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MICRO-TEXTURAL FEATURES OF THE SANDSTONES IN THE ÜZÜMDERE FORMATION (NORTH OF AKSEKİ, ANTALYA)

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ABSTRACT.- Üzümdere formation, Liassic aged is the oldest unit of the paraautochthonous sequence in the region and located within the Anamas-Akseki carbonate platform Lithological units cosist of sandstones and limestone, claystone, and conglomerates. The Üzümdere sandstones are claret-green in color, medium-thick bedded, well sorted, and highly fractured. The unit is petrographically described as quartz arenite-quartz wacke and sublitharenite based on the classification of Folk (1968). X-ray diffractometry studies have revealed that illite, kaolinite, and montmorillonite are the main clay minerals in the sandstones. Scanning electron microscope (SEM) and x-ray micro analyses (EDS) performed on some samples indicated that the development of cement in these rocks are of calcite, dolomite (?), iron oxide, chlorite and kaolinite. Moreover, calcite and iron-oxide are developed as filling the pores within the fractures. The unit, in which authigenic clay occurrences and quartz overgrowths are observed, has a poor porosity.

INTRODUCTION

Sandstones of the Üzümdere formation, Liassic aged are exposed on the core of Akseki anticline at the north of Akseki (Antalya) (Fig. 1). The studies carried out in the investigated area so far are based on the petroleum geology (Demirtaşlı, 1979, 1987; Ayyıldız, 1992). These studies revealed the presence of a unit as the source rock in the region. In addition, it has been stated that sandstone levels in the Üzümdere formation are of importance as reservoir rock (Demirtaşlii, 1979).

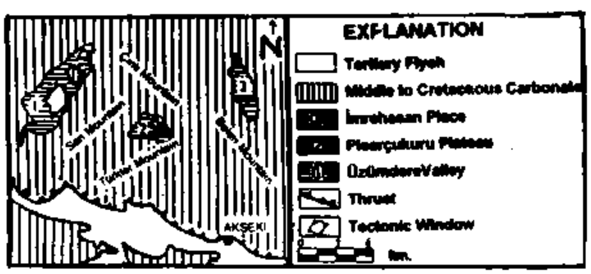

Fig. 1- Location map showing exposures of the Üzümdere formation in the study area.

As it is known, sandstones can form important hydrocarbon reservoirs depending on their depositional facies and, permeability and porosity conditions which they gain and preserve under some events they subjected. However, authigenic clays and other minerals developed in the structures of this type of rocks can worsen the reservoir conditions and lower porosity and permeability. Therefore, micro-textural features of this type of clastic sediments should be determined.

That is why, in this study, permeability and porosity properties of the sandstones of Üzümdere formation have been determined based on the examinations of their petrographic, mineralogic, and micro-textural parameters.

During these studies, petrographical descriptions of the sandstones and evaluations based on mineralogic and micro-textural features were made in accordance to Folk (1968) and McDonald (1979a, *b),* respectively. A number of 30 samples was collected from the sandstones of the Üzümdere formation and their petrographic description was made on thin sections. Mineralogic descriptions (whole rock day) x-ray diffractometry method with a Rigaku Geigerflex D/Max-Q/Q WC model diffractometer. Scanning electron microscope (SEM) studies for micro-textural features (grain-grain, gram-cement and grain-porosity relations) and x-ray micro analyses (EDS) studies were performed with Jeol JSM 840 A and Tracer TN 5502 machines, respectively. In addition, in order to determine the pore surfaces and their percentages, blue dyed epoxy was performed in the thin sections of all samples. With the aid of a Swift model point counter, modal analyses tecnique was also applied to determine the quantitative mineralogic composition of some selected samples. Furthermore, in order to determine the type of secondary iron oxide fillings within the fractures, polished samples was prepared and they were examined under the Nicon model ore microscope.

DESCRIPTION OF ÜZÜMDERE FORMATION

Formation was first named by Martin (1969) and later was described in detail by the studies of Monod (1977) and Demirtaşlı (1979, 1987). The basement of the unit under investigation has a tectonic contact and it is concordant with the Pisarçukuru formation in Dogger-aged above. The dominant lithologic assemblage of the Üzümdere formation is claret-green in color sandstone, limestone, claystone, and conglomerate. Its real thickness can not be determined due to the tectonic contact at the basement. However, in the measured stratigraphic sections of the Üzümdere valley (M.S.S. 1), Pisarçukuru plateau (M.S.S. 2) and Imrehasan places (M.S.S. 3) the thicknesses of 250, 450, and 400 m were measured, respectively.

In the Üzümdere M.S.S. 1, formation starts with limestones at the basement and continues with well sorted, medium to thick bedded, highly fractured sandstone and claystone alternations. Alternating sandstone levels are claret-green m color whereas claystone levels are red in color. Above these units in the Üzümdere village is the conglomerate levels (Plate 1, photo 1). The lower and upper levels of conglomerates of petromictic character, whose lateral transition is limited, are grain and matrix supported, respectively. The basement of conglomerates are erosional and imbricated are developed in them. In the upper most part, sandstone-claystone and dolomitic timestones in places are found. The stratigraphic sequence observed in M.S.S. 1 is also traced in M.S.S 2 and M.S.S. 3. The sandstone in M.S.S. 2, however, contains significant amount of iron oxide concretions (Plate 1, photo 2). On the contrary, at the basement of M.S.S. 3, bituminous bearing levels are observed.

PETROGRAPHIC ANALYSES

Petrographic studies indicate that the constituents of sandstones in the Üzümdere formation are composed mostly of quartz, calcite, muscovite, magmatic-metamorphic rock fragments and little amounts of feldspar and opaque minerals. The cement of the sandstones is dominantly calcite and iron oxide, but clay in some samples. They are described as quartz arenite, quartz wacke and sublit arenite.

Under the microscope, quartz grains are mostly monocrystalline, but in some samples polycrystalline grains are also observed. It was also observed that quartz grains are generally highly fractured, angular, but are sub-rounded and oval in some samples. Most of fractured quartzs are filled by secondary calcite and partly by iron oxide (Plate II, photo 3). Muscovite inclusions were also observed in quartzs Iron oxide interferences are detected as filling the rock Assures (Plate II, photo 4). It was also determined polycrystalline quartz grains are schistose structured metamorphic quartzites. Due to the tectonic activity, calcite grains in places shown pressure twin growths. Calcite grains are medium to coarse grained, partly rounded and have well developed cleavages. Calcite is observed as both a fixing agent and secondary pore filling, while feldspars appear to have been subjected to alteration and are transformed to cericite. Textural studies reveal that grains are well sorted and they show point, concave, and convex contacts with each other, and that they have a medium degree maturity. The results of modal analyses conducted on selected sample are given in Table 1. The results are obtained from an average counting of 1650.

Table 1- Average composition of sandstone determined by the modal analyses method

Sample No	*Quartz*	*Feldspar*	*Calcite*	*Rock Fragment*
ÜZ-4	1863	15	363	205
ÜZ-7	391	17	770	152
ÜZ-9	546	31	231	286
ÜZ-11	987	57	195	513

X-RAY DIFFRACTOMETRY ANALYSES (XRD)

XRD studies for the mineralogic descriptions of the sandstones of the Üzümdere formation were realized as whole rock and clay analyses (analyses with no treatment, with ethylene glycol and with treatment of HCl). Of these, the main minerals of samples, examined by the whole rock analyses, are quartz, muscovite, chlorite, calcite, feldspar (K-feldspar-plagioclase) and lesser amounts of dolomite (Fig. 2 a-b-c).

First the analyses with no treatment was done for the clay analyses of these samples (Fig. 3 a-b). In order to differentiate the clays in the rock, then the analyses were repeated with the treatment of ethylene glycol (Fig. 2 d). Finally, to test kaolinite and chlorite minerals detected, analyses were made with treatment of HCl. During this experiment, samples were boiled 1 hour in a mixture consisting of 1 mol HCl and 1 mol pure water. After samples were washed out with the remnant pure water and dried, the analyses were repeated. Chlorite peaks became extinct at the end of this analyses. This results confirms the presence of chlorite within the-rock. Different amounts of muscovite, kaolinite, chlorite and montmorillonite were determined by the analyses. The presence of a little amount of illite was also detected 'as coinciding with the peaks of muscovite.

MICRO-TEXTURE STUDIES (SEM-EDS)

As a result of SEM-EDS studies on some selected sandstone samples, detailed information were obtained for some features, such as cementing, porosity, clay neomorphism and the relations of grain-grain and grain-cement. There is almost no porosity in all the examined samples, and authigenic clay occurrences together with the compaction of sandstones are well developed. In addition, quartz overgrowths of authigenic origin and radial developments are well distinguished (Plate III, photo 5). On the other hand, calcite crystals have partly a zoning structure and dissolution pores in places are detected on their surfaces (Plate III, photo 6). Microporosity and cave occurrences in places are observed in calcite cement (Plate IV, photo 7). It was also detected in some samples that chlorite cement fills the pores between grains (Plate IV, photo 8).and that microporosity fields (Fig. 4a) are widespread in the iron-chlorites which were particularly detected with EDS studies. In some samples of the Üzümdere sandstone having a cement of kaolonite it was observed that smectites together with kaolinite completely fill pore fields as semi-booklets (Plate V, photo 9, 10; Fig. 4b).

Dissolution and alteration effects are typical for feldspar (Plate VI, photo 11). Secondary fracture fields are filled with calcite and iron oxide (Plate VI, photo 11,12; Fig. 4c). Filling of fractures negatively affects the porosity (Ayyıldız, 1992; 1994). These secondary iron oxide fillings have been determined as "hematite" based on the field observations by Martin (1969) and Demirtaşlı (1979). However, ore microscopy and x-ray diffractometry studies reveal that this iron oxide filling is limonite (goethite and lepidocrosite) rather than hematite. Pyrite occurrences were also detected along the fractures.

DISCUSSION

The events observed in the sandstones of the Üzümdere formation are in the order of; calcite and iron oxide cementing, compaction, secondary dissolution of calcites, quartz overgrowth, alteration of feldspar, authigenic clay occurrences, development of secondary fracture systems, and filling of these fractures by calcite, limonite (geothite and lepidocrosite) and pyrite.

Of these, carbonate cement was formed by the neoformation of possible primary micritic cement depending on the compaction. Based on blue dyed epoxy test and SEM studies it is believed that secondary dissolution and dissolvements observed in the calcite cement were formed by the expelling CO_2 during the development of kerogen in the organic material-bearing levels of the Üzümdere formation. Similar statements are also found in the study of Schmidt and McDonals.(1979a). Iron oxide developments in the sandstones of the Üzümdere formation are observed as both cement and secondary fracture filling. Iron oxide in a cement character must have been probably brought to the basin by been absorbed on the detritic clay minerals (Greenland, 1975) or by mixing with humic acid (Picard and Felbeck, 1976). The source of secon-

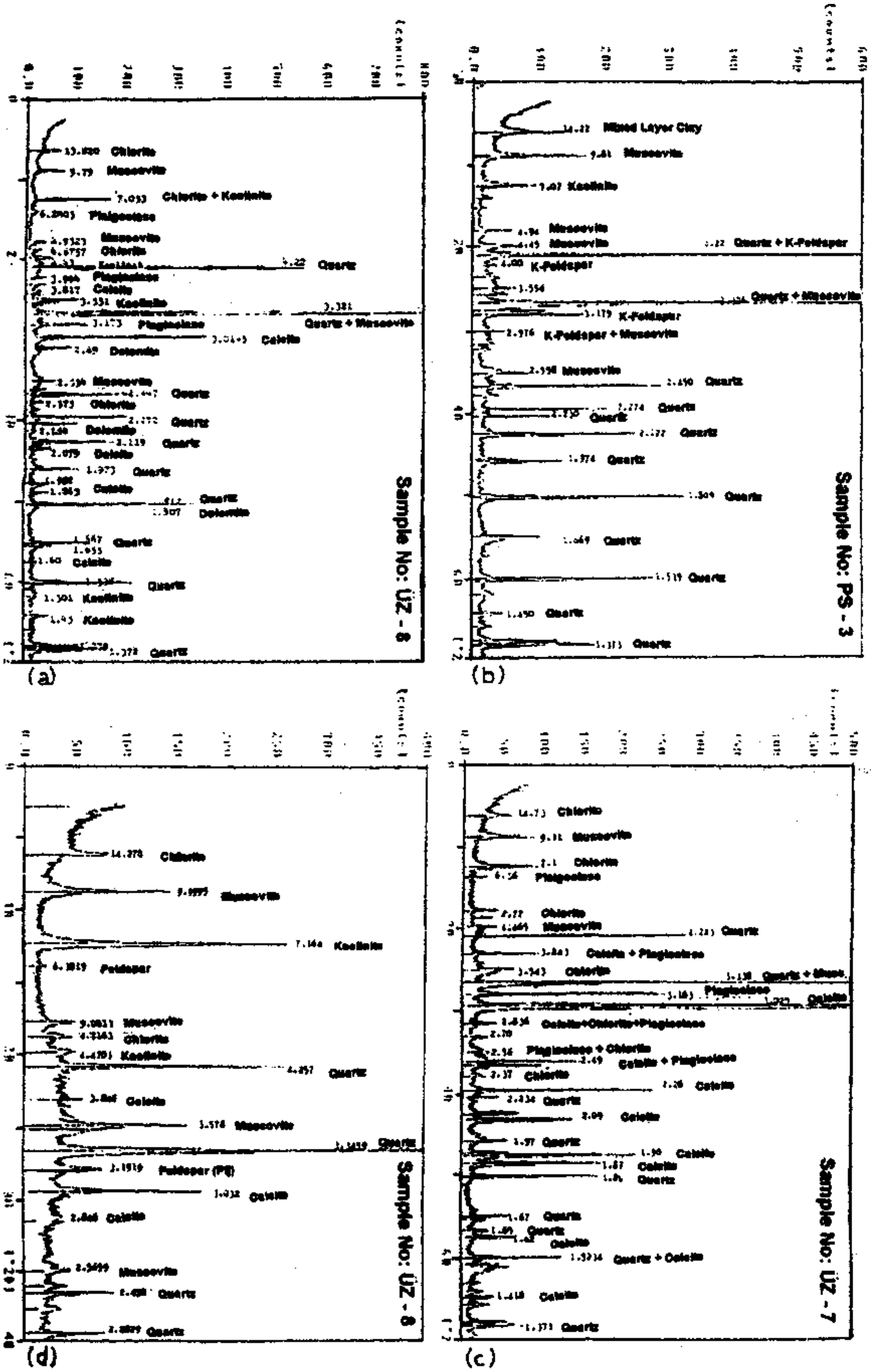

Fig. 2- X-ray diffractometry diagrams of whole rock and clayey units upon treatment with ethylene glycol.

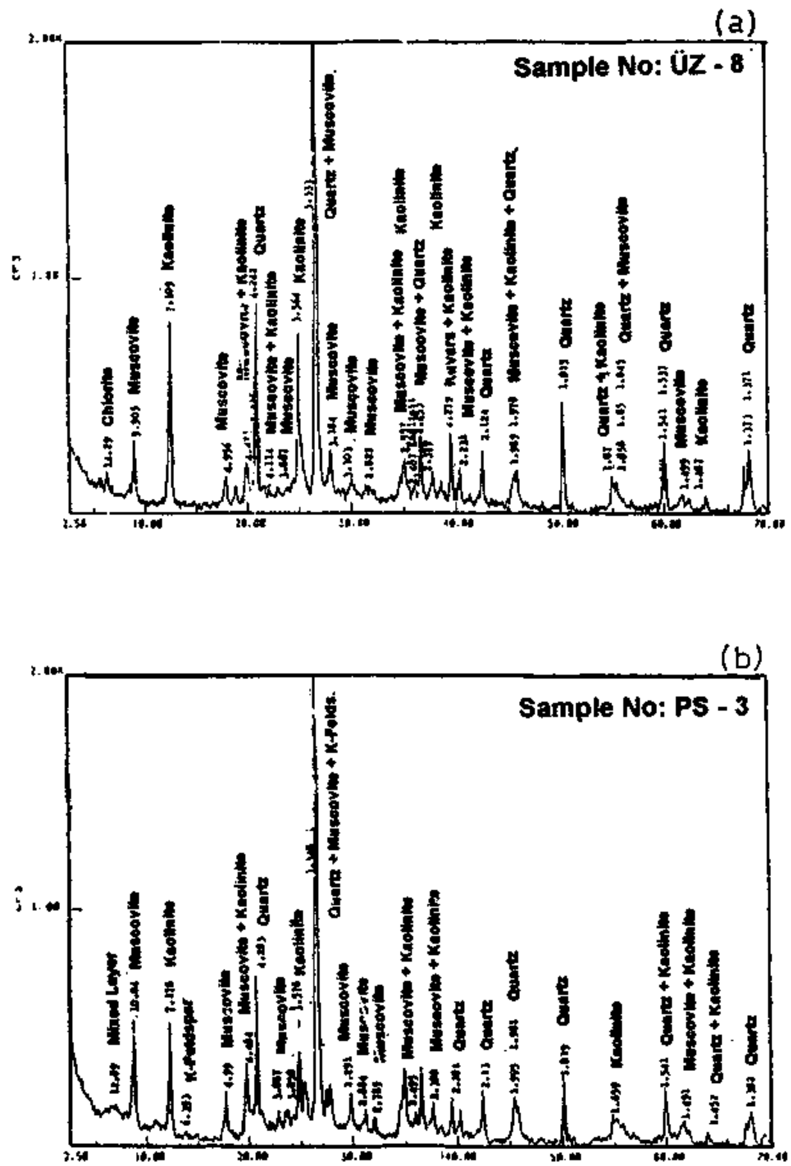

Fig. 3- X-ray diffractometry diagrams of clayey units.

source of secondary-fracture-filling iron oxide may be flushing in the atmospheric conditions as stated by Thomas (1974). Because, microporous iron-chlorites were observed on the edges of iron oxide zonings filling the fractures. These microporous developments give rise to the opinion that iron-chlorites are subjected to flushing time to time and, hence, are the source of iron in the environment. However, if it is assumed that chlorites are formed as the last product, speculation given above fails. Alteration of mafic minerals such as pyroxene, amphibole, and hornblend, detected in the heavy mineral analyses carried out for the investigation of source rock (Ayyıldız, 1992), may be the source of

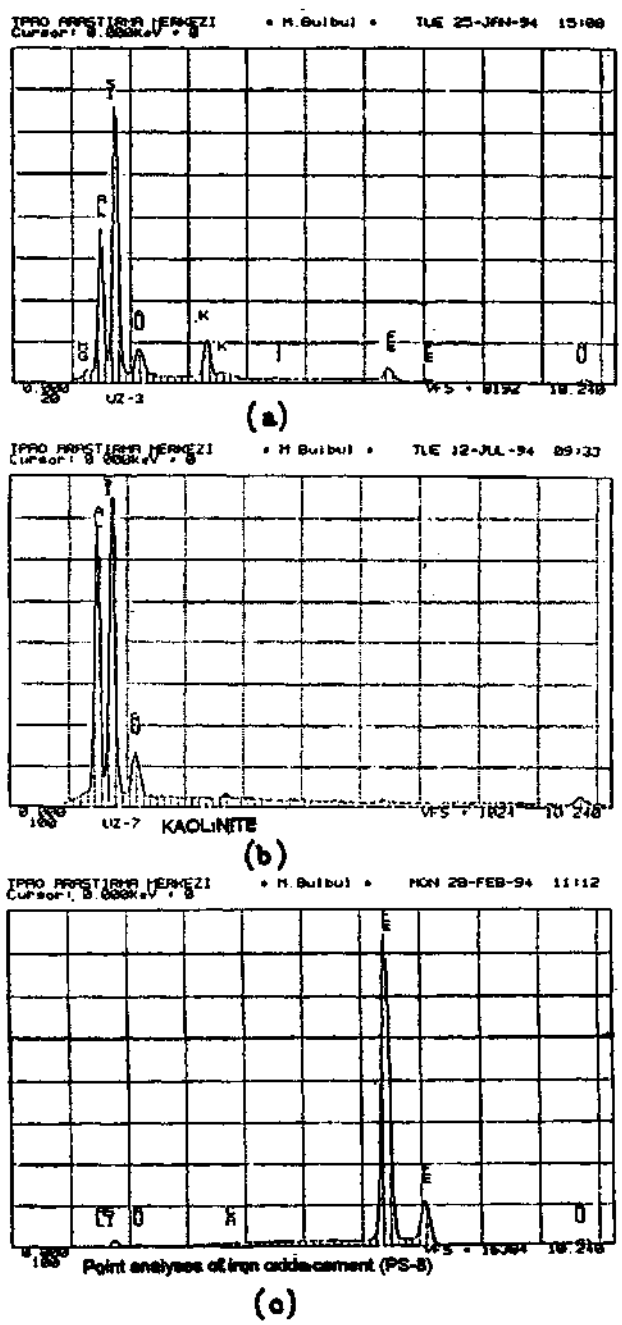

Fig. 4- Semi-quantitative EDS diagrams of components determined by SEM studies.

authigenic iron oxide minerals. Similar results were also given in the study of Sayın (1984). Quartz overgrowth detected in the quartz grains by SEM studies are formed by Si^{+2} concentrations yielding from the dissolution of partly amorph unstable aliminosiliceite minerals through the reaction with the fresh wators in the pores that are come to exist due to lowering of PH by the intense bicarbonate formation of aerobic bacteries. Similar formation mechanism are also presented in the studies of Garrets and Christ (1965) and Curtis (1978).Al^{+2} expelled from the some mechanism is thought to be consumed in the formation of kaolinite. Kaolinite may also be formed as a result of alteration of K-feldspar. According Curtis and Spears (1971), both formation type are possible to occur.

In addition, the possible source of authigenic chlorites, which were observed as grain bounding and pore filling during the SEM studies, could be the reaction of kaolinite with Fe^{+2} ve Mg^{+2} which are supplied to the system. The study of Boles and Franks (1979) gives information on this manner.

RESULTS

Calcite, iron oxide, silica, and clay cement detected in the sandstones of the Üzümdere formation have negatively affected the porosity and permeability properties of the unit.

Development of silica and clay cement may decrease the secondary porosity.

Fracture systems developed after the unit was exposed have been destroyed by the secondary calcite and iron oxide fillings.

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PLATES

PLATE-I

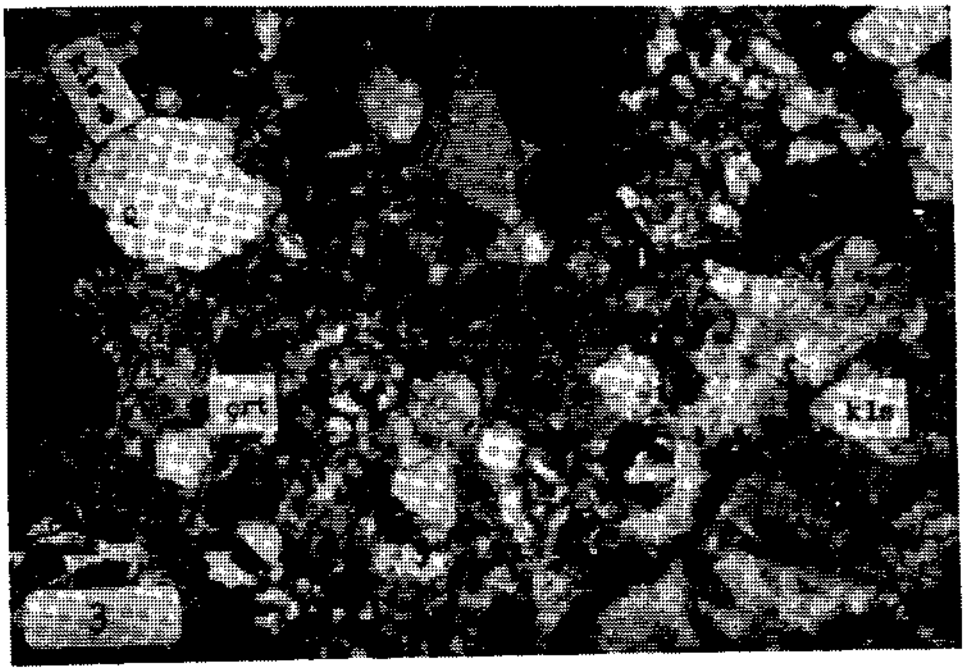
Photo 1- A wiev of conglomerate and sandstones belonging to the Üzümdere formation (NW of Üzümdere village. View direction is from SE to NW).

Photo 2- A view of iron oxide concretion-bearing sandstones of Üzümdere formation (Pisarçukuru pletau. View direction is from SE to NW).

PLATE-II

Photo 3- Photorricrographic view of cakate fillings in the fractures of iron oxide and day cement-bearing quartz arenites and quartzs observed in the Üzümdere formation (Quartz (Q); Calcile (kls) and chert (çrt); crossed nicole: X63).

Photo 4- Photomicrographic view of iron oxide filling in the rock fracture (Quartz (Q); iron oxide (dmr); Pisarçukuru Pletau, PS-8, plane light; X63).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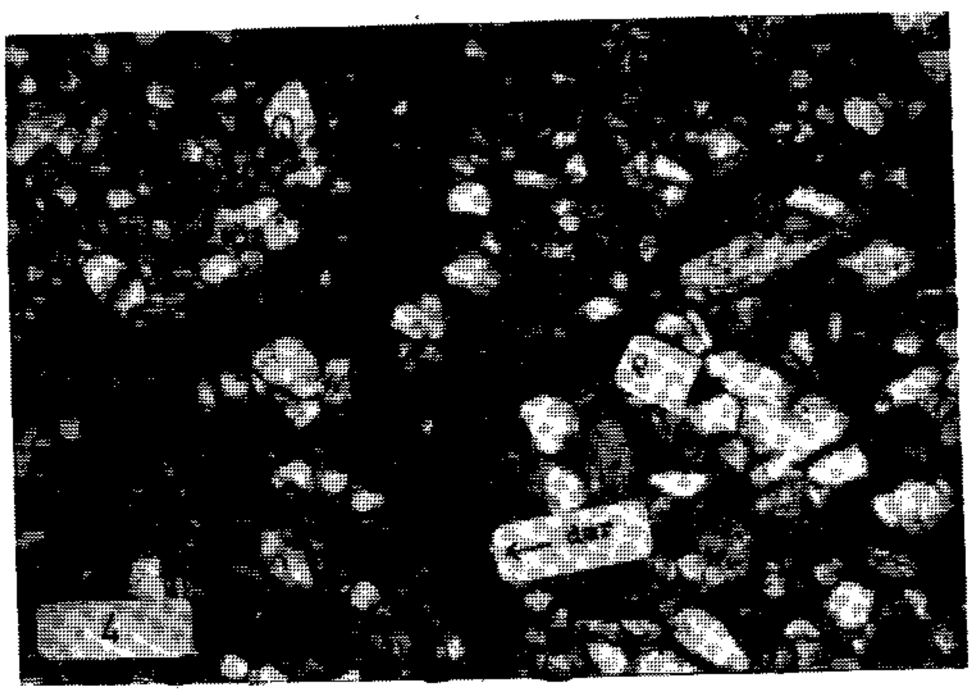
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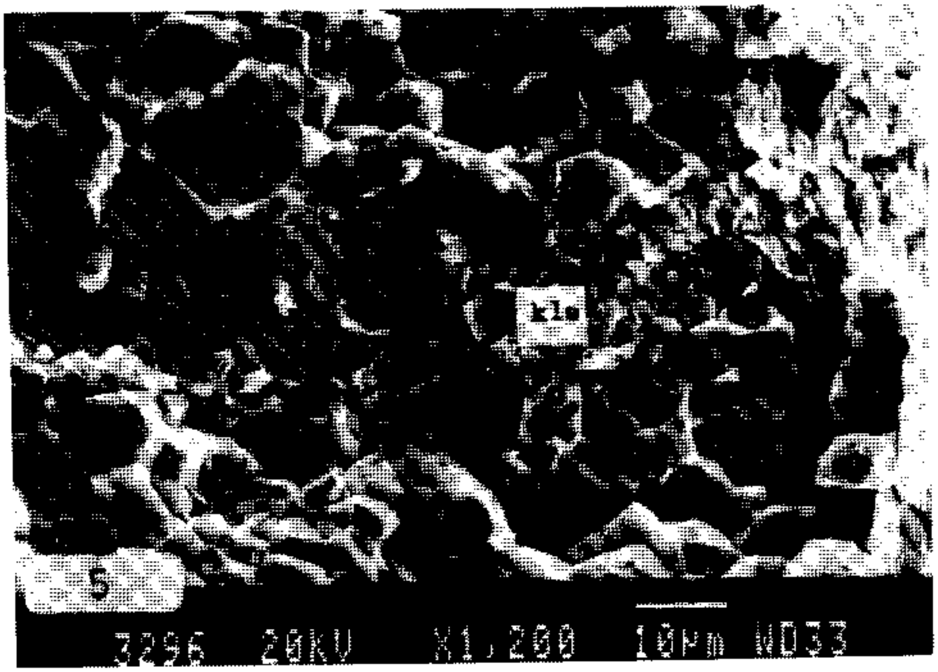
PLATE -III

Photo 5- SEM image of secondary quartz overgrowths and calcite fracture fillings (calcite (kls)).

Photo 6- SEM image of zonal growing calcite and feldspars aliered on the margins.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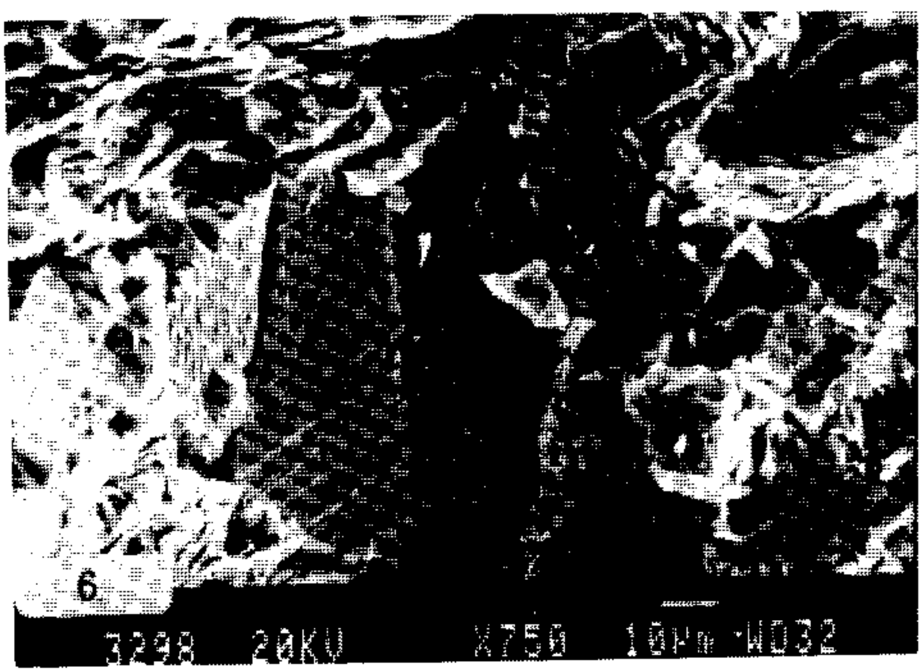
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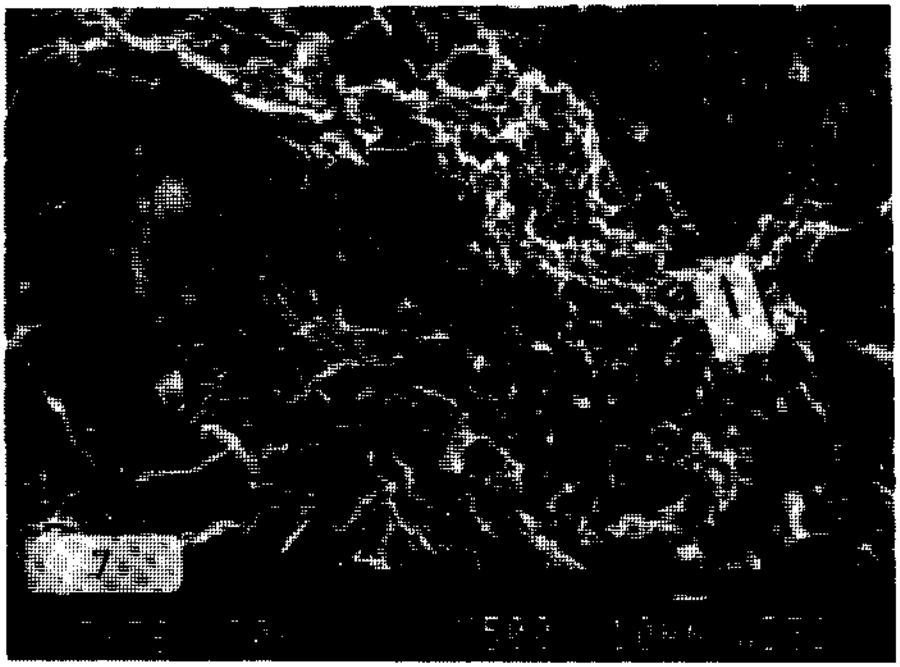
PLATE -IV

Photo 7- SEM image of microporosity and microform porosity between the calcite grains.

Photo 8- SEM image of chlorites developed in micropores.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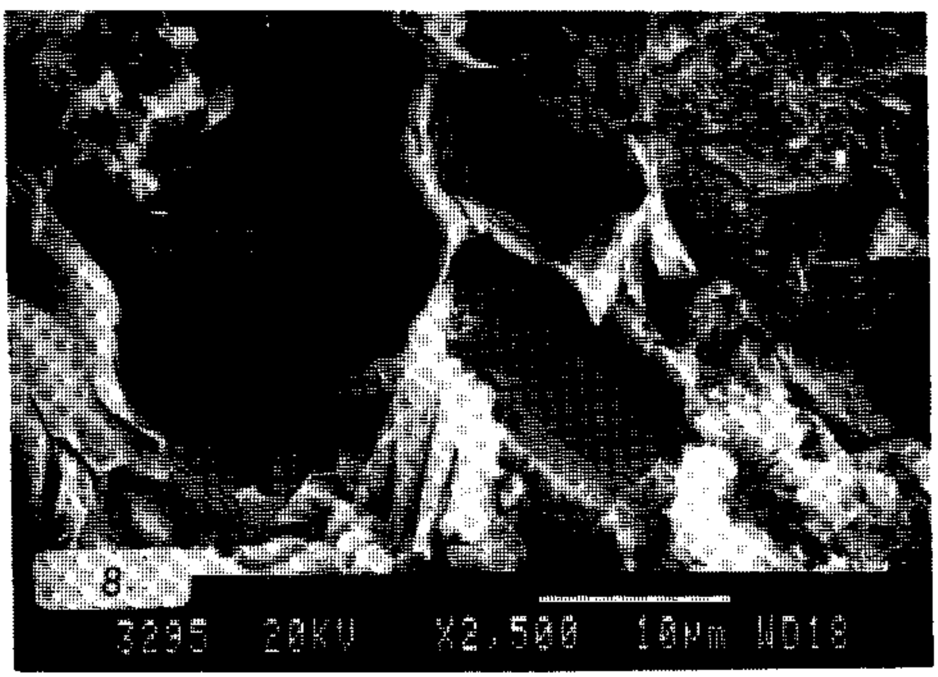
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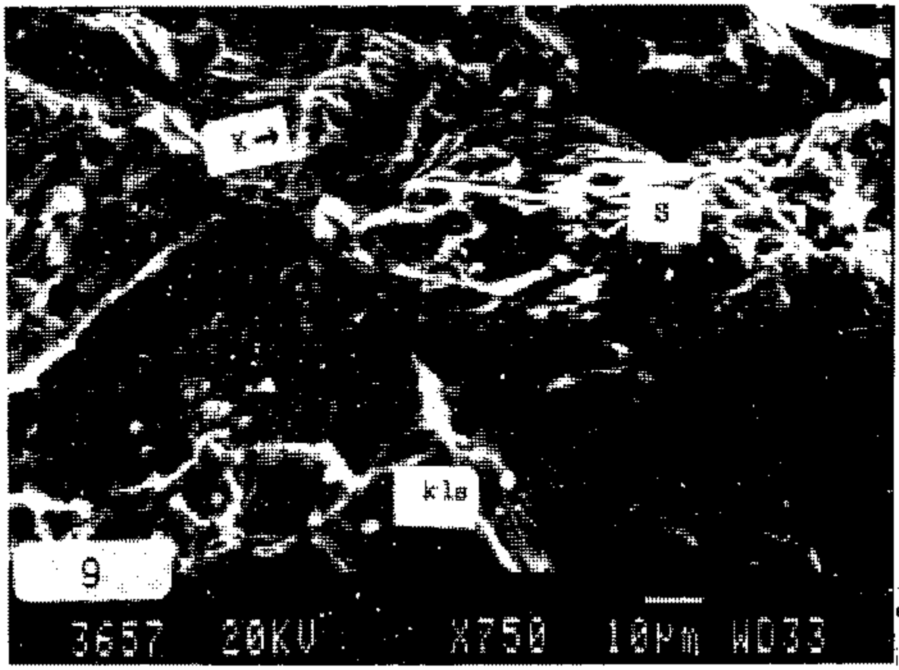
PLATE -V

Photo 9- SEM images of kaolinite, smectite, and calcite (kaolinite (k); smectite (s), and calcite (kls)).

Photo 10- SEM image of semi-booklet kaolinittes.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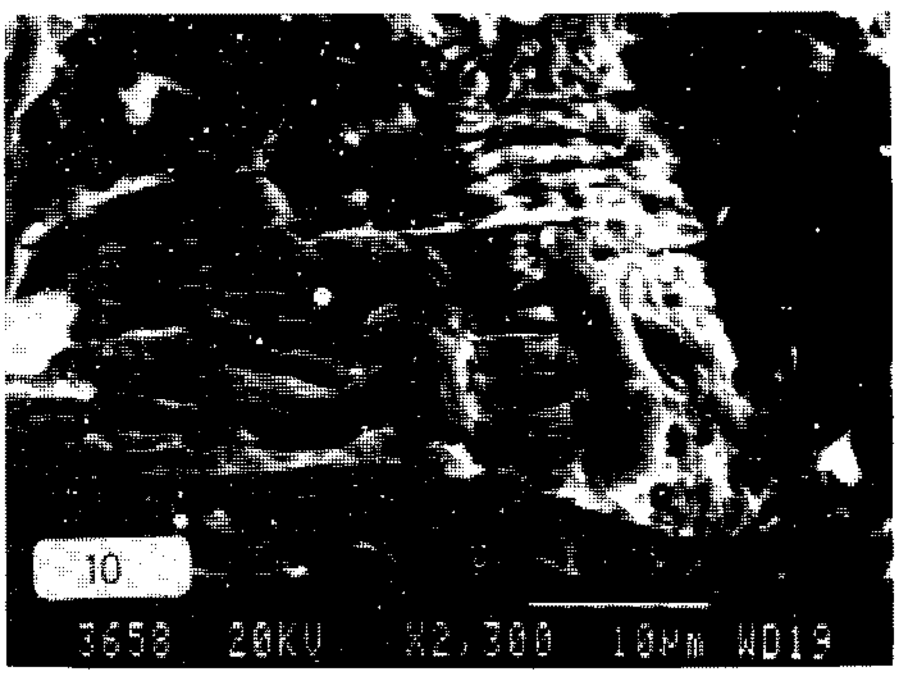
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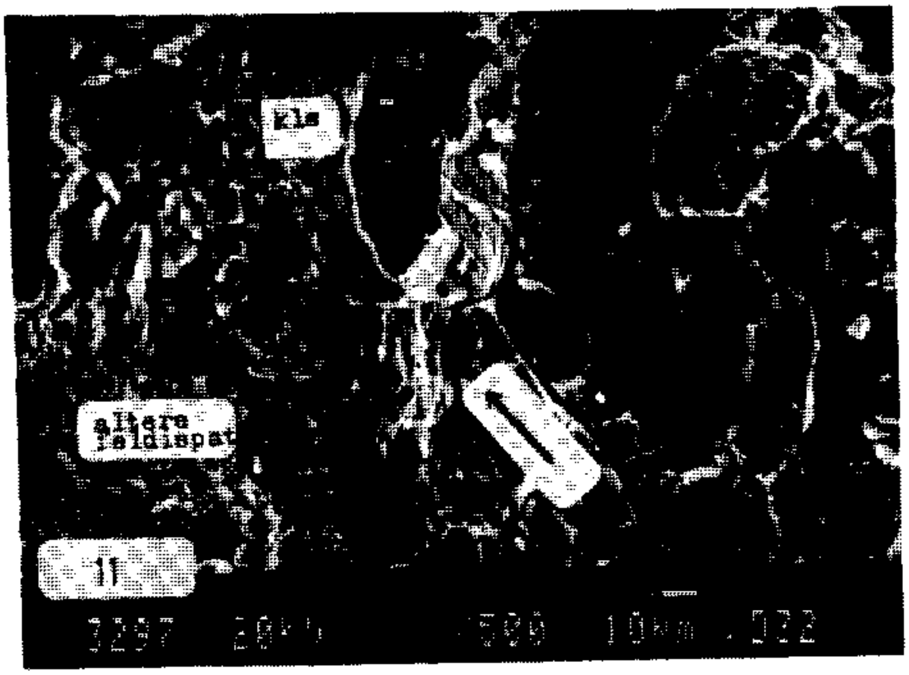
3658 20KV X2,300 10Pm WD19

PLATE -VI

Photo 11- SEM image of porosity developments in calcite and altered feldspars within the fractured zone.

Photo 12- SEM image of fracture filling iron oxide (dmr) and chlorites.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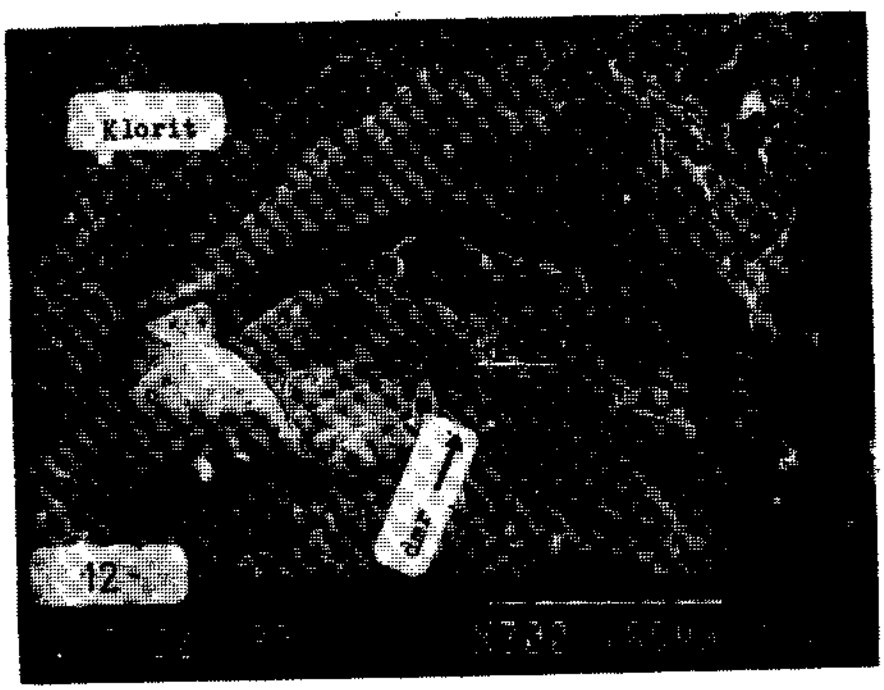
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