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Distribution and Origin of Clay Minerals in Konya Neogene Sedimentary Basin, Central Anatolia, Turkey

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Abstract: Neogene sediments having both fluvial and lacustrine characteristics are widespread in the Konya region of central Anatolia. The fluvial units are typically green in colour and thick at the margin of the basin and thinning laterally basinwards. The lacustrine sediments are represented by white, beige and cream, pure, dolomitic, sandy and clayey limestone alternating with claystone. Grain size, components and matrix of the fluvial and lacustrine sediments decrease from the margin of the basin toward its center. Smectite and chlorite in detrital fluvial sediments are associated with amphibole, illite and quartz, while sepiolite and palygorskite formed diagenetically in the carbonate units of the central part of basin.

Key Words: clay minerals, Konya, lacustrine environment, Neogene, Turkey

Konya Neojen Sedimanter Basenindeki Kil Minerallerinin Dağılımı ve Kökeni

Özet: Orta Anadolu'da Konya baseninde geniş bir yayılıma sahip olan Neojen yaşlı çökeller akarsu ve gölsel birimler ile temsil edilirler. Akarsu birimleri havzanın kıyı kesimlerinde kalın ve yeşil renkleri ile tipik olup, yanal yönde havzanın merkezine doğru geçiş gösterirler. Göl sedimanları beyaz, bej, krem renkli, saf, dolomitli, kumlu ve killi kireçtaşlarından oluşup, kiltaşları ile ardalanırlar. Akarsu ve göl sedimanlarını oluşturan tane bileşenlerin miktarı ile bağlayıcı malzemenin cinsi ve boyutları kıyıdan basen merkezine doğru azalır ve/veya küçülür. Akarsu sedimanlarındaki detritik kökenli simektit ve klorit minerallerine illit, amfibol, kuvars ve feldspat eşlik eder. Buna karşın, havzanın merkezi kesimlerinde karbonat birimlerinde egemen olan sepiyolit ve paligorskit mineralleri ise diyajenetik olarak oluşmuşlardır.

Anahtar Sözcükler: kil mineralleri, Konya, göl ortamı, Neojen, Türkiye

Introduction

The occurrence and distribution of clay minerals in sedimentary basins have been the subject of much discussion (Brooks & Ferrell 1970; Isphording 1973; Jones & Weir 1983; Jones 1986; Broxton *et al.* 1987; Compton 1991). No such study has yet been carried out in the Konya Neogene sedimentary basin. However, the formation of sepiolite and palygorskite in the carbonate unit of the central part of the Konya basin was determined to be the result of calcretion (Karakaş & Kadir 1998). Also, the economic importance of clay and aluminum sulphate occurrences in the western and southwestern parts of the basin was studied by Çelik *et al.* (1997).

The purpose of this study was to determine the lateral and vertical distribution of clay minerals within different lithologic units of the Konya Neogene sedimentary basin as well as to elucidate their genesis.

Methodology

Sixty two samples were collected from six stratigraphic sections in carbonate and fluvial sediments of the Konya basin (Figures 1 & 2).

The mineralogical characteristics of the samples were determined by X-ray powder diffraction (XRD) using CuKα radiation (Rigaku-Geigerflex), and scanning electron microscopy (SEM) (Jeol JSM 6400). For

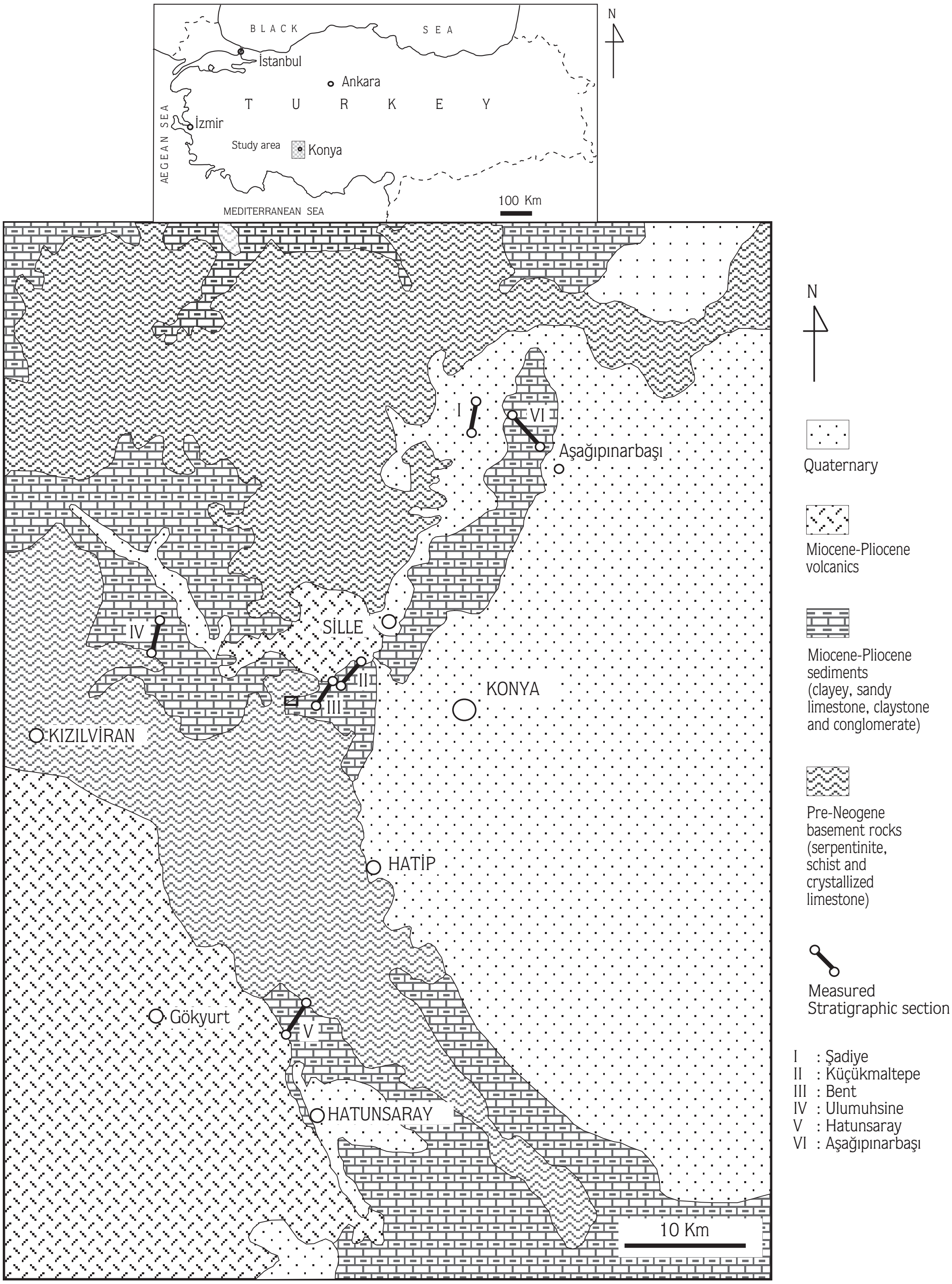

Figure 1. Geological map of the Konya basin (Simplified from 1:500,000 scale geological map of Turkey published by the General Directorate of Mineral Research and Exploration of Turkey).

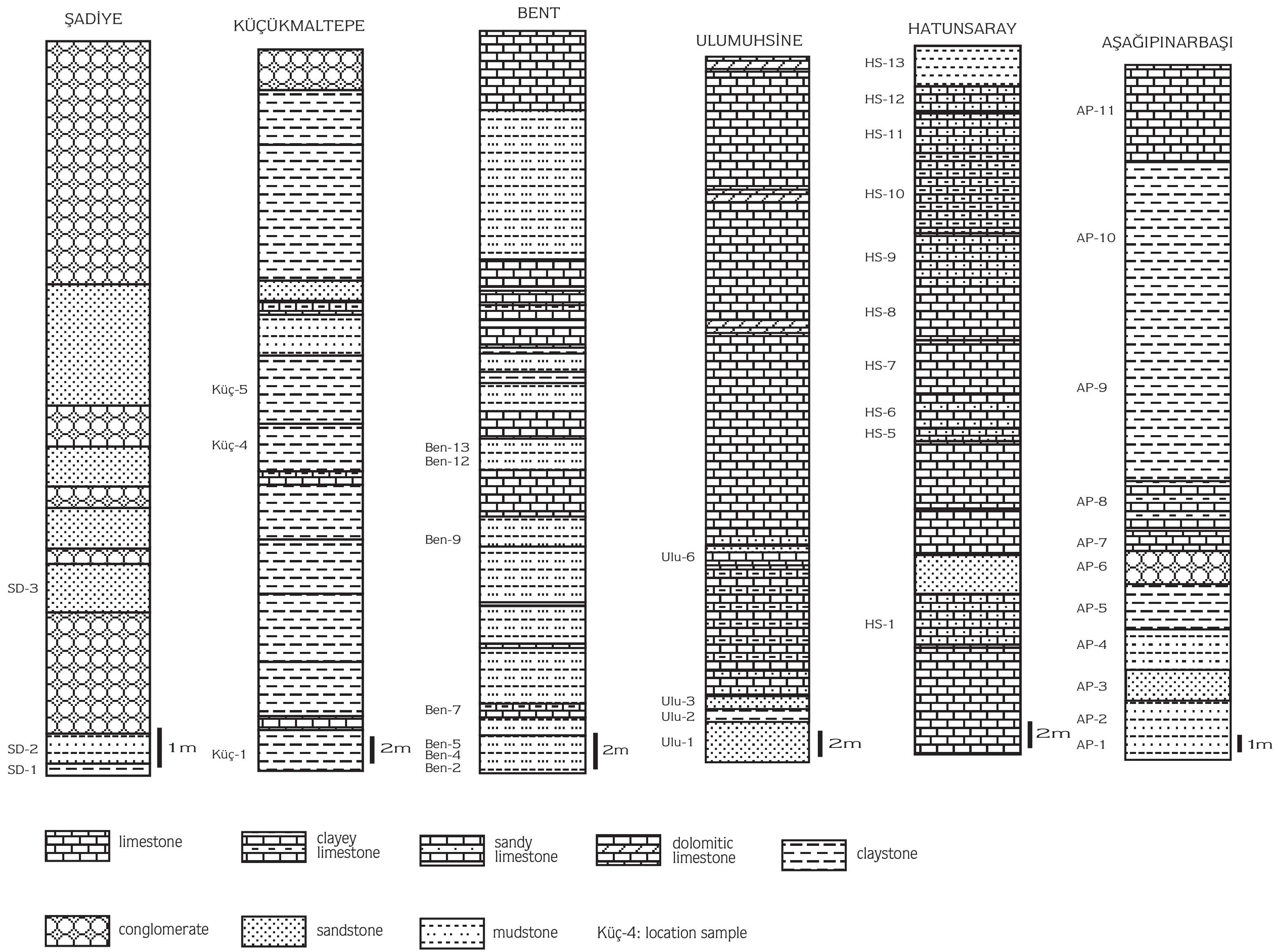

Figure 2. Measured stratigraphic sections. Showing the distribution of various lithologies in the sequences studied in the Konya basin (see Figure 1 for location).

petrographic studies, 35 thin sections were prepared from sandstone, conglomerate and limestone samples. Clay mineralogy was determined on <2 μm clay fractions prepared by sedimentation followed by centrifugation of the suspension after overnight soaking in distilled water. The clay particles were dispersed by a soil mixer and ultrasonic vibration for about 15 minutes. For identification, clay preparations that were air-dried, ethylene glycol solvated at 60°C/2H, and thermally treated at 350°C/2H and 550°C/2H were used. Semi-quantitative estimates of both clay fractions and rock-forming minerals of the <2 μm fractions were calculated by the external standard method of Brindley (1980).

Seven representative samples of different facies were chemically analysed for major oxides by XRF (Rigaku X-ray Spectrometer RIX 3000).

Geology

The pre-Neogene basement rocks of the Konya Neogene basin comprise serpentinite, schist, and crystallised limestones (Özcan *et al.* 1990; Hakyemez *et al.* 1992; Figure 1). These units are overlain by Neogene fluvial sediments and lacustrine deposits. Fluvial sediments (conglomerate, sandstone, mudstone and green claystone) are thick at the margin of basin and thin laterally toward the centre of the basin, where lacustrine units (limestone, clayey limestone and white claystone) dominate.

Green claystone, which alternates mainly with mudstone as well as with green sandstone and conglomerate is observed at all levels of the marginal sections. Brown and pale green mudstone in the Bent section is characterised by a clayey mudstone in contact with claystone units. On the other hand, in the lowest part of the central section, green claystone is exposed in thin layers alternating with fine-grained green sandstone; all layers have similar thicknesses. In contrast, white claystone is observed only in a small part of the Hatunsaray section (at the margin of the basin) but is dominant in the central part of basin. In places where there are alternations, white claystone and limestone are generally described as clayey limestone. Carbonate friability decreases in hard, fractured, and voidy limestone units. The lateral and vertical characteristics of these latter units can be used to distinguish sandy, clayey dolomitic and pure limestones.

Sedimentary Petrography

Carbonate units dominante in the Bent, Ulumuhsine, Hatunsaray and Küçükmaltepe sequences at the margin as well as in the Aşağıpınarbaşı sequence in the central part of the basin (Figures 1 & 2). XRD analyses show that the Neogene carbonate units of the section are composed mainly of dolomite and calcite. Thin sections of the carbonate units reveal the presence of micrite and sparite, as defined in the Folk (1959) classification (Figures 3a & b). Thus, on the basis of field observations, thin-section and XRD studies, carbonates in the area can be lithologically classified as pure, dolomitic, sandy and clayey limestone.

The grain size, components and matrix of the sandy limestone vary from the margins toward the center of the basin. The mineralogy of this unit comprises quartz, quartzite, chert, plagioclase, biotite and muscovite. The grain size of the terrigenous materials decreases from the margins basinward, while the matrix of the sandy limestone facies is sparitic, in contrast to the micritic facies of the central part of the basin (Figures 3a & b). In addition, ostracod and gastropod shells, as well as ooid and intraclast components have been detected in these units (Figure 3c). Pure and dolomitic limestones, implying only small amounts of clast material, are also micritic.

Mineralogy

Samples collected for identification of lithologies were analyzed by XRD (Table 1). These analyses revealed the presence of smectite, chlorite, sepiolite, palygorskite and illite (clay minerals), associated with quartz, feldspar and amphibole (detrital minerals), and dolomite, calcite and aragonite (carbonate minerals).

Smectite and chlorite are abundant in the marginal facies (Table 1). In addition, smectite is typically present in the Hatunsaray, Küçükmaltepe and Ulumuhsine sections. Chlorite is abundant in the Bent and Şadiye sections, which are dominated by fluvial units (Table 1, Figure 2). Smectite (commonly) and chlorite (rarely) are present in the sandstone and mudstone units in lower part of the sequence of the central part of the basin. These minerals are accompanied by illite, quartz, feldspar and amphibole. The evolution of smectite and chlorite from the marginal facies toward the lower part of stratigraphic sequence in the central facies indicates that these minerals have a genetic relationship to the detrital

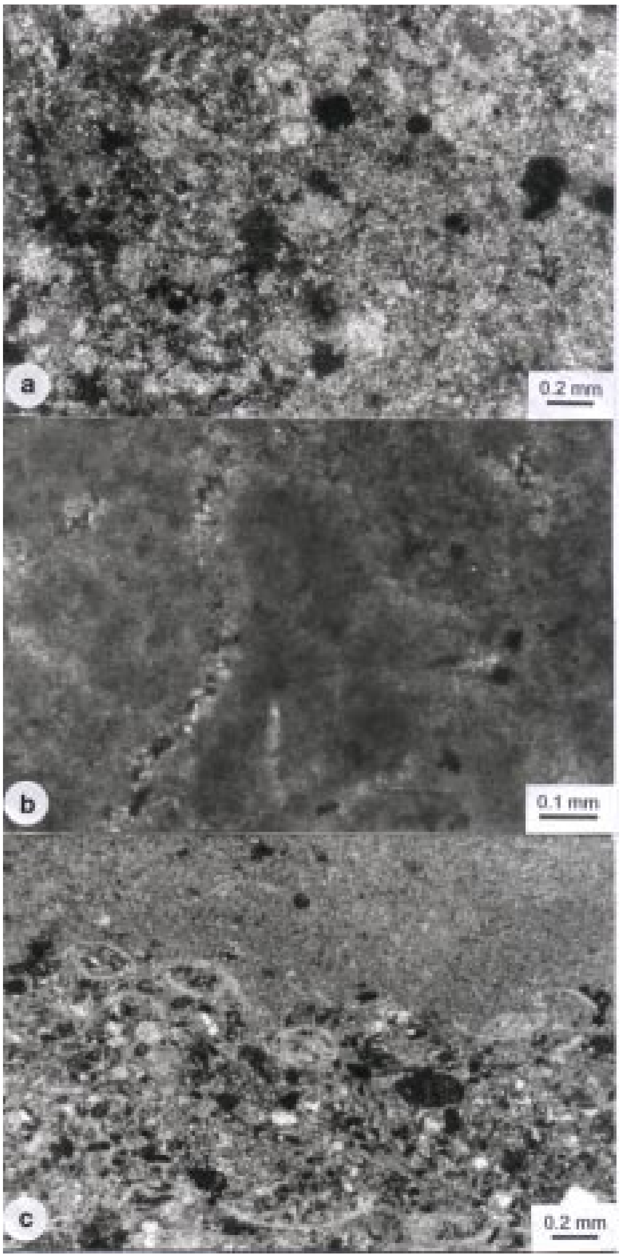

Figure 3. Photo micrographs of **(a)** sparitic limestone in the marginal facies of the basin (Ben-7); **(b)** micritic limestone in the central part of the basin (AP-11); and **(c)** Ostracode shells showing parallel concentration to the sharp contact between sparitic limestone at the lower part of the hinterland and micritic limestone at the uppermost (AP-7).

material supplied from the drainage area (Table 1, Figure 2). Sepiolite and palygorskite observed in the clayey dolomitic limestone of Aşağıpınarbaşı in the central part of the basin (Table 1, Figure 2) are generally associated with calcite and dolomite, while chlorite and smectite are absent. This shows that sepiolite, palygorskite and dolomite are not of detrital origin but, rather formed by diagenesis.

Table 1. The bulk mineralogy of different lithologies in the Konya basin.

Sample	Smc	Chl	Sep	Pal	Il	Amp	Feld	Qz	Cal	Dol	Arg
HS-1	++						ac	ac	+++		
HS-5	+						+	ac	+++		
HS-6	+				++	ac	++	ac			
HS-7	++						++		+		
HS-8	+				ac				++++		
HS-9	+				+	ac	++	ac	+		
HS-10			+				+		+++		
HS-11	+				+		+		++		
HS-12	+				+	ac	++		+		
HS-13	+	+		++			+	ac			
Ben-2		+			++			ac	++		
Ben-4		+			++			+	+		
Ben-5					+		+	+	++		
Ben-7		+			++			+	+		
Ben-9		+			+		ac	+	++		
Ben-12								ac	+++++		
Ben-13		+			+			+	++		
Ulu-1					+++	ac	++	ac			
Ulu-2	+++				+		+	ac			
Ulu-3	+				++		++	ac			
Ulu-6					ac			ac	+		++++
SD-1		+			++++			ac			
SD-2		ac			++++		ac	+	ac		
SD-3					++		ac	+	+	+	
Küç-1	+				++			+	+		
Küç-4	ac	ac			++			+	++		
Küç-5					++			ac	+++		
AP-1		++			++		ac	ac	+		
AP-2	++	ac			++		ac	ac	+		
AP-3	+	+			++		ac	ac	+		
AP-4	++				++		ac	ac	+		
AP-5	++				++		ac	ac	+		
AP-6	+	+			+		ac	+	+		
AP-7				++				ac	+++		
AP-8					+			ac	+++	+	
AP-9			+	+						+++	
AP-10			+++				ac		ac	++	
AP-11									+++	++	

Smc: Smectite, Chl: Chlorite, Sep: Sepiolite, Pal: Palygorskite, Il: Illite, Amp: Amphibole, Feld: Feldspar, Qz: Quartz, Cal: Calcite, Dol: Dolomite, Arg: Aragonite. +: Relative abundance of minerals, ac: Accessory.

SEM Determinations

Clay-dominated samples were studied by SEM in order to observe the micromorphology of the clay minerals and their relationships with non-clay minerals. Smectite appears to be generally concentrated in the voids between mineral grains and in the voids left by dissolved minerals in the mudstone (Figure 4a). In places, it may acts as a cement between grains. Chlorite generally formed in the voids left by dissolved minerals between grains in the detrital units, forming honeycomb-type patterns (Figure

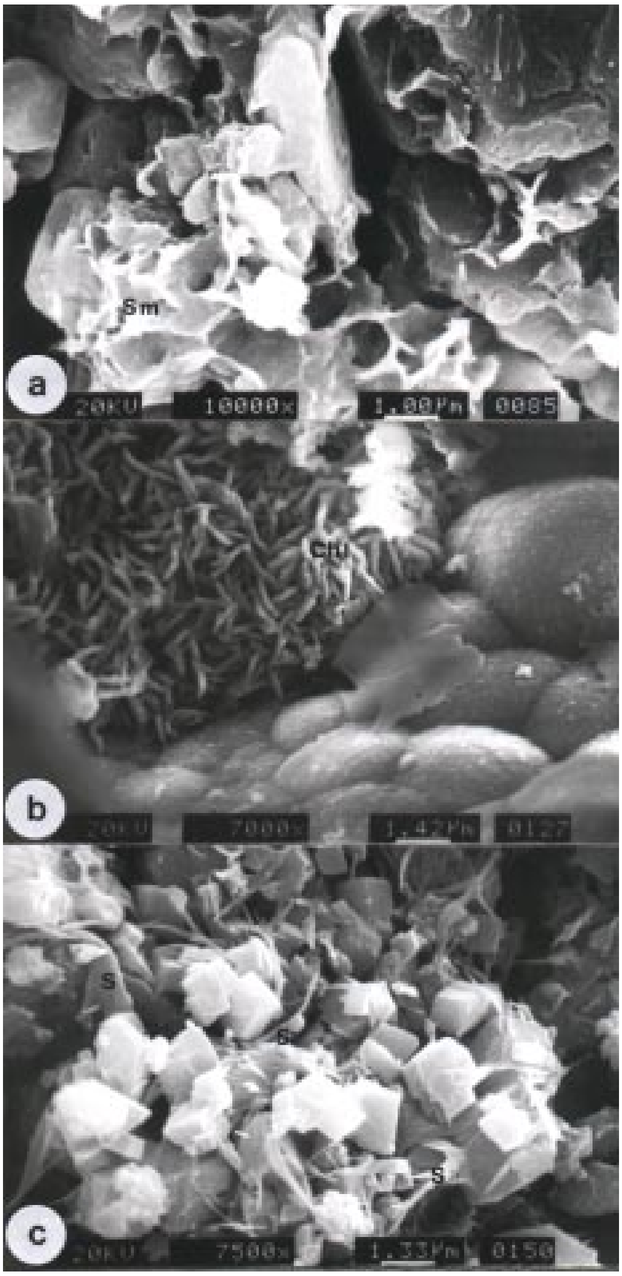

Figure 4. Scanning electron microscope (SEM) photographies showing. **(a)** formation of smectite (Sm) in the space between mineral grains and in the dissolution voids (Küç-1); **(b)** development of honeycomb chlorite (Chl) in between mineral grains (AP-4); and **(c)** formation of sepiolite (S) fibers between carbonate minerals (AP-10).

4b). In the carbonate units, sepiolite and palygorskite exhibit fiber and fiber bundle textures between carbonate grains and voids (Figure 4c).

Chemical Analysis

The results of chemical analyses for major elements of the different clay-bearing lithologies are given in Table 2. The chemical compositions of these samples change in relation to their mineralogical compositions. Therefore, the values of CaO, MgO, SiO_2 and Fe_2O_3 are controlled by the proportion of carbonate minerals, illite, feldspar, quartz and associated smectite, chlorite, sepiolite and palygorskite. SiO_2, Al_2O_3, K_2O and Fe_2O_3 concentrations are high in the marginal facies of the basin due to abundance of illite, feldspar, quartz and accompanying smectite and chlorite. CaO and MgO are relatively high and Al_2O_3 is low in limestone of the central part of the basin. SiO_2 and MgO values are high in sepiolite- and palygorskite-dominated samples.

Table 2. Chemical analyses of fluvial and carbonate sediments in the Konya basin. Results in % of total composition.

Sample No	Ulu-1	Ben-5	Küç-1	HS-10	HS-13	AP-11
SiO_2	61.9	21.79	63.5	10.28	56.65	0.43
MgO	2.09	1.4	2.6	2.2	5.28	18.6
CaO	5.29	33.69	4.8	45.35	3	31.7
Al_2O_3	14.38	8.4	15.9	1.7	13.57	1.5
Na_2O	1.9	0.2	3.4	0.2	0.7	0.1
K_2O	3.6	1.5	2.5	0.2	2.2	0.4
Fe_2O_3	2.9	3	5.6	0.7	5.49	0.75
MnO	0.1	0.1	0.1	0.1	0.1	0.1
TiO_2	0.4	0.4	0.6	0.1	0.9	0.1
P_2O_5	0.2	0.1	0.2	0.1	0.6	0.1
H_2O^-	2.3	1.45	0.05	1.4	5.28	0.05
SO_3	0.03	0.17	0.01	0.01	0.05	0.09
LOI	4.9	27.8	0.49	37.66	6.18	42.95
Total	99.99	100	99.75	100	100	99.87

Ulu-1: Sandstone, Ben-5: Mudstone, Küç-1: Green claystone,
HS-10: Clayey limestone, HS-13: Claystone, AP-11: Limestone,
LOI: Loss on ignition at 1050°C.

Conclusion and Discussion

The fluvial and lacustrine sediments of the Konya Neogene basin are widespread. Field observations and mineralogical determinations of these units reveal variations. In the fluvial sequences, detrital sediments transported by streams occur in thick sequences along the margin of the basin and thin laterally basinward, their grain sizes decrease toward the centre of the basin.

The carbonate units are partly exposed in the marginal facies but dominate the central part of basin. In this context, marginal limestone has sparitic character in contrast to the central limestone which is micritic and grain-poor. This facies distribution allows a partial reconstruction of original lake depth and depositional dynamics.

Mineralogical distribution in the Konya sedimentary basin indicates that formation of sepiolite-palygorskite-type clay minerals and dolomitic type carbonate rocks were related to increases in pH, Mg/Ca ratio and silica content, thus testifying to the increase in evaporation basinward. This basinward distribution of minerals reflects a decrease in aluminous material and an increase in magnesian silicates within the sediments, from the margin to the centre of the basin. Similar distributions and environmental conditions have been reported also by Millot (1970), Truc (1978) and Newman (1987). On the other hand, as would be expected, smectite and chlorite are associated with other fluvial sediments of detrital origin, such as amphibole, illite and quartz.

Field observations and mineralogical determinations indicate that the distribution and origin of clay minerals in the Konya Neogene sedimentary basin were controlled by physico-chemical environmental conditions within the sediments. Thus, sepiolite and palygorskite formed diagenetically in carbonate units of the central part of the basin, in contrast to smectite and chlorite occurrences which are of detrital origin in the marginal facies of the basin.

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