

DIAGENESIS OF CLAYS IN SEDIMENTARY AND PETROLIFEROUS SERIES

by

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ABSTRACT

In the argillaceous fraction of a sedimentary series of petroliferous sandstones from the Sahara two successive diagenetic changes are considered. The first is kaolinization of the original silicates. This is followed by illitization of the kaolinite by saline waters. The same formation is kaolinitic where it produces petroleum and illitic where it is non-productive.

INTRODUCTION

The oil-bearing rocks of the Hassi-Messaoud and El-Gassi localities in the eastern Sahara are Cambro-Ordovician sandstones. Their depth below the surface is about 3000 m and their thickness varies from 300 to 500 m.

These sandstones have an argillaceous cement; they are more or less silicified and show silty intercalations. The original sediment contained feldspars, detrital micas, illite, and a small amount of kaolinite.

Two successive diagenetic changes appear to have altered this original material. Early post-depositional diagenesis changed feldspars, micas and illite into kaolinite having "fan" and "accordion" facies. These facies are preserved intact in the sandstones that are saturated with oil. On the other hand, in the sandstones containing native salt waters, a second diagenesis occurs: kaolinite having "fan" and "accordion" facies is changed into illite.

These two diagenetic changes are illustrated by Figs. 1-12.

FORMATION OF KAOLINITE FROM DETRITAL MICA

Figures 1-4 show a classical type of kaolinite developed between the sheets of detrital muscovite in permeable sandstone. The two minerals have the same optical orientation. Several stages of the development of kaolinite can be seen, beginning with a thin flake of mica showing a small amount of kaolinite on the edges or between the sheets and ending with a thick expanded crystal of kaolinite with only a few remaining sheets of mica.

All the pictures show sections parallel to the *c*-axis of the flakes. They were taken under crossed nicols.

In Fig. 1 the detrital mica shows bright colors due to its high birefringence. Between the sheets, kaolinite is pale gray. In Fig. 2 one end of the mica is largely expanded. The difference between the very bright mica and the gray kaolinite is obvious. In Fig. 3 the formation of kaolinite is complete; the detrital mica itself is almost entirely transformed. Only a few remaining sheets of mica are seen inside the kaolinite. Figure 4 shows another aspect of the crystallization of kaolinite. The mineral grows as small "worms" having no visible relationship with other minerals. These constitute the major part of the kaolinite in the sandstones.

CRYSTALS OF SECONDARY ILLITE

In Fig. 5 illite, with its high interference colors, replaces kaolinite in a previously expanded detrital mica. This picture is to be compared with Fig. 1. In Fig. 6 the illitization is more complete in the micas that were previously expanded and kaolinized. This picture is to be compared with Fig. 2. Figure 7 shows a previously kaolinized mica which is now completely illitized. This is to be compared with Fig. 3. Figure 8, the counterpart of Fig. 4, shows small "worms" of illite comparable to the "worms" of kaolinite in Fig. 4. This is an example of evolution of kaolinite "worms" into illite "worms".

RELATIONSHIPS BETWEEN KAOLINITE AND SECONDARY ILLITE

Figures 9–12 show relationships between kaolinite and secondary illite. Illite always forms around kaolinite crystals; never inside. It starts always in the cracks of the sandstone (Fig. 9) and between the quartz and the cement. This is also visible in Fig. 4, where secondary illite crosses kaolinite in a small crack. Figure 10 shows illite forming on the edge of a large crystal of kaolinite. In Fig. 11 illite starts in the cracks of the rock, replaces kaolinite on the edges of kaolinite crystals, and also begins to enter between the sheets of the crystal. In Fig. 12 illitization of large crystals which were previously kaolinized is complete.

CONCLUSION

Two diagenetic transformations of the clay fraction in the sandstones have been described and illustrated. The first change is transformation of mica into kaolinite. The second evolution shows that a micaceous lattice can develop from the kaolinite arrangement, under the influence of salt waters. This second diagenesis is related to the migration of salt waters after the loss of oil.

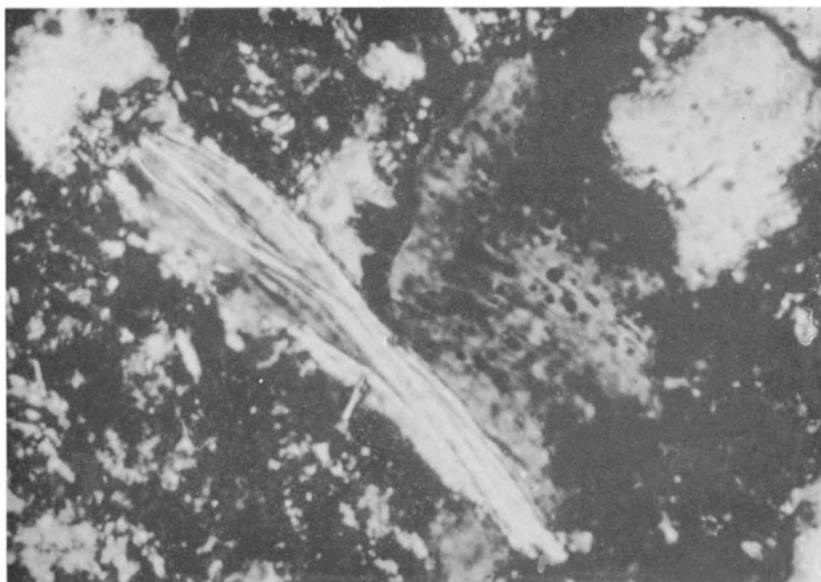


FIGURE 1.—Kaolinite developed between sheets of mica. $\times 300$.

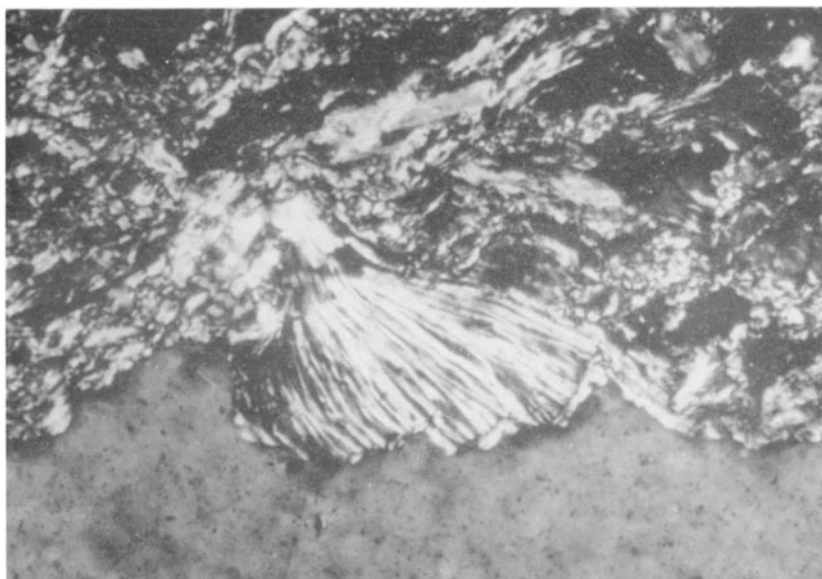


FIGURE 2.—One end of mica book is expanded in "fan". $\times 240$.

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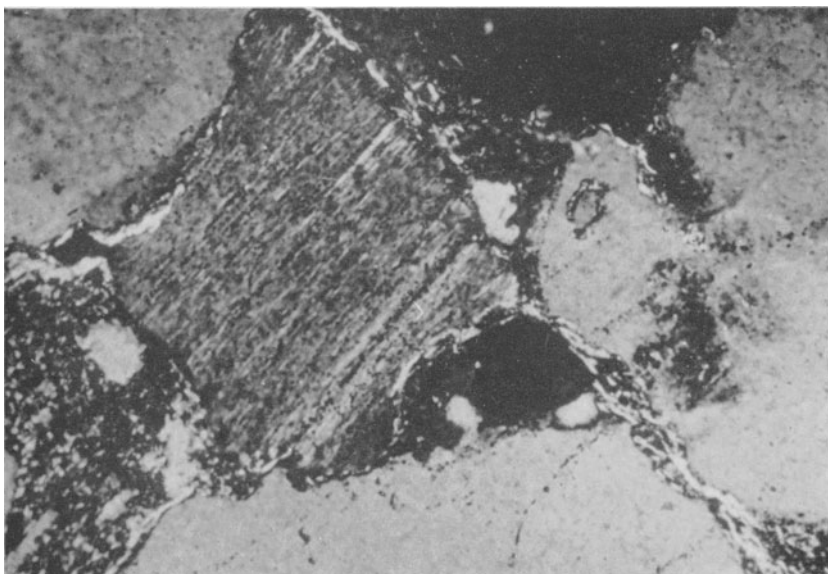


FIGURE 3.—The formation of kaolinite is complete. $\times 240$.

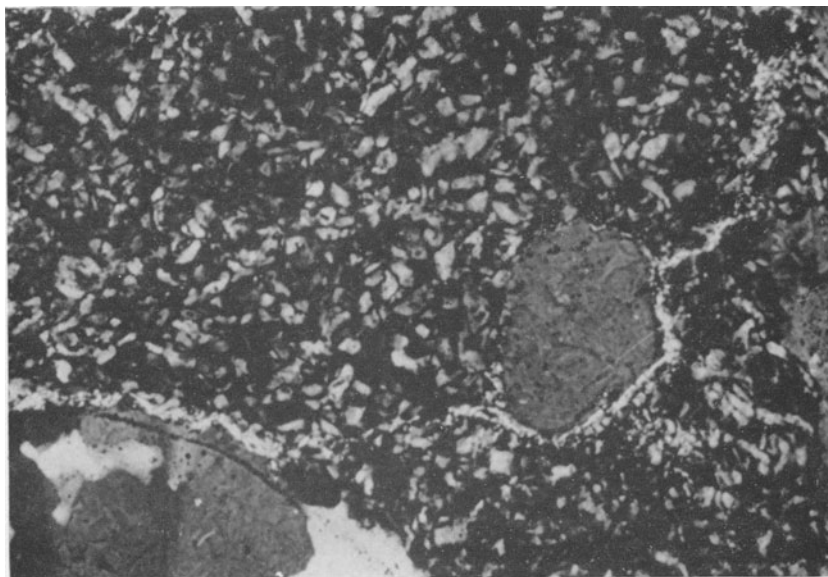


FIGURE 4.—Another aspect of kaolinite: small worms between the quartz grains in sandstone. $\times 150$.

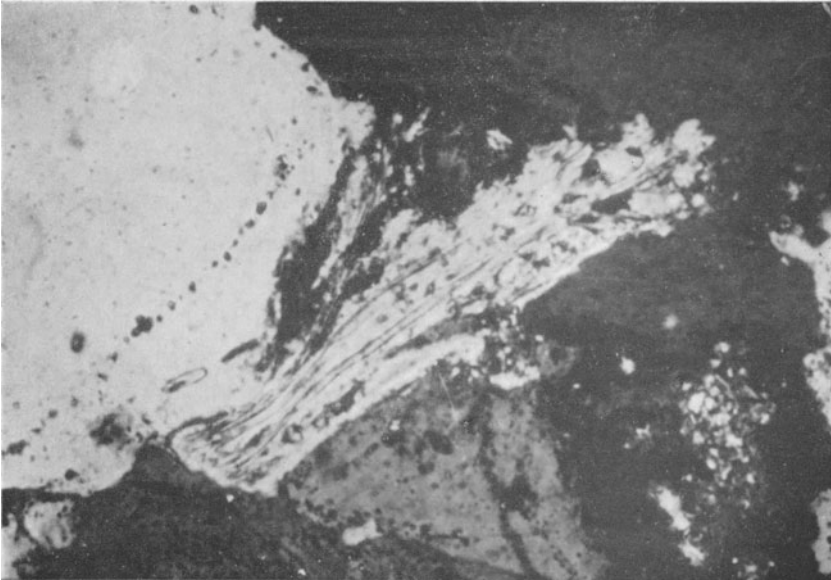


FIGURE 5.—Illite takes the place of kaolinite between the sheets of mica. $\times 300$.

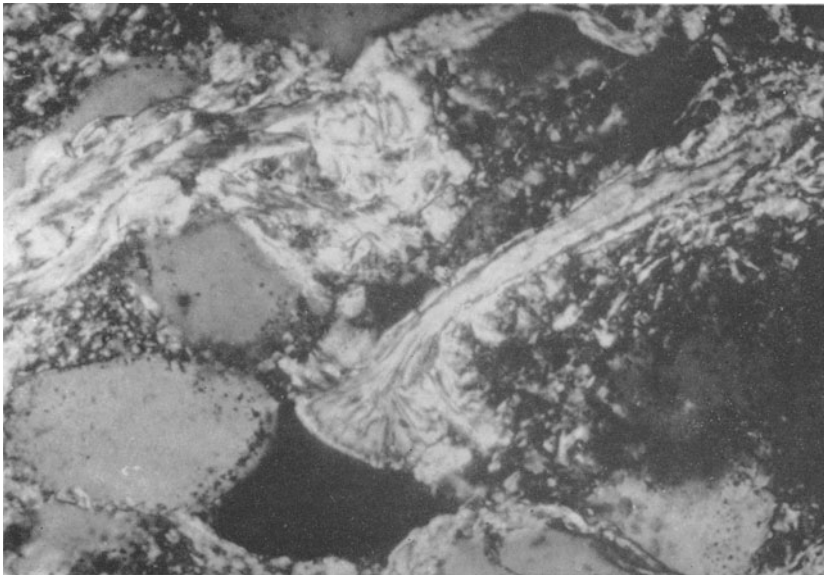


FIGURE 6.—Complete illitization of expanded and kaolinized mica. $\times 240$.

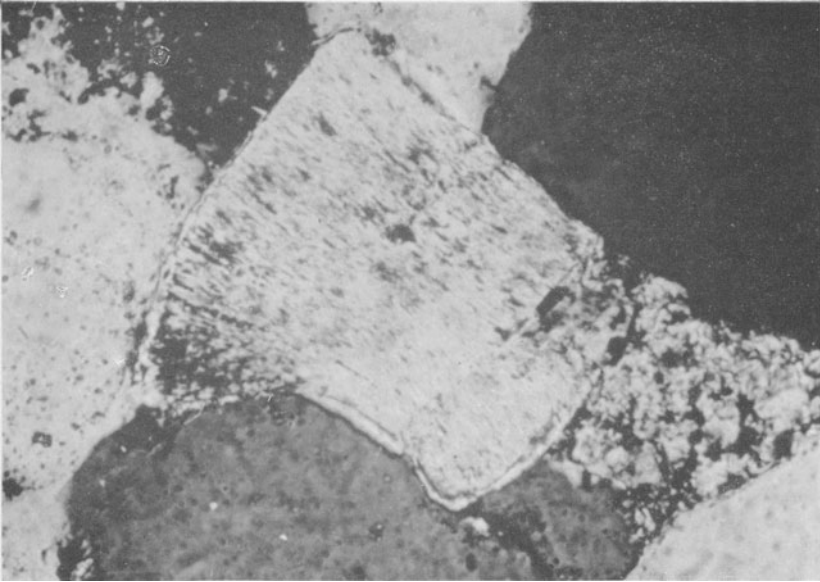


FIGURE 7.—Complete illitization of a kaolinized mica, comparable to that of Fig. 3. $\times 240$.

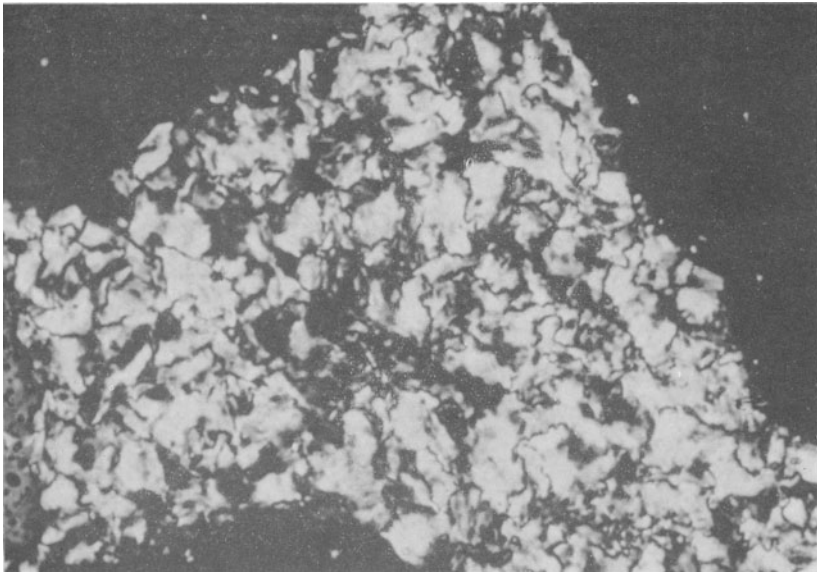


FIGURE 8.—Evolution of kaolinite worms into illite worms. $\times 300$.

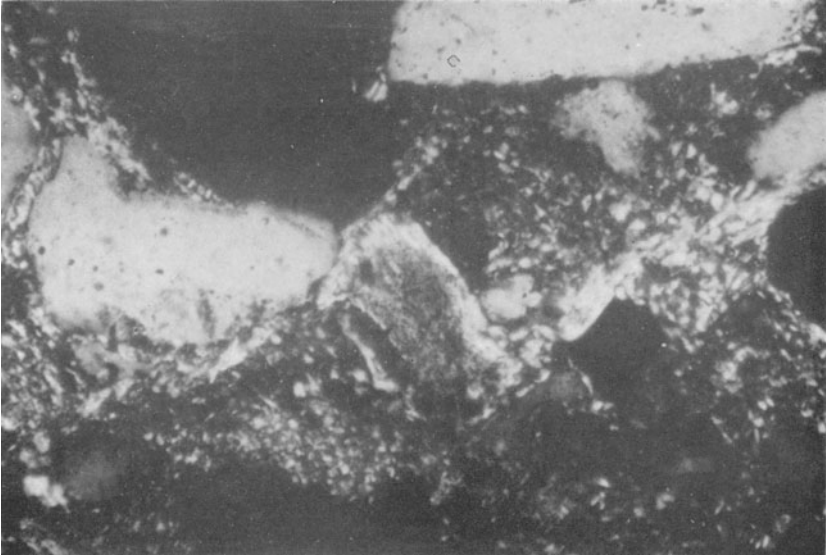


FIGURE 9.—Illite starts in the cracks of the sandstone. $\times 240$.

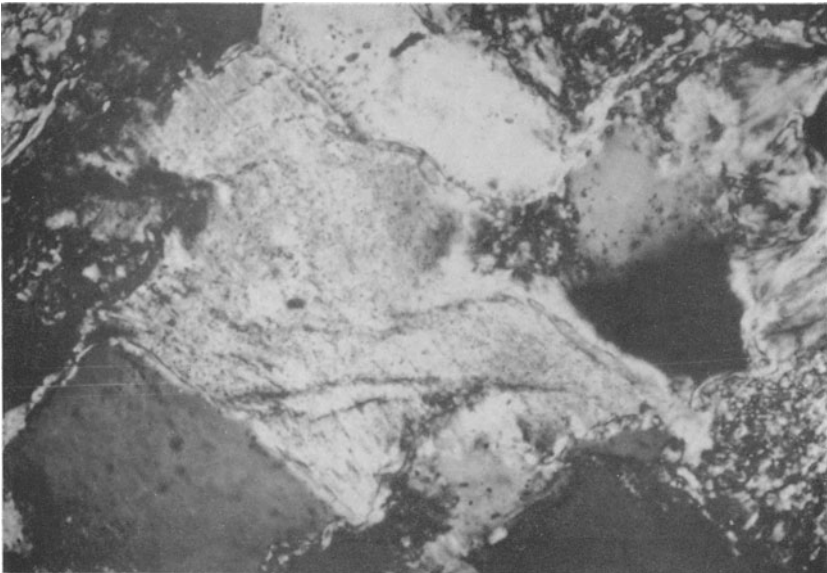


FIGURE 10.—Illite forms on edge of a large crystal of kaolinite. $\times 240$.

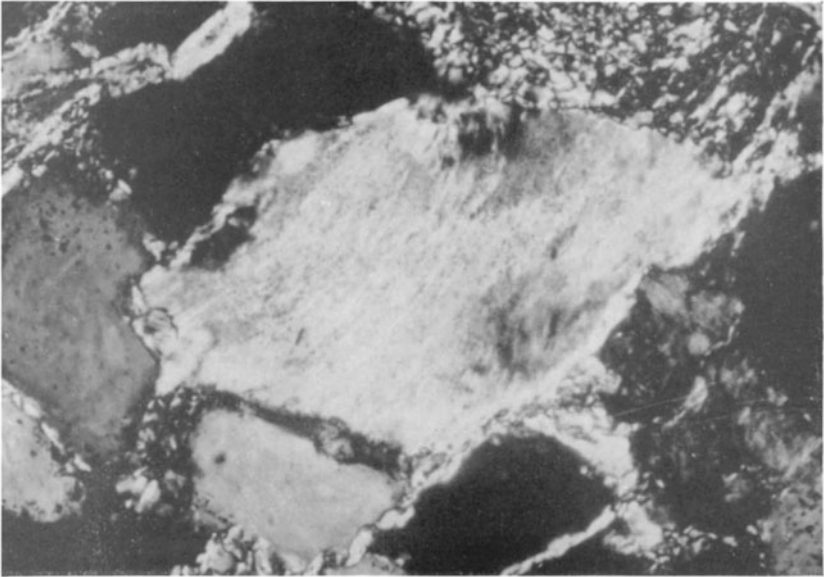


FIGURE 11.—Illitization progresses in the cracks, on the edges, and between the sheets of the crystal. $\times 240$.

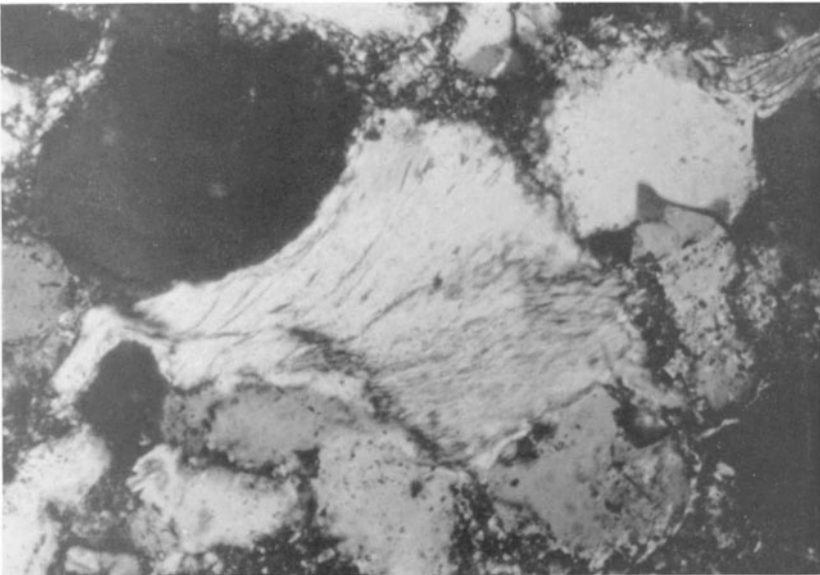


FIGURE 12.—Illitization of the large crystals is complete. $\times 240$.