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COMPOSITION AND ORIGIN OF "PHOSPHATE-LIKE" SEDIMENTS FROM EGYPT

Abstract. Apparent phosphatic sediments have been frequently recognized within the Upper Cretaceous—Lower Tertiary sediments of Egypt.

The geochemical and mineralogical investigations have shown that these sediments are very poor in apatite, but rich in clay minerals kaolinite and smectite, quartz, calcite, aragonite, and hematite.

The megascopic appearence of such phosphate-like sediments can be attributed to: *A* — presence of pelletal glauconite and shell fragments, *B* — yellowish-brown colour due to hematite-limonite impregnation, and *C* — variable sand grain size and poor degree of sorting.

These sediments are believed to be deposited in a shallow marine conditions below wave-base. They were affected by extensive diagenetic processes that led to serious kaolinitization.

INTRODUCTION

The present work deals with the composition and origin of the phosphate-like sediments encountered in Darb El-Bahnasawi area, 7 km to the north of Qur El--Abyd to the west of the Nile, latitude 28° 47' N, and longitude 30° 14' E (Fig. 1).

The studied area is covering about 200 km², where the Eocene rocks with its characteristic carbonate facies predominate. Topographically, the area is low hilly, dissected by small valleys, generally dipping to the north.

The distribution of investigated sediments is so wide as to be correlatable for a long distance till the Ammoniten-Berg area, in western most side of the Dakhla Oasis. This megascopic appearence was found to be the main cause for considering these sediments as phosphorite beds through correlation.

The material for this work consists of 30 samples collected from the studied area, where the bulk, sand and silt fractions were analysed separately. In addition, few samples were subjected to scanning investigations in order to elucidate the diagenetic changes. Some selected samples were examined by XRD method to reveal their mineralogical composition.

The analysis were done in the laboratories of the Institute of Geology, Bergen, Norway, using an XRF apparatus.

STRATIGRAPHY

Upper Middle Eocene section in Darb El-Bahnasawi area is generally similar to those recorded from other parts of Egypt.

The exposed section in the investigated area is 120 m thick, mainly of calcareous

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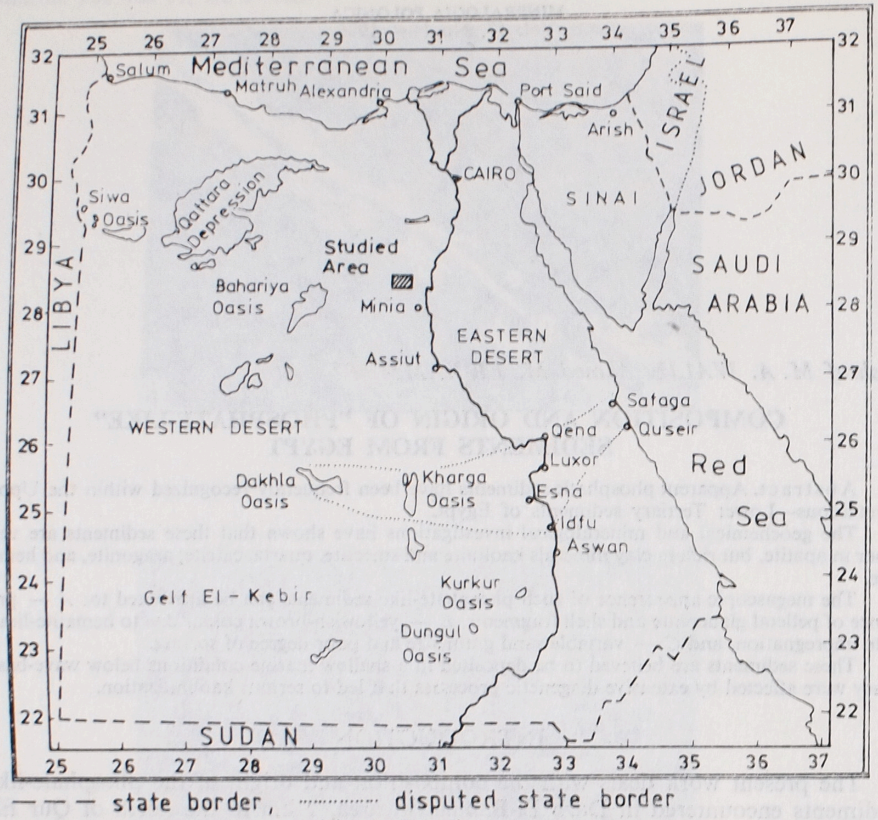

Fig. 1. Location map

and clastic facies. Following are details of the lithostratigraphic sequence from base to top:

1-Samalut Formation. This term was introduced first by Bishay (1961) as the equivalent of the Mokattam Formation (Zittel 1883) at the locality opposite Samalut city. At the type locality, the formation is up to 160 m thick, consisting mainly of snow white nummulitic limestone.

In the studied area, the exposed section is 58 m thick, built up mainly of multi-coloured crystalline fossiliferous limestone, containing mainly nummulites, echinoides, and shell fragments. It is Middle to Upper Lutetian in age.

2-Rayan Formation. It is conformably overlying the Samalut Formation, and represents transitional transgressive and regressive phases. Its name was introduced by Beadnell (1905) who describes 129 m thick section at Gebel Rayan (Fayum area). In the studied area, the section is 41 m, composed of phosphate-like sediments and sandstones in the lower part, and fossiliferous limestone in the upper part.

The Rayan Formation is overlain conformably by the lower part of Qazzun Formation (20 m thick) mainly composed of nummulitic limestone with chert concretions.

The Rayan Formation is the equivalent of the Mokattam Formation first proposed by Zittel (1883). According to Said (1962) the term is designating only the lower part, while the upper part is the equivalent to the Maadi Formation (the equivalent of the Qazzun Formation). The age of both formations is Upper Lutetian.

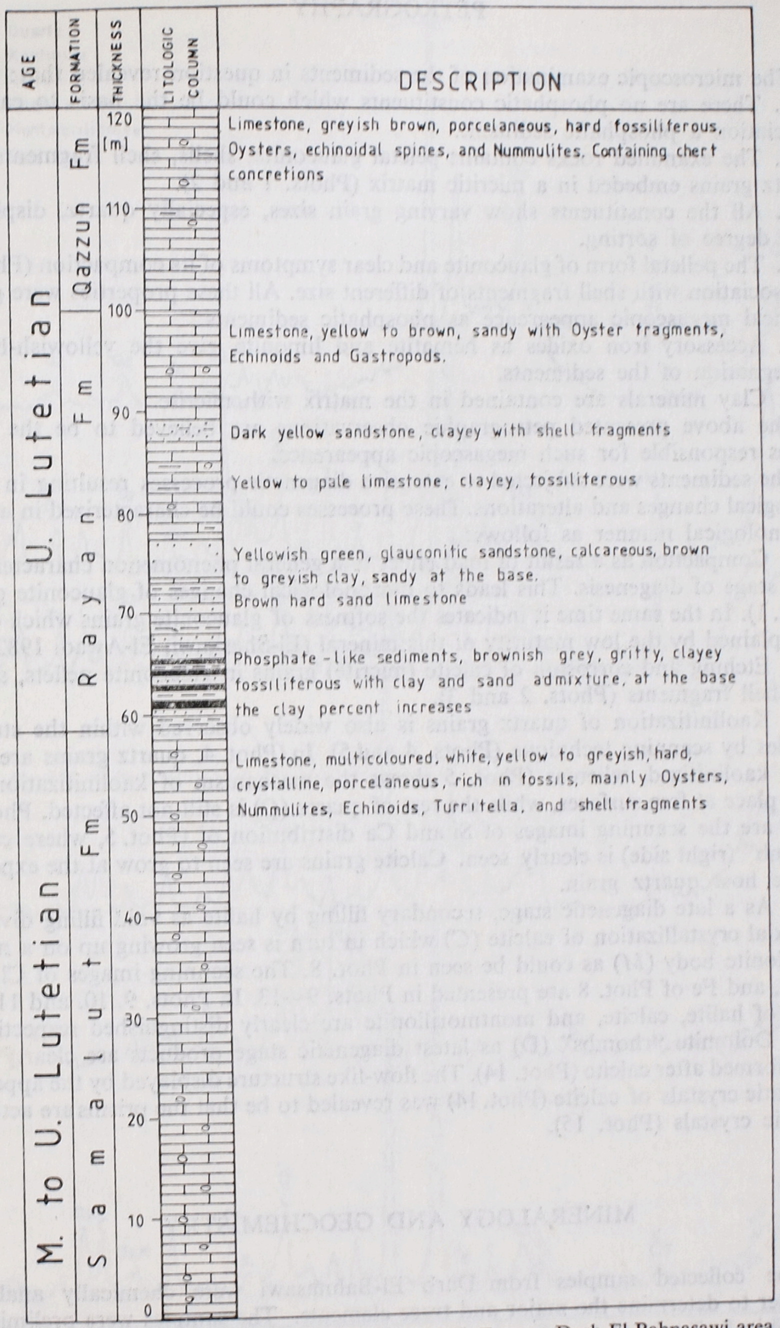

Fig. 2. Lithostratigraphic section of the Middle Eocene, Darb El-Bahnasawi area

PETROGRAPHY

The microscopic examination of the sediments in question revealed that:

1. There are no phosphatic constituents which could be the basis to call this association a phosphatic sediment.

2. The examined rocks contain: peletal glauconite, shells, shell fragments, and quartz grains embeded in a micritic matrix (Phots. 1 and 2).

3. All the constituents show varying grain sizes, especially quartz, displaying poor degree of sorting.

4. The pelletal form of glauconite and clear symptoms of its compaction (Phot. 1) in association with shell fragments of different size. All these properties were giving identical megascopic appearence as phosphatic sediments.

5. Accessory iron oxides as hematite and limonite give the yellowish-brown impregnation of the sediments.

6. Clay minerals are contained in the matrix with micrite.

The above presented petrographic observations are believed to be the main causes responsible for such megascopic appearence.

The sediments were subjected to extensive diagenetic processes resulting in morphological changes and alterations. These processes could be characterized in a non-chronological manner as follows:

1. Compaction as a result of load effect is a general phenomenon characterizing early stage of diagenesis. This leads to morphological changes of glauconite grains (Phot. 1). In the same time it indicates the softness of glauconite grains which could be explained by the low maturity of this mineral (El-Sharkawi, El-Awadi 1982).

2. Etching and corrosion of calcite (micrite) grains in glauconite pellets, shells, and shell fragments (Phots. 2 and 3).

3. Kaolinitization of quartz grains is also widely observed within the studied samples by scanning technique (Phots. 4 and 5). In (Phot. 4, quartz grains are seen to be kaolinitized, whereas (Phot. 5 shows the mechanism of kaolinitization (*K*) takes place at free surfaces, while the rest of quartz (*Q*) is still not affected. Phots. 6 and 7 are the scanning images of Si and Ca distribution of (Phot. 5, where calcite "rhomb" (right side) is clearly seen. Calcite grains are seen to grow at the expenses of the host quartz grain.

4. As a late diagenetic stage, secondary filling by halite as void filling dividing syntaxial crystallization of calcite (*C*) which in turn is seen growing up on a montmorillonite body (*M*) as could be seen in Phot. 8. The scanning images of Cl, Ca, Si, Al, and Fe of Phot. 8 are presented in Phots. 9—13. In Phots. 9, 10, and 11, the fields of halite, calcite, and montmorillonite are clearly distinguished respectively.

5. Dolomite "rhombs" (D) as latest diagenetic stage products are clearly seen to be formed after calcite (Phot. 14). The flow-like structure displayed by the apparent prismatic crystals of calcite (Phot. 14) was revealed to be that the prisms are actually micritic crystals (Phot. 15).

MINERALOGY AND GEOCHEMISTRY

The collected samples from Darb El-Bahnasawi were chemically analysed in order to determine the major and trace elements. The samples were preliminary mechanically analysed to separate the sand and silt fractions. The following major oxides were determined: SiO_2, Al_2O_3, TiO_2, Fe_2O_3, MnO, CaO, MgO, K_2O, Na_2O, and P_2O_5. Besides, the following trace elements were determined: Zn, Cu,

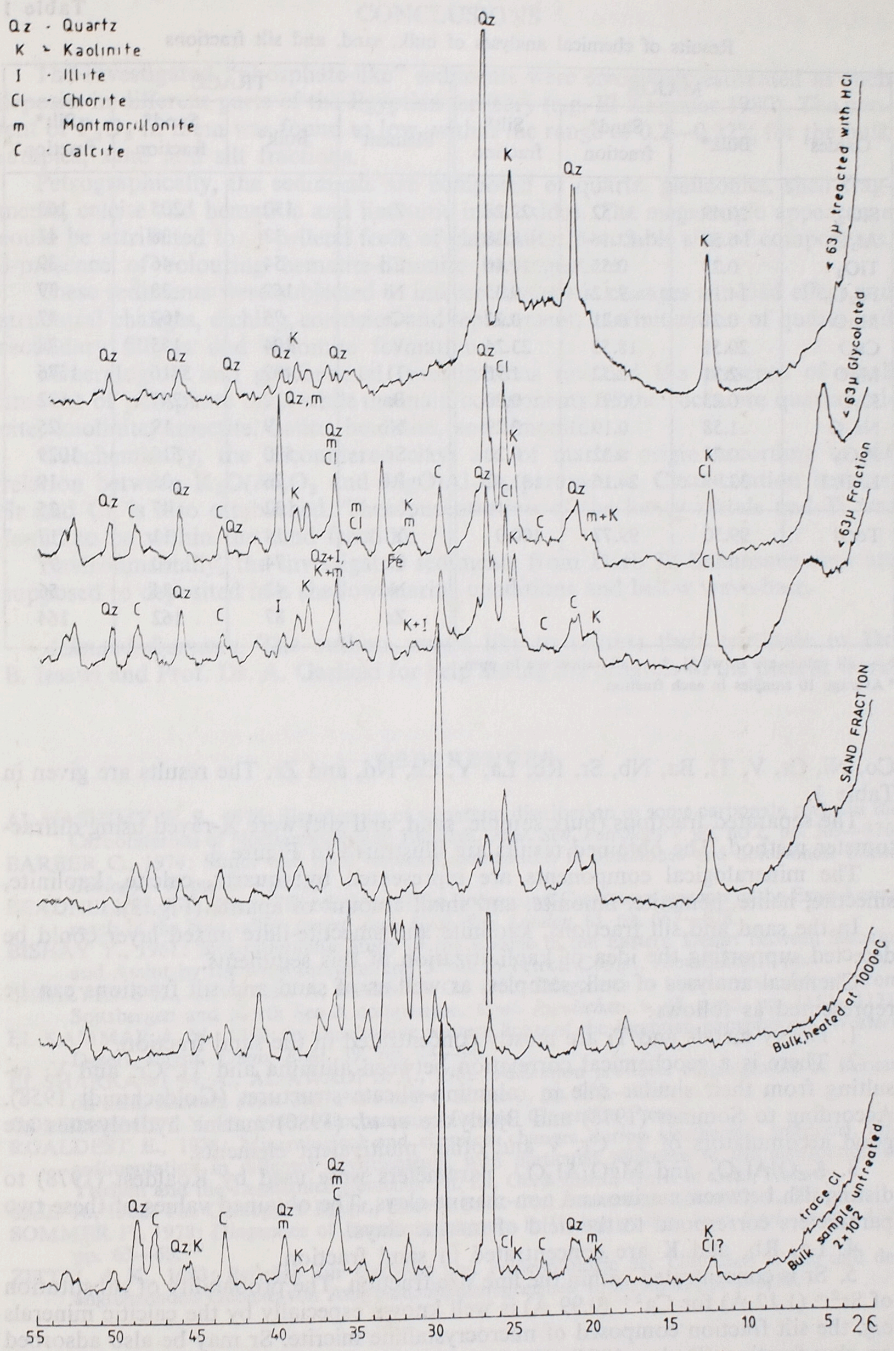

Fig. 3. XRD patterns of the bulk, sand and silt size samples

Table 1

Results of chemical analyses of bulk, sand, and silt fractions

MAJOR				TRACE			
Oxides[1]	Bulk*	Sand* fraction	Silt* fraction	Element[2]	Bulk*	Sand* fraction	Silt* fraction
SiO_2	20.49	31.52	22.28	Zn	130	205	163
Al_2O_3	6.52	12.46	8.38	Cu	33	38	41
TiO_2	0.23	0.55	0.46	Co	54	46	39
Fe_2O_3	14.16	9.12	9.35	Ni	169	38	39
MnO	0.21	0.21	0.22	Cr	75	107	47
CaO	20.51	18.53	23.24	V	104	155	78
MgO	2.31	2.52	1.96	Ti	1489	3416	1576
K_2O	0.23	0.91	0.20	Ba	212	247	132
Na_2O	1.58	0.19	2.29	Nb	9	19	25
P_2O_5	0.28	0.32	0.20	Sr	570	510	1029
L. O. I	32.98	24.16	31.42	Rb	26	35	18
				La	32	47	25
Total	99.50	99.77	100.0	Y	14	11	17
				Ce	74	60	97
				Nd	42	34	56
				Zr	87	162	164

1 — all values are in wt %, 2 — all values are in ppm.
* Average 10 samples in each fraction.

Co, Ni, Cr, V, Ti, Ba, Nb, Sr, Rb, La, Y, Ce, Nd, and Zr. The results are given in Table 1.

The separated fractions (bulk sample, sand, and silt) were X-rayed using diffractometer method. The obtained results are illustrated in Figure 3.

The mineralogical components are represented by: quartz, calcite, kaolinite, smectite, halite, hematite, limonite, and small amount of apatite (Fig. 3).

In the sand and silt fractions, kaolinite and smectite-illite mixed layer could be detected supporting the idea of kaolinitization of this sediments.

Chemical analyses of bulk samples, as well as of sand and silt fractions can be represented as follows:

1. Heavy metals and Ti are mostly concentrated in the sand fraction.
2. There is a geochemical correlation between alumina and Ti, Cr, and V, resulting from their similar role in alumino-silicate structures (Goldschmidt 1958). According to Sommer (1978) and Bjørlykke *et al.* (1980) marine hydrolysates are good accumulators of Ti, Cr, V and other multivalent elements.
3. K_2O/Al_2O_3 and MgO/Al_2O_3 parameters were used by Roaldest (1978) to distinguish between marine and non-marine clays. The obtained values of these two parameters correspond to the field of marine clays.
4. La, Rb, and K are concentrated in sand fraction.
5. Sr is concentrated within the fine size fraction. The probability of substitution of Sr^{2+} (1.12 Å) for Ca^{2+} (0.99 Å) is well known especially by the calcitic minerals e.g. the silt fraction composed of microcrystalline micrite. Sr may be also adsorbed on clay fraction (Barber 1974). We have to take into consideration the possibility of leaching Sr during dolomitization (Al-Hashimy 1976).

CONCLUSIONS

The investigated "phosphate-like" sediments were erroneusly estimated as such deposits in different parts of the Egyptian territory (e.g. El-Kammar 1980). The content of P_2O_5 in them was found to low, within the range of 0.2—0.32% for the bulk samples, sand and silt fractions.

Petrographically, the sediments are composed of quartz, glauconite, shell fragments, calcite and hematitic and limonitic iron oxides. The megascopic appearance could be attributed to: 1-pelletal form of glauconite, 2-variable size of components, 3-presence of colouring hematite-limonite impregnation.

These sediments were subjected to intense diagenetic changes as: load effect and structural changes, etching, corrosion and replacement, kaolinitization of quartz and secondary fillings and dolomite formation.

Mineralogical and geochemical investigations revealed the presence of small amount of phosphate only, while the main components of the rocks are quartz, calcite, kaolinite, smectite, halite, hematite, and limonite.

Geochemically, the encountered clays are of marine origin according to the relation between $K_2O(Al_2O_3$ and $MgO)Al_2O_3$ parameters. Clear relation between Sr and Ca is also established. The concentration of the heavy metals and Ti was found to be within the sand fraction.

Environmentally, the investigated sediments from Darb El-Bahnasawi area are supposed to deposited in a shallow marine conditions and below wave-base.

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SKŁAD I POCHODZENIE OSADÓW Z EGIPTU PODOBNYCH DO FOSFORYTÓW

Streszczenie

Wśród osadów górnej kredy i dolnego trzeciorzędu w Egipcie często były rozpoznawane utwory fosforytowe. Badania geochemiczne i mineralogiczne wykazały jednak, że osady te zawierają bardzo mało apatytu, lecz są bogate w minerały ilaste (kaolinit i smektyt), kwarc, kalcyt, aragonit i hematyt.

Makroskopowy wygląd takich podobnych do fosforytów osadów można wiązać z:

a) obecnością ziarn glaukonitu i fragmentów muszli,

b) żółtobrązowym kolorem jako wynikiem impregnacji hematytowo-limonitowej,

c) wielkością ziarn piasku i słabym stopniem ich wysortowania.

Osady te uważa się jako powstałe w środowisku płytkomorskim, poniżej podstawy falowania. Zostały one poddane długotrwałym procesom diagenetycznym, które doprowadziły do znacznej kaolinizacji.

OBJAŚNIENIA FIGUR

Fig. 1. Mapa lokalizacji badań
Fig. 2. Profil litostratygraficzny środkowego eocenu obszaru El-Bahnasawi
Fig. 3. Dyfraktogramy rentgenowskie próbek (w całości oraz wydzielonego piasku i mułu)

OBJAŚNIENIA FOTOGRAFII

Plansza I

Fot. 1. Ziarna glaukonitu. Widoczny efekt nacisku na kulki glaukonitu. Nikole skrzyżowane, podziałka = 200 μm
Fot. 2. Muszle i fragmenty muszli w impregnacyjnym spoiwie hematytowo-limonitowym. Nikole skrzyżowane, podziałka = 200 μm
Fot. 3. Korozja ziarn kalcytu w obrębie kulek glaukonitu. Nikole skrzyżowane, podziałka = 200 μm
Fot. 4. Kaolinizacja (*K*) ziarn kwarcu (*Q*) (?)
Fot. 5. Powiększenie szczegółu fotografii 4 pokazujące kaolinizację rozpoczynającą się od brzegów ziarn
Fot. 6 i 7. Obrazy skanningowe fotografii 5 pokazujące rozkład Ca i Si

Plansza II

Fot. 8. Halit jako wypełnienie pustek, rozdzielających kryształy kalcytu (*C*) widoczne na tle montmorillonitu (*M*)
Fot. 9—13. Obrazy skanningowe Cl, Ca, Si, Al i Fe z fotografii 8
Fot. 14. Podobna do spływowej struktura kalcytu
Fot. 15. Powiększenie szczegółu fotografii 7 pokazujące pryzmatyczne kryształy kalcytu, które są obecnie mikrytem

СОСТАВ И ПРОИСХОЖДЕНИЕ СХОЖИХ С ФОСФОРИТАМИ ОТЛОЖЕНИЙ ИЗ ЕГИПТА

Резюме

Среди верхнемеловых и нижнетретичных отложений в Египте часто были опознаваны фосфоритовые образования. Геохимическими и минералогическими исследованиями однако было обнаружено, что эти отложения содержат очень мало апатита, но богаты глинистыми минералами (каолинитом и смектитом), кварцем, кальцитом, арагонитом и гематитом.

Макроскопический вид таких похожих на фосфориты отложений может быть обусловлен:

а) присутствием зерен глауконита и фрагментов раковин,

б) желто-коричневой окраской как следствием пропитания гематитом и лимонитом,

в) размерами зерен песка и слабой степенью их отсортирования.

Считается, что эти отложения образовались в мелководной морской среде, ниже базиса волнения. Они были подвержены продолжительным диагенетическим процессам, которые привели к значительной каолинизации.

ОБЪЯСНЕНИЯ К ФИГУРАМ

Фиг. 1. Местоположение района исследований
Фиг. 2. Литостратиграфический разрез среднего эоцена области Эль-Бахнасави
Фиг. 3. Рентгеновские дифрактограммы образцов (полностью, а также выделенных песка и алеврита)

ОБЪЯСНЕНИЯ К ФОТОГРАФИЯМ

Таблица I

Фото 1. Зерна глауконита. Заметен эффект давления на шарики глауконита. Скрещенные николи. Масштаб = 200 мкм
Фото 2. Раковины и фрагменты раковин в пропиточном гематит-лимонитовом цементе Скрещенные николи. Масштаб = 200 мкм
Фото 3. Коррозия зерен кальцита в пределах шариков глауконита. Скрещенные николи. Масштаб = 200 мкм
Фото 4. Каолинизация (*K*) зерен кварца (*Q*) (?)
Фото 5. Увеличение детали фотографии 4, показывающее начинающюося от периферии зерен каолинизацию
Фото 6 и 7. Сканированные изображения фотографии 5, показывающие распределение Ca и Si

Таблица II

Фото 8. Галит в качестве выполнителя пустот, разделяющих кристаллы кальцита (*C*), заметные на фоне монтмориллонита (*M*)
Фото 9—13. Сканированные изображения Cl, Ca, Si, Al и Fe из фотографии 8

Фото 14. Кальцит со структурой похожей на текстуру оползания
Фото 15. Увеличение детали фотографии 14, показывающее призматические кристаллы кальцита, которые в настоящее время представляют собой микрит

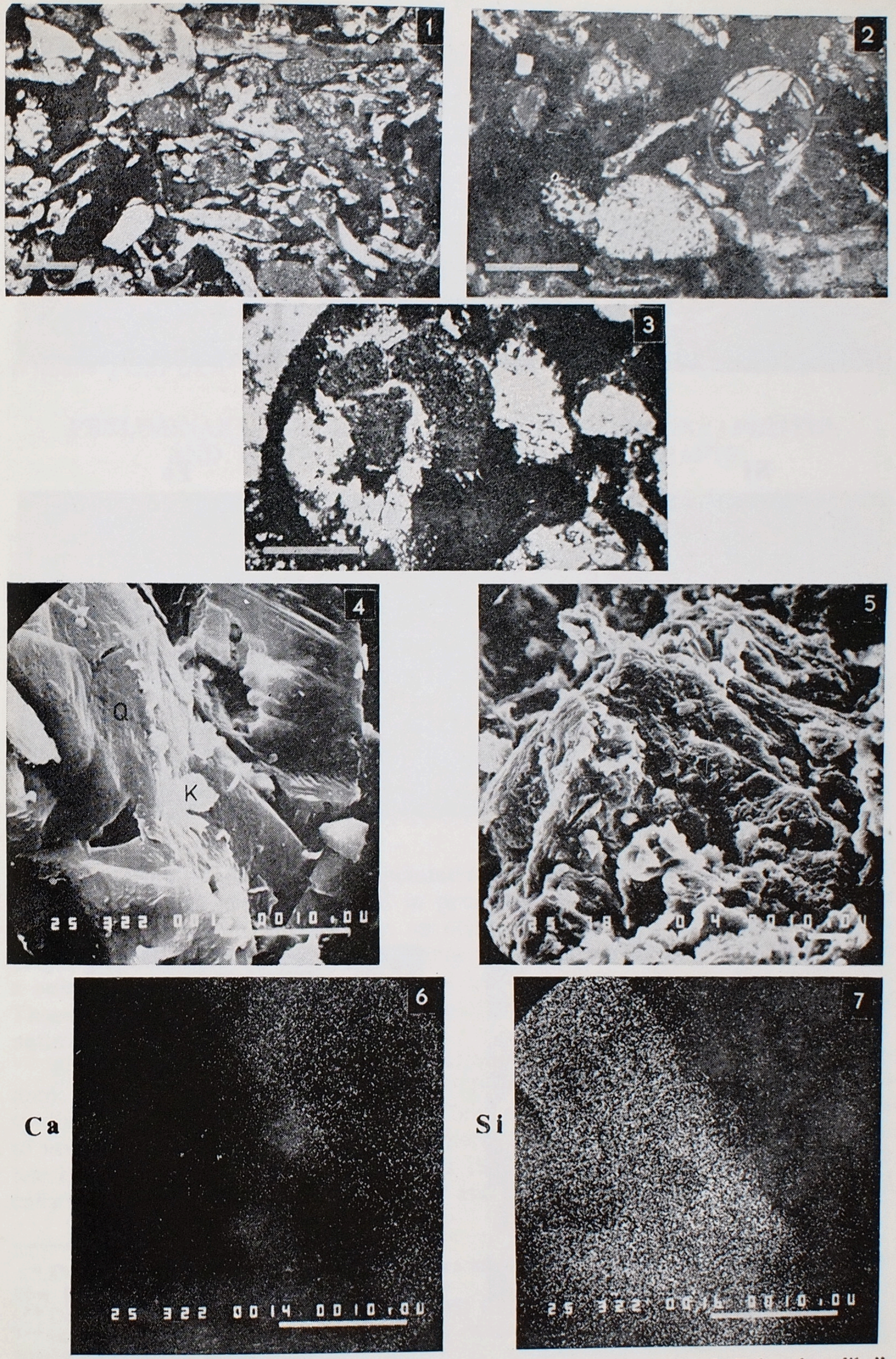
EXPLANATIONS OF PLATES

Plate I

Phot. 1. Glauconitic biomicrite. Notice the load effect on glauconite pellets. Crossed nicols, bar is 200 μm
Phot. 2. Shells and shell fragments embeded within hematitic-limonitic impregnated matrix. Crossed nicols, bar is 200 μm
Phot. 3. Corrosion of calcite in glauconite pellets. Crossed nicols, bar is 200 μm
Phot. 4. Kaolinitization (*K*) of quartz grain (Q)
Phot. 5. Close up view of Phot. 4 showing that kaolinitization is starting from the peripheries
Phots. 6 and 7. Scanning images of Phot. 5 showing the distribution of Ca and Si

Plate II

Phot. 8. Halite as void filling dividing syntaxial crystallization of calcite (*C*) which is seen growing on a montmorillonite body (*M*)
Phots. 9—13. Scanning images of Cl, Ca, Si, Al, and Fe of Phot. 1
Phot. 14. Flow-like structure displayed by calcite crystals
Phot. 15. Close up view of Phot. 7 showing that the prismatic crystals of calcite are actually "micritic" crystals



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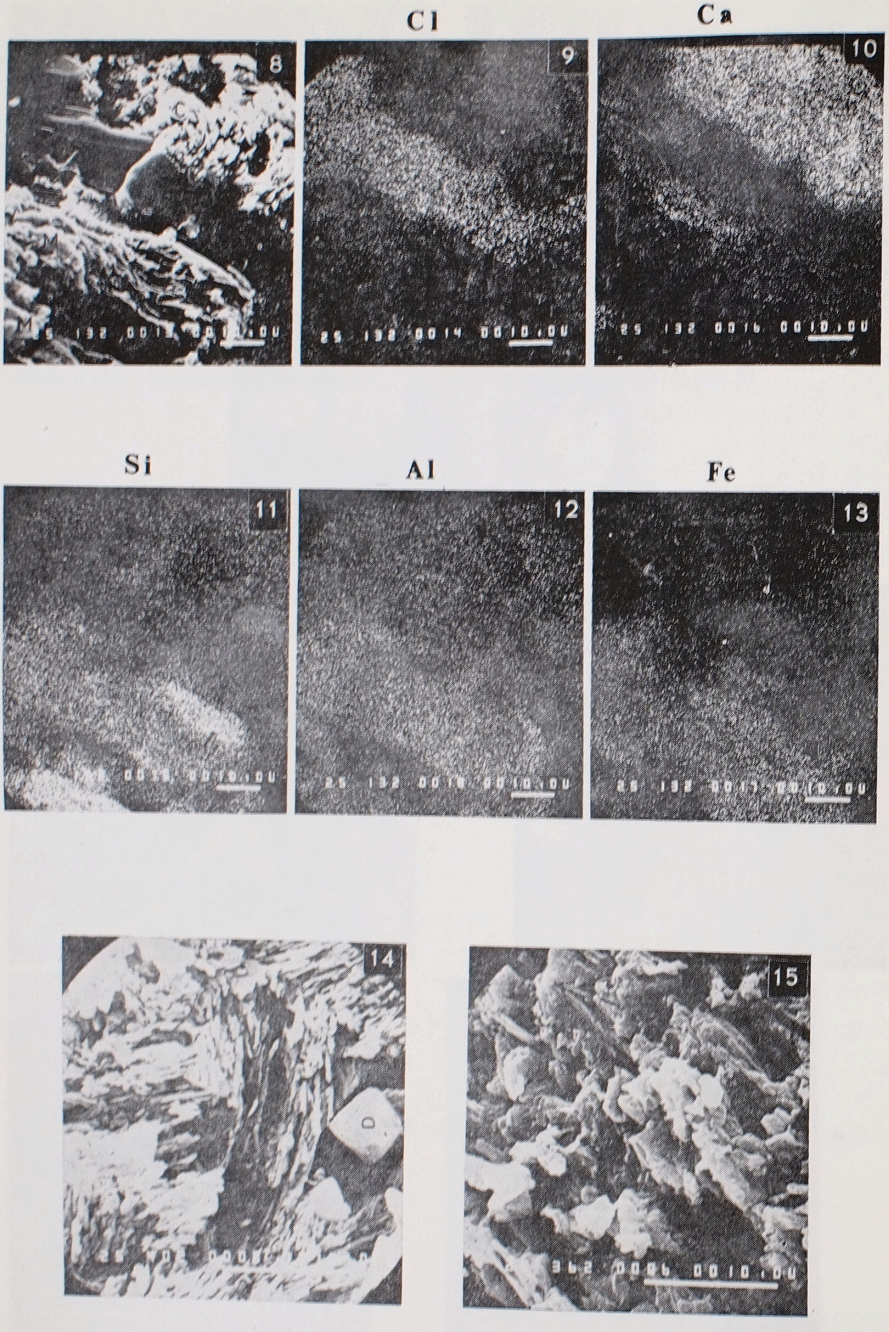

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