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Determination of the properties of various diatomite deposits within Aegean Region of Turkey

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Abstract

Properties of diatomite in general have been outlined, location and reserves of the related deposits in Turkey are given. The results of mineralogical studies, chemical and physical analysis which have been carried out on various samples are tabulated. From the results of these findings possible application areas have been suggested.

Introduction

Diatomite in its natural state is a soft rocklike material consisting esentially of the skeletal remains of a variety of singlecelled microscopic plants known as diatoms. They are generally amorphous, hydrated or opaline silica, $SiO_2 \times n \, . \, H_2O$, with various amounts of impurities such as silica sand, clay minerals, metal salts and organic matter. Because of these contaminants, silica content may range from 58 to 90% of the dry product. As mined, diatomite may contain from 10 to 60% of free water. Size of diatoms varies between 20 to 200 microns. The most important properties of diatomite are its porosity (80–85%), low density (1.95 to 2.3 g/cm³) and whiteness (as high as 96). The color of diatomite changes depending on the impurities present in the sand. For example an increase in the amount of organic matter causes the color to change from white to brown or even to green. Diatomite is not dissolved in acidic solutions except in hydrofluoric acid but it dissolves in concentrated alkaline solutions. The hardness of the diatom skeleton is between 4–6.5 on the Moh's scale the same as opaline silica. Heat conductivity of diatomite is low; 0.08–0.1–0.11 kcal/m.°C.h at temperatures of 300, 800–1200°C respectively. Its melting point is PCE 8–33 and the pressure resistance is between 3–18 kg/cm².

Because of its unique and desirable properties mentioned above, diatomite is a superior material to many alternative substances in many industrial applications. The widest use of processed diatomite is as a filter aid for separation of suspended solids from fluids. About 50% of all processed diatomite is channeled into this application. Other important uses include soft abrasives, industrial fillers, lightweight aggregates and insulation. As a filler and extender it is used in paint, asphalt products, paper and plastics. Other uses include catalysts in petroleum refining, hydrogenation of oils, insecticide carriers, anticaking agents for fertilizers and explosives, soil conditioner and as an additive in cement (Kadey, 1983).

Processing of diatomite involves a series of basic steps developed primarily to take advantage of the unique characteristics of the commodity for its various applications, such as filter aids, fillers and insulation. The major processed diatomite products are powders and aggregates of variable sizes and grades that have been uncalcined, straight-calcined or flux-calcined. Processing of uncalcined or »natural« grade diatomite simply comprises the drying and crushing of crude ore to reduce the high moisture content. Further size reduction and removal of water is usually accomplished by a blower-hammer mill in combination with a pneumatic feed and discharge system to suspend the particles. The suspended particles and impurities are separated and removed through a series of cyclone classifiers. The variously sized products are then collected in a baghouse for market preparation, principally for fillers and other uses than filter aids. For filtration uses »natural« grade diatomite is calcined by heat treatment in a rotary kiln at a temperature of about 1000°C for the following purposes:

– To remove any organic matter or contained water
– To convert some impurities into a fused slag
– To fuse broken diatoms into a fritted product

The resultant straight-calcined powder is of light weight, cream to slightly pink color, chemically inert, and from which the chemically combined water has been removed. Its main use is as a filter aid, on liquids with larger suspended particles where medium flow rates are required. For filtering that requires faster flow rates, up to 10% of alkaline salt ($NaCl + NaOH$ or Na_2CO_2) may be added to the diatomite in calcining, and it sinters the diatomite particles, increasing the particle size therefore increasing the speed of filtration with satisfactory classification (Weiss, 1985).

Location and reserves of diatomite deposits in Turkey

Deposits occur mainly in three different regions in Turkey;
a – Central Anatolian deposits
b – Eastern Anatolian deposits
c – Western Anatolian (Aegean region) deposits

Location, known and estimated reserve potential of Turkish diatomite deposits are shown in figure 1. (Private communication with the authorities of MTA – Mineral Research and Exploration Organization – and Turkısh Sugar Industries General Management, 1988).

The total consumption of natural-grade and processed diatomite according to the figures obtained in 1980 is given in table 1 (Devlet, 1979).

Turkey's demand for natural-grade diatomite is met by domestic resources. Processed diatomite is imported except for the sugar industry which produces its own diatomite in the plant which started with operation in 1982.

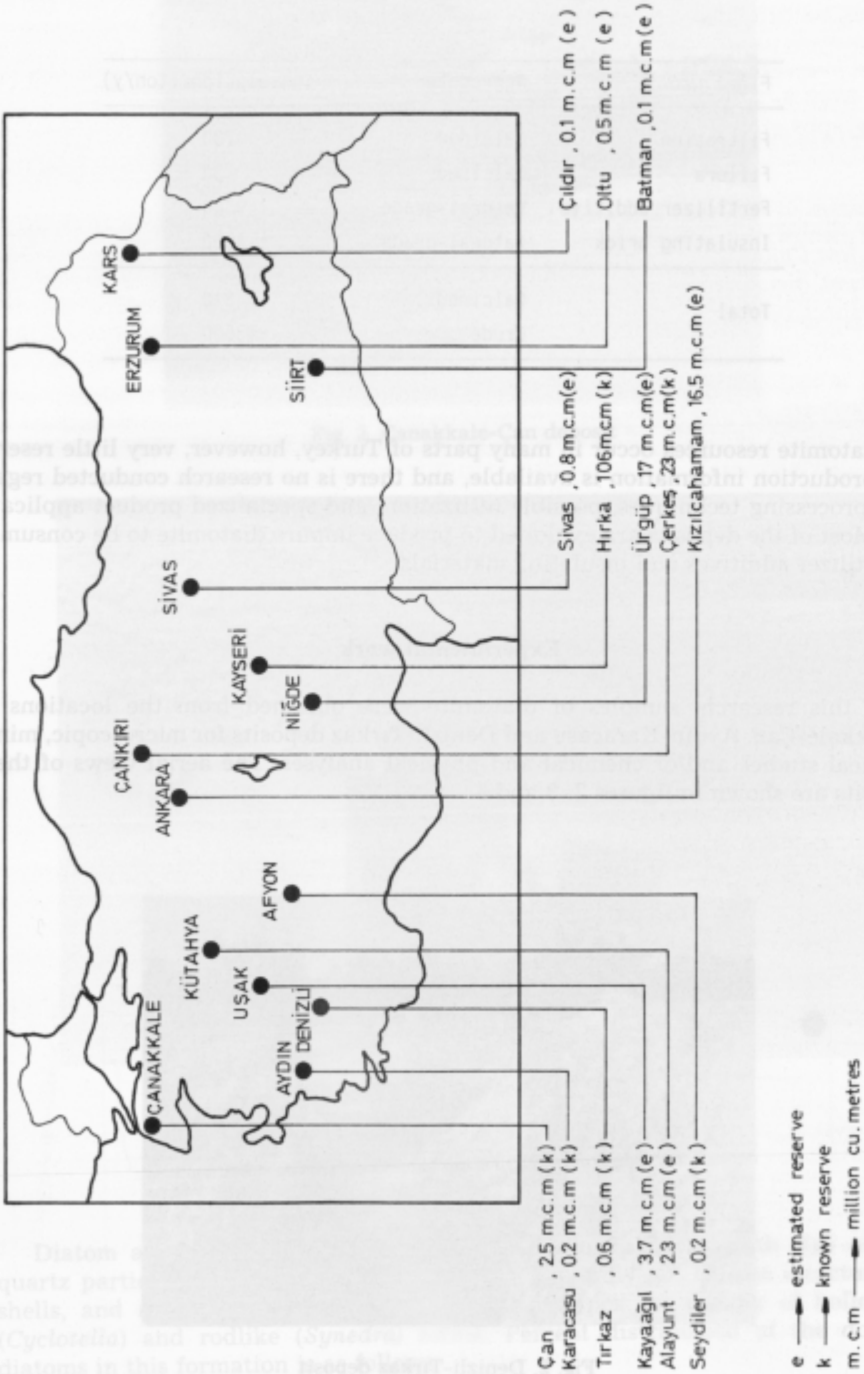

Fig. 1. Location and reserves of Turkish diatomite deposits

Table 1. Total diatomite consumption of Turkey

Final use	Aggregate	Consumption (ton/y)
Filtration	Calcined	780
Fillers	Calcined	30
Fertilizer additive	Natural-grade	9500
Insulating brick	Natural-grade	4000
Total	Calcined	810
	Crude	13500

Diatomite resources occur in many parts of Turkey, however, very little reserve and production information is available, and there is no research conducted regarding processing techniques, possible utilization, and specialized product applications. Most of the deposits are exploited to produce impure diatomite to be consumed as fertilizer additives and insulating materials.

Experimental work

In this research, samples of diatomite were obtained from the locations of Çanakkale-Çan, Aydın-Karacasu and Denizli-Tırkaz deposits for microscopic, mineralogical studies and/or chemical and physical analyses. The aerial views of these deposits are shown in figures 2, 3 and 4.

Fig. 2. Denizli-Tırkaz deposit

Fig. 3. Çanakkale-Çan deposit

Fig. 4. Aydın-Karacasu deposit

A) Microscopic studies:

Denizli-Tırkaz location

Diatom assemblages of this location are mixed-up partly with clay and fine quartz particles. The examined diatoms have generally got broken structure, thin shells, and a weak appearance. The dominant types are mainly of hollow disc (*Cyclotella*) and rodlike (*Synedra*) forms. Percent distribution of the dominant diatoms in this formation is as follows:

Disc types –40 %
Long rodlike types –40 %
Cocconeis placentula –10 %

The average length of the diatoms is in the range from 30–50 microns and the width from 8–10 microns. Diameter of the disc types is in the order of 15 microns. Micrographs of diatom assemblages of this region are given in plate 1.

Çanakkale-Çan location

The diatoms of this location are mainly small single or double celled *Melosira* with a few *Cylotella operculata* and *Cymbella* types as shown in the samples of plate 2. Percent distribution of the types, on the samples examined, is 75 %, 15 % and 5 % respectively.

Aydın-Karacasu location

The diatoms of this location exhibit a variety of different types. A considerable amount of quartz and clay present in the samples. The types mainly examined are as follows and are shown in plate 3: *Pinnularia major, Cymbella lanceolata, Stephanodiscus* sp., *Coscinodiscus* sp., *Amphora ovalis, Rhamhoneis augustata* and *Navicula semen.*

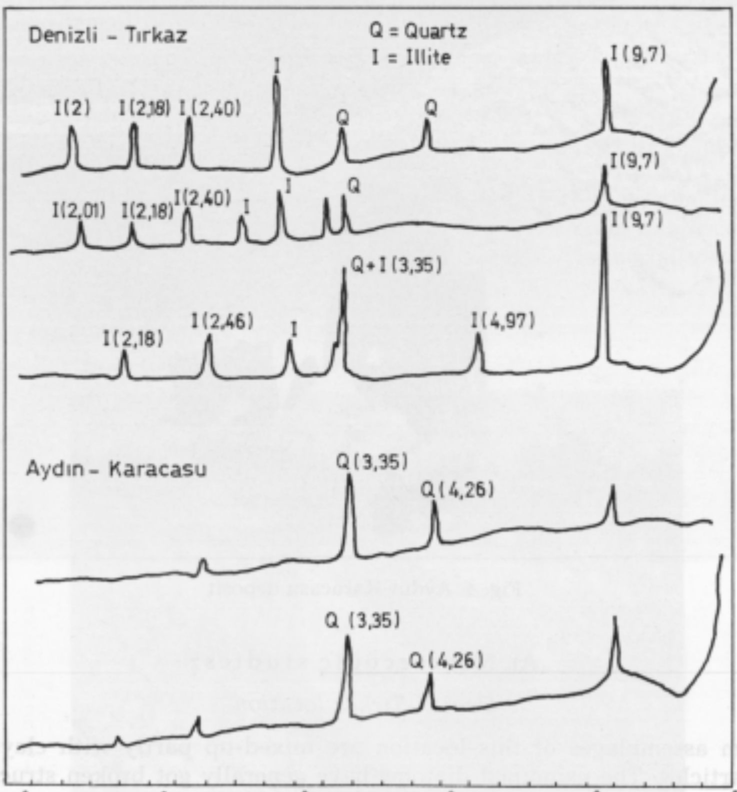

Fig. 5. X-Ray diffraction data on Denizli-Tırkaz and Aydın-Karacasu samples

B) X-Ray diffraction tests

X-ray diffraction patterns for minus 150-mesh samples of Denizli-Tırkaz and Aydın-Karacasu locations are shown in figure 5.

C) Differential thermal analysis (D.T.A.) and thermal gravimetric analysis (T.G.A)

Samples of diatomite from three different locations were ground to minus 150-mesh for D.T.A. The curves are shown in figure 6a. In general quartz is known to give an endothermic reaction between 560–565 °C, calcite and dolomite between 690–720 °C and water between 70–130 °C. On the other hand, volatile organic compounds give exothermic reactions between 300–670 °C and feldspar and alumina minerals between 780–850 °C. These expected reactions cannot be seen from the curves, which is probably due to slow removal of bound water up to a temperature of 1050 °C coinciding the same temperatures for exothermic and endothermic reactions and thus resulting in indiscernible peaks. Minor peaks seen in all three curves indicate that the determination of impurities within diatomite by D.T.A. is difficult.

The curves of thermal gravimetric analysis of the same samples are also given in figure 6b. These curves can be utilized in the determination of the optimum temperature in flux-calcination process.

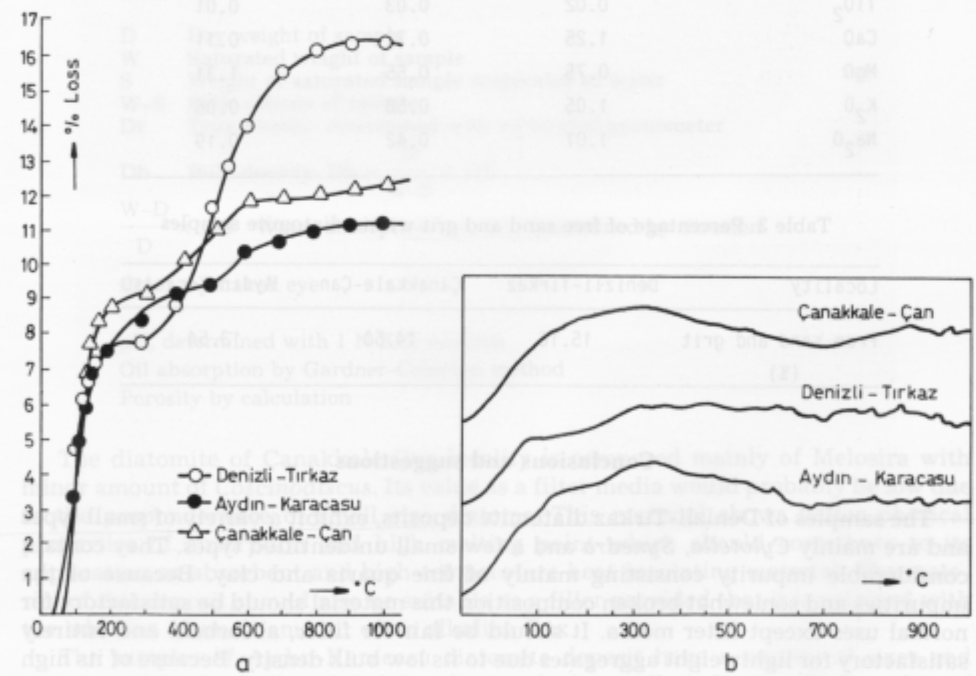

Fig. 6. The curves of thermal gravimetric and differential thermal analyses

D) Chemical analyses

Chemical analyses were performed on the representative samples of diatomites from three localities and average results are tabulated in table 2, and table 3 indicates the amount of free sand and grit within samples.

E) Physical tests

Various samples from the localities under investigation were selected at random for determinations of physical properties and the average results are given in table 4.

Table 2. Chemical composition of natural diatomites

Constituent	Locality		
%	Denizli-Tırkaz	Çanakkale-Çan	Aydın-Karacasu
Original moisture	35	38	39
Ignition loss	10.48	6.60	6.22
SiO_2	78.37	87.22	88.50
Al_2O_3	5.21	2.71	2.22
Fe_2O_3	1.84	1.15	1.35
TiO_2	0.02	0.03	0.01
CaO	1.25	0.72	0.11
MgO	0.75	0.55	1.31
K_2O	1.05	0.58	0.06
Na_2O	1.01	0.42	0.19

Table 3. Percentage of free sand and grit within diatomite samples

Locality	Denizli-Tırkaz	Çanakkale-Çan	Aydın-Karacasu
Free sand and grit (%)	15.16	14.50	13.54

Conclusions and suggestions

The samples of Denizli-Tırkaz diatomite deposits, exhibit a variety of small types and are mainly *Cylotella, Synedra* and a few small unidentified types. They contain considerable impurity consisting mainly of fine quartz and clay. Because of the impurities and somewhat broken composition this material should be satisfactory for normal uses except filter media. It should be fair for filler, absorbent and entirely satisfactory for lightweight aggregates due to its low bulk density. Because of its high content of silica, this material is particularly suitable for lime-silicate insulation powders.

Table 4. Physical properties of natural diatomite samples

Physical Properties	Locality		
	Denizli-Tırkaz	Çanakkale-Çan	Aydın-Karacasu
True density (g/cm^3)	2.27	2.15	2.02
Bulk density (g/cm^3)	0.51	0.58	0.56
Water absorption (%)	198	178	195
Retained on 150 mesh (% wt)	0.51	0.35	0.32
Retained on 325 mesh (% wt)	1.54	1.21	1.35
Surface area (m^2/g)	58.70	25.40	22.25
pH	7.30	7.38	7.46
Color	White-gray	Dark yellow	Light yellow
PCE (°C)	1350	1520	1480
Filtration rate (ml/min)	18	28	48
Oil absorption (% wt)	65	79	68
Porosity (%)	77.53	73.02	72.28

The following definitions and methods were used to obtain values given in table 4:

D Dry weight of sample
W Saturated weight of sample
S Weight of saturated sample suspended in water
W–S Bulk volume of sample
Dt True density, determined with calibrated pycnometer

Db Bulk density, $Db = \frac{D}{W-S} \times 100$

$\frac{W-D}{D} \times 100$ Water absorption percent, determined by titration

Color, by naked eye

pH, determined with 1 N KCl solution
Oil absorption by Gardner-Coleman method
Porosity by calculation

The diatomite of Çanakkale-Çan locality is composed mainly of Melosira with minor amount of *Coscinodiscus*. Its value as a filter media would probably be low due to the preponderance of small size diatoms. This material shows better physical properties of absorption and high melting point which should contribute to its application as absorbent and high-temperature heat insulating material. The material of this deposit should also be suitable as a filler provided that it is calcined with the addition of small amount of an alkaline flux.

The samples of Aydın-Karacasu diatomite deposit have a variety of sizes and shapes with large elongated and disc forms which usually indicate a high quality of filtration crude. Due to its sufficient physical and chemical properties this material should also be suitable for use as light-weight mineral filler in the powder form after general refining processes.

Deposits of diatomite within the Aegean Region of Turkey may have various uses. However, further detailed studies than those described in this work will be necessary to determine whether such uses are feasible.

References

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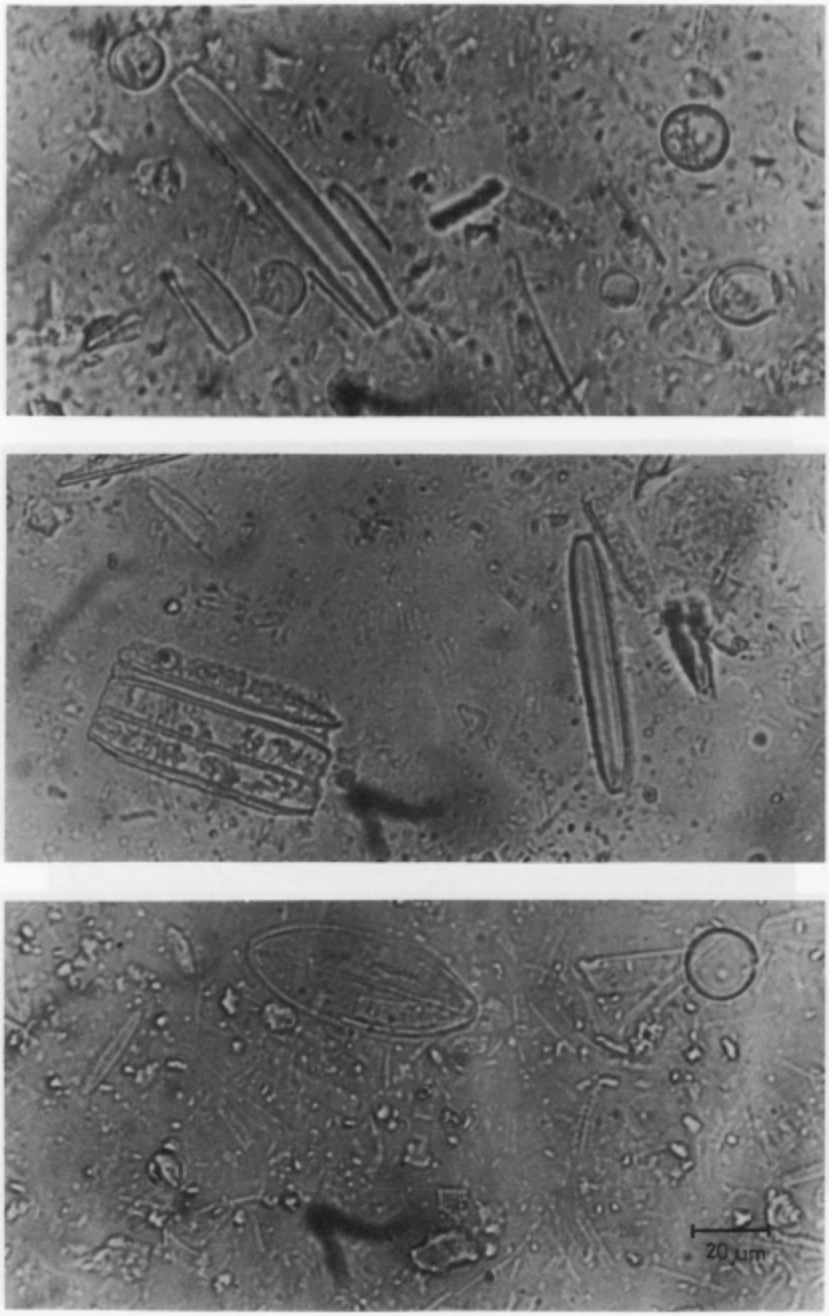

Plate 1

Micrographs of Denizli-Tırkaz diatomite samples

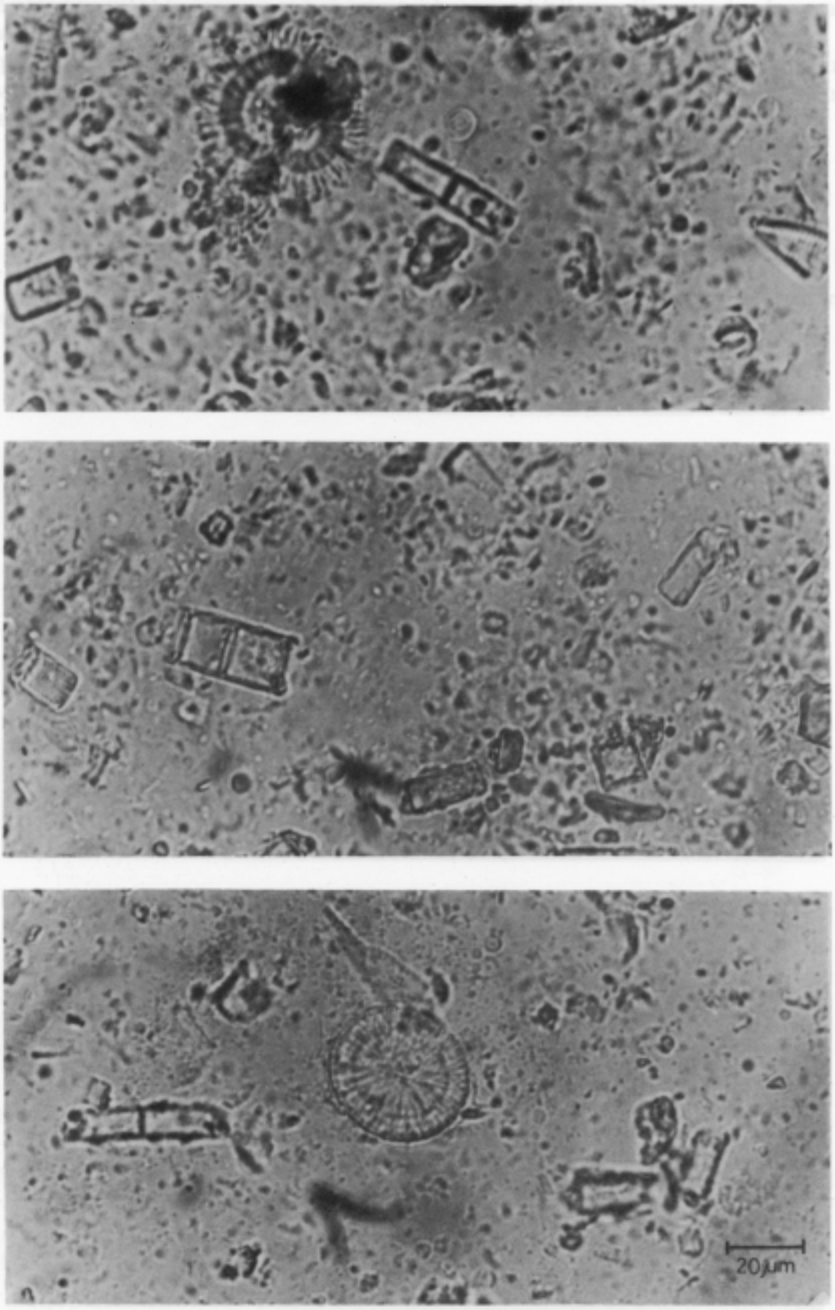

Plate 2

Micrographs of Çanakkale-Çan diatomite samples

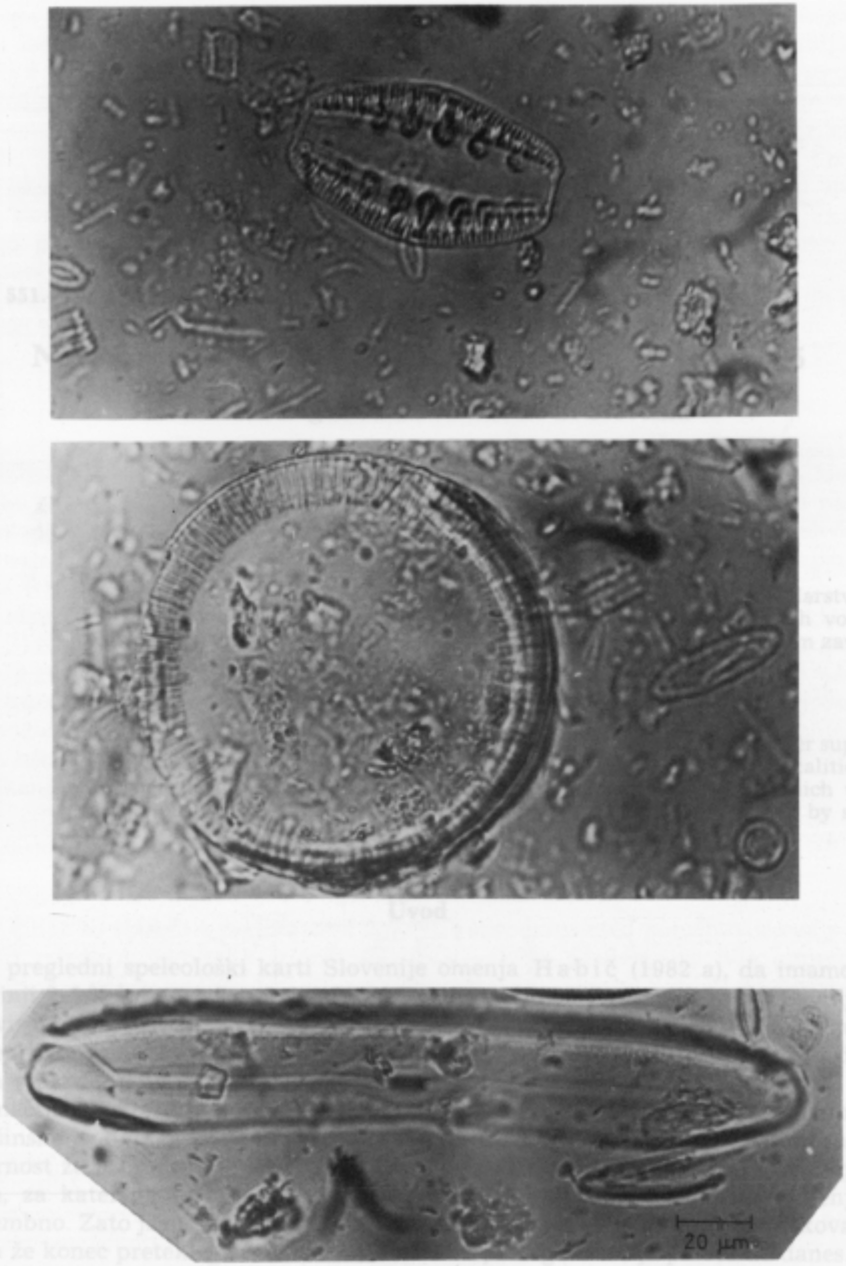

Plate 3

Micrographs of Aydın-Karacasu diatomite samples