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MINERALOGICAL AND TECHNOLOGICAL PROPERTIES OF THE ZEOLITES FROM FOÇA (İZMİR), BİGADİÇ (BALIKESİR) AND GÖRDES (MANİSA)

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ABSTRACT.- Technological analyses of zeolites are important for their areas of use. Zeolite samples were collected from different regions (İzmir-Foça, Balıkesir-Bigadiç, Manisa-Gördes) for this study.
First mineralogical and chemical analyses of the samples were conducted in the study. Later on, technological tests of the samples were made for their utilizing in ceramic industry (pre- technological), in paper industry (filling and coating) and as cat litter. Finally the results were evaluated.
It was concluded that some samples can be used in baked ceramics in ceramic industry; they have high whitening properties to be used in paper industry. As for cement additives, their flexural strength is observed in a range between 0,94 - 12,85 kgf/cm^2 while their compressive strength is between 2,08 - 51,20 kgf/cm^2. Porosity of some samples are above 40% which means they meet the criteria to be used as soil conditioners.

Key words: Zeolite, Foça, Bigadiç, Gördes

INTRODUCTION

Zeolites which are defined as hydrous aliminium silicates with alkaline and earth alkaline elements are among significant industrial raw materials because of their physical and chemical properties.

In this study the zeolite samples collected from İzmir (Foça), Balıkesir (Bigadiç) and Manisa (Gördes) regions were investigated for their mineralogical and technological properties to define their areas of usage (Figure 1).

For this reason, thin sections of the samples were prepared and their mineralogical determinations, XRD and XRF analyses were performed. By thin sections and XRD analyses types of zeolites were determined. As for the technological properties, pre-technological investigation methods, water and oil absorption capacities, cat litter test, whiteness and abrasion tests, porosity and pozzolanic tests were applied to reach to the results of the areas of usage. Experiments and tests were conducted in the laboratories of the Department of MAT of MTA.

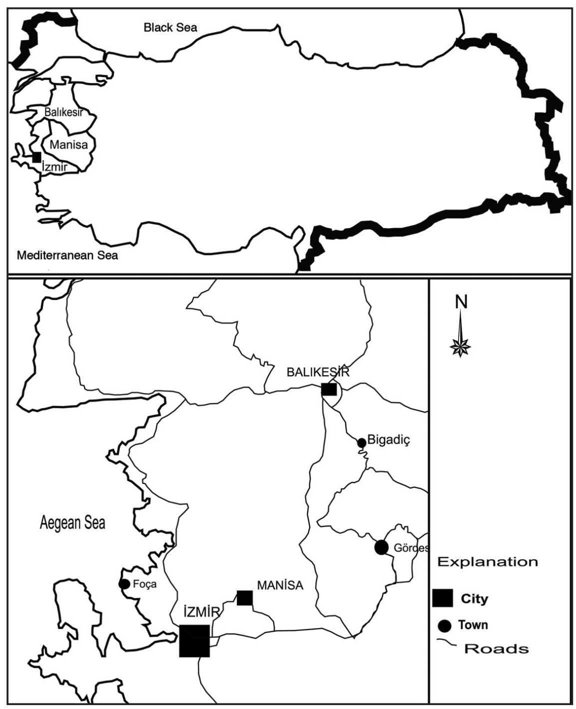

Figure 1- Location map of the study area (Foça,Bigadiç and Gördes)

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Literally the word “ZEOLITE” means “boiling rock”. The name was given to the rock since it explodes and decomposes when heated. In general, the natural zeolites are used as light building rocks and light aggregates in construction industry and as additives in paper industry and as soil conditioner and additive for fertilizers in agriculture industry (Yücel, 1987).

Zeolite minerals include empty spaces and channels in their structures. Since they can lose the water in these empty spaces and channels without changing their structures under high temperatures, based on their loose skeletal structures, they have replaceable cations. For this reason, they are succesfully used in adsorbtion, ion Exchange and dehydration areas.

Öner et al., (2000) have studied different aspects of the zeolites collected from Manisa-Gördes area in course of their project titled “Geological, mineralogical and chemical properties of zeolitic tuffs and their areas of usage in industry”.

Albayrak et al., (2001) have used zeolite (clinoptilolite) instead of quartzite to produce gas concrete during their Project titled “Production of light building Stones from zeolites”.

Kalafatoğlu et al., (2002) prepared “Bibliography of Zeolite Research” in TÜBİTAK Marmara Research Center in which, researches on zeolites in Turkey based on earthsciences; researches on characterization of zeolites in Turkey; application-oriented researches on zeolites, synthetic zeolites and zeolitic borophosphates were discussed.

GEOLOGY

MANİSA GÖRDES REGİON

The volcanosedimentary formations known as Gördes zeolites were formed by flowing and deposition of rhyolitic, rhyo - dacitic eruptions of Kobaklar Volcanism (Göktaş et al., 1996) located in the north of Gördes into the Lake Gördes which was a sedimentation basin in that period.

In Gördes and the surrounding area, metamorphic rocks (gneiss, migmatite, micaschist, quartzite) of Menderes massif are located at the basement (Figure 2).

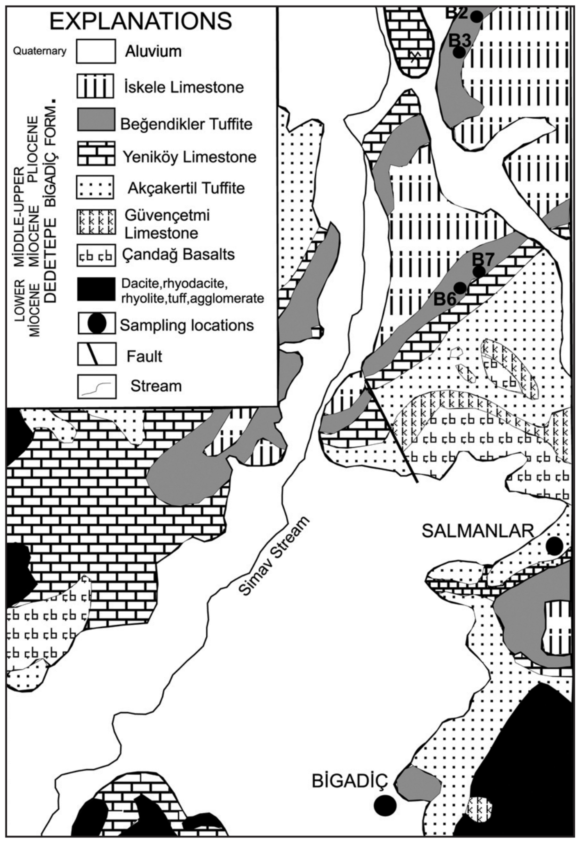

Figure 2- Geological map of Bigadiç and its surroundings and sampling locations (modified from Ercan et al., 1984).

Lower Miocene Kürtköyü, Yeniköy and Çıtak formations unconformably overlie the Menderes massif. Kürtköyü formation is dominantly composed of boulderstone, coarse conglomerate, conglomerate and sandstones. It is unconformably overlain by Yeniköy formation which is comprised dominantly of conglomerate, sandstone and mudstones which includes lignite levels. There are algal limestone interbeds at the upper levels of this formation.

Küçükderbent formation conformably and transitively overlies the Yeniköy formation. It is dominantly comprised of clayey limestone, shale, mudstone, sandstone, tuff and less bituminous shales which reflect a lacustrine environment. This unit is unconformably overlain by Gökyar formation which is made up of rhyolitic tuffs. In Manisa-Gördes region mostly clinoptilolite minerals and less hoylandite and analcime bearing levels are observed (Vural and Albayrak, 2005). Calcalkaline volcanism comprised of lava and tuffs of dacitic, rhyodacitic composition which activated in Early Upper Miocene ends the Küçükderbent lacustrine deposition. These volcanics were defined as Karaboldere Volcanics (Ercan, 1983). All these units were unconformably overlain by Upper Miocene-Pliocene sedimentary sequence.

BALIKESİR (BİGADİÇ) REGION

The sequences cropping out in Balıkesir-Bigadiç region were compiled from Ercan et al., (1984a, b) (Figure 3).

Figure 3- Geological columnar section of Gördes and the surrounding area (modified from Göktaş, 1966).

The Lower Miocene Dedetepe formation is comprised of dacite, rhyodacite, rhyolite, tuff and agglomerate. At the lower levels of the formation brown, pink, grey colored, locally altered dacite, rhyolite and agglomerates take place, on the other hand, at the upper levels tuffs are dominant. The Çandağ basalt which is located on the unit is comprised of basalt, trachy - basalt, agglomerate and tuffs, from bottom to top. The fresh surfaces of the rocks are black colored while the altered parts are red-brown. The unit is quite hard and irregular. Flow structures and hexagonal cooling (columnar jointings) structures are observed in the lavas. On these volcanic rocks unconformable lacustrine deposits known as Bigadiç formation are observed. This formation is comprised of five members. These are: Güvemçetmi Limestone Member, Akçakertil tuffite member, Yeniköy limestone member, Beğendikler tuffite member, İskele Limestone Member. Bigadiç formation is probably of Upper Miocene-Lower Pliocene age. Akçakertil tuffite member which conformably overlies the Güvemçetmi limestone member in the study area is quite widespread, its tuffite levels are light grey, white, yellowish in color and they are dacitic and rhyodacitic in composition. It is locally calcite and silicium cemented. Tuffs are also observed in Akçakertil tuffite member. The tuffs which are intercalated with tuffs have various grain size, they are glassy and irregularly distributed. Ataman (1977) determined zeolite formations in these tuffs. Beğendikler tuffite member is coarse grained in general, however fine grains also can be observed. It is formed by deposition of rhyolitic glassy tuffs in a lacustrine environment. The coarse grained and porous, thick tuffites are located at lower levels but fine grained glassy tuffites are observed in the upper levels. These levels also include zeolite (clinoptylolite) formations as Akçakertil tuffite member does. The youngest units in the study area are unconsolidated or less consolidated alluviums. Alluviums are mostly observed along Simav stream and in Bigadiç plain.

FOÇA-İZMİR REGION

In Foça region Miocene and younger units crop out. Stratigraphically andesite, basalt, rhyolite, dacite, tuff and agglomerates overlie conglomerate, sandstone, siltstone, claystone and marly sequence. At the upper levels dirty white, beige colored limestones take place. Alluviums are mostly in form of loosely consolidated blocks, pebbles, sand, silt and clay intercalations (Lengeranlı et al., 1998).

In Foça-İzmir region, the apparent + probable reserve with high clinoptilolite content is about 120 million tons (Esenli, 2002).

During the research carried out by MTA, besides clinoptilolite, presence of hoylandite and mordenite minerals were determined (Albayrak, 2008).

EXPERIMENTAL STUDIES

During the research, experimental studies were carried out on the areas of usage for the zeolites (clinoptilolite) collected from Foça, Bigadiç and Gördes regions. First, the chemical and mineralogical analyses of the samples were conducted. Second, pre-technological tests (original position and color, baking condition and color, reaction with dilute acid, dispersion in water, plasticity) and tests for usage in paper industry as filling and coating materials, and usage in cement industry and cat litter were performed.

TESTS APPLIED AND APPLICATION STAGES

1. Drying.- This is the process of drying of the samples at 105 °C in drying ovens before weigh bridge.

2. Grinding.- This is the process of grinding of the samples in ball mill until the desired grain size is reached.

3. Pre-Technology Observation Tests as Ceramic Raw Material

a- Original color and condition.- Expresses the original color and condition of the sample (crushed or as particles).

b- Dispersion in water.- Shows whether a part of the material is dispersed or not in the water.

c- Plasticity.- A small part of the crushed material is mixed with water and plasticity is examined by hand.

d- Reaction with dilute acid.- 10% dilute HCl is dripped on the sample to see whether the sample foams or not. If foaming is observed, ths is due to presence of carbonaceous material.

e- Baking condition and color.- Baking conditions and colors are observed at 1150 °C, 1300 °C, 1430 °C.

4. Water Absorption (for samples as particles) Test.- This test is conducted according to “TS699 January 1987” standard.

5. Oil Absorption Test.- This test is conducted according to “TS 2583 EN ISO 787 – 5 / December 1997” standard.

6. Cat Litter Test.- This test is conducted according to “TS 12131 / February 1997” standard.

7. Whiteness Test.- This test is conducted according to “TS 12131 / February 1997” Standard under Canadian Research Institute, Model CG – 166 reflectometer using green fitler.

8. Abrasion Test: - This test is conducted according to “TS 10521 / December 1992” standard using the “Voith Allis Valley Laboratory Equipment” at 6000 revolution.

9. Porosity Test.- This test is conducted according to “TS 699 January 1987” standard.

10. Pozzolanic Cement Test.- This test is conducted according to “TS 25 / April 1975” standard.

Tests were conducted at laboratories of Department of MAT. Mineralogical determinations of the samples were carried out in Mineralogy and Petrography Unit. Chemical properties of the samples were determined at Analytical Chemistry Unit. Thechnological properties, on the other hand, were determined in the laboratories of the Industrial Raw Materials and Ceramic Materials Research Unit.

Sample numbers, sampling locations, coordinates, 1: 100 000 scale topographical map numbers are given in table 1.

Table 1- Sampling locations, coordinates and sample numbers.

İzmir (Foça)			Balıkesir (Bigadiç)			Manisa (Gördes)		
Sample No.	Map Sheet No.	Coordinates	Sample No.	Map Sheet No.	Coordinates	Sample No.	Map Sheet No.	Coordinates
FO-17	K18	X:286 Y:345	B2	J20	X:71952 Y:98052	KIR-3	K20	X:14170 Y:10225
FO-20	K18	X:356 Y:520	B-3	J20	X:71725 Y:97977	KIR-7	K20	X:11875 Y:13168
FO-23	K18	X:728 Y:958	B-6	J20	X:68442 Y:97868	KAL-1	K20	X:4762 Y:9449
Fo-35	K17	X:79465 Y:82707	B-7	J20	X:68846 Y:98338	KAL-4	K20	X:6447 Y:8311
						KAY-9	K20	X:11169 Y:3264
						KAY-14	K20	X:14228 Y:7505
						SA-2	K20	X:8585 Y:11227

MINERALOGY

XRD analyses results of the samples are given in table 2. According to these results, it is observed that the samples in general include clinoptilolite and hoylandite minerals as well as glassy materials, quartz, opal and illite and smectite group clay minerals. Minerals are given in table 2 according to abundance in the rock.

It was observed also that, the dominant minerals in the samples from İzmir-Foça region are hoylandite, in contrast, the samples collected from Balıkesir-Bigadiç and Manisa-Gördes clinoptilolite mineral is more dominant.

GEOCHEMISTRY

Results of the chemical analyses of the samples collected from Balıkesir, İzmir and Manisa regions and their density values are given in table 3. It is observed that SiO_2 values of the samples are equal to or higher than 70% and Al_2O_3 values are higher than 10% for all the samples. Density values of the samples vary between 1.98 and 2.40, and fire loss values are between 3.40 and 9.65.

Table 2- Mineralogical descriptions of the samples based on XRD analyses.

Sampling Location	Code of the Sample	Mineralogical Description
İzmir (Foça)	FO-17	Hoylandite, Amorphous substance
	FO-20	Hoylandite, Quartz, Mica, Feldspar, Smectite group clay mineral
	FO-23	Hoylandite,
	FO-35	Opal CT, Hoylandite, Quartz, Feldspar
Balıkesir (Bigadiç)	B2 (Tülü Quarry)	Clinoptilolite, Amorph substance
	B3 (Tülü Quarry)	Amorphous substance , İllite
	B6 (Simav Quarry)	Clinoptilolite, Quartz, Amorphous substance
	B8 (Simav Quarry)	Clinoptilolite, Amorphous substance , Quartz, İllite
Manisa (Gördes)	KIR-3 (KIRANKÖY)	Clinoptilolite, Amorphous substance
	KIR-7 (KIRANKÖY)	Clinoptilolite, Amorphous substance
	KAL-1	Clinoptilolite, Opal CT, Smectite group clay mineral, Mica, Amorphous substance
	KAL-4	Clinoptilolite, Mica, Amorph substance
	KAY-9	Clinoptilolite, Amorph substance
	KAY-14	Clinoptilolite, Amorphous substance
	SA-2	Clinoptilolite, Mica, Smectite group clay mineral, Amorphous substance

Table 3- Results of chemical analyses of the samples and their density values

Samling Location	Code of Sample	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	NaO %	K_2O %	P_2O_5 %	A.Z %	Density. g/cm^3
İzmir (Foça)	FO-17	70,6	0,1	11,6	1,3	0,1	0,6	2,4	0,3	5,0	K*0,1	8,23	2,01
	FO-20	72,2	0,1	11,8	0,3	K*0,1	0,6	3,0	0,2	4,2	K*0,1	7,60	2,13
	FO-23	72,0	0,2	11,5	0,9	K*0,1	0,8	3,5	0,5	2,0	K*0,1	8,70	2,20
	FO-35	77,3	0,1	11,5	0,5	K*0,1	0,3	0,9	0,3	6,0	K*0,1	3,40	2,13
Balıkesir (Bigadiç)	B-2	70,5	0,1	11,6	0,9	0,1	0,9	3,2	0,3	3,8	K*0,1	9,26	2,01
	B-3	70,6	0,1	11,5	0,9	K*0,1	0,9	3,0	0,4	3,9	K*0,1	9,65	1,98
	B-6	72,5	0,1	12,1	0,8	K*0,1	0,7	2,1	0,2	5,5	K*0,1	5,88	2,31
	B-7	72,5	0,1	11,8	0,9	0,1	0,8	2,3	0,1	5,2	K*0,1	6,65	2,31
Manisa (Gördes)	KIR-3	73,0	0,1	11,8	1,0	K*0,1	0,5	2,1	0,5	4,0	K*0,1	7,39	2,00
	KIR-7	73,5	0,1	13,5	1,2	K*0,1	0,3	1,8	1,8	4,0	K*0,1	3,51	2,25
	KAL-1	74,5	0,1	11,5	1,4	K*0,1	0,8	2,8	0,1	1,3	K*0,1	7,65	2,06
	KAL-4	73,0	0,1	11,0	1,1	K*0,1	1,0	3,0	0,2	2,0	K*0,1	8,98	2,30
	KAY-9	74,0	0,1	10,8	0,8	K*0,1	0,8	3,0	0,3	2,0	K*0,1	8,62	1,99
	KAY-14	74,0	0,1	11,6	0,3	K*0,1	0,8	2,0	0,6	3,4	K*0,1	7,83	2,03
	SA-2	70,5	0,1	12,3	0,7	K*0,1	0,7	6,0	0,7	2,4	0,1	6,79	2,40

DETERMINATION OF AREAS OF USAGE OF ZEOLITE

RESULTS OF PRE-TECHNOLOGY TESTS AS RAW MATERIAL

Pre-technological examination of the samples for ceramic were carried out and the results are given in table 4. Water disperssion test of the samples is the control whether a small part of the sample disperses in the water or not. The behaviour of the sampe gives an idea about the grain size and decreases the grinding cost of a sample which can easily disperse in the water. However, no dispersion in the samples were observed (Table 4).

The crushed samples were mixed with some water and plasticity is examined by hand. After the test, it was observed that the plasticity is very little or none for the samples. Therefore, they can be used after mixing with some materials with high plasticity. The acid reaction of the samples is made by pouring some dilute acid drips on the sample and carbonate content of the samples is observed consequently.

Presence of carbonate causes cracks during and after baking. Fort his reason, materials containing carbonates are not good for ceramics. The results of the tests carried out by 10% HCl is given in table 4.

During the baking tests, the materials were baked at 1150 °C -1300 °C -1430 °C to see their colors. Figure 4 shows the colors of the samples after baking test and table 4 shows the colors and conditions after the test.

According to the results of the chemical analyses (Table 3), the Al_2O_3 content is too low to be used in ceramic industry, however, the percentage of the color providing oxides, Fe_2O_3 and TiO_2 are between the limits according to TS 5396/December 1987 standards.

Consequently, these zeolites can be taken into consideration to be used in ceramic industry at certain percentages together with kaolin.

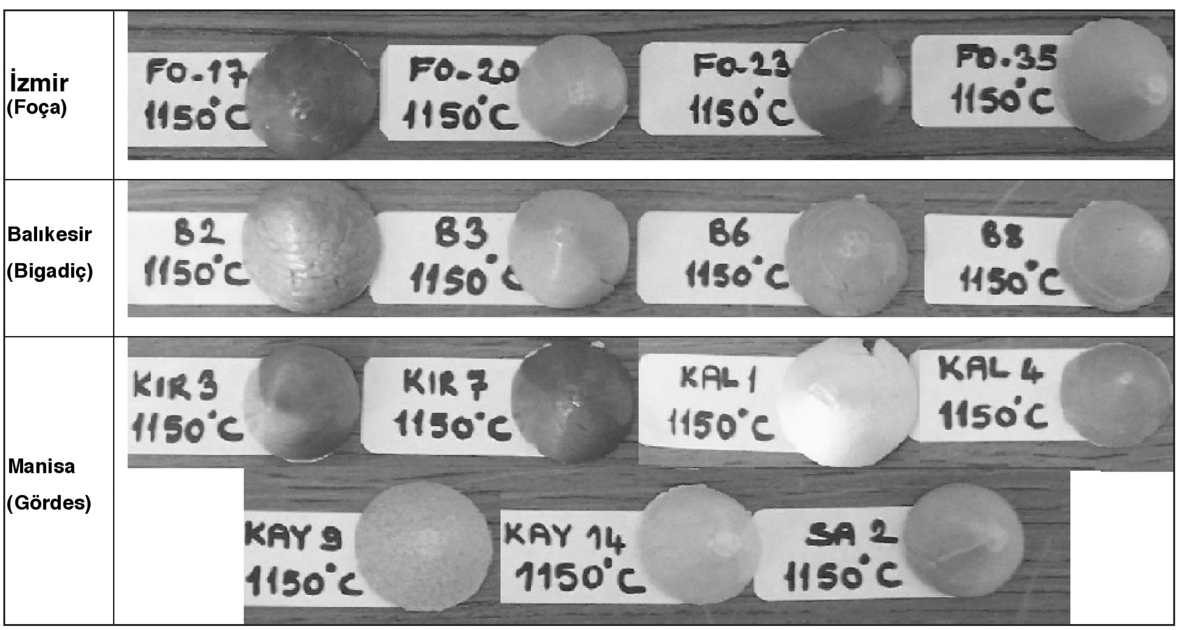

Figure 4- Baking conditions and colors of the samples (1150 °C).

Table 4- Ceiramic pre-technological evaluation of the samples

Sampling Location	Code of Sample	Original Position and Color	Dispersion in Water	Plasticity	Reaction in Acid	Baking Condition / Color		
						1150 °C	1300 °C	1430 °C
İZMİR (FOÇA)	FO-17	Coarse particles – yellowish cream	no	no	no	Light red brown / melting		
	FO-20	Coarse particles – yellowish cream	no	less	no	Greyish white / melting		
	FO-23	Coarse particles – yellowish cream	no	no	no	Dark brown / melting		
	FO-35	Coarse particles – greenish cream	no	no	no	Cream / melting		
BALIKESİR (BİGADİÇ)	B-2	Coarse particles – dark green	no	no	no	Grey spotted Brown / melting		
	B-3	Coarse particles – dark green	no	no	no	Milky brown / melting		
	B-6	Coarse particles – yellowish green	no	no	no	Light brown / melting		
	B-7	Coarse particles – black spotted cream	no	less	no	Light brown / melting		
MANİSA (GÖRDES)	KIR-3	Coarse particles – cream	no	less	no	Brown / melting		
	KIR-7	Coarse particles – light green	no	no	no	Light red brown / melting		
	KAL-1	Coarse particles – greenish cream	no	plastic	no	Yellowish white / baking	Greenish cream sinter	Melting / light green
	KAL-4	Coarse particles – greenish cream	no	less	no	Milky white / beginning of melting	Light gren / melting	
	KAY-9	Coarse particles – yellowish green	no	no	no	Grey spotted Brown / baking		
	KAY-14	Coarse particles – cream	no	no	no	Dirty white / melting		
	SA-2	Coarse particles – grey spotted	no	no	no	Dark cream / melting		

WATER ABSORPTION TEST AS PARTICLES

Water absorption tests of the samples were conducted according to “TS 699 January 1987 Natural Building Stones Inspection and Test Methods” and the results are given in table 5.

CAT LITTER TEST

The prerequisite for the samples to be used as cat litter is to define mudding in the samples. An amount of the sampe is left in the still water. In case the sample is dispersed in the water, the water absorption test is not conducted and the sample is recorded as not suitable to be used as cat litter. If no mudding is observed, water absorption test is applied. When the results are evaluated according to table 6, since the water absorption value is low, we can think that the samples can anly be used after being mixed some highly absorbent materials.

WHITENESS, ABRASION AND OIL ABSORPTION TESTS

In paper production, many industrial raw materials, mainly calcite and zeolite are being

Table 5- Water absorption values of the samples.

Sampling Locattion	Code of Sample	Water Absorption under Atmospheric Pressure	
		By Mass(%)	By Volume (%)
İzmir (Foça)	FO-17	33	39
	FO-20	31	39
	FO-23	24	31
	FO-35	8,8	16
Balıkesir (Bigadiç)	B-2	17	25
	B-3	20	28
	B-6	24	38
	B-7	19	28
Manisa (Gördes)	KIR-3	21	30
	KIR-7	23	32
	KAL-1	Dispersed in water	
	KAL-4	22	30
	KAY-9	14	21
	KAY-14	20	29
	SA-2	18	26

Tablo 6- Cat litter water absorption values.

Sampling Location	Code of Sample	% Water Absorption
İzmir (Foça)	FO-17	43,4
	FO-20	49,0
	FO-23	40,2
	FO-35	29,3
Balıkesir (Bigadiç)	B-2	33
	B-3	32
	B-6	32
	B-7	36
Manisa (Gördes)	KIR-3	37
	KIR-7	40
	KAL-1	Dispersed
	KAL-4	40
	KAY-9	37
	KAY-14	36
	SA-2	40

used. These materials are also being used as filling and coating materials.

The minerals used as filling materials are used to increase the opacity and softness of the paper, and when added to whitened paper, they are useful in increasing the whiteness of the paper, and absorption of the ink in the paper and consequently to increase the printing quality. Therefore, among the features expected from an ideal filling material, higher whiteness, grain distribution, high immersion in the pulp, non-dispersion in the water, low hardness (abrasion) and cheapness from economical point of view can be counted. For this reason, abrasion, whiteness and oil absorption tests were made to see the usage of the samples in paper industry, (Table 7).

Table 7- Whiteness / abrasion values according to TS 10521 and TS11653 standard

Standard	Class	Whiteness % (Minimum)	Abrasion (mg/100g) (Maximum)
TS 10521	Class I (for coating)	90,2	6
	Class II (for filling)	80	
TS11653	Class I (for coating)	90	10
	Class II (for filling)	85	15

When we evaluate the results of the whiteness and abrasion tests of the samples, we see that, when the values indicated in (TS10521, TS11653) standards, the whiteness values of the samples FO-20, FO-35 and KIR-3 are observed to be at usable limits. In this case, the sample FO-20 can be used for filling purposes according to TS 10521 and TS 11653 and the sample FO-35 can be used as filling material according to TS 10531 and as filling material according to TS 10521.

The abrasion values are above the values indicated in the standards, therefore the samples are considered as not suitable.

In general, as a result of the examination for the purposes of paper industry, the whiteness percentage of the samples FO-35 and KIR-3 are suitable to be used as filling material. The high abrasion index requires low additives with respect to the paper quality used for filling.

According to table 8, in order to make an evaluation for oil absorption characteristics, it must be compared with another material of which oil absorption value is known.

POROSITY TESTS

For porosity tests, the samples were dried until fixed weighing at 105±5 °C and then their porosities and unit voluminar weights were determined accordding to TS 699 January 1987 standards (Table 9). The porosity values of the samples are observed to be high.

According to the regulations published in "official newspaper" dated and numbered of 04.05.2004, 25452 about the Production, Exportation, Importation and market supply of the Organic, Organomineral Soil Conditioners including special microbial and enzymes, the porosity value must be 40% minimum to use as soil conditioner.

Table 8- Whiteness – abrasion – oil absorption values of the samples.

Sampling Location	Code of Sample	Whiteness	Abrasion (mg/100g)	Oil Absorption cm^3 /100gr
İzmir (Foça)	FO-17	66,4	142	60
	FO-20	85,6	-	60
	FO-23	76,1	85	60
	FO-35	82,0	96	40
Balıkesir (Bigadiç)	B-2	64,2	71	45
	B-3	64,5	70	65
	B-6	71,3	194	48
	B-7	67,8	151	50
Manisa (Gördes)	KIR-3	80,2	77	55
	KIR-7	66,3	161	55
	KAL-1	76,6	52	65
	KAL-4	72,5	39	50
	KAY-9	73,0	120	48
	KAY-14	75,9	237	50
	SA-2	68,0	167	55

Table 9- Unit voluminar weight and porosity percentage of the samples.

Sampling Location	Code of Sample	Unit voluminar weight (U.V.W) (gr/cm^3)	Porosity (%)
İzmir (Foça)	FO-17	1,26	37,3
	FO-20	1,33	37,5
	FO-23	1,36	38,1
	FO-35	1,88	11,7
Balıkesir (Bigadiç)	B-2	1,60	20,4
	B-3	1,48	25,2
	B-6	1,29	44,1
	B-7	1,59	31,1
Manisa (Gördes)	KIR-3	1,48	26,0
	KIR-7	1,53	32,0
	KAL-1	Dispersed in water	
	KAL-4	1,42	38,2
	KAY-9	1,62	18,5
	KAY-14	1,39	31,5
	SA-2	1,51	36,6

The research conducted by us is based on this regulation, and the porosity test results show that the sample B-6 complies with the requirements of the above mentioned regulation and can be used as soil conditioner.

PUZZOLANIC CEMENT (TRASS) TESTS

The natural zeolites are potential cement additives due to their SiO_2 and Al_2O_3 contents. They have puzzolanic features which can be defined as, because of their high SiO_2 and Al_2O_3 contents, they can form binding products when reacted with dead lime ($Ca(OH)_2$) and water. So, they can be used as puzzolans in cements and concrete systems. Addition of puzzolans to cements and concrete systems increase the permeability and workability of the concrete and similarly increase the resistance to external factors such as alkali silica reaction and sulphate effect (Uzal et al., 2003).

In puzzolanic activity tests, crushed tras (this is a silica and alumino-silica bearing tuff, a natural puzzolanic material, and it does not have any hydrolic property when it is used alone, but when crushed in to small particles, in aquaeous mediums and with calcium hydroxide under normal temperature, it starts chemical reaactions and displays hydraulic properties), dead lime mixture and standard sand is used.

The tests for it to be used as cement-additive materials are conducted according to “TS 25 – April 1975 Trass” standard. For it to be used as cement additive, the preliminary conditions are as follows:

Total % SiO_2+Al_2O_3+Fe_2O_3 must be higher than 70%,

% MgO must be 5.0 % maximum,

% SO_3 must be 3.0 % maximum, and,

% A.Z. must be 5.0 % maximum.

Puzzolanic activity of the samples were calculated according to “TS 25 April 1975” standard. According to TS 25 the flexural strength and compressive strength must be at least 10 kgf/cm^2 and 40 kgf/cm^2, respectively.

The tests to evaluate zeolite as cement additive material were started acccording to the suitability of the results of the density and chemical analyses. According to the standard (TS 25), the requested minimum 7 days compressional strength must be 40 kgf/cm^2, and 7 days flexural strength must be at least 10 kgf/cm^2.

Accordingly, when the table 10 is studied, we see that the samples FO-35 and B-2 can be used as cement additive materials.

Table 10- Results of flexural and compressive strength tests of the samples.

Sampling Location	Code of the Sample	Flexural Strength (kgf/cm^2)	Compressive Strength (kgf/cm^2)
İzmir (Foça)	FO-17	2,50	7,29
	FO-20	0,94	2,08
	FO-23	2,81	7,94
	FO-35	12,85	51,20
Balıkesir (Bigadiç)	B-2	10,45	43,20
	B-3	4,26	13,98
	B-6	5,06	16,17
	B-7	2,75	10,39
Manisa (Gördes)	KIR-3	2,68	15,62
	KIR-7	3,25	23,64
	KAL-1	1,09	8,23
	KAL-4	0,74	3,33
	KAY-9	3,78	14,38
	KAY-14	3,28	11,98
	SA-2	4,37	15,73

RESULTS AND DISCUSSIONS

Technological and mineralogical research was conducted to determine the areas of usage of the zeolites collected from İzmir-Foça, Balıkesir-Bigadiç and Manisa-Gördes regions.

The minerals determined after thin section studies and XRD analyses and the results of XRF analyses of the samples collected from the study areas were given as tables.

In this study which aims to determine the areas of usage of zeolite, research was conducted to see whether they can be used in ceramic, paper industries and as cat litter and cement additives. Some samples were found to be suitable to be used in ceramic, paper and cement industries.

As a result of the mineralogical and technological analyses the samples FO-35 and B-2 were found suitable to be used as cement additives. The sample B-6 ca be used as soil conditioner according to the regulations published in the Official Gazzette dated 04.05.2004 and numbered 25452. It was shown that the samples FO-20, FO-35 and KIR-3 displayed whiteness values which indicate they can be used as filling materials in paper industry, however, since this sample has high abrasion index, its percentage amount must be decreased depending on the type of the paper being produced.

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REFERENCES

Albayrak, M., 2008. Batı Anadolu, Trakya, Kapadokya Yöresi Zeolitleri Mineralojik Veri , (unpublished).

Albayrak, M., Karahan, S. and Atlıhan. S., 2001. "Zeolitten Hafif Yapı Gereci Üretilmesi(Zeoton 2000)", MTA Servisi, Derleme Rapor No: 10471. Ankara, (unpublished).

Ataman, G., 1977. Batı Anadolu Zeolit Oluşumları,Yerbilimleri Dergisi, H.Ü Yayını 3, 85

Ercan, T., 1983. Gördes Volkanitlerinin (Manisa) Petrolojisi ve Kökensel Yorumu, Türkiye Jeoloji Kurultayı Bülteni, 26. 41-49.

______, Türkecan A., Günay E., Çevikbaş A., Ateş M., Can B. and Erkan M., 1984*a*. Dikili Çandarlı Bergama (İzmir) ve Ayvalık Edremit Korucu (Balıkesir) Yörelerinin Jeolojisi ve Mağmatik Kayaçların Petrolojisi. MTA Genel Müdürlüğü Derleme Rapor No: 7600, Ankara, (unpublished).

Ercan, T., Güney, E., Çevikbaş, A., Ateş, M., Küçükayman, A., Can, B., Erkan, M., 1984*b*. Bigadiç Çevresinin (Balıkesir) Jeolojisi, Magmatik Kayaçların Petrolojisi ve Kökensel Yorumu, MTA Derleme Rapor No: 7601, Ankara, (unpublished).

Esenli F., 2002. Türkiye'de Doğal Zeolit Rezervleri, Madenciliği, Üretim ve Pazar Durumu,Zeolit Sempozyumu, TÜBİTAK-MAM, 24 Haziran 2002, Gebze, Kocaeli,1-10.

Göktaş,F., 1996. Gördes Neojen Havzasının Jeolojisi,MTA Derleme Rapor No: 9931, Ankara, (unpublished).

Kalafatoğlu, İ.E., 2002. Zeolit Araştırmaları Türkiye Bibliyografyası, Tübitak MAM, Malzeme ve Kimya Teknolojileri Araştırma Enstitüsü.

Lengeranlı,Y., Baykal,A., Sun,A., Işın, R., Metli,F., Avşar,M., Türkbileği,H., Tan,T. and Kurt, H.İ., 1998. İzmir İlinin Çevre Jeolojisi ve Doğal Kaynakları Raporu. No:10137, İzmir.

Öner, F., Albayrak, M. and Kayabalı, İ., 2000. "Zeolitli Tüflerin Jeolojik, Mineralojik, Kimyasal özellikleri ve Sanayide Kullanılabilirliğinin Araştırılması", MTA Derleme Servisi, Rapor No. 10338, Ankara (unpublished).

Resmi Gazete, 2004. "Tarımda Kullanılan Organik, Organomineral, Özel Mikrobiyal ve Enzim İçerikli Organik Gübreler ile Toprak Düzenleyicilerin Üretimi, İthalat, İhracat, Piyasaya Arz ve Denetimi" Yönetmeliği, sayı no:25452 .

Türk Standartları Enstitüsü., 1975. TS 25- Nisan 1975 Tras

______, 1987. TS 699 -Ocak 1987 Tabii Yapı Taşları Muayene ve Deney Metotları

______, 1997. TS 2583 EN ISO 787- 5 - Aralık 1997 Pigmentler ve Türk Standartları Enstitüsü., Dolgu Maddeleri İçin Genel Deney metotları-Bölüm 5:Yağ Absorplama Değerinin Tayini

______, 1992. TS 10521- Aralık 1992 Talk - Kağıt Sanayinde Kullanılan

Türk Standartları Enstitüsü, 1995. TS 11653-Nisan 1995 Kalsit - Kağıt Sanayinde Kullanılan

______, 1997. TS 12131- Şubat 1997 Sepiyolit - Kedi Kumu Üretiminde Kullanılan

______, 1987. TS 5396- Aralık 1987 Kaolin-Seramik Sanayinde Kullanılan

Uzal B., Bektaş F. and Turanlı L. 2003. "Öğütülmüş Doğal Zeolitin Alkali ve Sülfat Etkisi ile Genleşmesinin İncelenmesi. 5. Ulusal Beton Kongresi / İstanbul, Bildiriler, 403-409.

Vural A. and Albayrak M., 2005 Gördes ve Civarı Zeolitlerinin Mineralojisi. 58.Türkiye Jeoloji Kurultayı Bildiri Özleri, 11-17 Nisan, MTA Kültür Sitesi, Ankara

Yağmurlu, F., 1983. Akhisar Doğusu, Neojen Topluluğu'nun Jeolojisi ve Kömür yatakları ile olan ilişkisi. Dokuz Eylül Üniversitesi Fen Bilimleri Enstitüsü, Doktora Tezi. 217 s. İzmir

______, 1983. Akhisar Doğusu, Neojen Tortulların Depolanma Ortamları ve Kömür yatakları ile olan ilişkisi. Türkiye Jeoloji Kurultayı Bildiri Özetleri.

Yücel H., 1987. "Zeolitler ve Uygulama Alanları" III. Ulusal Kil Sempozyumu, Bildiriler, s391-402.