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Diapirism in Northern Tunisia*

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Abstract—The diapirs of Northern Tunisia, composed mainly of evaporitic Triassic material, are the result of a complex evolution initiated by local basement movements of NNE–SSW faults, which at the end of the Early Cretaceous. This first uplift, occurring during a period without any folding of the sedimentary series, is purely halokinetic. Such diapiric activity remained in active progress throughout the Cretaceous and Early Tertiary, causing local disturbance in the related series. And then, during the Alpine Atlas orogeny, the diapiric structures underwent deformation according to their position in the orogenic area.

Résumé—Les diapirs de Tunisie septentrionale, constitués surtout de matériel triasique en grande partie évaporitique, sont le résultat d'une évolution complexe débutant à la fin du Crétacé inférieur et dont le déclenchement est dû au jeu d'accidents de socle de direction NNE–SSO. Le premier mouvement ascensionnel, qui se place à une période dépourvue de tout plissement de la couverture, a été uniquement halocinétique. Cette activité halocinétique s'est poursuivie pendant toute la fin du Crétacé et le début du Tertiaire, et a provoqué des anomalies sédimentologiques locales dans les séries correspondantes. Par la suite, pendant l'orogenèse atlasique, les structures diapiriques ont subi des déformations plus ou moins importantes suivant leur position dans l'orogène.

INTRODUCTION

TUNISIA occupies a peculiar tectonic position as a section of the Atlas Orogenic Belt, enclosed to the south and east by stable platforms. The northern part of the orogenic belt is covered by allochthonous formations, the Numidian and Tellian units. In the southern part, the sedimentary formation of Central Tunisia are autochthonous but they have been deformed by the Atlas orogenic movements.

The migration of nappes occurred during the Late Oligocene and Early Miocene. It seems to have been a flow motion on large flat surfaces, without any regional compression (Rouvier 1977). The compressive movements, during the Late Miocene and Early Quaternary, have caused the folding of the allochthonous and autochthonous formations along NNE–SSW directions.

Triassic outcrops are numerous in Northern Tunisia. They are particularly common to the north of a line joining Tunis and Tebessa (Fig. 1). In the southeastern part of this region, the Triassic series forms intrusive bodies piercing Cretaceous and Tertiary strata. This is the so called 'zone des diapirs' which is 40 km wide. In the allochthonous region the Triassic has been dragged under the nappes and forms here and there irregular beds between the autochthonous and allochthonous formations.

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COMPOSITION AND STRUCTURE OF THE DIAPIRS

The diapiric series

The Tunisian diapiric series generally appears as a strongly deformed, chaotic mass of gypsum, anhydrite, sandstones and carbonates. The lack of halite in the outcrops is probably due to surficial solution (collapse features are common), and the occurrence of saline springs suggests the local presence of halite beds at depth.

Because of the structural complexities and possible removal of halite in the diapirs, it is very difficult to estimate the original thickness of the Triassic series. Nevertheless, it is likely to be more than 1000 m thick (Perthuisot 1978). From these complications and scarcity of palaeontological evidence, age determination of the visible series is very doubtful. Authors generally accept an Upper Triassic age but the top of the series may be Lower Jurassic.

The evaporite layers frequently contain dolomite crystals and black idiomorphic quartz crystals with anhydritic inclusions. Carbonate strata exhibit scattered albite crystals often altered into K-feldspars. Sometimes K-feldspars are concentrated, often with Mg-phyllites, and form nearly the totality of the rock. These concentrations are nearly all of the rock. These concentrations are common in the brecciated zone marking the contact between the diapirs and the pierced strata, and seem to be related to preferential fluid paths during the diapiric evolution. On the other hand the albite and black quartz crystals are probably the result of *in situ* diagenetic processes.

The radiometric ages of K-feldspars and phyllites

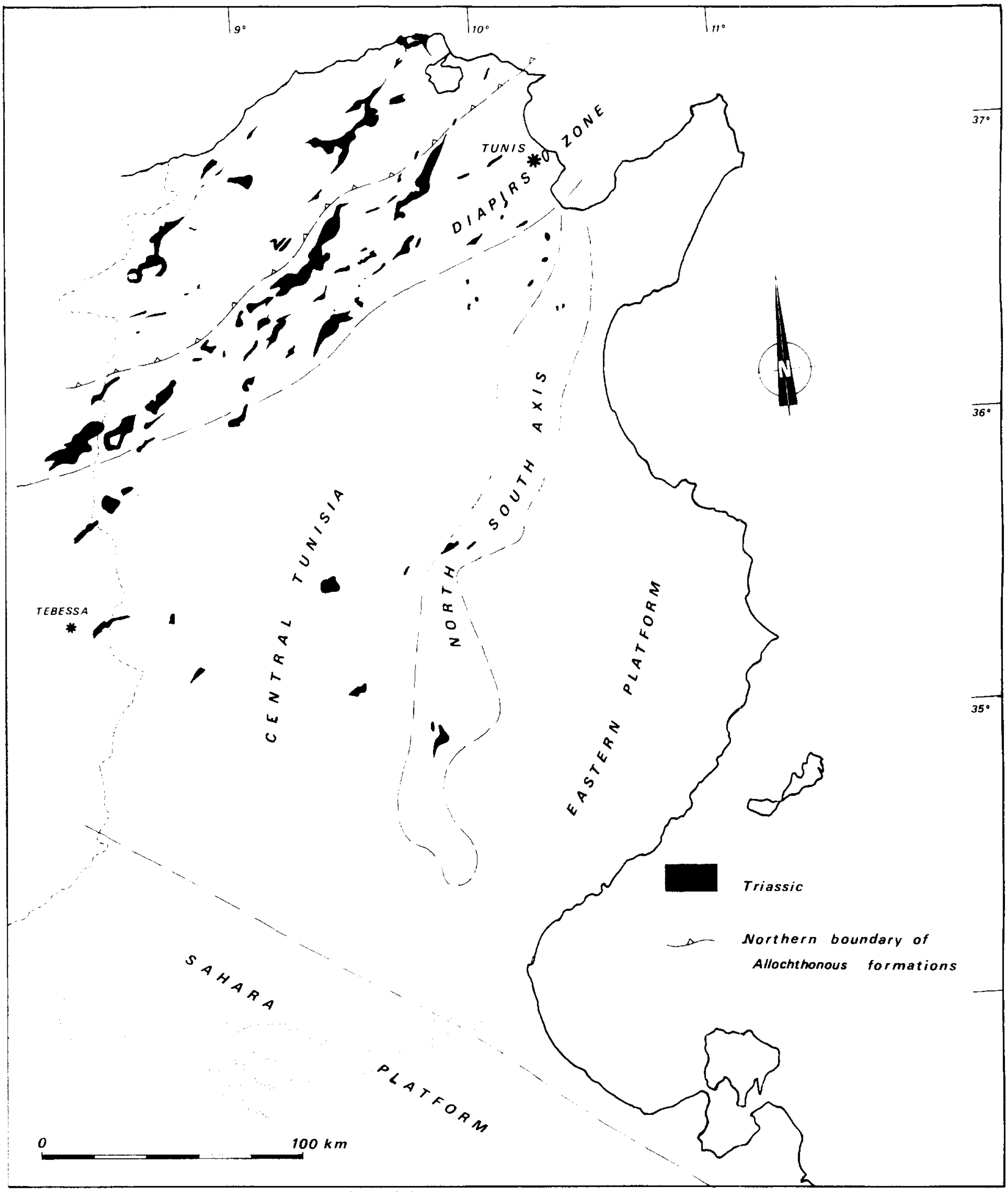

Fig. 1. Schematic structural map of Tunisia.

(K/Ar dating) are scattered between 97 Ma (Dj. Zag et Tir, in the south) and 18 Ma (Dj. Ichkeul, in the north) (Bellon & Perthuisot 1977). These data have been interpreted as follows: the first crystallization of potash minerals corresponds to an important circulation of Si-, K-, and Mg-rich fluids occurring at about 100–110 Ma, and the more recent ages correspond to a thermal episode about 15 Ma old, slightly later than the youngest measured age.

The diapiric structures

At surface, the diapirs are mushroom-shaped and elongated along a NE–SW direction. Against the flanks of the diapirs, the post-Triassic beds are generally overturned and strongly crushed or brecciated.

THE POST-TRIASSIC SERIES

Thickness and lithological differences have been noted between the post-Triassic autochthonous series in the peri- and interdiapiric areas. In the immediate vicinity of the diapirs, the peridiapiric series is characterized by a marked thickness reduction, mainly in the marly members. This thinning of the marine series indicates the presence of a positive structure at the site of the present

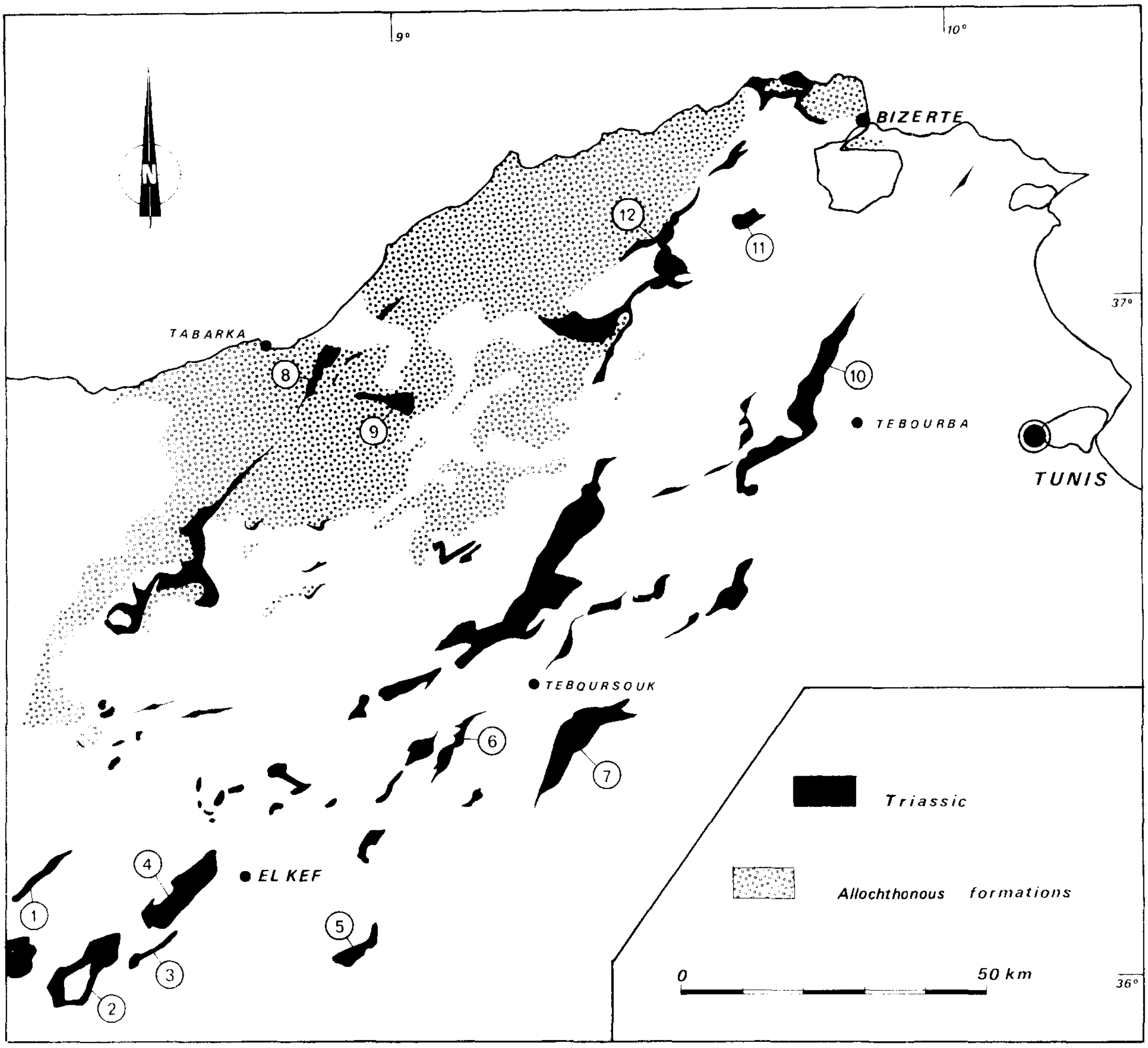

Fig. 2. The triassic outcrops in Northern Tunisia. (1, Dj. Ouenza; 2, Ben Gasseur; 3, Dj. Zag et Tir; 4, Dj. Debadib; 5, Dj. Lorbeus; 6, Dj. Fedj el Adoum; 7, Dj. ech Cheid; 8, Aïn Draham; 9, Dj. Zouza; 10, Dj. Lansarine; 11, Dj. Ichkeul; 12, Bazina).

diapirs from the Aptian to the Middle Eocene (Fig. 3).

Other lithological variations include local developments of conglomerate and the presence of Triassic detrital material (sandstone or limestone pebbles, quartz idiomorphic crystals) in the peridiapiric series. These features point to the emergence of the diapirs during the deposition of the Aptian–Middle Eocene sequence.

During the Late Aptian–Early Albian the first known piercements occurred in the south-western part of the diapir zone (Dj. Ouenza, Dj. Ben Gasseur, Dj. Fedj el Adoum). This phase is marked by an important development of detrital facies around the diapirs. Reefal limestones probably capped the top of some of these structures (Fig. 4). Such a palaeogeography in the diapir zone is analogous to the present situation in the southern part of the Persian Gulf, near the Qatar peninsula, where salt diapirs have reached sea level.

Similar phenomena were associated with other diapirs during the Cenomanian (Dj. Lorbeus), Maastrichtian (Dj. ech Cheid) and Early Eocene (most diapirs). However, for a given diapir it is very difficult to date the first piercement because the marks of penetration and reaching the sea-floor, usually recorded in the post-Triassic series, may have disappeared during the erosive phases if they were not widely spread around the diapiric core. Nevertheless, a piercing phase during the Aptian is evident wherever rocks of this age crop out around diapirs, and this suggests a similar evolutionary history for all the diapirs.

STRUCTURAL EVOLUTION OF THE DIAPIRIC ZONES

There was no important folding in Northern Tunisia during Aptian times. The only known deformation seems to be in connection with movements of large basement blocks. They are expressed by local unconformities and notably are located in the vicinity of some lineaments such as the North–South Axis structure, in the western part of the Sahel coastal plain (Burollet 1967). This structure corresponds to folding during the recent orogenic phases

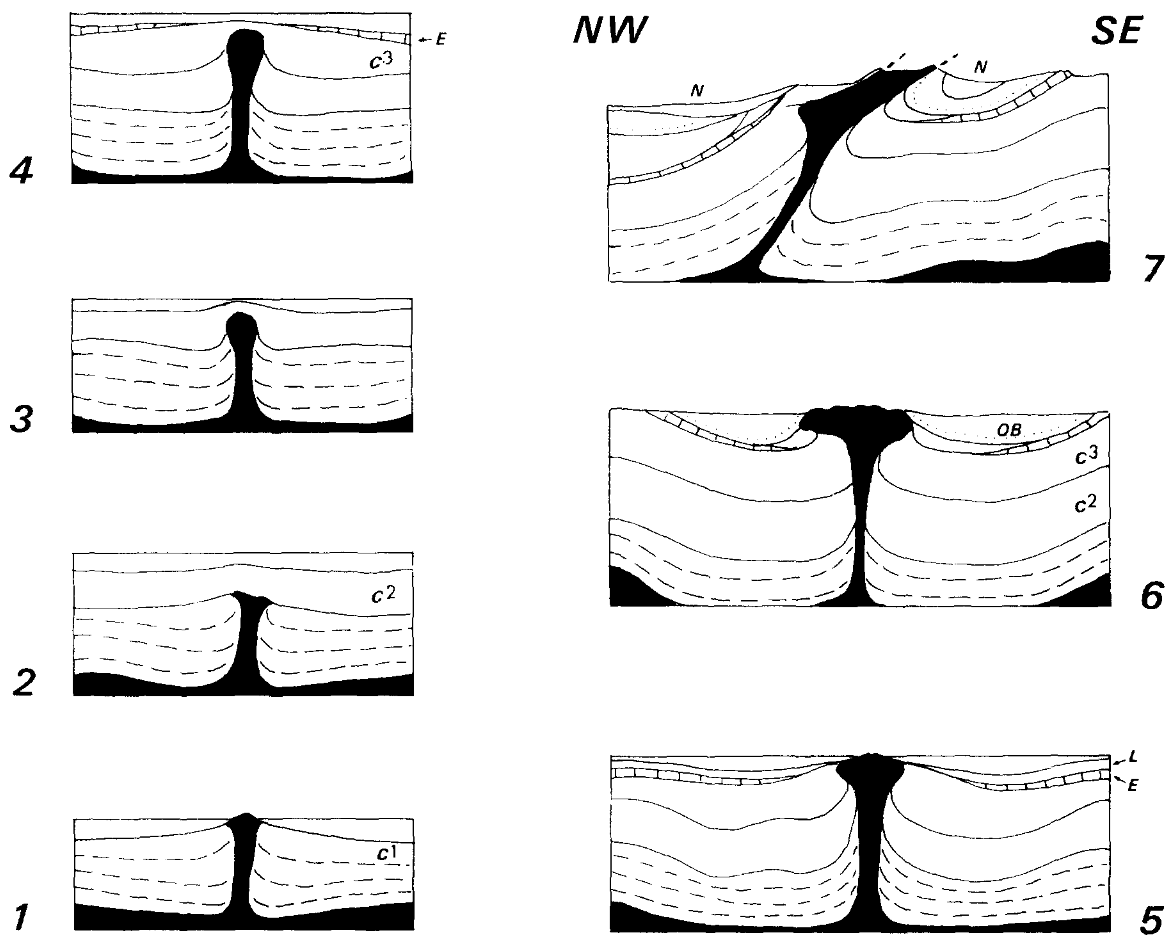

Fig. 3. Evolution of the Fedj el Adoum diapir (without scale) (1, Upper Aptian; 2, Upper Cenomanian; 3, Turonian; 4, Middle Eocene; 5, Upper Eocene; 6, End of Burdigalian; 7, Upper Tertiary. Cl, Jurassic and Lower Cretaceous; C2, Middle Cretaceous to Lower Eocene; E, Middle Eocene; L, Upper Eocene; OB, Oligocene and Lower Marine Miocene; N, continental Neogene).

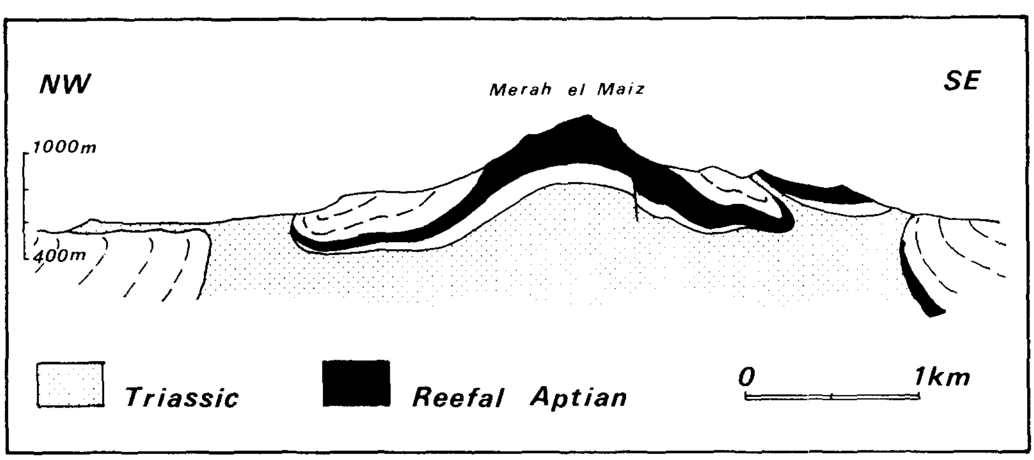

Fig. 4. Cross-section through the Ouenza diapir.

of an elongated zone marked by thickness reduction and local instability since the Jurassic period. This peculiar development has been probably induced by a N–S crustal fault separating two basements blocks. Such faults are probably common in the Tunisian basement, but their directions are various and their surficial effects are less visible. It is likely that these deep movements were the triggering mechanism for the first halokinetic uplift in areas where the post-Triassic series was thick enough. This would explain the synchronism of the first uplift during the Aptian and the alignment of diapirs along possible NNE–SSW trending faults, which are common in the African basement.

During the following period (Albian to Middle Eocene)

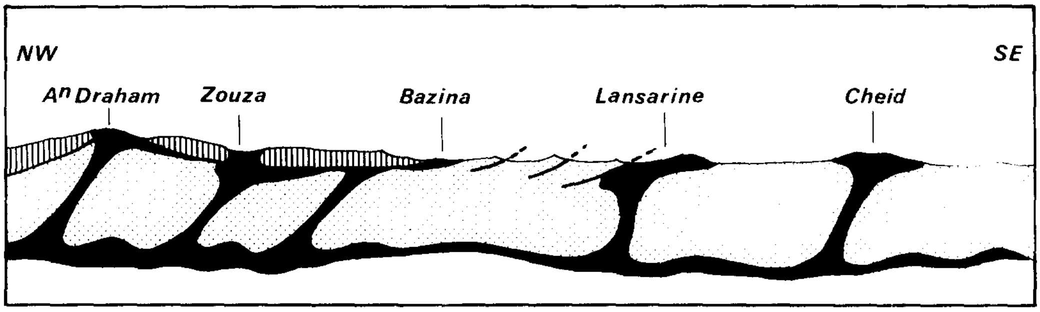

Fig. 5. Idealized cross-section through Northern Tunisia showing the relations between Atlas deformations and diapiric structures (without scale). Geographical names indicate only types of structures, without any precise localisation.

the rise of diapirs was probably continuous, but it increased during periods of tectonic instability: Middle Cenomanian, Maastrichtian and Early Eocene.

After the Eocene, diapiric structures were deformed and locally amplified. In areas where tectonic movements were more intense, Triassic bodies were bent towards the SE, crushed and dragged under the nappes (Fig. 5). Piercement of allochthonous overthrust material locally occurred when great amounts of plastic material were available for a last halokinetic uplift of the earlier diapirs (Dj. Zouza). During the Quaternary and even at the present time, diapirs are still rising and recent sediments are deformed by the movements.

CONCLUSION

The analysis of the behaviour of diapiric bodies from the Cretaceous to the Recent shows that these structures have been strongly influenced by the superficial Atlas deformation, folding and overthrusting, but that the earlier period of their evolution was probably closely linked to the movements of the Pre-Triassic basement. A part of the structural history of this basement is thus reflected by the local sedimentological variations which are displayed around the diapiric structures.

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