2	19.59	0.407	3.475	3.911	0.067	14.39	23.04	0.045	0.343	0.034	35.45	100.75	2.65	0.88	0.85
	SectionI-Sample 3	18.17	0.404	3.147	3.592	0.062	14.68	23.97	0.058	0.237	0.03	37.38	101.72	2.69	0.87	0.96
	SectionI-Sample 4	32.07	0.555	5.566	5.209	0.078	12.79	14.42	0.01	0.465	0.032	30.09	101.28	2.97	1.06	0.33
	SectionI-Sample 5	36.67	0.539	5.772	5.19	0.059	12.58	11.65	0.002	0.423	0.032	27.15	100.07	3.34	1.11	0.24
	SectionI-Sample 6	26.45	0.438	4.273	4.178	0.058	13.69	18.66	0.034	0.391	0.034	33.33	101.55	3.13	1.02	0.53
	SectionI-Sample 7	24.36	0.358	3.653	4.883	0.069	14.47	19.93	0.012	0.209	0.04	34.55	102.53	2.85	0.74	0.6
	SectionI-Sample 8	47.13	0.539	7.319	6.45	0.09	11.22	5.17	0.084	0.489	0.065	21.67	100.22	3.42	1.11	0.08
	SectionI-Sample 9	25.78	0.352	3.987	4.746	0.083	9.86	24.26	0.018	0.426	0.07	30.39	99.98	2.95	0.84	0.7
	SectionI-Sample 10	31.08	0.315	4.018	5.691	0.083	13.19	17.01	0.035	0.385	0.045	30.43	102.3	3.2	0.7	0.41
Section 2	Section 2-Sample 1	24.61	0.413	4.307	3.605	0.066	2.12	29.5	0.025	0.769	0.095	36.73	102.24	3.11	1.19	0.9
	Section 2-Sample 2	19.53	0.316	3.863	3.543	0.103	2.76	41.74	0.222	0.455	0.097	28.23	100.87	2.63	1.09	1.54
	Section 2-Sample 3	24.3	0.359	4.653	3.353	0.092	2.89	34.24	0.013	0.69	0.092	31.2	101.88	3.03	1.38	1.05
	Section 2-Sample 4	23.79	0.419	4.503	3.879	0.09	2.64	34.6	0.038	0.802	0.012	30.87	101.63	2.83	1.16	1.07
	Section 2-Sample 5	33.31	0.445	5.637	4.01	0.088	2.59	26.99	0.038	0.859	0.095	27.09	101.15	3.45	1.4	0.62
	Section 2-Sample 6	25.48	0.468	5.953	4.641	0.087	2.83	30.79	0.052	0.692	0.12	30.61	101.72	2.4	1.28	0.85
	Section 2-Sample 7	27.72	0.434	4.777	3.822	0.092	2.47	27.93	0.053	0.883	0.11	32.24	100.54	3.22	1.24	0.76
	Section 2-Sample 8	28.31	0.417	5.056	3.66	0.06	1.83	31.3	0.007	0.573	0.826	29.48	101.5	3.24	1.38	0.84
Section 4	Section 4-Sample 1	5.68	0.06	0.884	0.861	0.062	15.45	37.19	nd	0.058	0.085	40.08	100.39	3.24	1.02	0.5
	Section 4-Sample 2	18.6	0.198	2.16	2.93	0.061	20.72	20.4	0.067	0.26	0.09	36.18	101.66	3.65	0.73	0.85
	Section 4-Sample 3	21.68	0.261	2.831	3.386	0.069	19.18	18.66	0.064	0.405	0.085	33.94	100.56	3.48	0.83	0.66
	Section 4-Sample 4	19.01	0.218	2.345	2.655	0.064	21.13	20.2	0.103	0.343	0.117	34.35	100.53	3.8	0.88	0.84
	Section 4-Sample 5	7.8	0.095	1.068	1.303	0.048	19.51	29.77	0.047	0.132	0.044	40.05	99.85	3.29	0.81	2.92
	Section 4-Sample 6	10.07	0.102	1.162	1.453	0.046	20.07	27.63	nd	0.141	0.057	40.93	101.65	3.85	0.79	2.17
	Section 4-Sample 7	8.93	0.079	0.824	0.886	0.035	20.78	28.64	0.005	0.08	0.073	40.57	100.9	5.22	0.93	2.7
	Section 4-Sample 8	6.77	0.101	1.112	1.362	0.048	19.61	30.32	0.042	0.139	0.037	40.36	99.9	2.74	0.81	3.27
	Section 4-Sample 9	7.4	0.124	1.43	2.072	0.092	17.52	31.79	0.014	0.202	0.06	40.22	100.93	2.11	0.69	2.91
	Section 4-Sample 10	7.52	0.12	1.165	2.708	0.111	17.22	36.35	0.031	0.181	0.07	33.81	99.28	1.94	0.43	3.19

The MgO values on the clay samples in section 1, are in the range of 9.86% and 14.68%, and these values confirm the presence of dolomite minerals in the rocks of all samples. When section 2 is checked, due to the MgO content, it has not contained the dolomite between 1.83% and 2.89% of all samples values. Similar to section 1, the MgO values of section 4 are in the range of 15.45% and 21.13%. Thus, all samples of section 4 contain dolomite minerals abundantly. Also, the existence of the dolomite minerals in the system was verified by the XRD results (Tables 1 and 3).

The range of Al_2O_3 contents in the section 1 samples is between 3.14% and 7.31%. In this range, the clay minerals were evaluated as illite. While the illite minerals were found within all samples of section 1, and the presence of the illite minerals was confirmed by the XRD results (Table 1). Besides, sample 5 and sample 8 of section 1 were done with a clay fraction analysis. The Al_2O_3 value of sample 5 is 5.77%, while sample 8 contains up to 7.31%, and those two samples include a high amount of the illite minerals as a result of XRD clay fraction analysis (Table 1). The Al_2O_3 values are in the range of 3.86% and 5.9% in section 2 and are between 0.83% - 2.83% for section 4. However, the illite minerals could not be found in both two sections.

As a result of the performed analysis, the SiO_2 concentration in section 1 is in the range of 18.18% - 47.13%. These values obtained by the XRD and geochemical analysis approve that the SiO_2 concentration is based on the quartz phases in the rock (Table 1). Also, the SiO_2 content is between 19.53% - 33.31% on section 2, and this section contains the quartz minerals. Section 4 does not include the quartz minerals due to the amount of SiO_2 concentrations (5.68% - 21.68%).

When LOI values in section 1 were checked, these are in between 21.67% and 37.38%, thus, in sample 8, sample 9 and sample 10 contain dolomite and calcite minerals abundantly. Calcite was found in all samples in the value range of 28.23% and 36.73% in section 2. The highest LOI was measured in section 4 (33.81% - 40.39%), and most probably those samples of section 4 contain a higher amount of dolomite and also sample 1 includes calcite minerals.

The Fe_2O_3 values are between 4.17% - 5.69%, 3.35% - 4.64%, and 0.86% - 3.38% for section 1, section 2, and section 4, respectively. The Fe_2O_3 content of the rocks, obtained by the geochemical and XRD analyses, may depend on the presence of the minor or accessory ankerite minerals (Table 3). For this reason, finding the ankerite minerals in section 2 and section 4 is possible.

When the silica module, aluminum module, and hydraulic module values are checked as a result of the geochemical analyses, SM is over 2.7, making the clinker burning process more difficult (Duda, 1988). The values of the silica modules are between 2.65 - 3.42% for section 1, 2.40 - 3.45% for section 2, and 1.94 - 5.22% for section 4 (Table 4). In section 2, there are 2 samples (sample 2 and sample 3) with a silica module less than 2.7 that only 20 percent of the samples does not cause any problem for the burning process when those samples are compared to the whole section, while other 80% of the samples has a difficulty for the burning process. Likewise, two samples (sample 2 and sample 6) of section 2, and sample 9 and sample 10 point out the same situation. It might be said that the clay samples in the whole study area require more heat to increase burnability capacity. The acceptable value range of the AM for the cement industry is between 1.5 - 2.5 (Duda, 1988). When sections 1 and 4 are examined, samples cause problems during the pulverization process because all samples are under the accepted values. On the other hand, only sample 5 of section 2 has a higher value than the acceptable range of the aluminum module so it does not pose a problem in the pulverization process. The standard values range of the hydraulic module is between 1.8 - 2.2 based on the Duda (1988). The cement with lower than 1.7 showed mostly insufficient strength, thus, it can be said that the concrete in which this cement is used show brittle properties. However, when this value is 2.4 for HM, the volume of the produced cement changes and swells, thus it causes damage to the concrete. In this case, when section 1 and section 2 are checked, all samples are under the standard value ranges that's why the cements, produced by concrete, might show brittle behavior. Also, samples 1, 5, 6, 7, 8, 9, and 10 of section 4, may create havoc for the concrete because of higher hydraulic values than 2.4.

9. Results

This study was carried out on the marl - sandstone - claystone units of the Yenicekale formation Kışla member where exposed between Söğütlü and Şahintepe villages of Pazarcık district in Kahramanmaraş. The purpose of the study is to reveal whether the marl and clay units can be used as cement raw material. For this purpose, 3 stratigraphic sections were measured throughout the 3 different profiles where the formation is well observed, and 28 samples were collected for the purpose of geochemical analyses as well as 8 samples for petrographic analyses.

The XRD (X-ray diffraction) and geochemical studies were carried to test the usage of samples as cement raw material (Table 4). As a result of the XRD analysis, the calcite, dolomite, quartz, and chlorite in section 1; the quartz, calcite, and chlorite in section 1; the dolomite and calcite minerals were determined (Tables 1, 2 and 3).

Especially samples with high clay content were analyzed by XRD - WR (XRD - Whole Rock) without any other processing (Figure 16). In the samples separated by clay fraction, the illite is the dominant mineral in the XRD - diffractom extracted under the normal conditions (Figure 16, Tables 1, 2 and 3). Also, the same situation was observed in the samples treated with ethylene glycol at 550 ^{o}C condition (Figure 16). According to d_{001} values in the detailed clay fraction XRD analyses, the mineral was determined as illite in sample 5 and sample 8 of section 1.

Based on the Akıncı (1968) studies, the illite minerals were formed as a result of alteration processes. The author also mentioned that the illite beds may occur at the limestone form in marine layers, whose origin is sedimentary. Akıncı (1968) stated that the clayey limestone and dolomites which are exposed in large areas and observed in all rock samples, mainly contain illite minerals in terms of the clay content, while montmorillonite type cannot be seen much in such environments. Therefore, under the light of Akıncı (1968) studies, the depositional environment of the Yenicekale formation Kışla Marl Member which is exposed in the study area is of shallow marine origin and the study of Akıncı (1968) explain why Kışla Marl Member contain only illite type clay mineral or why does not contain any other type of clay minerals.

In geochemical analyses that carried out the samples collected from the Yenicekale formation, SiO_2 quartz, CaO calcite, K_2O illite, Fe_2O_3 ankerite, MgO dolomite, Al_2O_3 clayey minerals, and high loss of ignition values are depending on the carbonate-rich minerals (Bor, 2008).

When the obtained results of the geochemical analyses with the product which using as a cement raw material were compared with the limit values, the MgO values (Bor, 2008) were determined in between 9,86 - 14,68% at section 1, 1,83 - 2,89% at section 2, and 15.45 - 21.13% at section 4 respectively. When the limit values of the MgO for the cement raw material, the values of section 1 and section 4 were being over the limit values (max = 5%), while section 2 stayed under the limit values.

The limit values of Al_2O_3 (Bor, 2008) which will be used as a cement raw material, are in the range of 3.14 - 7.31% at section 1, 3.86 - 5.9% at section 2, and 0.82 - 2.83% at section 4 (min: 4%). Obviously, the values of section 2 and section 4 were below the required limit values, while the content of section 1 is in the range of limits.

The SiO_2 values (Bor, 2008) are expected to be around 31% for the cement industry, and the SiO_2 contents are between 18.17 - 47.13% in section 1, 19.53 - 33.31% in section 2, and 5.68 - 21.68% in section 4. In this case, the SiO_2 contents of section 4 were determined to be under the limit values.

The number of alkalis (K_2O and Na_2O) to be used in the cement industry is limited (approximately 2%) and it was observed that these values are so low in all samples.

The silicate and alimuna modules were calculated by using the SiO_2, Fe_2O_3, and Al_2O_3 values of the geochemical analyses. The required silica module values are between 2.2 - 2.6 % (Duda, 1988) in the Turkish cement industry, even though these values are 1.9 - 3.2 % based on the standards. The obtained silica module values after the geochemical analysis for the study area are in the range of 2.65 - 3.42% in section 1, 2.40 - 3.45% in section 2, and 1.94 - 3.85% in section 4. According to the results mentioned above, only a few samples fit with the standard limit values.

On the other hand, the standard values which belong to the alumina module are in 1.5 - 2.5 (Duda, 1988). In this study, the alumina modules were determined between 0.7 - 1.11% in section 1, 1.09 - 1.38% in section 2, and 0.43 - 1.02% in section 4, respectively. In this case, it is understood that all the results of the alumina module of the samples were below the standard values.

In summary, both the aluminum module values and the silicate module values determined as a result of the geochemical analysis are out of the standard values for the clay to be used in the cement industry, and as such, these units which belonging to the Yenicekale formation Kışla Marl Member are not suitable for use in the cement industry. However, it is feasible to produce a portland cement for trial purposes by adding some corrective additives (such as bauxite and iron ore) to the cement.

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