The early Pliocene Tirinesse basin (SW of Oued Laou, Rif, Morocco): proposal of a formation model

La cuenca de Tirinesse de edad Plioceno inferior (SO de Oued Laou, Rif, Marruecos): propuesta de un modelo de formación

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ABSTRACT

The Tirinesse basin, filled mainly by lower Pliocene marine sediments, is a small tectonic graben bounded by two NE-SW normal faults, with the eastern one surpassing 500 m in throw. These faults proved to belong to a much longer system of faults that transversally cut the entire Rifian Internal Zone. The subsidence of this basin was controlled by a jointed scissor movement of the two faults, which rotation axis coincided with the basin itself. This explains the important thickness of its sedimentary infilling, mainly occurred during the Zanclean.

Key-words: *Pliocene, neotectonics, normal fault, Tirinesse basin, Internal Rif.*

RESUMEN

La cuenca de Tirinesse, rellena por sedimentos marinos del Plioceno inferior, es una pequeña fosa tectónica limitada por dos fallas normales de dirección NE-SO, de las que la oriental tiene un salto vertical que supera los 500 m. Estas fallas forman parte de un sistema de fallas mucho más largo que corta transversalmente la Zona Interna Rifeña. La subsidencia de la cuenca fue controlada por el movimiento conjugado en tijera de ambas fallas, cuyo eje de giro coincide con la posición de la cuenca. Esto explica la importancia de su relleno sedimentario ocurrido fundamentalmente durante el Zancliense.

Palabras clave: *Plioceno, neotectónica, falla normal, cuenca de Tirinesse, Rif Interno.*

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Introduction

The existence of many discrete structures is something habitual and does not attract any especial interest. Nevertheless, some of them cannot be explained in an isolated way, as if they were independent from the rest of their regional setting. Their presence can give evidence for the existence of some more important structures, which, owing to different reasons, have passed unnoticed till the moment. This is the case of the Tirinesse basin. This basin occurs within the Rifian Internal Zone and to a distance of about 15 km from the Mediterranean coast, to the SE of the Oued Laou River, but not in its principal valley (Fig. 1). The faults limiting the basin affect the basement formed by three complexes stacked in a tectonic pile as follows: a) the Sebtide occupies the lowest tectonic position and is affected by polyphased processes including metamorphism. b) The Ghomaride, not affected or weakly affected by Alpine metamorphism, in this area occupies the highest position on both the Sebtides and the Calcareous Dorsale, is mainly formed by Paleozoic lutites. c) The Calcareous Dorsale consists of Triassic-Liassic (mainly) massive carbonate successions that form a near-continuous band close to the Ghomaride.

During the late Miocene this region was affected by a NNE-SSW compression, while the tension was perpendicular, with a WNW-ESE position. From the Pliocene, the compression progressively rotated, in the N of Morocco, to the NNW-SSE (Aït Brahim, 1991).

The Tirinesse basin is a NE-SW rectangular graben (Fallot, 1937; Wildi and Wernli, 1977) of 4 km long and ca. 1 km wide. Its SE and NW steep borders correspond to normal faults (Saji and Chalouan, 1995).

In the present article new data from the Tirinesse basin and surrounding areas, permit to construct a model explaining its formation.

The sedimentary filling of the Tirinesse basin

Three members form the filling sedimentary succession of Tirinesse basin: 1) the Basal Member (< 30 m of thickness) corresponds to the Ibou-harane conglomerates (Kornprobst and Wildi, 1970), resting unconformably over the Ghomaride Paleozoic rocks. It is formed by fluvial deposits with a paleoflow coming from the west, 2) the Middle Member, with a min-

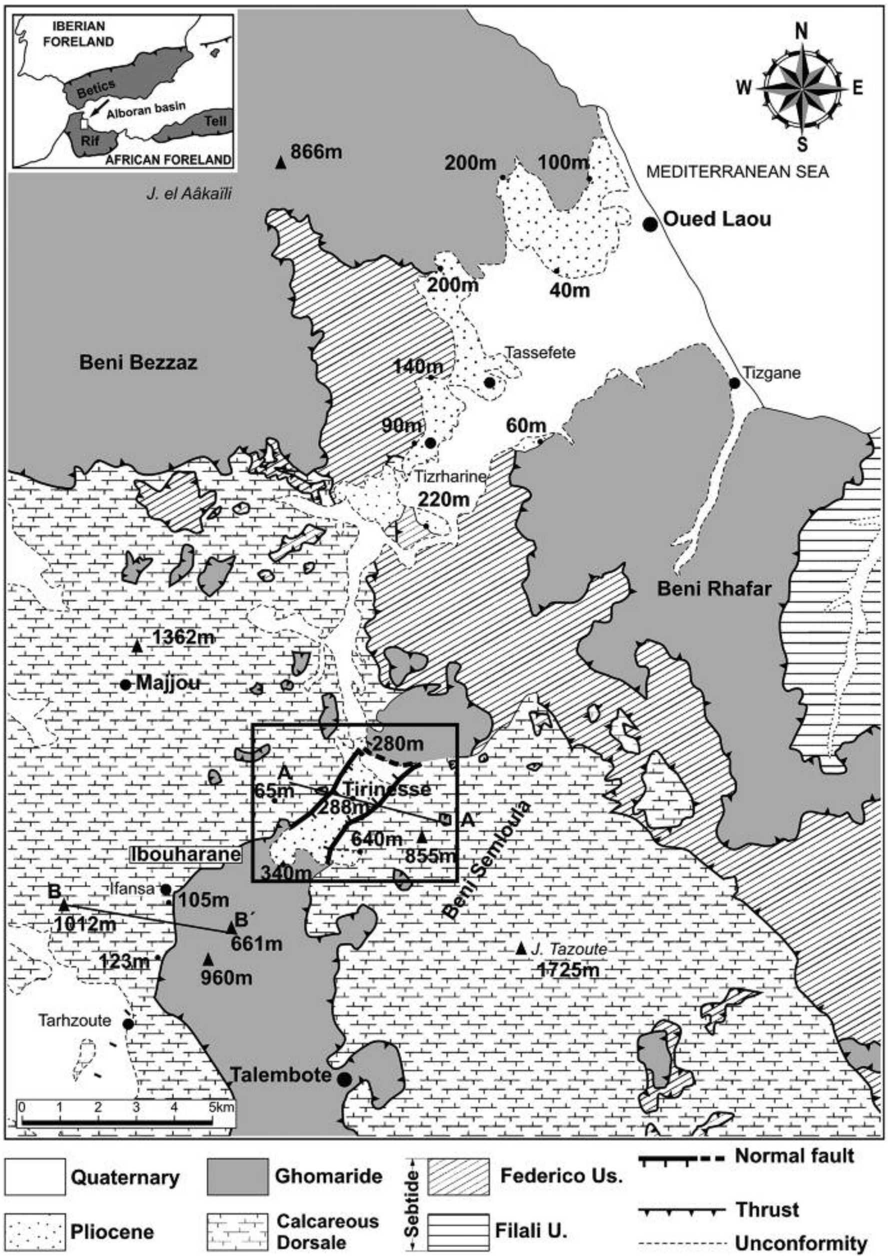


Fig. 1.- Geological scheme locating the Tirinesse Basin and the Oued Laou valley. The area is detailed in Fig. 2 and the position of the geological cross sections (Fig. 3) is marked.

Fig. 1.- Esquema geológico del área de Tirinesse y Oued Laou. Se señala la posición de la Fig. 2 y la de los cortes geológicos (Fig. 3).

imum thickness of 200 m, occupies the greater part of the basin. It is mainly formed by marine silts and grey marls spanning a probable early Zanclean, 3) the Upper Member (< 30 m of thickness) crops out in the SE of the basin and is formed by chaotic to poorly stratified conglomerates mainly sourced from the Dorsale (Tamrabete conglomerates). This member partially rests over a paleoscarp of the SE border of the basin and it surpasses the height of an abrasion platform excavated in the Dorsale. Although there are not direct data to determine the age of this platform, it may be also formed during the early Zanclean.

Structure of the Tirinesse basin

The two largest borders of the Tirinesse basin are fashioned by two normal faults, those of Tamrabete and Ibouharane, with a dip of the order of 70º (Figs. 1 and 2). The Tamrabete fault forms the SE border of the basin. Its uplifted border, the eastern one, consists of Triassic dolomites of the Dorsale. In the scarp of the fault, approximately at 580 m altitude, a marine abrasion platform is sculpted. At least 200 m thick Zanclean sediments are preserved in the hanging block. According to these data, the throw of the Tamrabete fault is at a minimum of the order of 500 m, perhaps even till 1000 m (Fig. 3). Even considering the sole value of 500 m, the throw proved very high for a fault of only 4 km in length (as directly observable in the basin).

The Ibouharane fault limits the NW border of the basin and is conjugated with that of Tamrabete. Its footwall is also formed by Triassic Dorsale carbonates. The throw of the fault, according the cross-section A (Fig. 3) is clearly minor.

The NE border of the basin shows a clear topographic contrast between the Pliocene marls and the reliefs of the Ghomaride Complex. The contact can correspond to a normal fault. According to this interpretation, this fault accommodated part of the subsidence forced by the two previously cited faults. In the SW border of the basin, the transgressive Pliocene sediments do not permit to verify the existence of important faults, although Saji and Chalouan (1995) indicated some WNW-ESE normal faults.

The two main faults exhibit striae and grooves with a rake of 90º and others, at least in the Tamrabete fault, with a slight sinistral component (their rake is 75-80º to the SW). In both faults there are small faults parallel to the main one, with deeps of the order of 70º and even more, forming echelons. Locally Zanclean sediments are clearly dragged by the movement of the faults. In the interior of the basin, the Pliocene sediments are affected by many vertical N 030º E joints, parallel to the two main faults. In the central part of the basin these sediments dip towards the Tamrabete fault (approximately 20-30º to the SE), a feature interpreted as owing to the subsidence of the fault, particularly in its central and northern parts.

Discussion

The genesis of the Tirinesse basin cannot be explained without considering the geologic regional setting. In fact, a so small basin limited by two faults of only 4 km and another transversal one, of a bit more of 1 km, with a filling of several hundred metres and a throw of one of the faults at least of

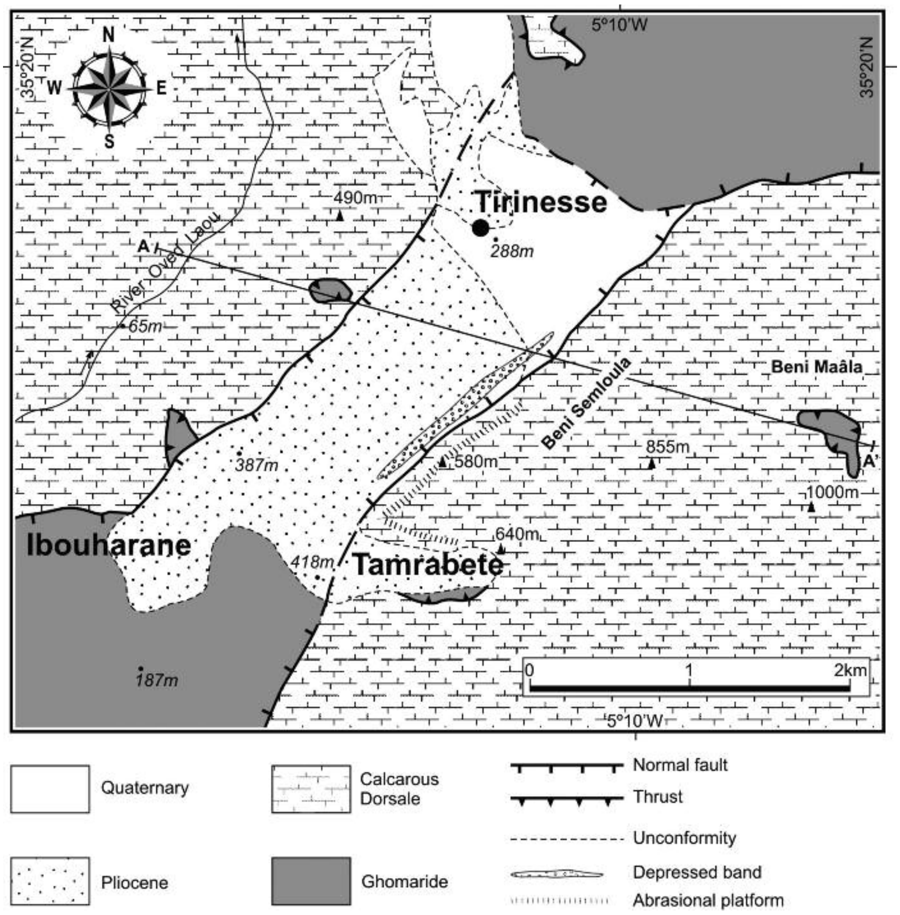


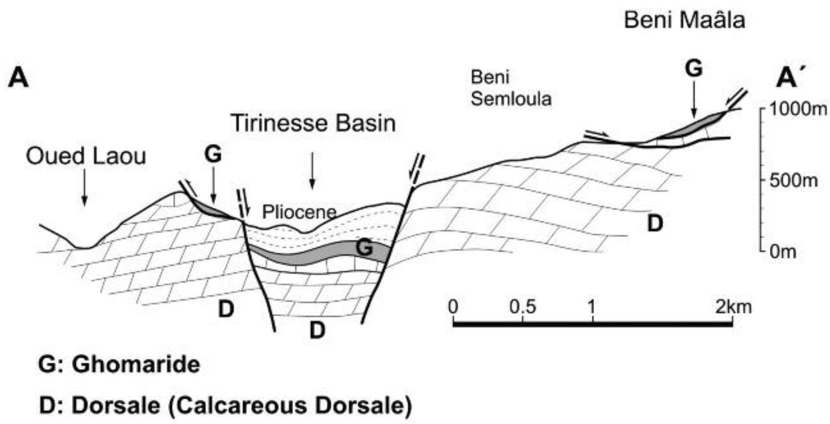
Fig. 2.- Geological map of the Tirinesse basin, with the location of the geological cross section A of the Fig. 3.

Fig. 2.- Mapa geológico de la cuenca de Tirinesse, con la situación del corte A de la Fig. 3.

500 m, cannot be formed independently from other greater geologic features. Consequently, it is necessary to consider that the cited faults form part of a longer system of faults of regional importance. In Talembote map (Kornprobst and Wildi, 1970), the Ibouharane Fault (although not mapped as a continuous line) can be prolonged to the SW (Figs. 1 and 4).

There, the cited map only shows discontinuous faults, sinking the SE border where the Ghomaride Complex is clearly sunk comparing with its position in the NW border (cross-section B, Fig. 3). This sinking continues, although attenuated, in the Ibouharane Fault. That indicates the existence of a regional cut sinking the SE part (or uplifting the NW one) affecting transversely the Rifian Internal Zone. Near the coast the sinking of the SE border is partially compensated by the Tamrabete Fault, prolonged to the NE, which has a conjugate displacement. All these movements of both faults, much longer than previously considered, contributed to the formation of the strongly subsiding small and limited Tirinesse trough. In this context the Tirinesse basin was formed between two approximate parallel but antithetic faults, with a much long regional extent than have been generally considered. The movement of these opposed faults, was approximately equivalent to that of one scissors. That is to say, the movement of the faults where are inserted those of the Ibouharane and Tamrabete was as follows: while the prolongation to the SW of the Ibouharane fault caused the sinking of its southern border in the Internal Zone, that of Tamrabete fault sank the NE border, where is situated the Oued Laou valley. They move in an opposite way and the Tirinesse trough occurred exactly in the area of the axis of this scissor-like movement. In such displacements, both long faults near cut transversally all the Internal Zone in this area (Fig. 4). This near total cut of the Rifian Internal Zone is different to other transverse cuts affecting this domain, namely the valley of Tetouan, the Jebha-Assifane fault (in the south border of the Internal Zone, Benmakhlouf *et al.*, 2012) or the Fahies fault, in the Gibraltar Strait. These two last are clearly associated with strike-slip faults.

These movements probably began at the end of the Miocene, but clearly continued during the Zanclean (Aït Brahim, 1991).



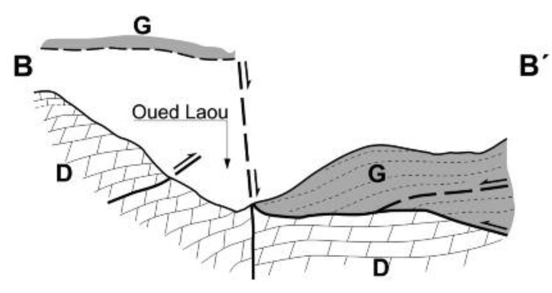


Fig. 3.- Geological cross sections for the Tirinesse area. The location of the cross sections is outlined in Figs. 1 and 2.

Fig. 3.- Cortes geológicos del área de Tirinesse. Su situación se indica en las Figs. 1 y 2.

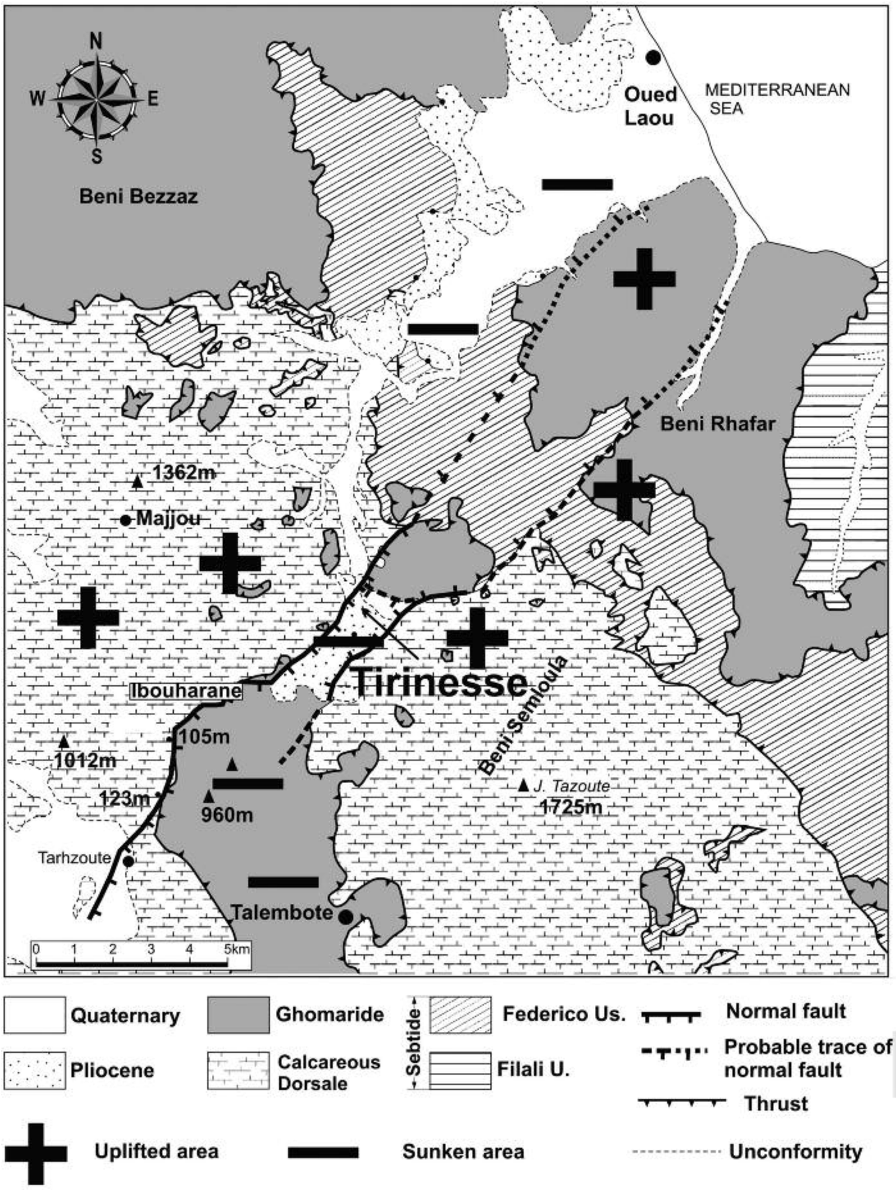


Fig. 4.- Vertical movements affecting the Oued Laou – Tirinesse sector, indicating the prolongation of the faults controlling the formation of the Tirinesse basin.

Fig. 4.- Movimientos verticales que han afectado al sector de Oued Laou-Tirinesse. Se indica la prolongación de las fallas que controlan la cuenca de Tirinesse.

Concerning the geodynamic context existing in the studied area, the same author indicated that from the late Miocene, the regional compression had a NE-SW direction, with an associated perpendicular tension. This direction of compression coincides with that of the main faults of the Tirinesse basin, and the tension facilitated their normal movements. Through the Pliocene, and according to this same author, the compression gradually turned into NNW-SSE.

Conclusions

The structure of the basin is a tectonic graben limited by two NE-SW normal faults with an important throw, particularly the SE one, Tamrabete fault, with a throw superior to 500 m. These large throws when compared with the small size of the basin, constrain us to admit that the faults limiting it are much longer, an interpretation supported by regional geologic data. Precisely, the combined scissor movements of both faults controlled the formation of the basin provoking its great subsidence (the sedimentary filling preserves is at least 200 m in thickness, despite its small size and its original thickness could be more than the double). Moreover, these faults produce a near complete transversal cut of the Rifian Internal Zone not referred till this moment. The age of the movements of these faults is attributed to the early Zanclean (early Pliocene), although probably should began at the end of the Miocene.

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References

Aït Brahim, L. (1991). *Tectonique cassante et états de contraintes récentes au Nord du Maroc*. Thèse de Doctorat d'état. Univ. Med V, Rabat. 273 p (inédit).

Benmakhlouf, M., Galindo-Zaldivar, J., Chaloan, A., Sanz de Galdeano, C., Ahmamou, M'F. and Lopez-Garrido, A.C. (2012). *Journal of African Earth Sciences* 73-74, 33-43.

Fallot, P. (1937). *Essai sur la géologie du Rif septentrional.* Notes et Mémoires du Service géologique du Maroc 40, 548 p.

Kornprobst, J. and Wildi, W. (1970). Carte géologique du Rif. Feuille de Talembote. Ministère de l'Énergie et des Mines. Royaume du Maroc. Échelle 1:50000.

Saji, R. and Chalouan, A. (1995). *Geogaceta* 17, 110-112.

Wildi, W. and Wernli, R. (1977). *Archives des Sciences (Genève)* 30, 213-228.