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An Investigation of the Globe Clays of Sogut

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ABSTRACT: *In this study, samples taken from clay quarries in Küre region of Söğüt, Bilecik province were investigated. After the evaluation, the clay samples were examined from an engineering point of view and the qualities of the clays of Küre region were emphasized. For this purpose, XRF, seismic velocity and consistency limits were determined on the samples taken from the clay quarry in the region.The relations among these were investigated and information was obtained about the use of clays in the vicinity of the Küre region of Söğüt District of Bilecik province. As a result of the research, it has been determined that the clays of Küre region can be used as ceramic and refractory industry raw materials.*

KEYWORDS: *Clay, Bilecik, Küre, Ceramic, Usage*

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I. INTRODUCTİON

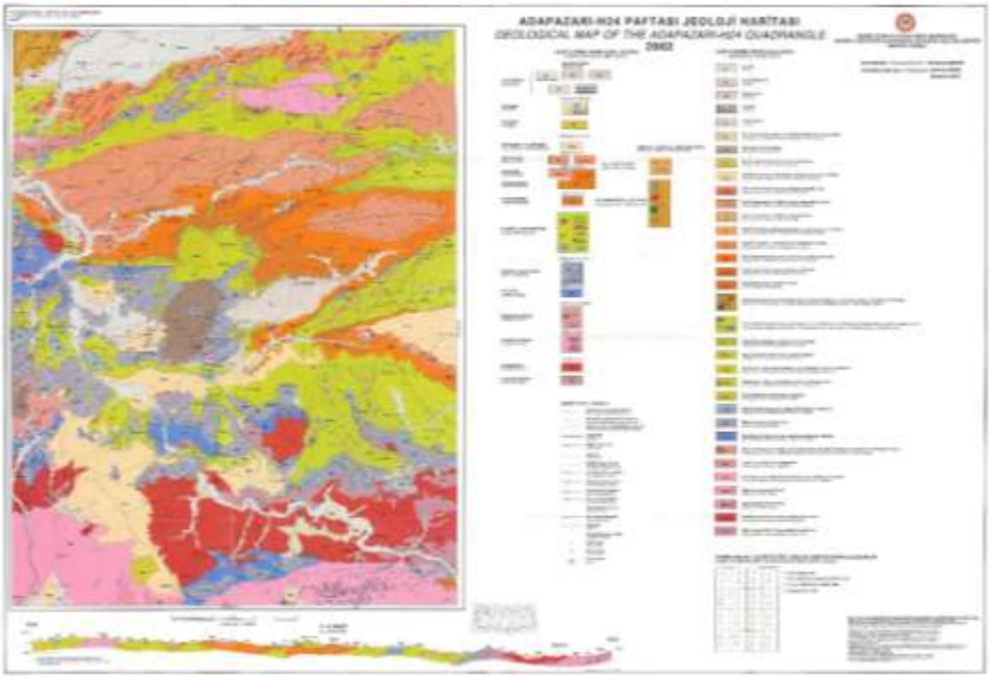
Clay, as a rock term, is used to expresses grain size in mechanical analysis of sedimentary rocks and soils. Wentforth proposed in 1922 that particles smaller than 4 microns (1/256 mm) in grain size to becalled as clay. Clays consist of extremely small, crystalline particles of one or more members of a mineral group known as the clay [1] .

Clay group minerals are used in different areas due to differences among theirhomogeneity, plasticity, moisture and dry strength, and other technological properties. 60% of produced kaolin are used in cement industry, 30% in ceramic industry, 10% in glass, paper and cement, drilling mud, filling and coating materials, cleaning, detergent, food and pharmaceutical industries [2].

In this study, it is aimed to determine the engineering features of XRF results and seismic velocities by mentioning various samples from the quarries of Küre Village, which is 14 km away from Söğüt District in the south-west direction.

II. REGİONAL GEOLOGY

The area of study is in the Küre Village of Söğüt District of Bilecik, and is located on the map of Adapazarı H24-d4.



Map 1: Küre Geology Map (MTA)[3]

Küre Formation, neogene-aged lacustrine basin formed by more than the fluviatic yields, the lower central claystone-conglomerate sediments, upper claystone-sandstone sediments and end product chemical carbonate sediments, and their sediments were investigated separately, and their characterized facies locations were determined. The formation was named after Küre village, which is the largest settlement in the region, where the emmision is best observed. [4] [5].

Küre Neogene Area: In this region, fluctuated fluvial yields with abundant discharge from the south and northwest have been effective. An alluvial fan which develops from these yields into the southern basin constitutes the most important material and water source that feeds the basin. They continued by reducing the effects of this spectrum to the depths of the lake [6].

The members of the central part of the Neogene lacustrine basin and which have economic value due to clay layers are exposed in four different areas. These regions, which are considered as clay fields in the region and in the literature, are the clay area of the Sakızbeli region, the Çiğdemlik-Alan clay area, the Akçaalan clay area and the Küre region where the member is the best and most extensive. Other regions except Küre region, these are topographic areas with small emitted light erosional surfaces. In the Küre region, the unit is exposed to larger areas.

III. MATERİAL AND METHOD

The samples used in the study to evaluate the clays of the region in terms of engineering and their usage areas were taken from 2 different quarries and named as KAL and AVDAN. XRF analyzes of these samples were performed in Bilecik Şeyh Edebali University's Central Research Laboratories and ultrasonic sound velocities were measured in the Geological Engineering Rock and Soil Mechanics Laboratory of Hacettepe University.

The clay samples were shaped as rectangular prisms and their surfaces were smoothed in order to obtain ultrasonic sound velocities. The samples to be analyzed for XRF measurements were made smaller than 5 mm by automatic stone crushing and automatic stone grinding machines. 4 grams were taken from the samples to be analyzed and 0.9 grams were prepared by compressing under the hydraulic press with the binder called WACHS for pres-lozenge analysis. The analyzes were performed with X-ray fluorescence (XRF) device by Axios brand PANalytical at the Central Research Laboratory of the Bilecik Şeyh Edebali University.

Special calibration set is used in XRF system which contains 21 standard (Al_2O_3, BaO, CaO, Cr_2O_3, CuO, Fe_2O_3, HfO_2, K_2O, MgO, Mn_2O_3, Na_2O, NiO, P_2O_5, PbO, SiO_2, SO_3, SrO, TiO_2, V_2O_5, ZnO, ZrO) for accurate quantitative analysis. This calibration program can perform real quantitative analysis of oxidized compounds (mineral, cement, glass industry, ceramic raw materials, etc.) at ppm level. X - Ray Fluorescence Spectroscopy allows quantitative analysis of the elements with an atomic number between 9 and 92 [7].

It is used to determine the dynamic Poisson ratio of the dynamic material of the rock material by using the propagation rates of the P and S waves passing through the rock samples by measuring the velocity of propagation of the ultra-sound waves in the rock. P-wave velocity is used in determining the strength of the seismic velocity. In addition, as a result of the measurement of the S wave, elastic modules of the floor, mechanical and physical properties can be better interpreted. The ultrasonic device has a transmitter (Tx) and a receiver (Rx) probe (Figure 1). The frequency of the P wave probes used is 50 kHz. The frequencies of this wave are applied between 20-250 kHz. While the wave was sent from one side of the sample, the wave arrival time was recorded and the velocity (V) was determined from the ratio of the distance (T) between Tx and Rx. [8].

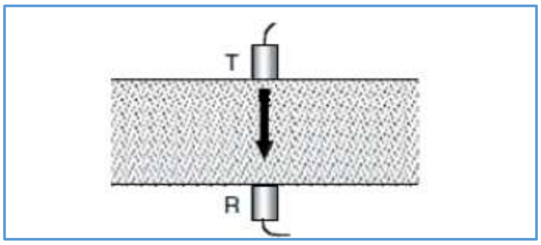


Figure 1: Schematic representation of the seismic velocity measurement on the sample

With the ultrasound velocity of the samples, the information about the compressive strength of the ultrasonic sound waves with frequencies between 50 and 150 kHz at the level of 20 and 200 kHz were obtained. Ultrasonic velocity measurements were made by direct detection method and the mean measurements taken in three axes direction were used[9].

IV. DİSCUSSİON AND FİNDİNGS

In our country, TS - 5396 standard of Turkish Standards Institute is used for kaolin with foundry sand. In this context, the test results of clay samples will be evaluated according to the given table below. [10].

Table 1: Kaolin product standards of Turkey

					Paper		Cement	
Rate (%)	Tiles	Electro Porcelain	Porcelain	Frit kaolin	Filling	Covering	1	2
SiO_2	55–80	55–60	58–65	58–78	44–46	50–60	78–80	57–60-
Al_2O_3	13–25	28–30	24–32	15–28	30–35	30–35	min 30	28
Fe_2O_3	max 1.0	max 0.6	max 0.6	max 0.4	max 0.4	max 0.4	max 0.4	max 1.5

23 samples were taken from 4 profiles taken on the quarry mirror and 8 samples were collected from the Avdan quarry. As the samples examined have clay content, SiO_2 Al_2O_3 Fe_2O_3 TiO_2 CaO MgO K_2O Na_2O values are given below in the table.

Table 2: Measurement of the 31 samples made quantitative XRF analysis

Name of Sample	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O
AVDAN-1–1	13.69	8.93	47.48	1.75	10.71	3.47	2.18	
AVDAN–1–3	38.49	21.15	18.48	5.74	2.99	2.21	6.82	0.21
AVDAN–1–5	38.71	22.63	16.55	6.24	3.02	2.56	6.54	0.25
AVDAN–1–6	47.28	20.00	7.67	8.58	4.49	1.76	6.39	0.28
AVDAN–2–1	45.12	26.92	4.81	7.75	1.66	1.23	8.62	0.23
AVDAN–2–3	45.18	23.46	6.20	7.20	2.04	1.45	8.04	0.25
AVDAN–3–2	42.14	27.39	6.77	6.43	1.50	1.79	10.11	0.18
AVDAN–3–3	44.36	25.76	7.53	6.61	2.15	1.68	8.05	0.15
KAL–1–1	50.28	37.37	3.98	3.09	0.78	0.30	1.05	0.04
KAL–1–2	48.35	38.36	5.00	3.13	0.86	0.27	0.81	0.04

KAL–1–3	48.23	37.67	5.35	3.32	0.86	0.37	1.24	
KAL–1–4	47.10	36.55	6.50	4.20	0.91	0.30	1.35	
KAL–1–5	33.87	17.44	16.83	9.83	11.76	2.51	4.20	0.23
KAL–1–6	44.15	27.00	5.44	7.48	1.68	1.19	8.88	0.15
KAL–2–1	49.77	36.08	4.90	3.62	0.87	0.29	1.49	
KAL–2–2	48.86	35.20	5.84	3.85	1.05	0.38	1.48	
KAL–2–3	49.91	35.66	4.77	3.60	0.91	0.35	1.50	
KAL–2–4	49.77	35.57	5.05	3.69	0.94	0.30	1.54	0.03
KAL–2–5	34.00	12.86	22.01	4.60	16.60	3.69	3.10	0.21
KAL–2–6	31.19	20.67	27.51	4.58	3.55	2.36	6.15	0.12
KAL–3–1	47.07	33.66	6.86	3.30	3.00	0.53	2.41	0.03
KAL–3–2	45.99	32.30	7.98	2.89	4.22	0.63	2.63	
KAL–3–3	49.22	35.87	4.97	3.83	1.03	0.36	1.78	0.03
KAL–3–4	48.50	35.17	6.33	3.72	1.20	0.45	1.82	
KAL–3–5	34.67	14.44	17.96	7.20	15.71	3.02	3.75	0.20
KAL–3–6	32.74	21.94	25.69	4.60	2.73	2.29	6.43	0.13
KAL–4–1	50.10	37.06	5.08	2.53	1.05	0.29	0.91	0.05
KAL–4–3	45.06	37.48	9.08	3.15	1.02	0.28	1.21	
KAL–4–4	45.96	37.32	8.40	2.85	1.07	0.29	1.11	
KAL–4–5	37.29	18.37	15.41	6.76	11.71	2.62	4.50	0.21
KAL–4–6	26.07	16.54	39.02	2.90	4.01	3.61	4.22	0.14

The findings of the samples were arranged separately for each furnace and transferred to charts and maps. The findings of the quarries were arranged and evaluated as follows.

XRF Findings of Kal Quarry

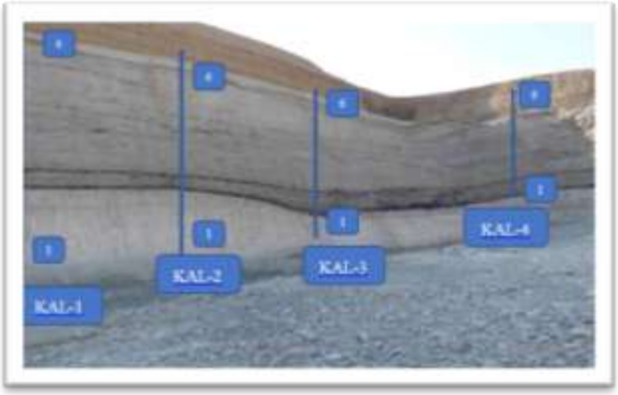
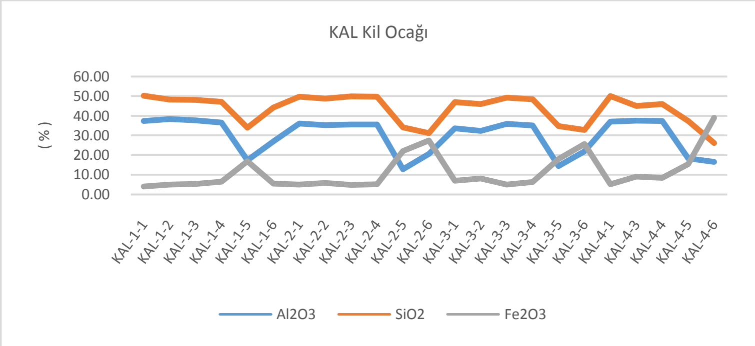


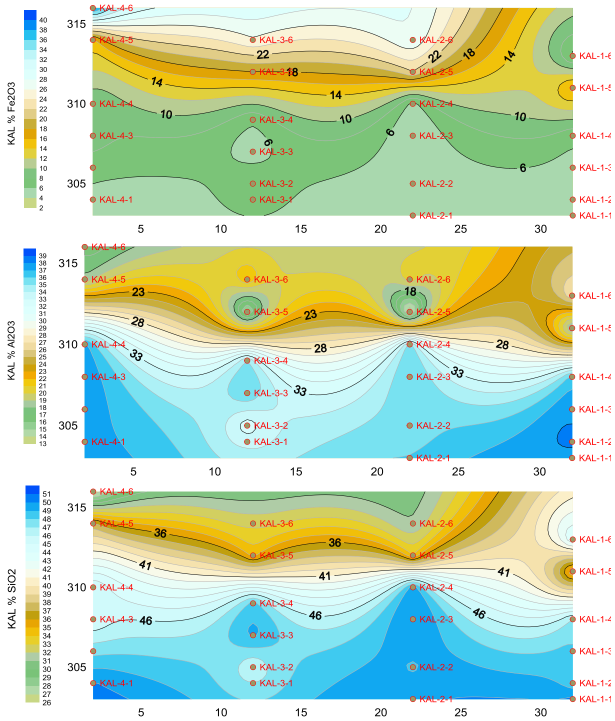
Figure 2: Furnace Image and Profiles of Küre Kal Quarry

The values of SiO_2, Al_2O_3 and Fe_2O_3 (%) of 4 profiles for KAL clay quarry are given in Graph 1 below.



Graph 1: Kal Quarry Calculation of Al_2O_3- SiO_2- Fe_2O_3

The results of the samples in the upper part of the quarryjust below the earth are presented in Chart 1. Fe_2O_3 (iron oxide) values increased and Al_2O_3 - SiO_2 values decreased.

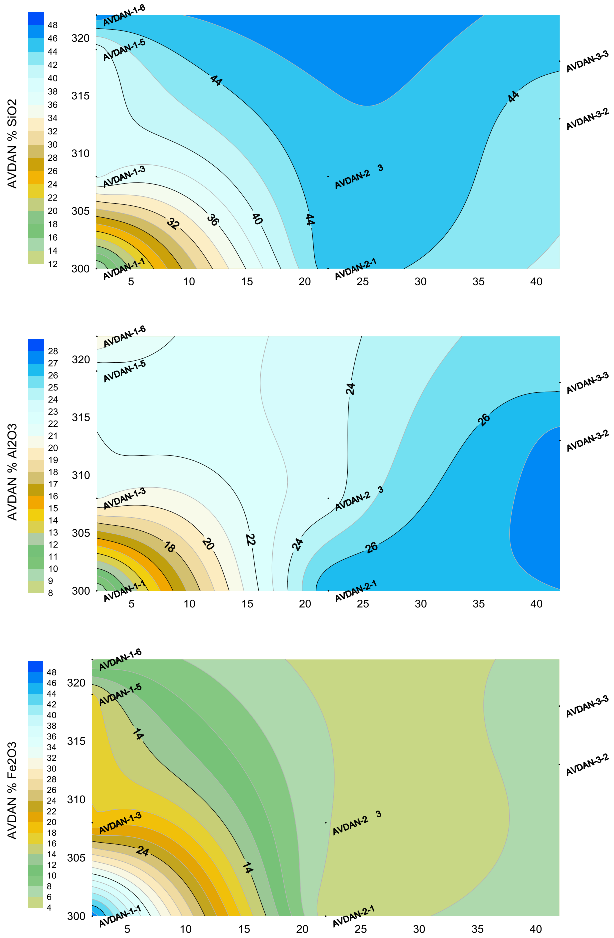


Map 2: distribution of % Fe_2O_3 -% Al_2O_3 -% SiO_2 in Kal Quarry

It was determined that Fe_2O_3 (iron oxide) values decreased or Al_2O_3 and SiO_2 values increased as the lower part of the quarry was reached. The high iron oxide content causes the brown colors of the clay to become brown-red. As shown in Map 1, the continuity of Al_2O_3 and SiO_2 values at the same height levels indicate that the samples belong to the same layer and continue as clay in the same character.

XRF Findings of AVDAN Quarry

8 samples were taken from Küre Avdan Quarry. Samples taken from the quarry are engraved on the maps, which are numbered from the bottom to the top.



Harita 1: distribution of AVDAN % Fe_2O_3 -% Al_2O_3 - % SiO_2

Fe_2O_3 (iron oxide) values were found to be quite high at the site of Avdan 1-1 and Avdan 1-3 samples. Samples from Avdan 3-2 and Avdan 3-3 are the richest samples of Al_2O_3 in this quarry.However, Fe_2O_3 (iron oxide) values as high as 6-8% are observed in the samples.

In this study, longitudinal and transverse wave velocities obtained by direct measurement technique on 31 different samples taken from 2 different quarries were determined by ultrasonic sound velocity measurement technique. With the direct measurement technique, longitudinal and transverse measurements were performed on 31 different samples and the average speed values of three directions were taken into account for each sample.

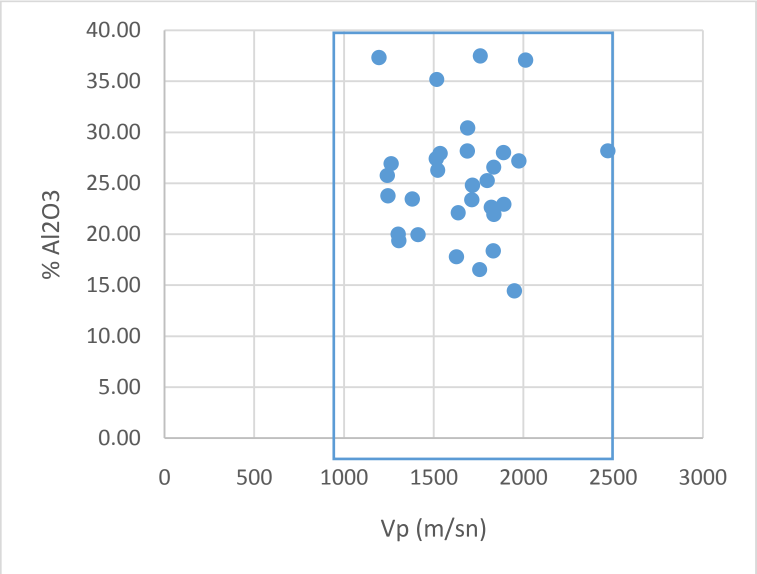
Table 3: P wave velocity with the detachability of floors or rocks (Bilgin 1989)

WAVE SPEED OF NECK (V_P) (m/s)	Rippability
300 – 600	Very Easy
600 – 900	Easy
900 – 1500	Middle
1500 – 2100	Difficult
2100 – 2400	Very difficult
2400 – 2700	Extremely Difficult

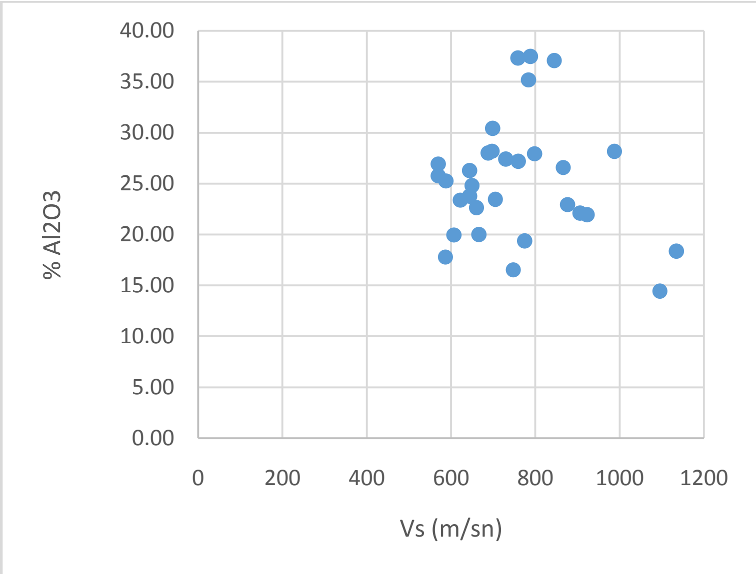
According to the Vp velocity ranges given in Table 2, the rock removability classifications were determined for the samples from the KAL and Avdan quarries and transferred to the Table 3 below. As a result of the classification made, 22 samples were found to be difficult, 8 samples were medium and 1 samples were very difficult to rip [11].

Table 4: Ultrasonic sound velocity and detachability of 31 samples measured

Name of Sample	Vsort	Vport	Rippability
AVDAN–1–1	660	1821	Difficult
AVDAN–1–3	666	1302	Middle
AVDAN–1–5	570	1263	Middle
AVDAN–1–6	705	1381	Middle
AVDAN–2–1	730	1514	Difficult
AVDAN–2 3	570	1242	Middle
AVDAN–3–2	988	1688	Difficult
AVDAN–3–3	650	1716	Difficult
KAL–1–1	784	1517	Difficult
KAL–1–2	1096	1950	Difficult
KAL–1–3	923	1835	Difficult
KAL–1–4	845	2013	Difficult
KAL–1–5	788	1760	Difficult
KAL–1–6	759	1195	Middle
KAL–2–1	1135	1833	Difficult
KAL–2–2	748	1756	Difficult
KAL–2–3	877	1891	Difficult
KAL–2–4	906	1637	Difficult
KAL–2–5	760	1975	Difficult
KAL–2–6	798	1536	Difficult
KAL–3–1	644	1245	Middle
KAL–3–2	775	1306	Middle
KAL–3–3	644	1522	Difficult
KAL–3–4	622	1712	Difficult
KAL–3–5	866	1835	Difficult
KAL–3–6	699	1690	Difficult
KAL–4–1	688	1889	Difficult
KAL–4–3	588	1798	Difficult
KAL–4–4	587	1627	Difficult
KAL–4–5	607	1412	Middle
KAL–4–6	697	2471	Extremely Difficult



Graph 2: Al_2O_3**-Vp velocity distribution of KAL and AVDAN quarries**



Graph 3: Al_2O_3**-Vs velocity distribution of KAL and AVDAN quarries**

As shown in Graphs 2 and 3, the velocity of the seismic velocities can be seen in the Vp velocities of 1000-2500 m / s and the Vs velocities in the 400-1000 m / sec range. These results show that the samples taken in terms of seismic velocities have a large amount of clay mineral content [12].

The relationships between the particles and the water of the ground, and the determination of the condition of the ground according to the varying water content were made with Attarberg limits. Plasticity values, liquid limit, plastic limit and plasticity results were obtained. Liquid limit test was carried out with Casagrande apparatus according to Casagrande method. The Plasticity Index was calculated based on the LL and PL arithmetic difference of the clayey material.

In the plasticity diagram, y axis plasticity index I_p x axis shows the liquid limit. Diagram is divided into 6 regions, 3 of which are above and below the line A. Differences between the various groups are reliably determined by the plasticity diagram. Differences between the various groups are reliably determined by the plasticity diagram.

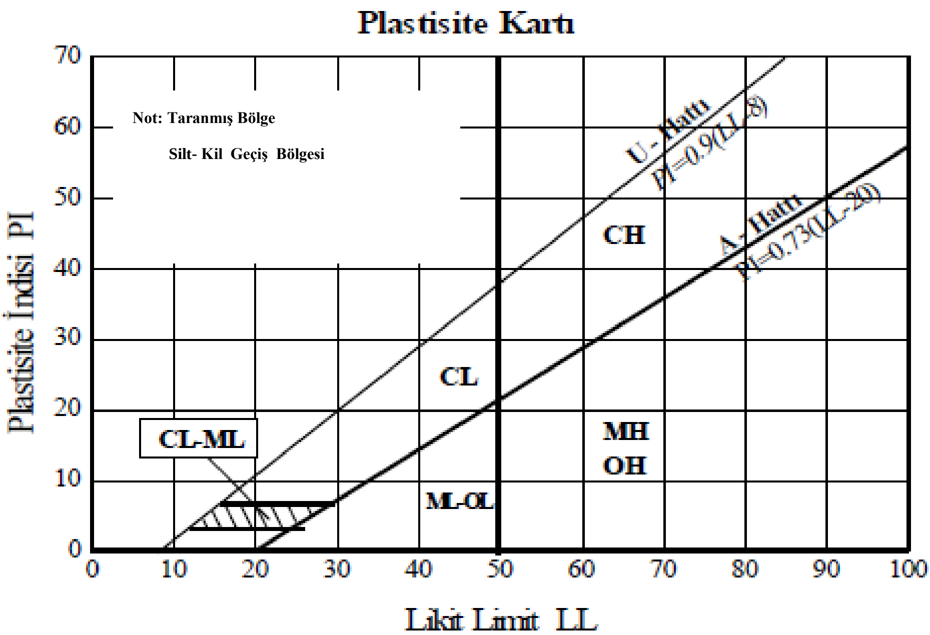


Figure 3: Plasticity diagram (Casagrande plasticity card) [13]

The measurements made to determine the consistency limits on each sample selected from each quarry were carried out in Eskişehir Atabey Consulting Engineering Company concrete and ground laboratories.

Numune Adı	LL	PL	PI	Birleştirilmiş Zemin Sınıflaması	Su muhtevası (%) (W)	Kıvam INDİSİ	KIVAM
KAL–2–3	30	20	10	CL	28.63	0.14	Soft
AVDAN–3–2	78	32	46	CH	76.52	0.03	Very Soft

Figure 4: Consistency results of samples according to thickness index

Thickness index values are evaluated according to Figure 3; AVDAN 3-2 samples were very soft and KAL 2-3 samples gave a soft consistency.

V. CONCLUSİON AND RECOMMENDATİONS

This study was carried out in order to determine the industrial properties of clay minerals in the vicinity of Küre Village in Söğüt (Bilecik) region.

The liquid limits of the samples used in the study vary between 30-78, plastic limit 20-32 and plasticity indices in the range of 10-46. When the samples taken in terms of plasticity findings were examined, it was found that the clays in the region had low plasticity values. In the light of this result, it is concluded that clay samples examined in the study in Söğüt region are not suitable for the sanitary industry, considering the positive effect of the clays with high plasticity especially in the sanitaryware sector.

When the Al_2O_3 values of the clay samples were taken into consideration, it was found that the values of 30 samples were higher than the values of Al_2O_3 over 16% in terms of the values given in Table 1. Considering these results, it is determined that the samples can be used in industrial products such as porcelain, sanitary ware, glazing, electro porcelain.

It is understood that the clay samples in the region are low in quality due to high Fe_2O_3 content and they are not suitable for the production of fine ceramics. It is concluded that these clays are suitable for refractory and ceramic industries as raw materials.

It is thought that the economic values can be increased by applying raw material enrichment processes to the samples taken from the clay quarries of the Küre region and thus it will be possible to use in different sectors such as cement, paper, glazur and electro porcelain production.

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