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Gravimetric evidences of active faults and underground structure of the Cheliff seismogenic basin (Algeria)

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ABSTRACT

The Cheliff basin (ex El Asnam) is known as one of the most seismic active zone in Algeria and the West Mediterranean region. We can cite the El Asnam earthquake which occurred in 10.10.01980 with magnitude of 7.3. It was generated by a thrust fault with NE–SW sinistral component. Until now, there is a little information about existence of deep active faults, which generate this strong activity. The gravity field is an important resource of information on crustal structure. The aim of this work is giving a reliable geometry of the major faults relative to the kinematics of this region.

The results obtained from various filtered maps (derivatives, upward continuation) of the gravity data, were used to generate a structural map of the studied area. Whilst the continuous wavelet transform method can help in automatic detection of elongated structures in 3-D, to estimate their strike direction, shape and depth. It gives a 3-D image or a model of the region and confirms the existence of several faults, localized or inferred, from former geological studies.

1. Introduction

This work is carried out under the CMEP Project (Comité Mixte d'Evaluation et de Prospective) which is about a geophysical and geological study of the seismogenic Cheliff basin. In this study we aimed at bringing a little contribution to try to understand and placing the studied area in a regional geodynamic context. This work concentrates on the relationships between the various geological formations that are clearer in the basin and those bounding the area and, especially the geometry of the faults at depth in relation to a general tectonic context. It is based on gravity analyses correlated with complementary geological and seismological information. The use of the continuous wavelet transform allows establishing a 3-D image of the region depicting thus a great number of deep or near surface faults and contacts that had remained unknown until the present time.

The studied area is situated in a box ranging from 01°00′ to 01°46′′ in longitude and 36°00′′–36°36′ in latitude. The region displays a complex geological setting (Fig. 1) and, its shallow seismicity is considered as diffuse because it spreads over a wide zone, instead of indicating a single major fault (Meghraoui and Morel, 1996) (Fig. 2). It is bounded in the North by the Mediterranean Sea and in the South by the Ouarsenis Mountains which are constituted by allochtonous lower Jurassic and Cretaceous formations. In the middle of the area, the E–W Mio-Plio-Quaternary intra-mountainous "post-thrust" Cheliff basin overlays an ante-Neogene basement consisting of Mesozoic series. It is a consequence of the distension phase that occurred during the Lower-Middle Miocene (Anderson, 1936; Perrodon, 1957). The E–W form of the basin implies N–S to NNW–SSE compressional movements (Meghraoui and Cisternas, 1986). The structure of the Cheliff basin is the result of the Alpine orogen (Perrodon, 1957). The neotectonics studies show that the main deformation is a NNW–SSE compression which is related with overthrusting reverse faults and strike-slips (Groupe de Recherche néotectonique de l'arc de Gibraltar, 1977; Philip and Thomas, 1977); this is confirmed by the studies of African plate movements (Philip and Thomas, 1977; Minster and Jordan, 1978; Anderson and Jackson, 1987) and focal mechanisms of the seismic events of 1954 and 1980 (Ouyed et al., 1981).

The main tectonic phases involving the formation of the basin is the subsidence in the Late Burdigalian followed by an extensional phase in Lower Tortonian with development of graben structures (Meghraoui, 1982). An important NNE–SSW compressive phase deformed the Miocene formations (Meghraoui and Cisternas, 1986). In the Quaternary, a second important compression phase occurred, with a NNW–SSE to NW–SE shortening direction and affected the Quaternary deposits (Meghraoui, 1982). The present

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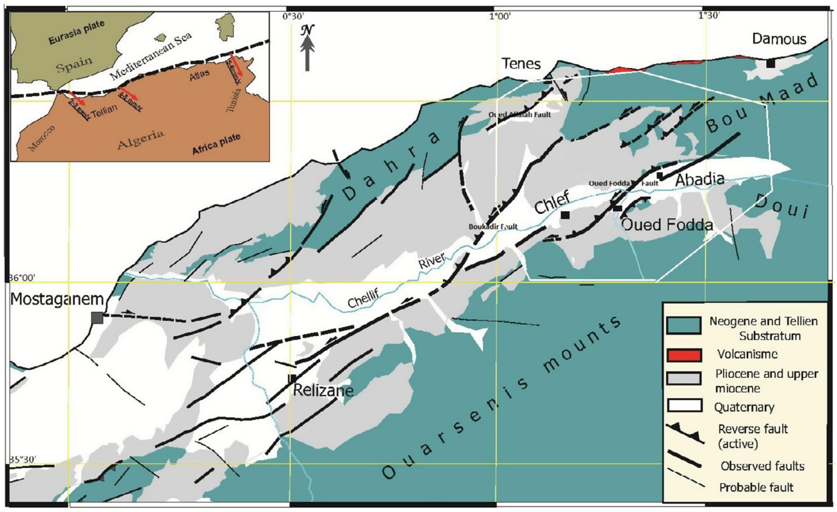

Fig. 1. Localization and geological setting of the Cheliff region (modified from Meghraoui, 1988). The studied area (four-sided white figure) is located in a box ranging from 01° to 01°46′ in longitude and 36° to 36°36′ in latitude.

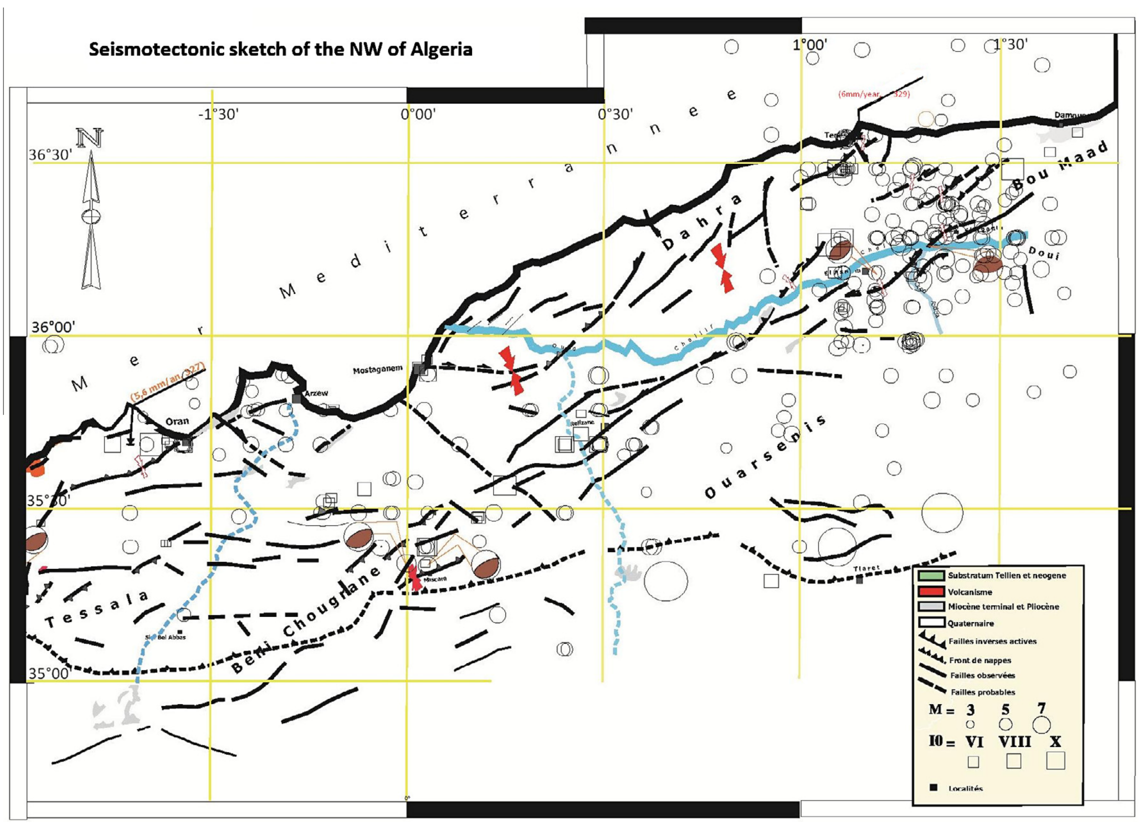

Fig. 2. Seismotectonic map of the NW of Algeria.

deformation in the Cheliff basin is mainly related to a transpression with N–S to NNW–SSE shortening direction, which is expressed by active tectonics responsible of the earthquake activity (Philip, 1983, Meghraoui and Cisternas, 1986). The NE–SW trending folds and NE–SW active sinistral transpressive faults were activated during the 1954 and 1980 destructive earthquakes (Bezzeghoud et al., 1995; Ouyed et al., 1981). These reverse faults and related folding are disposed on right lateral echelon and should be coupled with NW–SE to E–W trending strike-slip deep active faults (Meghraoui, 1982, 1986, 1988; Thomas, 1985; Chiarabba and Amato, 1997). The NE–SW faults are associated with asymmetric folds and the different tectonic structures define some NE–SW blocks (Morel, 1996). A kinematics model of block rotation related to a transpression with NNW-SSE direction of plates convergence is proposed in the Cheliff basin (Meghraoui and Cisternas, 1996) where the blocks rotation was previously studied with paleomagnetic investigations by Aïfa et al., 1992 and recently by Derder et al. (2011).

This work complements information on some of them and outlines especially those very deep. In the studied area, the Moho