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Physicochemical properties and availability of Tahar-Güzelöz (Nevşehir) diatomite

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Research Article

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ABSTRACT

In this study, utilization of Tahar-Güzelöz (Nevşehir) diatomites occurring within the late Miocene-Pliocene age vocanosedimentary units which formed due to volcanism and outcropping in Tahar and Güzelöz (Nevşehir) areas were investigated. In the study area, three stratigraphic sections were measured, one of which was measured in the Tahar area (TK), and the two others were measured in the Güzelöz area (GÜ1 and GÜ2). Various physicomechanical, chemical, mineralogical and analytical methods were used on the samples. Analyses results of the diatomites in the investigated area were determined as follow; amount of acid-insoluble matters; 74,20 - 84,20 %, amount of water-insoluble matters; 99,80 %, loss on ignition ratios (950 °C de); 8,18 - 22,82 %, whitenesses; 80,45 - 84,79 %, particle sizes; 0,7-209 µ , pore sizes; 1,448 e-03A – 5,888 e-04A, pore volumes; 1,148 e-02 – 8,515 e-02 cc/g , specific gravities; 2,33 – 2,49 gr/cm^3 , total porosities; 57 –60 %, cumulative specific surface areas; 4,047 e+01 – 5,160 e+01 m^2/g, pH; 5-7 (acit and neutral), filtration rates; 138 – 351 ml/dk, SiO_2 contents; 38,16 – 67,77 %. It was determined that, the samples are not contain palinological material and these generally formed from long and large diatom genus and species. The evaluation of the analyses results showed that, none of the three location's diatomites is suitable as construction material, carrier, mild abrasive and cleaner, isolution material. At the same time, determined that, the Tahar and Güzelöz–1 location's diatomites can not be used as filler material. In addition, it was determined that, the subject diatomites can be used in the manufacture of silicate, and in percolator by the enrichment in terms SiO_2 . Also, Güzelöz-2 location's diatomites can be used as filler material in the rubber and paper industries.

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1. Introduction

The study area is located in the Güzelöz and Tahar locations within 1/25000 scale Kayseri K33-c3 and L33-b2 sheets (Figure 1). Mostly; studies regarding the volcanism have been carried out in and around the study area. Among these, Pasquaré (1968) studied the Cenozoic volcanism in the Central Anatolia and stated that the volcanism in the region began with ignimbrites in the middle Miocene and ended with basaltic lavas of the Hasandağ in Quaternary. Pasquaré et al. (1988) asserted that Neogene and Quaternary volcanics in the Central Anatolia were continental arc volcanics which had been formed by the collision of the Afro-Arabian and Eurasian plates. Ayrancı (1970) detected that the Erciyes volcanism occurred in three stages. Innocenti et al. (1975) dated volcanic rocks around Tomarza, (Kayseri), Erciyes Mountain and İncesu, and detected 8,5-2,8 my for ignimbrites, 7,8 my for tuffs, 5 my for andesites, 5,4 my for rhyolites and 10,1 my for dacites. Güner and Emre (1983) stated that there had been a calcalkaline volcanism on the Erciyes Mountain and its vicinity. Sassano (1964) carried out a study on the Neogene and Quaternary volcanisms in the Acıgöl region. Özkuzey and Önemli (1977) investigated the petrography and

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economical geology of the Acıgöl perlites. Batum (1978) studied the geology and petrography of Acıgöl and Göllüdağ volcanics. Yıldırım and Özgür (1981) on the other hand asserted that the dimension of the Acıgöl caldera and completed its evolution in 5 stages. Duritt et al. (1995) investigated Quaternary rhyolites located in the Acıgöl complex. Schumacher et al. (1990) investigated mineralogical and geochemical characteristics of the Cappadocian ignimbrites in Ürgüp-Nevşehir-Kayseri regions. Temel (1992) studied mineralogical and geochemical features of the Cappadocian ignimbrites in the Ürgüp region. Aydar (1992) detected that the Hasandağ volcanism had been formed in three stages. Göncüoğlu and Toprak (1992) stated that the Melendiz Mountain were formed by the Tepeköy, Melendizdağ and Çınarlı volcanics. Aydar and Gourgaud (1998) investigated the Hasandağ volcanism. Gevrek et al. (1994*a* and *b*) made studies regarding the maars located in the Cappadocia and the Narköy maar. Toprak (1996) made a study on defining the basins of the Cappadocia Volcanic Province (CVP) and determining the volcanism and structural characteristics. Temel et al. (1998*a*) investigated the volcanic rocks of the CVP in terms of mineralogical, geochemical and petrographical characteristics and determined that these rocks had been derived from andesitic and dacitic magmas. They also explained that volcanic activities in the region had occurred as result of the effects of compressional and extensional tectonisms related to the subduction of the Arabian-African Plate beneath the Anatolian Plate. Le Pennec et al. (2005) studied ignimbrites and volcanic rocks of the CVP and dated 10 different ignimbrites emplaced in the region by means of paleontological data and K-Ar age determinations. Gürel et al. (2007) defined the Mustafapaşa Formation and the overlying rocks forming the Cemilköy Ignimbrite, and explained sand, silt and clay ratios of each unit and the formation of dominant clay minerals.

Some investigators have mapped the study area and its vicinity. Among them, Beekman (1966), Atabey et al. (1987, 1988) and Ayhan et al. (1988) have prepared 1/25.000 scale maps of Hasandağ and Melendiz Mountain locations, Niğde-Nevşehir-Kırşehir and Kayseri regions and Niğde-Aksaray-Derinkuyu regions, respectively.

Schumacher and Schumacher (1996), Dhont et al. (1998), Froger et al. (1998), Koçyiğit and

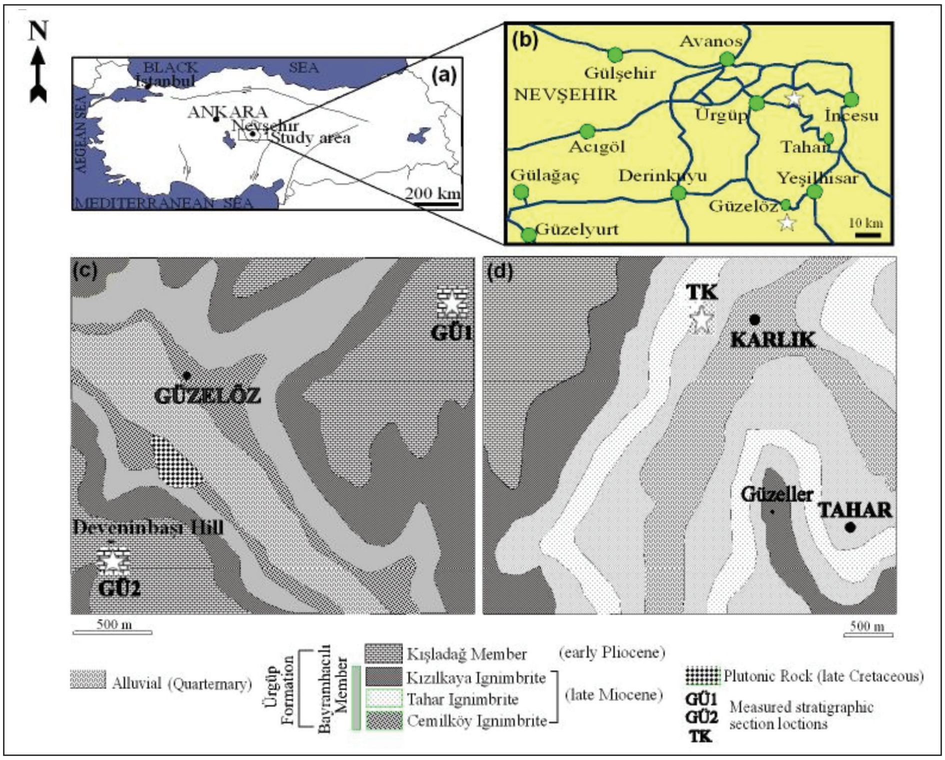

Figure 1- The stydy area location (a, b) and geological maps (c, d) and locations of the measured stratigraphic sections (modified from Pasquaré,1968; MTA, 1989; Toprak,1998; Gürel and Kadir, 2006; Yavuz-Işık and Toprak, 2010).

Beyhan (1998), Kürkçüoğlu et al. (1998), Temel et al. (1998*b*), Toprak (1998) and Dönmez et al. (2003) studied the mineralogical, geochemical, structural and petrographical characteristics of the CVP. However, Göz et al. (2014) has investigated the mineralogy and geochemistry of lacustrine formations deposited in the CVP in the late Miocene-Pliocene.

Viereck-Gotte and Gürel (2003), Kadir et al. (2006), Gürel and Kadir (2006) and Gürel et al. (2008) investigated the paleosol, caliche and clay formations located among ignimbrites in the CVP, around the study area. Yavuz-Işık and Toprak (2010) studied the palynostratigraphical characteristics of the Neogene terrigenous sediments alternating with the Cappadocian ignimbrites.

There are little studies carried out on diatomites in and around the study area. Kayalı et al. (2005) and Gürel and Kadir (2008) made a study on determining the qualitative and quantitative characteristics of clay and diatomites in the Central Anatolian Region. Yıldız and Gürel (2005) investigated the diatom assemblage and paleoenvironmental characteristics of diatomites in the Çiftlik Basin (Niğde) region. Gürel and Yıldız (2006) studied diatom assemblage and lithofacies characteristics of diatomites in the Ihlara-Selime locality. Yıldız and Gürel (2014) made a study on the fossil diatom assemblage and the paleoenvironmental characteristics for diatomites in the Karacaören-Ürgüp region (Nevşehir). Yıldız et al. (2016) have finally investigated the use areas of the diatomites for industrial raw material.

The physicochemical characteristics of diatomite levels located within the Bayramhacılı and Kışladağ members of the late Miocene-Pliocene Ürgüp formation and theirs utilities as an industrial raw material have been investigated in detail for the first time in the study area. Although, CVP is one of the place rich in diatomite in Turkey the studies regarding the physicochemical characteristics and utilities for diatomites located in this region have remained as limited until today. Therefore, the determination of physicochemical characteristics and utilities of diatomites in the Tahar and Güzelöz areas located in the CVP will contribute a lot to science and industry.

2. Material and Method

Total of three stratigraphical sections were measured one of which was from the Bayramhacılı Member (Tahar section: TS) (thickness: 50 m) and other two sections within the Kışladağ Member (Güzelöz-1 section: GÜ1, (thickness: 36 m) and Güzelöz-2: GÜ2) (thickness: 4 m.). These section were selected where diatomite units are best exposed within lacustrine deposits of the volcanic late Miocene-Pliocene Ürgüp formation in the study area. Total of 17 diatomite samples were collected along three sections and the field photos related to these sections were taken (Figures 2-4). In order to determine the

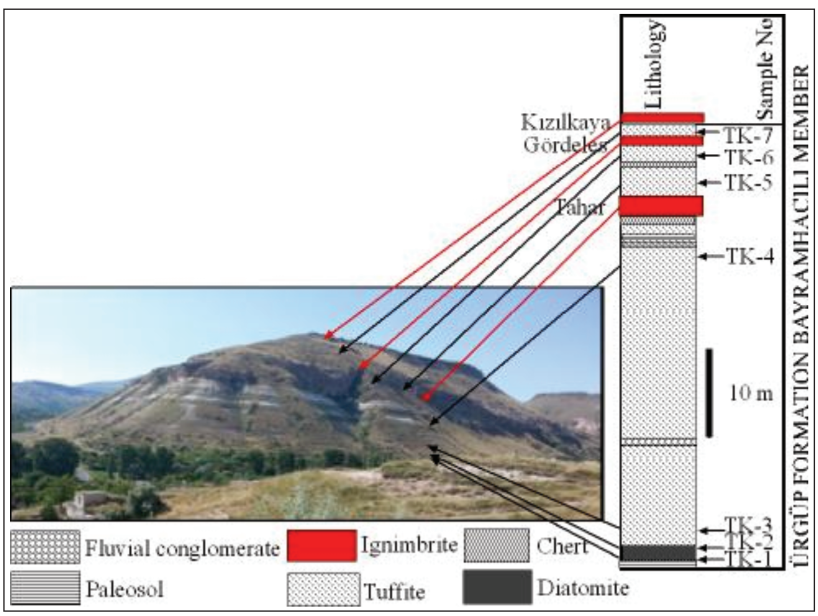

Figure 2- Tahar measured stratigraphic section.

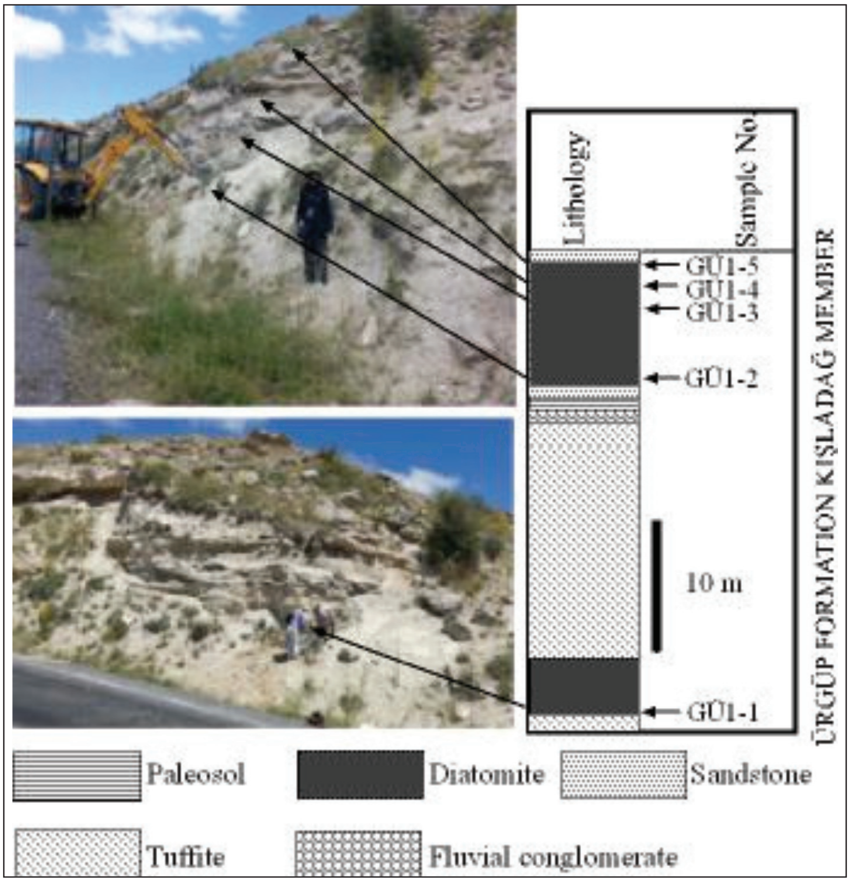

Figure 3- Güzelöz-1 measured stratigraphic section.

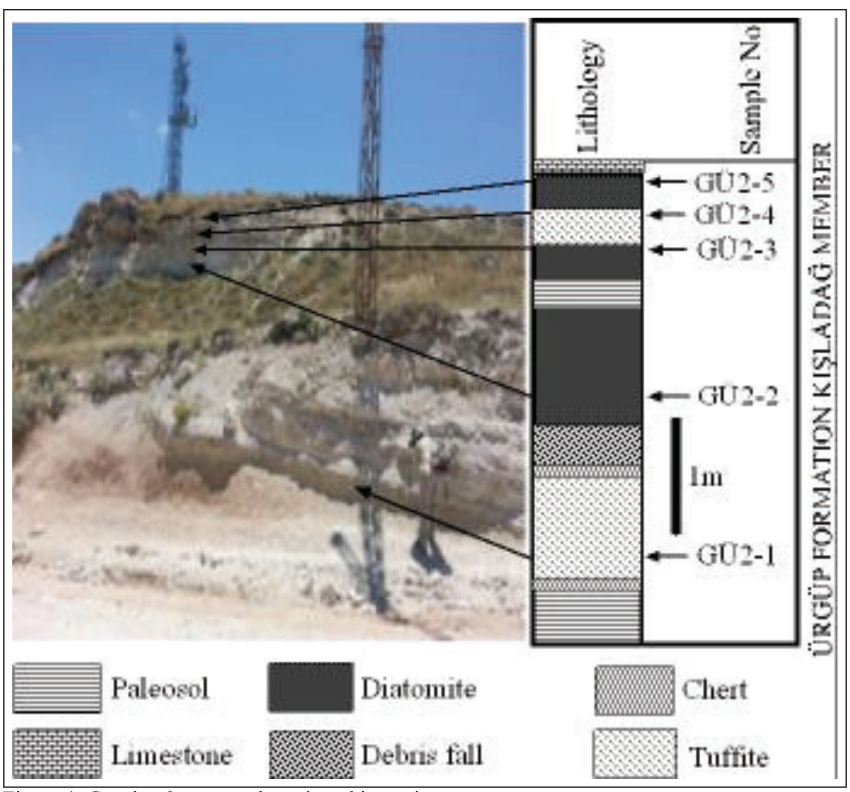

Figure 4- Güzelöz-2 measured stratigraphic section.

physicochemical characteristics and their areas of use, two diatomite samples (TK-1 and GÜ1-2) were subjected to X-Ray Diffraction (XRD) analysis in the General Directorate of Mineral Research and Exploration (MTA), Ankara, (using the Cu X-ray tube Bruker D8 Advanced XRD Analysis device as compatible with the ASTM standards), acid and water-insoluble matter amounts (results of their chemical analyses were detected by drying samples in 105°C), whiteness analysis (using Minolta Chroma Meter CR 300 device), specific surface area, porosity volume and porosity size analyses (based on the BET method using Quantochrome Nova 2200 device) (Tables 1-3). Total of six diatomite samples (TK–1, TK–2, GÜ1–2, GÜ1–4, GÜ2–2 and GÜ2–3) were subjected to pH analysis (based on TS6166 standards by the correlation made by pH indicator Strips pH 0-14) in the Soil Mechanics and Construction Materials,

Table 1- Results of qualitative XRD analysis of diatomite samples in the study area.

Sample No.		Analysis Result
Güzelöz-1 MSS	GÜ1-2	1- Calcite 2- Quartz 3- Feldspar minerals 4- Crystobalite 5- Clay minerals 6- Mica minerals 7- Amphibole minerals 8- Amorphous material
Tahar MSS	TK-1	1- Quartz 2- Crystobalite 3- Clay minerals 4- Pyroxene minerals 5- Amorphous material

Table 2 – Results of total porosity, whiteness, acid and water insoluble matter analysis of diatomite samples in the study area.

Sample No.		Total Porosity (%)	Results of Whiteness Analysis	Amount of Acid Insoluble Matter (%)	Amount of Water Insoluble Matter (%)
Güzelöz-2 MSS	GÜ2-3	57,8			
	GÜ2-2	58,1			
	GÜ2-1	57	80,45	74,20	99,80
Güzelöz-1 MSS	GÜ1-4	58			
	GÜ1-2	57,7			
Tahar MSS	TK-2	59,9			
	TK-1	60	84,79	84,20	99,80

Table 3- Results of specific surface area, pore volume and pore diameter analysis of diatomite samples in the study area.

Methods	Sample No.	
	Tahar MSS	Güzelöz-1 MSS
Specific Surface Area	TK-1	GÜ1-2
Multi Point BET	6,771 e+01 m^2/g	5,427 e+01 m^2/g
t- Method Outer Surface Area	4,787 e+01 m^2/g	2,922 e+01 m^2/g
t-Method Microporous Surface Area	1,984 e+01 m^2/g	2,505 e+01 m^2/g
NLDFT Cummulative Surface Area	5,160 e+01 m^2/g	4,047 e+01 m^2/g
Pore Volume		
t-Method Microporous Pore Volume	8,515 e-02 cc/g	1,148 e-02 cc/g
HK Method Cummulative Pore Volume	3,751 e-02 cc/g	2,966 e-02 cc/g
SF Method Cummulative Pore Volume	3,762 e-02 cc/g	2,975 e-02 cc/g
NLDFT Method Cummulative Pore Volume	5,580 e-02 cc/g	4,630 e-02 cc/g
Pore Diameter		
HK Method Pore Radius	2,158 e-04µ	2,158 e-04µ
SF Method Pore Radius	2,261 e-04µ	2,261 e-04µ
NLDFT Pore Radius	1,448 e-03µ	5,888 e-04µ

Quality Control Laboratory (Adana), seven diatomite samples (TK–1, TK–2, GÜ1–2, GÜ1–4, GÜ2–1, GÜ2–2 and GÜ2–3) were subjected to specific gravity and total porosity (%) analyses based on TS-1900-1 standards by using picnometer), six diatomite samples (TK–2, GÜ1–2, GÜ1–4, GÜ2–2, GÜ2–3 and GÜ2–5) were subjected to particle diameter distribution analysis (based on TS 1900-1 and TS 1500 standards by means of wet sieve method) and hydrometer analysis (based on TS 1900-1 standards), three diatomite samples (TK–1, GÜ1–2 and GÜ2–2) were subjected to compaction analysis [based on the Technical Specification of the General Directorate of Highways (2013)] (Tables 3-6). Total of 10 diatomite samples (TK–1, TK–2, GÜ1–1, GÜ1–2, GÜ1–3, GÜ1–4, GÜ1–5, GÜ2–2, GÜ2–3 and GÜ2–5) were subjected to X-ray fluorescent spectrometer (XRF) analysis and the Loss on Ignition (in 950°C) (by using Panalytical brand, Axios Max model Wave Length Distributed X-ray Flourescent (WD-XRF)), and three diatomite samples (TK–1, GÜ1–1 and GÜ1–2) were subjected to infiltration velocity analysis (Falling Head Permeability Test) in the Geochemical Analysis Laboratory (JAL) of the Faculty of Engineering, the Aksaray University (Aksaray). Total of 3 samples (TK–1, GÜ1–2 and GÜ1–3) were subjected to the Scanning Electron Microscope Analysis (SEM) in the Scientific and Technological Application and Research Center, Aksaray University, Aksaray (Figure 5). Four diatomite samples (TK–1, TK–2, GÜ1–1 and GÜ2–

Table 4 - Comparison of results of XRF, loss on ignition, moisture, particle size, density and pH analysis of diatomite samples from Güzelöz–1, Güzelöz–2 and Tahar measured stratigraphic sections in the study area.

	Tahar MSS		Güzelöz-1 MSS					Güzelöz-2 MSS			
	TK-1	TK-2	GÜ1-1	GÜ1-2	GÜ1-3	GÜ1-4	GÜ1-5	GÜ2-1	GÜ2-2	GÜ2-3	GÜ2-5
% SiO_2	61,25	66,18	43,67	67,77	43,84	44,73	38,16		61,02	61,83	56,59
% TiO_2	0,47	0,37	0,85	0,46	0,44	0,61	0,50		0,39	0,41	0,34
% Fe_2O_3	5,19	2,93	6,18	4,63	5,74	5,14	4,34		2,88	3,22	2,87
% Al_2O_3	11,13	14,40	11,20	8,75	11,92	12,96	10,31		7,07	7,44	6,17
% CaO	1,1	1,28	11,14	2,23	16,69	14,86	20,69		1,90	2,49	1,81
% MgO	2,5	2,02	1,9	1,5	0,2	2,05	2,08		7,43	8,18	14,12
% Na_2O	0,28	1,04	0,41	0,34	0,06	0,70	0,57		1,99	0,75	0,96
% K_2O	1,35	3,66	1,41	1,01	2,11	1,88	1,35		0,74	0,84	0,71
% P_2O_5	0,04		2,14	0,05	0,14		0,01		0,01	0,017	0,02
% MnO	0,02	0,06	0,06	0,06	0,07	0,06	0,05		0,05	0,06	0,043
% Loss on Ignition (950°C)	16,61	8,18	19,25	13,09	15,44	17,45	22,82		16,96	15,10	16,61
Average Particle Size (µ)		0,9		15		20			0,7	2	6
Particles Smaller than 20 µ (%)		9,42		55,25		14,45			26,78	27,07	23,32
Wet Density (gr/cm^3)	2,5	2,49		2,33		2,38		2,33	2,39	2,4	
Filtration Rate (ml/min)	351		138	185							
pH	5,5	5		6,5		6			6,5	7	6

Table 5- Results of pore dimeter distribution analysis of diatomite samples in the study area (wet sieve analysis + hydrometer analysis).

Sample No.		Pebble Amount (%)	Sand Amount (%)	Silt Amount (%)	Clay Amount (%)
Güzelöz-2 MSS	GÜ2-5	2,9	35,4	36,40	25,30
	GÜ2-3	5,5	22,7	41,72	30,08
	GÜ2-2	6,5	31,5	33,29	28,71
Güzelöz-1 MSS	GÜ1-4	2,5	32,8	50,14	14,66
	GÜ1-2	0,3	23,6	40,46	35,74
Tahar MSS	TK-2	0,7	46,4	40,20	12,70

Table 6- Results of compaction analysis of diatomite samples in the study area.

Material Criteria	Technical Specification for the General Directorate of Highways (2013)	Sample No.		
		Tahar MSS	Güzelöz-1 MSS	Güzelöz-2 MSS
		TK-1	GÜ1-2	GÜ2-2
Liquid Limit (%)	ὺ 60	NP	NP	NP
Plasticty Index	ὺ 35	NP	NP	NP
Material Class	A-4	ML	ML	ML
Maximum Dry Unit Volume Weight (pdmax)(gr/cm^3) / % Optimum Woter Content (wopt)	ň 1,450	0,992 / 50,3	0,972 / 49	1,00 / 54,6
% # 200 Subsieve		52,9	59,5	62
Organic Material Prediction	Not Organic Material (lighter than color no-1)	Darker than light color no-1	Darker than light color no-1	Darker than light color no-1

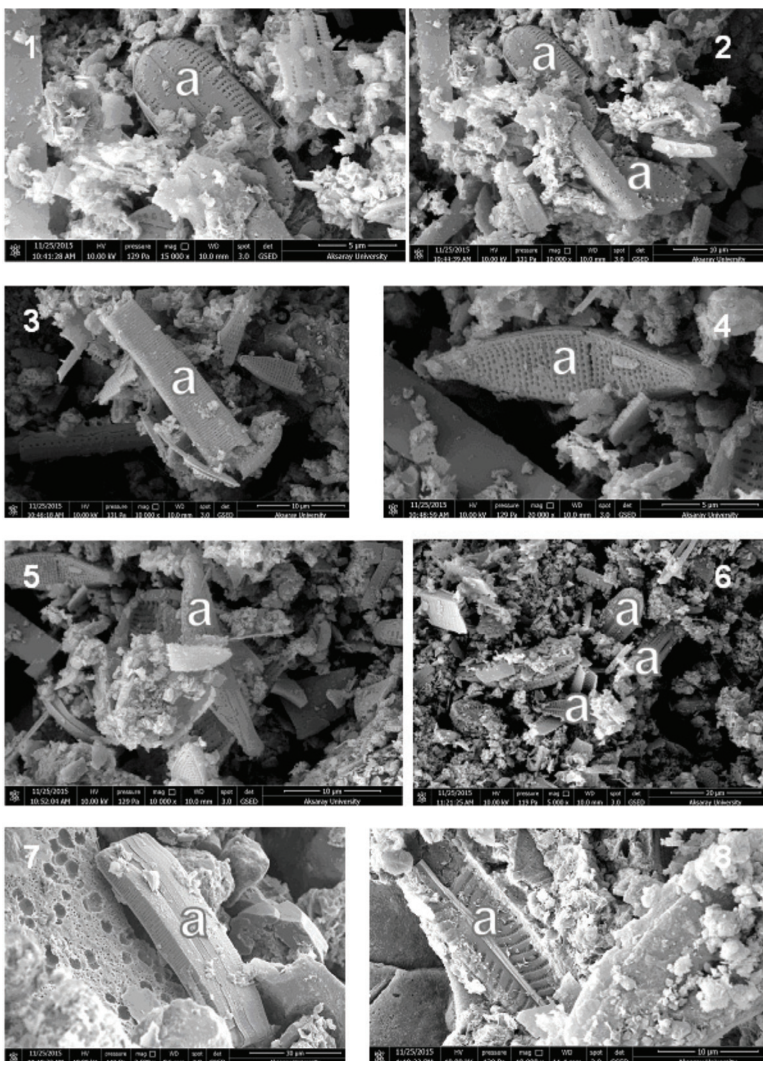

Figure 5- SEM photomicrographs from diatomite samples taken from the study area a- pennate diatom forms. 1- 6 from sample GÜ1–2, 7 from sample GÜ1–3 and 8 from sample TK–1.

1) were subjected to palynological analysis in the laboratory of the Geological Engineering Department of the Dokuz Eylül University (İzmir).

Evaluating the results of analyses performed, the physicochemical characteristics of diatomites in the study area were determined and the results were compared with standard analysis values of different diatomites which are used both in the world and in Turkey (Tables 7-9).

3. Regional Geology and Stratigraphy

The study area is located in the CVP which developed due to the closure of the Eurasian and the African-Arabian plates according to Batum (1978). The CVP is NE-SW extensional, 250-300 km long, 60 km wide and 1400-1500 m above the sea level (Aydar et al., 2012). The CVP is restricted by the Central Anatolian Fault in the east, by the Tuz Lake Fault Zone in the west and by the Central Kızılırmak Fault Zone in the north. In the south, the Derinkuyu Fault and the Niğde Fault Zones are located. The rock units of the CVP are divided into three groups as; the volcanic complexes, the volcanoclastic rocks and the cinder cone areas. Volcano-sedimentary rocks located in the region are discordant with the Paleozoic-Cretaceous basement rocks of the Niğde Massive in the south and the Kırşehir Massive in the north (Schumacher et al., 1990; Toprak, 1996). The sediments, which are located in the Ürgüp Basin, were defined as the Ürgüp formation by Pasquare (1968) and Viereck-Goette et al. (2010). According to the radiometric data these rocks were dated as the late Miocene-Pliocene (Besang et al., 1977). This stratigraphical level corresponds to the Massinian Salinity Crisis which formed in the late Miocene. The deposits of the Ürgüp formation, which

Table 7- Comparison of the analysis values of diatomites in the study area with the analysis values of different diatomites used in different areas in the World. 1) Spain, raw, 2) France, calcined, beer filtration, 3) İtalya, raw, light construction material, 4) Germany, fertilizer carrier, 5) Germany, calcined, beer filtration, 6) Germany, calcined and filler material, 7) Brazil, insulation material, 8) USA, calcined, filtering diatomite, 9) Basalt-Nevada (modified from Uygun, 2001; 8. Five years development plan, 2001).

	1	2	3	4	5	6	7	8	9	Tahar MSS	Güzelöz-1 MSS	Güzelöz-2 MSS
% SiO_2	86,6	89,9	88,6	69,7	82,9	92,1	86	88,4	83,13	61,25 - 66,18	38,16 - 67,77	56,59 - 61,83
% TiO_2	0,1	0,6	0,2	0,4	0,1	0,2	0,7	0,2		0,47 - 0,37	0,44 - 0,85	0,34 - 0,41
% Fe_2O_3	0,4	2,2	8,3	3,1	10,1	0,6	1,4	1,5	2	5,19 - 2,93	4,34 - 6,18	2,87 - 3,22
% Al_2O_3	0,9	3,9	1,7	4,9	1,8	2,6	9,4	4,1	4,60	11,13 - 14,40	8,75 - 12,96	6,17 - 7,44
% CaO	5,2	0,8	0,6	0,4	2,5	0,1	0,1	0,6	2,50	1,1 - 1,28	2,23 - 20,69	1,81 - 2,49
% MgO	0,6	0,2	0,1	0,1	0,4	0,1	0,4	0,8	0,64	2,5 - 2,02	0,2 - 2,08	7,43 - 14,12
% Na_2O	0,2				1,1	0,9		2,9	1,60	0,28 - 1,04	0,34 - 0,70	0,75 - 1,99
% K_2O	0,1	0,2	0,3	1,2	0,3	0,3	0,2	0,7		1,35-3,66	1,01 - 2,11	0,71 - 0,84
% P_2O_5	0,2	0,3	0,1	0,1	0,1	0,1		0,2		0,04	0,01 - 2,14	0,01 - 0,02
% V_2O_5 + TiO_2									0,23			
% MnO										0,02 - 0,06	0,05 - 0,07	0,043- 0,06
%Loss on Ignition (850°C)	5,5	0,7	0,5	19,1	0,5	3	2	0,3	5,30	16,61 - 8,18	13,09 - 22,82	15,10 - 16,96
Average Particle Size (μ)	3,4	2,7	2,4	4,7	4,5	1,2	2,7	14,7		0,9	15 -20	0,7 - 6
Particles Smaller than 20 μ (%)	3,7	0,8	1,6	23,4	6,8	2,7	4,6	31,8		9,42	24,45 - 55,25	23,32 - 27,07
Wet Density (gr/cm^3)	4,17	2,44	2,44	3	2,17	2,50	2,08	2,44		2,5 - 2,49	2,33 - 2,38	2,33 - 2,4
Filtration Rate (ml/min)	12	52	30	18	70	10	50	740		351	138 - 185	
pH	8,3							8,8		5,5 - 5	6 - 6,5	6,5 - 7
Quartz (%)				18								

Table 8- Comparison of the analysis values of diatomites in the study area with the analysis values of various commercial diatomite used in Turkey. 1) Kayseri, 2) Kayseri-Hırka, 3) Aydın-Dedeler, 4) Ürgüp, 5) Denizli-Sarayköy, 6) Kütahya-Alayunt, 7) Balıkesir-Balya, 8) Aksaray-Belisırma, 9) Afyon-İncehisar, 10) Afyon-Tınaztepe, 11) Ankara-Kızılcahamam, 12) Çankırı-Çerkeş (modified from Sarıiz and Nuhoğlu, 1992; Aruntaş et al., 1998; Bozkurt, 1999; Nuhoğlu and Elmas, 1999; Bentli, 2001; 8. Five years development plan., 2001; Uygun, 2001).

	1	2	3	4	5	6	7	8	9	10	11	12	Tahar MSS	Güzelöz-1 MSS	Güzelöz-2 MSS
%SiO_2	90,2	90,0	89,6	88,7	85,0	84,42	79,5	72,1	81,86	84,15	88,62	83,25	61,25 - 66,18	38,16 - 67,77	56,59 - 61,83
% TiO_2	0,1	0,2	0,01	0,06	0,01	0,05		0,2					0,47 - 0,37	0,44 - 0,85	0,34 - 0,41
% Fe_2O_3	0,8	1,1	1,4	3,38	2,8	1,55	3,24	4,4	1,87	3,36	0,57	1,20	5,19 - 2,93	4,34 - 6,18	2,87 - 3,22
% Al_2O_3	3,3	2,9	2,1	1,11	5,0	5,02	6,14	13,1	3,91	4,50	3,30	5,50	11,13 - 14,40	8,75 - 12,96	6,17 - 7,44
% CaO	0,6	0,7	0,01	1,35	0,01	0,96	1,2	0,9	0,86	1,07	0,74	1,30	1,1 - 1,28	2,23 - 20,69	1,81 - 2,49
% MgO	0,3	0,5	1,2	0,38	1,6	0,74	1,19	3,7	0,15	1,03	0,80	0,90	2,5 - 2,02	0,2 - 2,08	7,43 - 14,12
% Na_2O		0,6	0,06	0,28	0,13	0,62		0,17		0,47	0,77	0,95	0,28 - 1,04	0,34 - 0,70	0,75 - 1,99
% K_2O	0,1	0,2	0,15	0,32	0,4	0,60		1,9		0,44	0,71	1,30	1,35-3,66	1,01 - 2,11	0,71 - 0,84
% P_2O_5			0,01	0,42	0,01			0,1					0,04	0,01 - 2,14	0,01 - 0,02
% MnO													0,02 - 0,06	0,05 - 0,07	0,043- 0,06
% Loss on Ignition (850°C)	4,2	4,6	5,5	2,7	5,25	6,09	8,35	4,2	11,31	4,92	4,24	5,54	16,61 - 8,18	13,09 - 22,82	15,10 - 16,96
Average Particle Size (µ)	3,3					10					145	90	0,9	15 -20	0,7 - 6
Particles Smaller than 20 µ (%)	2,7												9,42	24,45 - 55,25	23,32 - 27,07
Wet Density (gr/cm^3)	2,94					1,9 2,4					1,95	1,90	2,5 - 2,49	2,33 - 2,38	2,33 - 2,4
Filt. Rate (ml/min)	48												351	138 - 185	
pH		8									7,87	7,28	5,5 - 5	6 - 6,5	6,5 - 7
Color						White					White	White	White	White	White

Table 9- Comparison of the analysis values of diatomites in the study area with standardly accepted values of diatomites used in various branches of industry for commercial purposes (modified from Özbey and Atamer,1987; Açıkalın, 1991; Aruntaş et al., 1998; Bentli, 2001).

	Commercial	Diatomites used in Turkey Sugar Factories	Filter		Filling			Abrasive Car Polish	Regulatory Fertilizer	Tahar MSS	Güzelöz-1 MSS	Güzelöz-2 MSS
			Wine	Sugar	Paper	Dye	Rubber					
%SiO_2	>85	87,3								61,25 - 66,18	38,16 - 67,77	56,59 - 61,83
% Fe_2O_3	<1,5	1,95								5,19 - 2,93	4,34 - 6,18	2,87 - 3,22
% Al_2O_3	<5	3,23								11,13 - 14,40	8,75 - 12,96	6,17 - 7,44
% CaO	<1	1,09								1,1 - 1,28	2,23 - 20,69	1,81 - 2,49
% MgO	<0,5	0,45								2,5 - 2,02	0,2 - 2,08	7,43 - 14,12
% Na_2O	<1	0,47								0,28 - 1,04	0,34 - 0,70	0,75 - 1,99
% K_2O	<1	0,44								1,35-3,66	1,01 - 2,11	0,71 - 0,84
% Loss on Ignition (850°C)	< 6	4,43								16,61 - 8,18	13,09 - 22,82	15,10 - 16,96
Average Particle Size (µ)			2,5	22		6,8	5,1	5,5		0,9	15 -20	0,7 - 6
Wet Density (gr/cm^3)			2,3	2	2,4	2,2	2,8	2,4	1,7	2,5 - 2,49	2,33 - 2,38	2,33 - 2,4
Water Absorption (%)	>280 >180											
pH		4,49	7	10	7	10	7	9,4	7	5,5 - 5	6 - 6,5	6,5 - 7
Moisture (%)	<15											
Color	White	Dirty White	Pink	White	Grey	White	Pink	White	Yellowish	White	White	White

intercalates with lake and river sediments, has a wide spread within the CVP. The Formation is divided into three groups as; the Bayramhacılı, Mustafapaşa and Kışladağ members (Viereck-Goette et al., 2010; Göz et al., 2014).

From bottom to top, the stratigraphical units observed in the study area are; the late Cretaceous plutonic rocks (Ortaköy Granitoid), the late Miocene-Pliocene Bayramhacılı Member of the Ürgüp formation (consisting of Cemilköy, Tahar and Kızılkaya ignimbrites), Kışladağ Member and Quaternary alluvial (Figure 6).

Plutonic Rocks (Ortaköy Granitoid): It was defined by Atabey et al. (1987) considering the exposures around Ortaköy. It is formed from the rocks of gabbro, banded gabbro, porphyry diorite, monzonite, syenite, monzodiorite, leucogranite and porphyry granite (Atabey, 1989). Gabbro, gneiss and marble enclaves are present in granites, and occasionally consist of coarse orthoclase crystals. Granite and granodiorites are occasionally disintegrated and mylonitized and cut metamorphic units. Ortaköy Granitoid corresponds to the Baranadağ Pluton (Seymen, 1981). Granitic rocks outcropping in the region were dated as; the Paleocene by Seymen (1981), the late Cretaceous by Ataman (1972) and the early Cenomanian by Göncüoğlu (1986) in the Niğde Massive.

Ürgüp Formation: The age of the formation is late Miocene-Pliocene (Besang et al., 1977) based on radiometric data. It outcrops between the Kırşehir Massive and Taurides and covers a wide area in Kayseri, Nevşehir and Niğde in the Central Anatolia. The volcanosediments, which consist of pyroclastics and ignimbrites with different particle sizes in terrigenous facies, were defined as the Ürgüp formation by Pasquaré (1968). The Ürgüp formation is divided into Bayramhacılı, Mustafapaşa and Kışladağ members (Viereck-Goette et al., 2010; Göz et al., 2014).

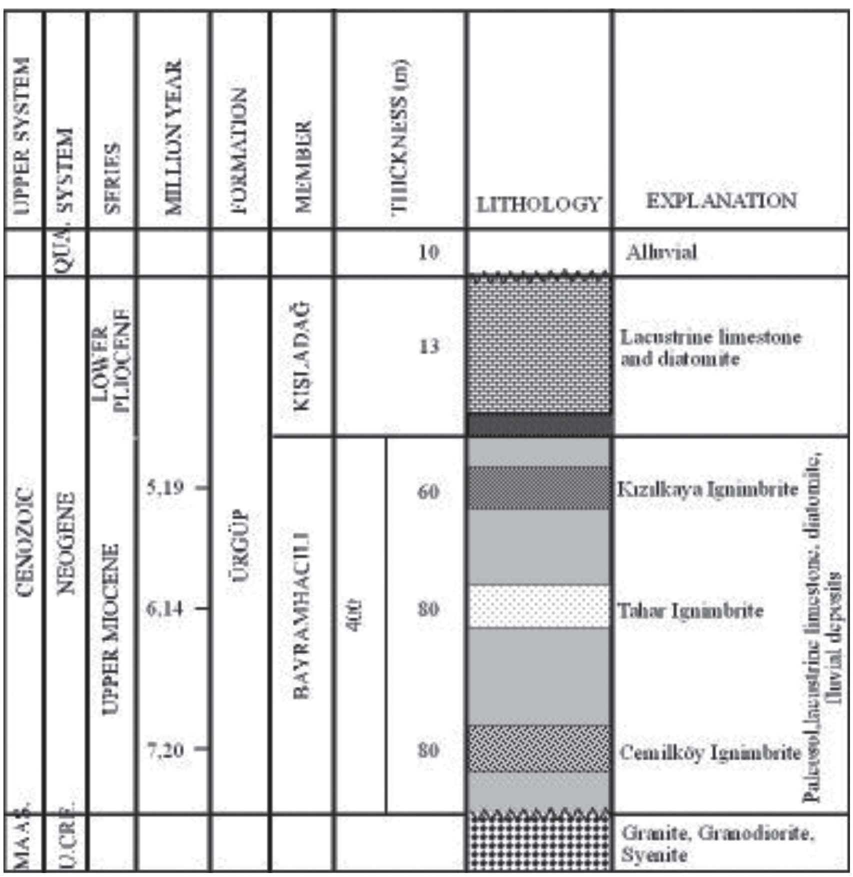

Figure 6- Unscaled generalized stratigraphic section of the study area (modified from Pasquaré, 1968; MTA, 1989; Viereck-Goette et al., 2010; Göz et al., 2014).

Bayramhacılı Member: It is formed by the river and lake sediments consisting of conglomerate, sandstone, limestone, marl and diatomites. In the Bayramhacılı member, ignimbrites (the oldest ignimbrite, Güvercinlik, Kavak, Zelve, Sarımadentepe (or Sofular), Cemilköy, Tahar, Gördeles and Kızılkaya ignimbrites), basalts (Domsa, Topuzdağı and Çataltepe basalts) and lava layers are observed (Atabey, 2013). Kavak, Zelve and Sarımadentepe ignimbrites are white-gray, however the Cemilköy ignimbrite is light gray in color. The pink colored Tahar ignimbrite, light gray colored Gördeles ignimbrite and red-pink colored Kızılkaya ignimbrite are widespread (Le Pennec et al., 1994). The age of ignimbrites in the Ürgüp formation were detected as 9-1 my based on $^{40}Ar/^{39}Ar$ and U-Pb dating (Aydar et al., 2012; Lepetit et al., 2014).

Kışladağ Member: This unit is Pliocene and formed by the lacustrine limestone and diatomites. Within lacustrine limestones of the unit the ostracod and gastropod fossils are present (Viereck-Goette et al., 2010; Göz et al., 2014).

Quaternary Alluvials: The alluvials in the study area are formed by pebble, sand, silt and soil which are observed on branches of the Kızılırmak River (Atabey, 2013).

4. Stratigraphical Sections Measured in the Study Area

Total of three stratigraphical sections one of which was from the Bayramhacılı member (Tahar section TS) and other two sections within the Kışladağ Member (Güzelöz-1 (GÜ1) and Güzelöz-2 (GÜ2)) were measured from the late Miocene-Pliocene lacustrine sediments of the Ürgüp formation (Figures 1-4).

Tahar Measured Stratigraphical Section (TS): TS was measured as 50 m thick in the 1/25000 scale Kayseri K33-c3 sheet (with starting coordinates (in UTM) of (Y): 0672742, (X): 4269675, (Z): 1320 m and end coordinates (UTM) of (Y): 0672625, (X): 4269784, (Z): 1370 m) and the total of 7 samples were taken along the section. TS begins with light brown paleosol layer at the bottom then continues with 2 m thick white diatomite layers above. Diatomite layers are then overlain by 12 m thick light gray tuffites, 50 cm thick fluvial conglomerate, 22,5 cm thick light gray tuffites. Tuffites are then overlain by 50 cm thick fluvial conglomerate, 50 cm thick light brown-cream colored paleosol, 1 m thick light gray tuffites and by 50 cm thick light brown chert layer. Above the cherts, nearly a 2 m thick pink colored Tahar ignimbrite are observed. This ignimbrite is then overlain by a 3 m thick white tuffites, 50 cm thick light brown cherts, 2 m thick light gray tuffites, then 1,5 m thick light gray Gördeles ignimbrite and 1,5 m thick white tuffites take place. In the uppermost part, the red-pink colored Kızılkaya ignimbrite is observed (Figures 1 and 2).

Güzelöz-1 (GÜ1) Measured Stratigraphical Section*:* The GÜ1 section was measured as 36 m thick in the 1/25.000 scale Kayseri L33-b2 sheet (with starting coordinates (in UTM) of (Y): 0672269, (X): 4251444, (Z): 1525 m. and end coordinates (UTM) of (Y): 0672278, (X): 4551642, (Z): 1561m.) and total of 5 samples were taken along the section. The GÜ1 section begins with 1,5 m thick light gray tuffites at the bottom and then 4,5 m thick white diatomite layer takes place. Diatomites are then overlain by a 17 m thick light gray tuffite layer. Tuffites are overlain by the light colored fluvial conglomerates, light brown paleosol layer and light gray sandstones, each layers as being in one meter thickness. The sandstones are then overlain by a 9 m thick white diatomites. Nearly one meter thick, light gray sandstones form the uppermost layer of the section (Figures 1 and 3).

Güzelöz-2 (GÜ2) Measured Stratigraphical Section: The GÜ2 section was measured as 4 m. thick in the 1/25000 scale Kayseri L33-b2 sheet (with starting coordinates (in UTM) of (Y): 0670066, (X): 4249808, (Z): 1514 m (UTM); and end coordinates of (Y): 0670099, (X): 4249776, (Z): 1518 m) and total of 4 samples were taken along the section. The GÜ2 section begins with 50 cm thick light brown paleosol layer at the bottom. Then from bottom to top, it is overlain by a 10 cm thick light brown chert layer, a 90 cm thick white colored tuffite layer, 10 cm thick light brown-cream colored second chert layer. The cherts are then overlain by a 40 cm thick debris and nearly 1 m thick white colored diatomite layer. Diatomites are then overlain by a 20 cm thick light colored paleosol layer and by a 25 cm thick second diatomite layer, 30 cm thick tuffites and by a 25 cm thick third diatomite layer. The white colored limestones form the uppermost part of the section (Figures 1 and 4).

It was observed that diatomites in three locations were light, relatively soft and easily disintegrated in hand.

5. Results of the Analyses of Samples Collected From the Study Area

In order to determine the physicochemical characteristics and the areas of use of diatomites in the study area, SEM photos of diatomite assemblages, which are consisted by three samples (TK–1, GÜ1–2 and GÜ1–3) taken from the study area, were evaluated and noticed that they were generally formed from coarse, long and coarse pennate diatom forms (Figure 5).

As a result of the XRD analysis (qualitative) applied on samples, it was noticed that results of analysis of samples collected from both locations (Tahar and Güzelöz) showed differences from each other. It is observed that clay, pyroxene minerals and amorphous materials were present in addition to quartz and crystobalite minerals in samples collected from the Tahar section (TS). However; the calcite, quartz, crystobalite, feldspar mineral, clay, mica, amphibole minerals and amorphous materials are observed in samples collected from the Güzelöz-1 (GÜ1) section (Table 1).

As a result of total porosity, whiteness, water and acid insoluble matter amount analyses applied on the samples, it was determined that results of analysis for the samples collected from both locations (Tahar and Güzelöz) showed resemblances with each other. The have high porosity between 57-60%, whiteness values varying between 80,45-84,79, acid insoluble matter in 74,20-84,20%, water insoluble matter in 99.80%, and thus they are inert against chemical reactions. The colors of diatomites can be white, light yellow, beige, and gray. However, the ones rich in organic matter can be in colors closer to green, brown and black (Cummins, 1960; Uygun, 1976; Brady and Clauser, 1991). Diatomites in the study area are in white color, so it can be said that they are pure and do not contain any organic material (Table 2).

As a result of specific surface area, pore volume and pore size analyses the following results were obtained as; the multi-point BET values between 5,427 e+01 - 6,771 e+01 m^2/g, t-method outer surface area values between 2,922 e+01 - 4,787 e+01 m^2/g, t-method micropore surface area values between 2,505 e+01 - 1,984 e+01 m^2/g, NLDFT cumulative surface area values between 4,047 e+01 - 5,160 e+01 m^2/g, t-method micropore volume values between 1,148 e-02 - 8,515 e–02 cc/g, t-method micropore surface area values between 2,505 e+01 - 1,984 e+01 m^2/g, HK method cumulative pore volume values between 2,966 e-02 - 3,751 e–02 cc/g, SF method cumulative pore volume values between 2,975 e-02 - 3,762 e–02 cc/g, NLDFT method cumulative pore volume values between 4,630 e-02 - 5,580 e–02 cc/g, HK method pore radius values between 2,158 e-04 µ, SF method pore radius values between 2,261 e-04 µ and NLDFT pore radius values between 5,888 e-04 µ -1,448 e-03 µ, for diatomites collected from the study area. Thus, they have a high porosity (Table 3).

As a result of XRF, loss on ignition, particle size, density and pH analyses applied; it was detected that diatomite samples collected from the Tahar locality contained 61,25 - 66,18% SiO_2, 0,37 - 0,47% TiO_2, 2,93 – 5,19% Fe_2O_3, 11,13 - 14,40% Al_2O_3, 1,1 - 1,28% CaO, 2,5 - 2,02% MgO, 0,28 - 1,04% Na_2O, 1,35 - 3,66% K_2O, 0,04% P_2O_5, 0,02 - 0,06% MnO. Loss on ignition values for the samples in 950°C vary between 8,18-16,61% and the average particle size values are 0,9 µ. The percentage of particle size values smaller than 20 µ are 9,42%, so the particle size of the samples are smaller than the sand size. It was also detected that their densities varied between 2,49-2,5 g/cm^3 and the infiltration rate values were 351 ml/min. The pH values vary between 5 - 5,5, reflecting the acidic environment (Tables 4-9).

The diatomite samples collected from the Güzelöz-1 locality contain 38,16 - 67,77% SiO_2, 0,44 - 0,85% TiO_2, 4,35 - 6,18% Fe_2O_3, 8,75 - 12,96% Al_2O_3, 2,23 - 20,69% CaO, 0,2 - 2,08% MgO, 0,06 - 0,70% Na_2O, 1,01 - 2,11% K_2O, 0,01- 2,14% P_2O_5, 0,05 - 0,0%7 MnO. Loss on ignition values of the samples in 950°C vary between 13,09-22,82%. Average particle size values are in between 15-20 µ and the percentage of the particle sizes smaller than 20 µ is between 14,45-55,45%, so the particle size of samples are below the sand size. Their densities are 2,33-2,38 g/cm^3, the infiltration rates vary between 138-185 ml/min, and pH values are in between 6,5-6. The samples reflect the acidic environment (Table 4-9).

Diatomite samples collected from the Güzelöz-2 locality contain 56,59 - 61,83% SiO_2, 0,34 - 0,41% TiO_2, 2,87 - 3,22% Fe_2O_3, 6,17 - 7,44% Al_2O_3, 1,81 - 2,49% CaO, 7,43 - 14,12% MgO, 0,75 - 1,99% Na_2O, 0,71- 0,84% K_2O, 0,01 - 0,02% P_2O_5, 0,043 – 0,06% MnO. Loss on ignition values of the samples in 950°C vary between 15,10-16,96%. Average particle size values are in between 0,7-6 μ and the percentage of the particle sizes smaller than 20 μ is between 23,32-27,07%, so the particle sizes of samples are below sand size. Their densities are 2,33-2,40 g/cm^3 and pH values are in between 6-7. The samples reflect the acidic and neutral environments (Table 4-9).

As a result of compaction analyses applied in order to determine whether diatomite samples in the study area could be utilized in road fillings the following values were detected; the maximum dry unit volume weight (pdmax) 0,992 g/cm^3 and optimum water content (wopt) 50,3% for samples TK1-2 collected from the Tahar locality; the maximum dry unit volume weight (pdmax) 0,972 g/cm^3 and optimum water content (wopt) 49,0% for samples GÜ1-2 collected from the Güzelöz-1 locality; the maximum dry unit volume weight (pdmax) 1.00 g/cm^3 and optimum water content (wopt) 54,6% for samples GÜ2-2 collected from the Güzelöz-2 locality. Again, as a result of the organic material detection test carried out on the same samples the solution colors were detected as darker than no-1 light color due to the correlation made by using the No: 815 Hellige Tester Color Plate at the end of 24 hours (Table 6).

Besides; there were not observed any palynomorph as a result of palynological analysis performed on diatomite samples which were collected from each three section in the study area.

6. Discussion and Results

Diatomites are amongst the natural raw materials required by the modern technology and have a wide area of use such as; filter, filling and insulating material, structural material, absorbent, carrier, catalyzer and catalyzer carrier, silicate manufacturing, mild abrasive and cleaner. The diatomite is used in the industry as the filtration material (58%), filling material (19%), insulating material (4%) and in different purposes (19%) (Uygun, 2001).

According to the data obtained in analyses, which were carried out on diatomite samples in the study area, the areas of utilization were given below.

For commercial purposes: The standard values of diatomites, which are commercially used in different areas in the world contain; 69,7 – 92,1% SiO_2, 0,1 – 0,7% TiO_2, 0,4 – 10,1% Fe_2O_3, 0,9 – 9,4% Al_2O_3, 0,1 – 5,2% CaO, 0,1 – 0,8% MgO, 0,2 – 2,9% Na_2O, 0,1 – 1,2% K_2O and 0,1 – 0,3% P_2O_5 and have loss on ignition values between 0,3-19,1% (in 850°C), the average particle size between 1,2-14,7 μ, wet density values between 2,08-4,17 g/cm^3, filtration rate values between 10-740 ml/min and pH values between 8,3-8,8 (reflecting the basic environment) (Uygun, 2001; 8th Five Years Development Plan, 2001) (Table 7). The diatomites in the study area have low SiO_2 values (between 38,16-67,77% in three locations), Al_2O_3 (11,13 – 14,40% in the Tahar location and 8,75 – 12,96% in the Güzelöz–1 location), MgO (0,2 – 14,12% in three locations), K_2O (1,35 – 3,66% in the Tahar location and 1,01 – 2,11% in the Güzelöz–1 location), CaO (2,23 – 20,69% in the Güzelöz–1 location), P_2O_5 (0,01 – 2,14% in the Güzelöz–1 location) and high loss on ignition values (in 950°C) (13,09 – 22,82% in the Güzelöz–1 location). They also have low pH values (in between 5-7) in three locations reflecting both the acidic and neutral environments. Therefore, they are not compatible with standard analysis values for diatomites which are commercially used in different areas in the world (Tables 4 and 7).

The diatomites commercially used in Turkey contain 72,1 – 90,2% SiO_2, 0,01 – 0,2% TiO_2, 0,2 – 4,4% Fe_2O_3, 1,11 – 13,1% Al_2O_3, 0,01 – 1,35% CaO, 0,15 – 3,7% MgO, 0,06 – 1,7% Na_2O, 0,1 - 1,30% K_2O and 0,01 – 0,42% P_2O_5 and have the loss on ignition values between (in 850 °C) 2,7 – 11,31%, the average particle sizes between 3,3 – 145 μ, the wet density values between 1,9 - 2,94 g/cm^3, the infiltration rate values at 48 ml/min and pH values between 7,28-8 (reflecting the basic environment) (Sarıiz and Nuhoğlu, 1992; Aruntaş et al., 1998; Bozkurt, 1999; Nuhoğlu and Elmas, 1999; Bentli, 2001; 8th Five Years Development Plan, 2001; Uygun, 2001). Low SiO_2 values for diatomites in the study area (38,16 – 67,77% in three locations), Al_2O_3 (11,13 – 14,40% in the Tahar location), TiO_2 (0,34 – 0,85% in three locations), Fe_2O_3 (4,34 – 6,18% in the Güzelöz–1 location), CaO (2,23 – 20,69% in the Güzelöz–1 location; 1,81 – 2,49% in the Güzelöz–2 location), MgO (7,43 – 14,12% in the Güzelöz–2 location), K_2O (1,35 – 3,66% in the Tahar location; 1,01 – 2,11% in the Güzelöz–1 location), P_2O_5 (0,01 – 2,14% in the Güzelöz–1 location), high loss on ignition values (in 950°C) (13,09 – 22,82% in three locations) and low pH values (between 5 – 7 in three locations) (reflecting acidic and basic environments) indicate that these diatomites are incompatible with those of commercially used in Turkey (Tables 4 and 8).

Besides; diatomites, which are generally used for commercial purposes should contain > %85 SiO_2, <%1,5 Fe_2O_3, < %5 Al_2O_3, < % 1 CaO, < % 0,5 MgO, < %1 Na_2O, < %1 K_2O, with loss on ignition values (in 850°C) < %6, water absorption values > % 280 and > % 180, moisture ratios < % 15 and their colors should be white according to Özbey and Atamer, 1987 and Aruntaş et al., 1998 (Table 9). The diatomites located in the study area in three locations have low SiO_2 values (38,16 – 67,77%), Fe_2O_3 (2,87 – 6,18%), Al_2O_3 (6,17 – 14,40%), CaO (1,1 – 20,69%), MgO (0,2 – 14,12%), Na_2O (0,06 – 1,99%), K_2O (0,71 – 3,66%) and high loss on ignition values (in 950°C) (8,18 – 22,82%) though they have white colors. Their color is the only one resemblance with the standard characteristics of commercially raw diatomites. Therefore, they are not suitable for commercial use (Tables 2, 4 and 9).

For filtering material: In order diatomites to be used as filtering material, they should at least contain 80-84% SiO_2 (Işık, 1984, Bozkurt, 1999). For filters, the diatomites which form from pure pennat and coarse diatom genus and species are preferred (Uygun, 2001). The diatomites in the study area seem to suitable for filter use with their high porosities (57 – 60%, pore volumes 1,148 e-02 – 8,515 e-02 cc/g, pore sizes 1,448 e-03A – 5,888 e-04A), resistances against chemical effects (amount of acid-insoluble matter 74,20 - 84,20%, amount of water-insoluble matter 99,80%), purities (whiteness values range between 80,45- 84,79) and were formed from long, coarse diatom genus and species. However, the diatomites in three locations do not seem to be compatible for use in filters with their low SiO_2 values (38,16-67,77%). In order diatomites in the study area to be used in filters, they should be subjected to SiO_2 enrichment (Tables 2-4) (Figure 5).

In wine filtering processes, the pink colored diatomites with particle size of 2,5 μ, wet density of 2,3 g/cm^3, pH value of 7 are used (Açıkalın, 1991) (Table 9). The particle sizes of diatomites in the study area to be high (between 6-20 μ), pH values to be relatively low (between 5-7) and their colors to be white, and only the wet density values in three locations (2,33-2,5 g/cm^3) indicate that they are suitable for the use in wine filtering processes, however the remaining values do not seem to be proper (Tables 4 and 9).

However, in sugar filtering the white colored diatomites with particle size of 22 μ, wet density of 2 g/cm^3, pH value of 10 are used (Açıkalın, 1991) (Table 9). Besides; when looking at diatomite values used in sugar factories in Turkey it is seen that they contain 87,3% SiO_2, 1,95 Fe_2O_3%, 3,23 Al_2O_3%, 1,09 CaO%, 0,45 MgO%, 0,47 Na_2O%, 0,44 K_2O%, have loss on ignition values of 4,43% (in 850°C) and pH values between 4,49-10 with their dirty white colors (7th Five Years Development Plan, 1996; Bentli, 2001) (Table 9). The white diatomite samples collected from three locations in the study area, the average particle sizes (between 15-20 μ) and wet density values (2,33-2,38 g/cm^3) of diatomites in the Güzelöz-1 location and only the wet density values (2,33-2,4 g/cm^3) of diatomites in the Güzelöz-2 location indicate that they are suitable for sugar filtering processes. However, pH values (between 5-7) of diatomites collected from three locations and the average particle sizes of diatomites in Tahar and Güzelöz-2 locations (0,7-6 μ) to be in low values show that they are not appropriate for sugar filtering processes. Besides, the white color, Na_2O values (0,28-1,99%) and pH values (between 5-7) of diatomites in the study area show compatibility with the diatomites currently used in sugar factories in Turkey, however the other characteristics do not display any compatibility (Tables 2, 4 and 9).

It is known that the diatomites, which are used in France, Germany and the USA for filtering material, contain 82,9 – 89,9% SiO_2, 0,1 – 0,2% TiO_2, 1,5 – 4,0% Fe_2O_3, 1,8 – 4,1% Al_2O_3, 0,2 – 0,8% CaO, 0,2 – 0,8% MgO, 1,1 – 2,9% Na_2O, 0,2 – 0,7% K_2O, 0,1 – 0,3% P_2O_5. Their loss on ignition values range between 0,3-0,7% (in 850°C), with the average particle size of 2,7-14,7 μ, wet densities of 2,17-2,44 gr/cm^3, filtering rate values of 52-740 ml/min and pH values of 8.8 (basic) (Uygun, 2001) (Table 7). As diatomite samples collected from three locations in the study area have low SiO_2 (38,16 – 67,77%), TiO_2 (0,37 – 0,85%), Fe_2O_3 (2,87 – 6,18%), Al_2O_3 (6,17 – 14,40%), CaO (1,1 – 20,69%), MgO (0,2 – 14,12%), K_2O (0,71 – 3,66%), P_2O_5 (0,01 – 2,14%) and high loss on ignition values (8,18-22,82%) (in 950°C), it is seen that they do not show any similarities with diatomites which are used as filtering material in France, Germany and the USA except for the NaO content (0,06 – 1,99%), wet density (2,33 – 2,5 g/cm^3) and filtration rate values (138 – 351 ml/min) (Tables 4 and 7).

For filling material: In diatomites, which are used for filling material, the purity, whiteness, fine grain texture, high porosity, lightness, resistance against chemicals, ability for heat, sound and electricity insulations and high absorption characteristic are required and should contain minimum 70-80% SiO_2 (Mete, 1982). As diatomites located in three locations have low organic matter ratios, white colors (whiteness value: 80,45-84,79), fine grain textures (particle sizes between 0,7-20 μ), high porosities (57-60%), with pore volumes of 1,148 e-02 – 8,515 e-02 cc/g), pore sizes of 1,448 e-03A – 5,888 e-04A, densities of 2,33-2,5 g/cm^3, high resistance against chemical effects (the amount of acid insoluble matter 74,20-84,20%, the amount of water insoluble matter 99,80%) and high absorption characteristic (specific surface area values 1,984 e+01 – 6,771 e+01 m^2/g), they seem to be suitable for use as the filling material except for their low SiO_2 values. In order that these diatomites in the study area could be used as the filling material they should be subjected to SiO_2 enrichment (Tables 2-4).

In dye sector, 200-300 μ particle size diatomite is generally added into dye in 2-3 % ratio and used. Table 9 shows the complete criteria list of diatomites used in dye, rubber and paper sectors. In the dye sector, the white colored diatomite with the average particle size of 6,8 μ, wet density of 2,2 g/cm^3 and pH value of 10; in the rubber sector pink diatomite with the average particle size of 5,1 μ, wet density of 2,8 g/cm^3 and pH value of 7 (neutral) and in the paper sector gray diatomite with the wet density of 2,4 g/cm^3 and pH value of 7 are preferred (Türkiye Diatomit Envanteri, 1968; Özbey and Atamer,1987; Açıkalın, 1991; 7th Five Years Development Plan, 1996; Bentli, 2001). Only the diatomites located in the Güzelöz-2 location in the study area are suitable for use as the filling material in rubber and paper sectors (with the average particle sizes of 0,7-6 μ, the wet densities of 2,39-2,4 g/cm^3 and pH values of 6-7). Diatomites located in three locations are not suitable for use in dye sector in terms of pH values (5-7). Besides, diatomites located in the Tahar and Güzelöz-1 locations are not also suitable for use in rubber and paper sectors in terms of pH values (5-6,5) (Tables 4 and 9).

When we have a look at the diatomite values, which are used for filling material in Germany, it seen that they contain 92,1% SiO_2, 0,2% TiO_2, 0,6% Fe_2O_3, 2,6% Al_2O_3, 0,1% CaO and MgO, 0,9% Na_2O, 0,3% K_2O and 0,1% P_2O_5 and have loss on ignition value around 3% (in 850°C), average particle size value of 1,2 μ, wet density value of 2,50 g/cm^3 and the filtration rate value of 10 ml/min (Uygun, 2001) (Table 7). The analysis results of diatomites collected from three locations in the study area do not show any compatibility with diatomite values, which are used as the filling material in Germany, except for NaO (0,06-1,99) and wet density values (2,33-2,5 g/cm^3) (Tables 4 and 7).

According to the Tecnical Specification of the General Directorate of Highways (2013) , the dry unit volume weight (pdmax) of the material to be used in the road filling should be equal or greater than 1450 g/cm^3 and should not contain any organic matter (Table 10). The maximum dry unit volume weight (pdmax) of the sample TK1-2 collected from the Tahar location in the study area is 0,992 g/cm^3 with the optimum water content (wopt) value of 50,3%; the maximum dry unit volume weight (pdmax) of the sample GÜ1-2 collected from the Güzelöz-1 location is 0,972 g/cm^3

Table 10- Properties of the material to be used in the road fill according to the Technical Specifications of Highways (2013). in various branches of industry for commercial purposes (modified from Özbey and Atamer,1987; Açıkalın, 1991; Aruntaş et al., 1998; Bentli, 2001).

Material Criteria	Technical Specification for the General Directorate of Highways (2013)
Liquid Limit (%)	ủ 60
Plasticity Index	ủ 35
Material Class	A-4
Maximum Dry Unit Volume Weight (pdmax)(gr/cm^3) / **% Optimum Water Content (wopt)**	ῆ1,450
% # 200 Subsieve	
Organic Material Prediction	Not Organic Material (lighter than light color-1)

with the optimum water content (wopt) value of 49% and the maximum dry unit volume weight (pdmax) of the sample GÜ2-2 collected from the Tahar location in the study area is 1 g/cm^3 with the optimum water content (wopt) value of 54,6%. Again, as a result of organic material detection test carried out on the same samples the solution colors were detected as darker than no-1 light color due to the correlation made by using the No: 815 Hellige Tester Color Plate at the of 24 hours. Samples collected from three locations have fragility and fragmentation characteristic as they have low maximum dry unit volume weight (≥ 1,450 g/cm^3) and as a result of organic matter test they are also darker than the light color number #1. Therefore they do not have compatibility for use as the filling material (Tables 6 and 10).

For construction material: There is also a possibility to benefit from the low quality diatomites in the area of construction material (Türkiye Diyatomit Envanteri, 1968; 8th Five Years Development Plan, 2001; Uygun, 2001). Therefore, the diatomites in the study area can be used as the construction material.

Besides, the diatomite can also be used as a mineral additive matter in the portland cemented concretes; for this, the sum of SiO_2+Al_2O_3+Fe_2O_3 should be minimum 70% and the loss on ignition should be maximum 10% (Aruntaş et al., 1998). The SiO_2+Al_2O_3+Fe_2O_3 sums and the loss on ignition values (in 950°C) of diatomites for the Tahar, Güzelöz-1 and Güzelöz-2 locations in the study area are respectively given as follows; for Tahar location 75,31-85,77% and 8,18-16,61%; for Güzelöz-1 location 51,54-86,91% and 15,10-16,96%; and for Güzelöz-2 location 65,63-72,49% and 1309-22,82%. So; diatomite samples collected from three locations cannot be used as the mineral additive matter without applying a direct process in portland cemented concretes as they have loss on ignition values higher than the standards (Table 4).

When we have a look at the analysis values of diatomites, which are used as the construction material in Italy, it is seen that they contain 88,6% SiO_2, 0,2% TiO_2, 8,3% Fe_2O_3, 1,7% Al_2O_3, 0,6% CaO, 0,1% MgO and P_2O_5 and 0,3% K_2O and have loss on ignition value of 0,5% (in 850°C), the average particle size values of 1,6 μ, the wet density values of 2,44 g/cm^3, the filtration rates of 30 ml/min (Uygun, 2001) (Table 7). The results of analyses of diatomites collected from three locations in the study area do not show any similarity with the analysis values of diatomites, which are used as the construction material in Italy, except for the Fe_2O_3 (% 2,87 – 6,18) and wet density values (2,33 – 2,5 gr/cm^3) (Tables 4 and 7).

As carrier: The diatomites, which are preferred as the carrier in fertilizer industry, are required to have a wet density of 1,7 g/cm^3 and pH of 7 (Özbey and Atamer, 1987; Açıkalın, 1991; 7th Five Years Development Plan, 1996; Bentli, 2001) (Table 9). Diatomites in the study area are not suitable for use as the carrier with wet density values of 2,33-2,5 g/cm^3 and pH values between 5-7 (Tables 4 and 7).

The values of diatomites, which are used as the fertilizer carrier in Germany, contain 69,7% SiO_2, 0,4% TiO_2 and CaO, 3,1% Fe_2O_3, 4,9% Al_2O_3, 0,1% MgO and 1,2% K_2O and have the loss on ignition value of 19,1% (in 850°C), the average particles size value of 4,7 μ, the wet density value of 3 g/cm^3, the filtration rate value of 18 ml/min and contain 18% quartz (Uygun, 2001) (Table 7). The results of analyses of diatomites collected from three locations do not show any similarity with diatomite values, which are used as the fertilizer carrier in Germany, except for the values of Fe_2O_3 (2,87 – 6,18%), K_2O (0,71 – 3,66%), the loss on ignition (8,18 – 16,96%) and the wet density (2,33 – 2,5 g/cm^3) (Tables 4 and 7).

In silicate manufacturing: The diatomites located in the study area can be used in silicate manufacturing with SiO_2 values of 38,16-67,77% as there was not given any limiting value (Table 4).

As mild abrasive and cleaner: The average particle size, wet densities and pH values of diatomites, which are preferred as the abrasive in auto polishes are; 5,5 μ, 2,4 g/cm^3 and 9,4, respectively (Özbey and Atamer, 1987; Açıkalın, 1991; 7th Five Years Development Plan, 1996; Bentli, 2001) (Table 9). The diatomites in the study area have low pH values (between 5-7), therefore they are not suitable for use as the mild abrasive and cleaner (Tables 4 and 9).

As insulating matter: The diatomites should contain minimum 94% SiO_2 in order to be used as the insulating matter (Bentli, 2001). Diatomites located in the study area are not suitable for use as the insulating matter as they have low SiO_2 content (38,16-67,77%) (Table 4).

The diatomites, which are used as the insulating matter in Brasil, contain 86% SiO_2, 0,7% TiO_2, 0,1% Fe_2O_3 and CaO, 9,4% Al_2O_3, 0,4% MgO and 0,2%

K_2O and have the loss on ignition of 2% (in 850°C), the average particle size of 2,7 µ, the wet density of 2,08 g/cm^3, the infiltration rate of 50 ml/min (Uygun, 2001) (Table 7). The results of analyses of diatomites collected from three locations do not show any similarity with diatomite values used as the insulating matter in Brasil except for the values of TiO_2 (0,34 – 0,85%) and Fe_2O_3 (2,87 – 6,18%) (Tables 4 and 7).

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