Thermal effects of magmatic activity on clay sediments in eastern Tunisia

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Abstract. During the Cretaceous, a polyphase fissural magmatic activity affected Eastern Tunisia, as indicated by the major E-W, NS and N140 structural-magmatic fractures. A petrological study, obtained mainly from subsurface data, reveals two magmatic lineages: (1) an effusive tholeiitic magmatism represented by slightly fractured basalts; (2) an effusive and intrusive alkaline magmatism represented by basalts, their differentiated trachytic products accompanied by pyroclastic materials and dolerites.

The tholeiitic and alkaline characters of this magmatism emphasize the extensional geodynamics of the Eastern Tunisian domain during the Cretaceous between 110 and 85 Ma. This magmatism may be considered as a marker of the opening of the Syrte grabens and also the S-E movement of Iberia. Since late Senonian, the explosive character of these magmatic events is dominant and indicates the presence of magma chambers close to the surface with more complex structures. These are related to a change in the tectonic style initiated by the convergence of the African and European plates.

Cretaceous clay layers located near the basaltic flows allowed us to characterise two clay mineral associations: (1) In the reference borehole (classified as such based on the absence of igneous rocks), we have identified kaolinite, smectite, illite, non specified interstratified clays, and illite-chlorite interstratified clays (with the d002) at approximately 12 Å). (2) In the other boreholes containing igneous rocks, the mineralogical composition of the clays showed kaolinite, smectite, illite, interstratified clays and 14 Å chlorite. The presence of chlorite near the igneous rocks (especially those which are basaltic) is an indicator of the temperature gradient, suggesting synsedimentary volcanism. Therefore, there is a transfer of heat from the igneous rocks and their associated fluids to the surrounding sedimentary beds. The increase of the temperature near the igneous rocks induces the formation of new minerals like chlorite, illite and illite-chlorite interstratified clays. The clay mineral rates (illite and chlorite) correlates nicely with the depth. However the rates of kaolinite, smectite and the interstratified clays decrease.

This study would lead us to conclude that the observed change in the clay mineral association was caused by two factors acting simultaneously: the temperature increase caused by the igneous rocks and a light burial diagenesis.

Keywords. Eastern Tunisia, Cretaceous, magmatism, subsurface clays, clay minerals

1 Introduction

During the Cretaceous many magmatic episodes have been recognized in the eastern margin of Tunisia (Fig. 1). Some of them are exposed as outcrops, others have been intersected in the oil wells drilled in this area. The emplacement of igneous rocks is controlled by major faults oriented EW, N 140 and NS. This would suggest that the magmatic activity was under the control of deep faults having the same orientation. These structural-magmatic directions were activated in normal faults. The volcanic extrusions took place on the sea floor. These volcanic rocks are mainly basalts and their differentiated trachytic products. They may or may not be accompanied by brecciated and pyroclastic facies and were emplaced in areas of external carbonated platforms (Laridhi Ouazaa 1994). These effusive materials were followed by great magmatic intrusive activity, which is made of numerous dykes metres to tens of metres wide (dolerites and micro dolerites) .

2 Materials and methods of study

The mineralogical study of argillaceous beds was been carried out by using X-Ray diffraction (XRD) and by the electronic microscope in order to identify the nature and morphology of the clay minerals. In this paper, we have tried to

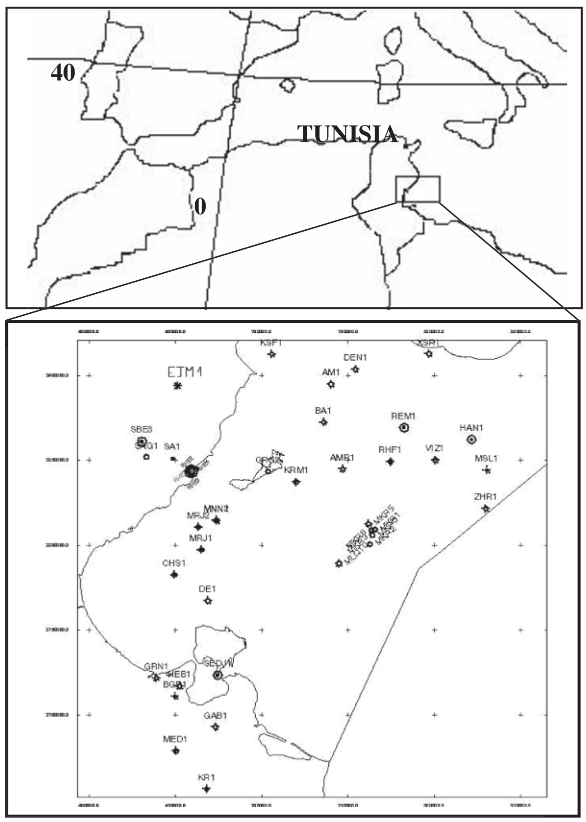

Figure 1: Map showing Tunisia and the distribution of different studied wells.

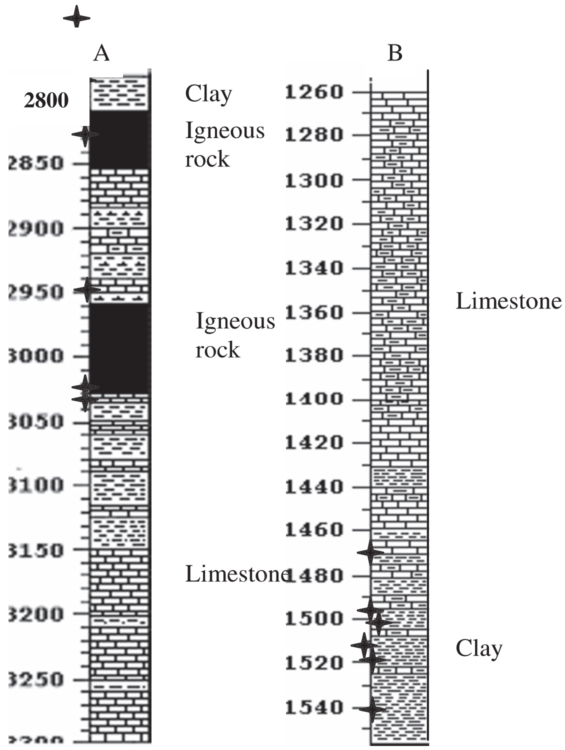

Figure 2: Survey of the contents A - Rhemoura-4 (RHE-4), B-KSAR-1 (XSR-1) log well and location of the studied samples

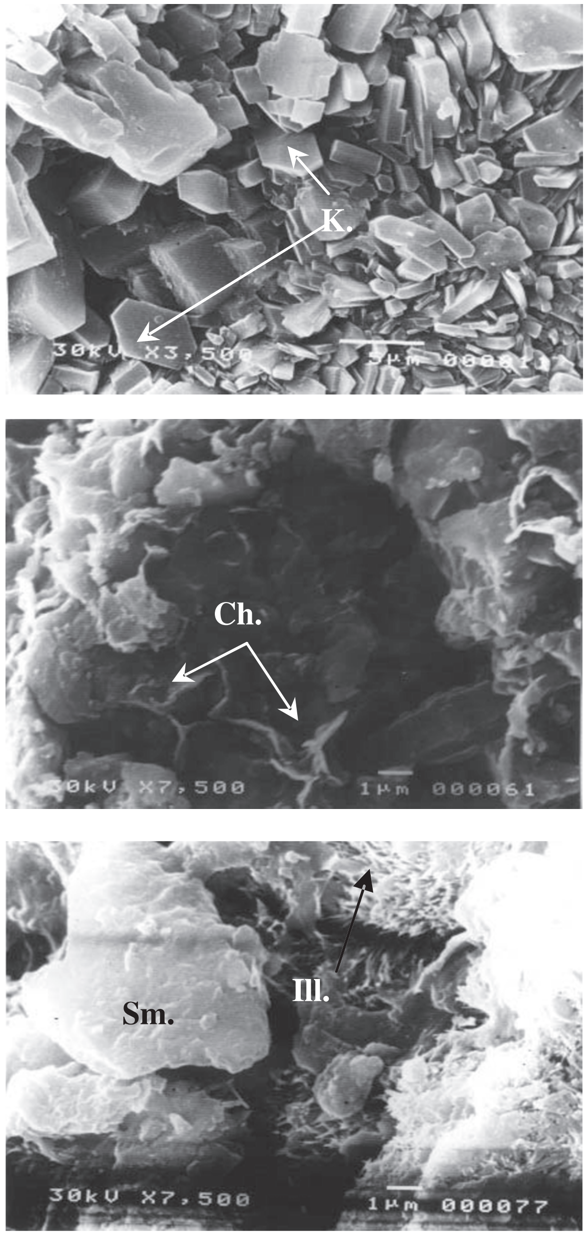

Figure 3: Electronic microscope photomicrographs showing Chlorite (Ch.), Illite (Ill.), Kaolinite (K.) and Smectite (Sm.)

compare the clay minerals intersected by the oil wells: 1- With igneous rocks 2- Without igneous rocks (Fig. 2).

2.1 XRD study

This study allowed us to make the following remarks:. 1- The clay mineral species are represented by: kaolinite, smectite, interstratified clays, illite and chlorite. 2- The cristallinity and the percentage of kaolinite and smectite are decreasing with depth. Where the illite percentage increases, its degree of cristallinity increases. 3- The chlorite occurs only in association with igneous rocks.

2.2 Study of the evolution of clay minerals with depth

With the burial of the sedimentary beds, kaolinite and smectite percentages decrease whereas illite increases. We also notice that the chlorite is: 1- Related to the magmatic activity. 2- More abundant in the clay beds which are in direct contact with the igneous rocks. 3- Becomes more abundant with depth.

2.3 Study of the evolution of clay minerals in relation to magmatic activity

Kaolinite is present in all the studied wells. However it becomes rarer where the intensity of volcanic activity increases. Illite percentages show a slight increase near the igneous rocks. On the other hand, the smectite does not show a direct link with the magmatic activity. Chlorite is present in wells containing igneous rocks. Its percentage and cristallinity increase with the intensity of the magmatic activity (Mattoussi Kort 2003).

2.4 Electron microscope study

The electron microscope study reveals that the samples in contact with igneous rocks show sharp angled crystals with a jagged aspect. Chlorite is present in the form of bow crystals (Fig. 3). The existence of dickite indictaes transformation of kaolinite at high temperatures. The presence of illite in the form of elongated laths indicates action of hydrothermal fluids in the area of this study.

3 Conclusions

During the Cretaceous a fissure-controlled polyphased magmatism took place in Eastern Tunisia. This magmatic activity was guided by the large structural- events oriented EW, NS and N140. This igneous activity is characterized by the abundance of basaltic lava flows, their differentiated trachytic products and numerous intrusive dykes (dolerites and microdolerites) (Laridhi Ouazaa 2004).

However, from the Senonian, the explosive dynamisms became dominant resulting in a different magmatic products (tuffs, pyroclastites). These rock types indicate a change in the tectonic style, which heralded the beginning of the closing up between the African and Eurasian plates (Laridhi Ouazaa 1994).

The presence of fluids in contact with the sedimentary formations produced a thermal interaction between the hot magmas and the argillaceous rocks. These fluids circulate through the fault conduits and produced changes of the clay mineral species. This lead to the growth of new phyllosilicates, such as illite, illite-chlorite interstratified clays and chlorite. Their morphology and nature of the clays studied with XRD and the electronic microscope prove that high temperatures were associated to the magmatic activity. This paragenesis characterized by the presence of a 14 Å clay (chlorite) is found only in the igneous rocks crossed by oil wells.

References

Laridhi Ouazaa N (1994) Etude minéralogique et géochimique des épisodes magmatiques mésozoïques et miocènes de la Tunisie. Thèse Es – Sciences. Université de Tunis II 426

Laridhi Ouazaa N, Bédir M (2004) Tectonic-magmatic migration from triassic to miocene on the Tunisia eastern margin. Africa Geoscience Review 11(2):177-194

Mattoussi Kort H (2003) L'effet thermique des intrusions magmatiques sur l'encaissant sédimentaire argileux d'âge crétacé supérieur. Mémoire D. E. A., Univ., Tunis 181