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GEOLOGY AND ORIGIN OF CLAY DEPOSITS AT ORTA (ÇANKIRI) AREA

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ABSTRACT. - Kaolinitic clay layers interbedded with lignite seams are observed in the Orta (Çankırı) area. In order to reveal the genesis of these clays, geological, mineralogical, petrographical and micromorphological studies were carried out in the vicinity of the clay deposits and in their surrounding country rocks. Rock samples were examined by means of optical microscope, X-ray powder diffractometer and scanning electron microscope. Kaolinitic clays were formed in the clayey and silly Orta formation of Pliocene age. These elastics were transported and deposited by streams in a lacustrine environment located on a paleotopographic depression. The country rocks providing detritic materials which mainly consist of smectite comprise pyroclastic rocks (Kepezinkaş, formation) and lava flows (Naltepe basalt). In addition to this, some data indicating the development of smectite related to the authigenic processes were also obtained. It is concluded that the clay layers were formed by the transformation of smectite to kaolinite in an acid swamp environment.

INTRODUCTION

In this paper the results of the studies on the clays of Orta (Çankırı) area have been used to determine the geologic origin and mineralogic characteristics of the clay deposits occurring within the provincial boundaries of Ankara and Çankırı were dealt with in this paper. Kaolinite-rich clay layers interbedded with low quality lignite seams are found within a depositional basin surrounded by volcanic and pyroclastic rocks in Orta area. According to Has and others (1977) these clays are covered by a blanket of alluvium occupying an area of almost 80 km2 between the villages of Kalfat, Kırsakal, Sakarcaören, Bastak, Hasanhacı, Büğdüz and Kanlıca. Orta town is located at the center of this area (Fig. 1). Lignite bearing kaolinitic and bentonitic clay deposits are encountered both in Cretaceous flysch and in the tuffs of Miocene Pliocene age in the Çankırı basin. Clays of Orta area belong to the latter group (Turgut and Altınay, 1979). Limestones of Early Mesozoic age, andesitic pyroclastics, and, andesitic basaltic lavas and tuffs of Miocene age constitute the basement rocks for the formations involving lignite seams (Has and others, 1977).

According to Kartal (1978) clays at Orta area were transported by streams and settled in lakes surrounded by acidic volcanic rocks. Their quality was further improved by the activity of humic acid in the environment. The genesis of bentonites and kaolinite rich clays (tonsteins) interbedded with lignite is still controversial (Loughnan, 1978). However, the idea of in situ bentonilization of volvanic ash followed by the transformation of bentonite to tonstein in an acid environment has recently gained importance depending on the chemical, mineralogical and micromorphological investigations (Senkayi and others, 1984; 1987).

For the purpose of better understanding of the geologic origin and of the factors controlling the mineralogy of clays found at Orta area located in the Çankırı basin, detailed geologic, mineralogic and petrographic investigations were carried out in the study area lying within the boundaries of the topographic maps of G30 dl-d2-d3 and d4 at the scale of 1:25.000. Alteration products of the country rocks providing detritic materials for the depositional basin were also studied in detail. Clay mineralogy studies were carried out in the Department of Geological Engineering, Middle East Technical University by means of a JEOL-JDSX-100S X-ray powder diffractometer. Micromorphological examination was performed by using CAMBRIDGE Stcreoscan scanning electron microscope in the Department of Metallurgical Engineering.

GEOLOGY OF THE STUDY AREA

The distribution of rocks having different lithologies within the study area is shown in Figure 2. Lava flows, pyroclastic and epiclastic units constitute the basement rocks of the area. The cover rocks including lignites and interbedded clays of Orta region crop out at the south of the study area. In general, these rocks are overlain by the alluvial deposits of the Devrcz creek and only exposed along the Karabalçık valley at which clay samples were collected from a small quarry (Fig. 1).

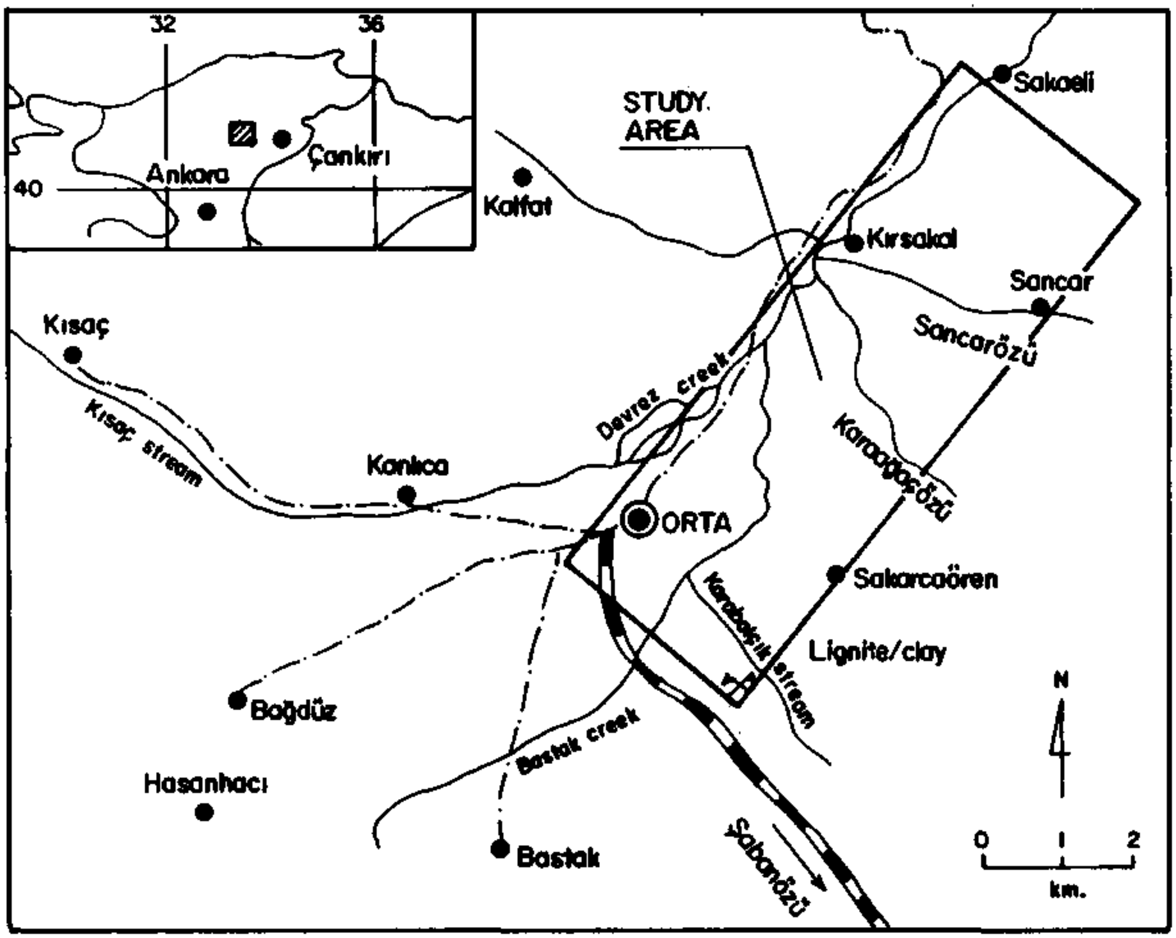

Fig. 1 - Location map of the study area.

A generalized stratigraphic column comprising the basement and cover rocks is shown in Figure 3, based on the field studies, laboratory work and earlier investigations (Akyürek, 1981; Akyürek and others, 1984).

Basement rocks

Basement rocks consist of Sancar andesite, Devrez formation, Kepezinkaş, formation and Naltepe basalt of Upper Miocene age (Fig. 2 and 3).

Sancar andesite. _ Sancar basaltic andesite forms the oldest unit and has a very narrow outcrop within the study area. Its lower boundary is not observed and the relationship with the overlying epiclastic unit (Devrez fm.) is not well established (Fig. 3). Sancar andesite has dark color and exhibits porphyritic texture. Plagioclase and pyroxene are the main minerals embedded in a glassy groundmass. Palagonitc is a common alteration product causing the greenish appearance of the rock. This unit can be correlated with the Kurtsivri volcanics of Akyürek (1981).

Devrez formation. _ This unit outcrops along the Sancarözü stream valley (Fig. 2). It has a normal upper boundary with Kepezinkaş formation but is overlain unconformably by Naltepe basalt. Devrez formation has a dark color and consists of subroundcd fragments derived from Sancar andesite and other volcanic rocks. It is an epiclastic unit rich in clay cement. This unit can be correlated with the Hancılı formation described by Akyürek (1981).

Kepezinkaş formation. _ This unit has a widespread occurrence in the study area (Fig. 2). There is an angular unconformity between the Kepezinkaş formation and the overlying Naltepe basalt (Fig. 3). It has white color and exhibits various

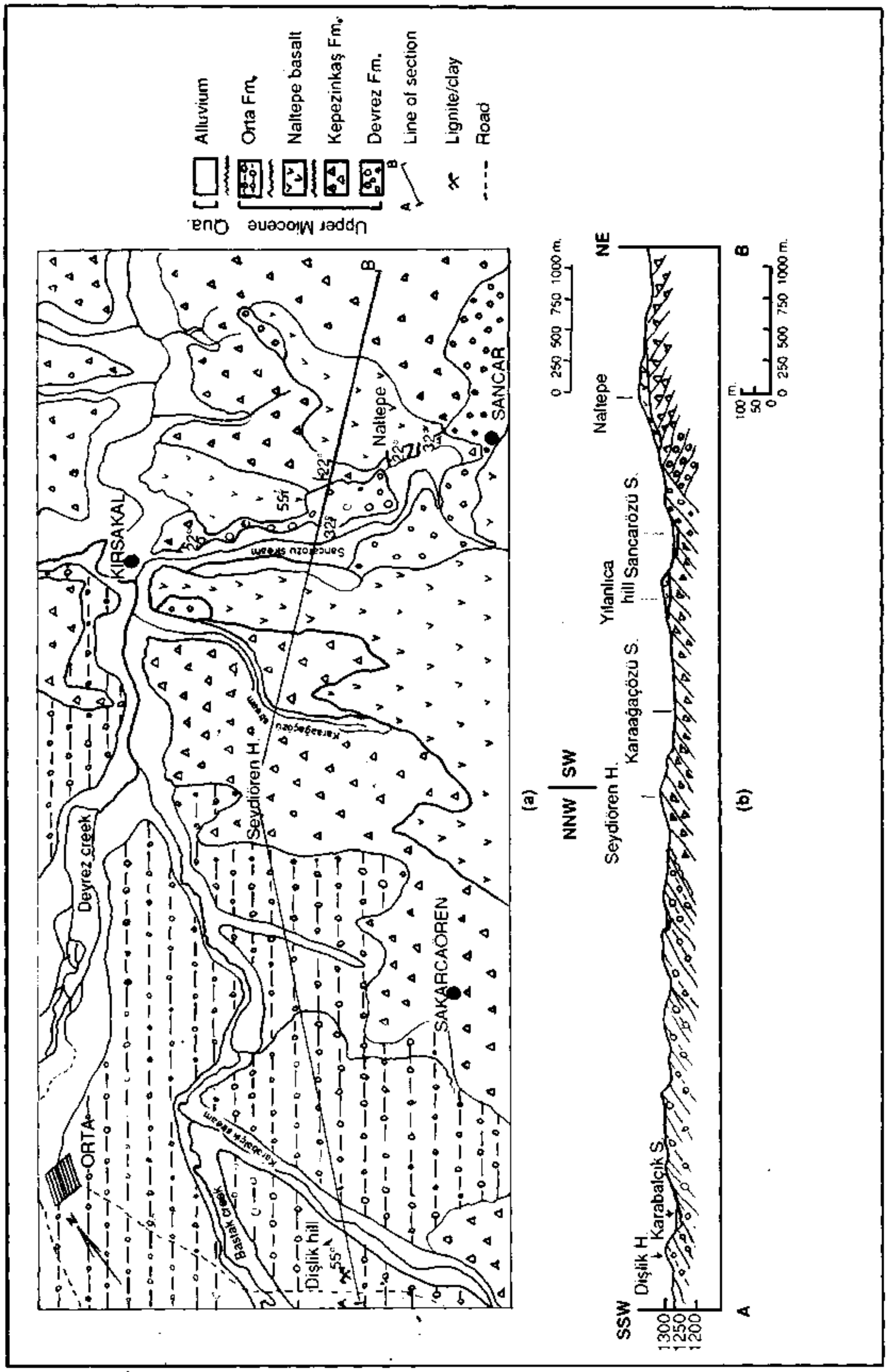

Fig. 2 - a- Geologic map of the area between Orta-Kirsakal-Sancar-Sakarcaören. b- Geologic cross-section.

lithologies such as conglomerate, tuff, dolomitic limestone and marl. Tuff has andesitic composition and is rich in volcanic glass shards. In addition, quartz, biotite, sanidine, volcanic rock fragments and pumice are common. Agglomerate consists of dark colored basalt, pink colored andesite and basaltic andesitc (Sancar andesite) fragments. Dolomite is identified in the samples from lacustrine limestones interbedded in this unit. Kepezinkaş formation is analogous to the Eregez agglomerate (Akyürek, 1981).

Naltepe basalt. _ All of the hills in the study area are covered by this unit (Fig. 2). It has an unconformable relationship with the overlying Orta formation (Fig. 3). It is dark colored massive and vesicular, olivine, pyroxene and plagioclase are the common minerals. Volcanic glass is present in the groundrriass. The vesicles are lined with green colored secondary minerals. The Naltepe basalt can be correlated with Aydos basalt of Akyürek (1981).

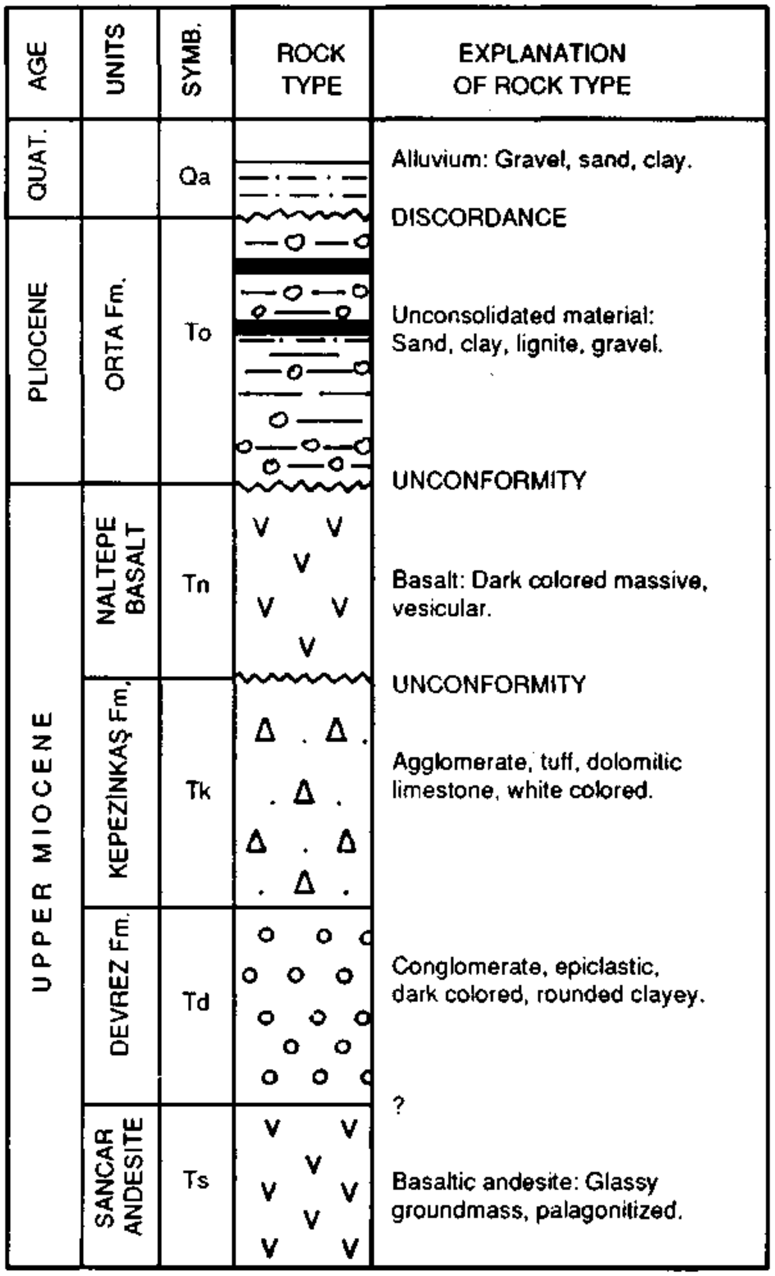

Fig. 3 - Generalized stratigraphic columnar section of the study area (not to scale).

Cover rocks

Cover rocks consist of Pliocene Orta formation and Quaternary alluviums (Fig. 2 and 3).

Orta formation. _ This unit unconformably overlies the basement rocks while it is disconformably overlain by the alluviums of Devrez creek. It consists of layers striking in the N 80° W direction and dipping 32° SW when observed from the section at the valley of Karabalçık stream. At the uppermost part of this exposure red colored soil and silt is observed. Varying thicknesses of the light brown to white colored clay and lignite layers lie underneath of this upper horizon. Lower part of the section contains 1.5 m. and 30 cm. thick upper and lower lignite seams which are underlain by 1 m. and 15 cm. thick clay layers, respectively. Clay rich horizons of the formation include macro plant fossils. Orta formation is found to be equivalent of Büyükyakalı formation of Akyürek (1981).

Alluvium. _ The alluvium composed of loose gravel, sand and clay occupying large areas in the valleys formed by Devrez creek and its tributaries, represents the youngest unit in the study area (Fig. 2).

MINERALOGY AND ALTERATION PRODUCTS

In addition to the geological investigations, a detailed study of mineralogic features and the determination of alteration products of basement and cover rocks were required in order to understand the genesis of the clay deposits at Orta area. According to the general stratigraphic relations, the Orta formation unconformably overlies the lava flows and pyroclastic materials which arc thought to be the products of Upper Miocene volcanism. There is no clear evidence of volcanic activity in Oligocene within the study area.

A worldwide close relationship exists between the kaolinite and bentonitic clay layers interbedded with coal and lignite, and the pyroclastic products of volcanic activity. Based on mineralogic and chemical evidences, Senkayi and others (1984, 1987) and Zielinski (1985) suggested that such clays originate through diagenesis of pyroclastic material in a lake and swamp environment. The existence of quartz, biotite, sanidine, cristobalite and glass shards all of volcanic origin coupled with their textures and alteration products indicate this kind of geologic origin.

Mineralogic and morphologic properties of clays

Clay exhibit abundant fossils in thin section (Plate 1; fig.1). Their study with the scanning electron microscopy displayed porous and tubular fossils associated with clay minerals having enhedral crystal morphology (Plate I; fig. 2, 3). According to Ercüment Sirel (oral communication, 1990) they are believed to be diatoms. Similar fossils have been identified in the diatomaceous earth from the Emmiler-Hırka (Kayseri) Neogene basin (Uygun, 1976). 7.16 Ao peak in the X-ray powder diffraction patterns of the Orta clay samples indicated that the clay mineral is kalinite. Badaut and Risacher (1983) suggest that poorly crystalline authigenic Mg-smectite may develop on the surfaces of diatom frustules in salt waters of some Bolivian lakes.

Alteration products of the basement rocks

Alteration products of the Kepezinkaş, formation and Naltepe basalt having widespread occurrences in the study area were investigated in detail. In thin-sections, opal-CT is observed as infilling material within the vesicles of tuffs from Kepezinkaş formation Plate II, fig. 1, 2). Precipitation of opal-CT from silica rich solutions is most probably occurring while the alteration of volcanic glass causes a pitted surface (Plate II; fig. 3). Electron microscope observations reveal the presence of smectite within these depressions (Plate II; fig. 4, 5) Plagioclase crystals in tuffs also alter and clay minerals from on their surfaces (Plate II; fig 6).

Basaltic glass in the groundmass of Naltepe basalt alters to palagonite and carbonate minerals to give rise to a banded texture (Plate III; fig. 1). In hand specimens green colored alteration products occupy the inner walls of vesicles. Palagonite surfaces have a botryoidal appearance under the electron microscope (Plate III; fig. 2).

Serpentinization of olivine crystals and carbonate formation from orthopyroxene are also a common phenomenon Feldspar crystals, however, arc generally fresh.

RESULTS

Orta clay deposits originated from the kaolinization of transported clay material by the effect of water in a Pliocene lake swamp environment. Major source of clays transported by streams into the depositional basin is the smectite rich soil developed by the alteration of volcanic and pyroclastic rocks surrounding the lake. This conclusion is further supported by the transformation of volcanic glass into smectite in the tuffs of andesitic composition. Evidences are also obtained implying the authigenic growth of some smectite crystals from the surfaces of diatom frustules. The model of smectite to kaolinite transformation during diagenesis is favored by the lack of textures which otherwise would indicate that these lignite interbedded clay deposits originated through in situ alteration of air-fall tuff.

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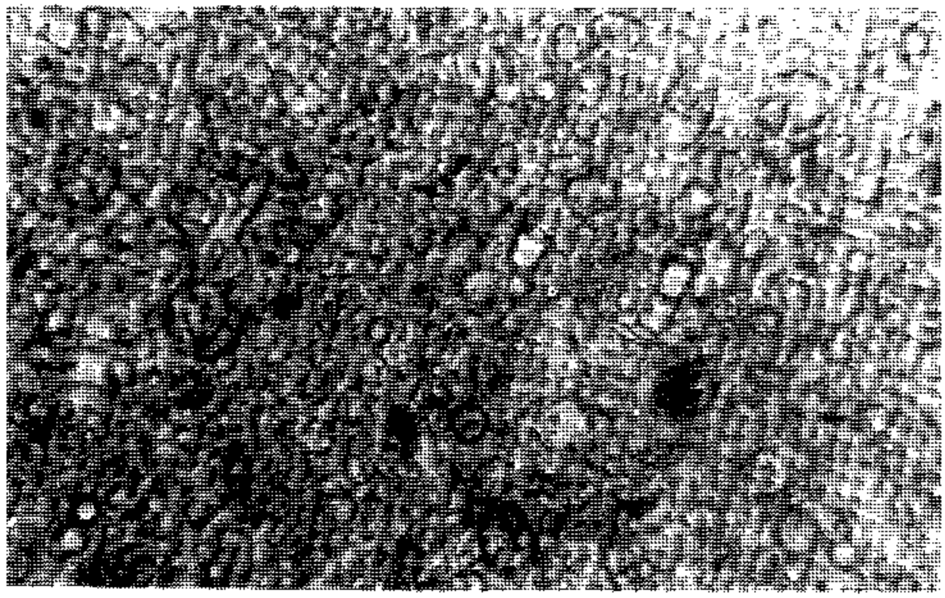
PLATES

PLATE-I

Fig. 1 - Photomicrograph showing fossils in clays (plane polarized light, X25).

Fig. 2- Scanning electron microscope view of an unusual fossil type (X 700).

Fig. 3- Scanning electron microscope view of diatoms and clay crystals (X 1600).



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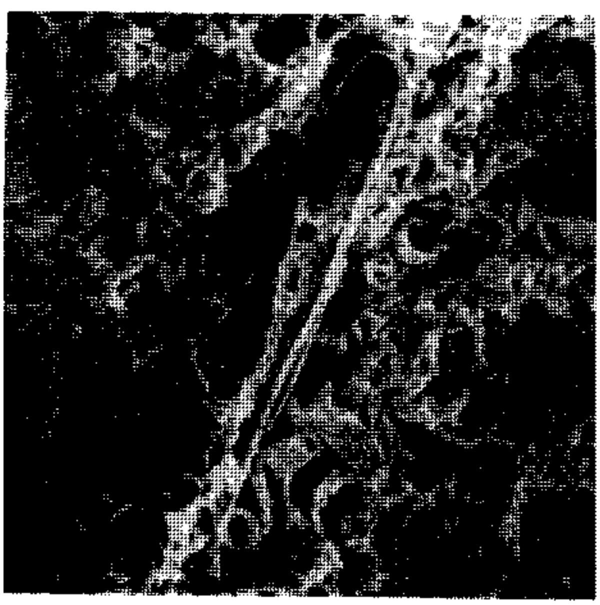

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PLATE-II

Scanning electron micrographs of tuffs:

Fig. l-Opal-CT(X900).

Fig. 2- Close-up view of opal-CT (X 4500).

Fig. 3- Solution pits from volcanic glass (X 1800).

Fig. 4- Smectite crystals formed within the volcanic glass (X 900).

Fig. 5- "Cornflake" morphology of smectite (X 4500).

Fig. 6- Kaolinization on the surface of plagioclase crystal (X 1800).

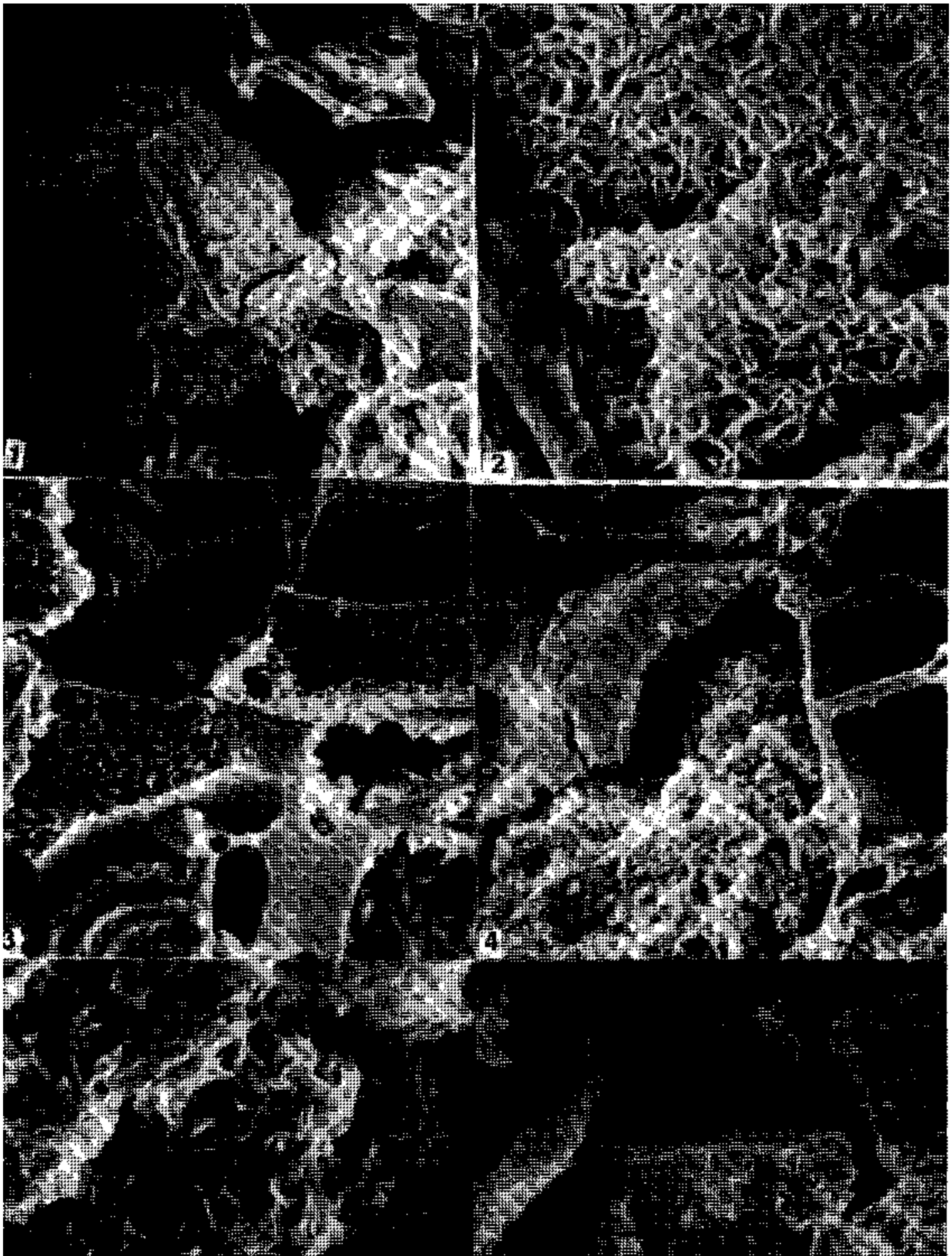
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PLATE-III

fig. 1- Photomicrograph showing the palagonization in Naltepe basalt (plane polarized light, X 10).

fig. 2- Scanning electron micrograph showing fresh volcanic glass (black) and botryoidal morphology of palagonite within a vesicle (X400).