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Recent tectonic activity of the Gafsa fault through morphometric analysis: Southern Atlas of Tunisia

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A B S T R A C T

This article focuses on the neotectonics of the southern Atlas of Tunisia based on morphometric analyses. Five major relevant morphometric parameters were processed and analyzed: residual topography, hypsometric index, drainage anomalies, maximum vertical curvature, and terrain roughness, and compared to the structural and tectonics of the study area. These are relevant to describe the topographic changes, and therefore suggest possible neotectonic activity.

The analysis of these morphometric indices reveals that two structures in the study area (Jebels Ben Younes and Bou Ramli) are distinguished by a specific morphometric footprint: high residual topography, high hypsometric integral value of some watersheds (HI > 0.6), high frequency of drainage anomalies, high maximum vertical curvature, and high roughness index. The correlation of these geomorphic indices with the structural pattern of the study area confirms the neotectonic reactivation (dating from the Quaternary) and the dextral strike-slip component of the Gafsa fault (the major tectonic feature in the southern Atlas of Tunisia). Thus, the morphometric analysis of the Digital Elevation Model and the drainage network provide a more accurate insight into the morphodynamics of the study area.

1. Introduction

Although Tunisia has undergone N–S convergence of the African and Eurasian plates since Aptian time, little is known of the neotectonics of the Gafsa fault. This N–S compressive stress field created E–W elongated tight anticlines and large synclines with many small topographic displacements due mainly to its location in the Tunisian margin. The numerous seismic events (Dlala and Hfaiedh, 1993; National Institute of Meteorology, 1995; Ben Hassen, 2012; ISC, 2012) have revealed that the southern Atlas of Tunisia is strongly influenced by this compressive geodynamic context.

Several methods were used to describe the active tectonic zone, including geomorphometry. This method describes, analyses, and measures the morphology of the land surface (Pike and Dikau, 1995). It is based essentially on the analysis of changes in altitude as a function of distance (Deffontaines, 1990; Pike and Dikau, 1995; Dehn et al., 2001; Pike, 2002; Bolongaro-Crevenna et al., 2005). This paper describes the morphology of the study area, applies quantitative geomorphometric analysis of the ground, the results are interpreted in terms of morphostructural analyses, and the recent tectonic deformations are identified.

2. Location and description of the study area

The southern Atlas of Tunisia is bounded on the north by the Central Atlas, on the south by the Saharan platform, by the North–South axis and the plains of the Sahel (Sahel block) on the east and by Atlas of Algeria on the west (Fig. 1). This domain is marked mainly by the extension of folded ranges E–W trending and by the presence of two NW–SE major shear zones: the Gafsa and the Tozeur-Negrine accident (Zargouni, 1985; Deffontaines et al., 2008). In the study area, the seismicity, which is relatively high (Dlala and Hfaiedh, 1993; National Institute of Meteorology, 1995; Ben Hassen, 2012; ISC, 2012), reflects the continuation of Atlas and alpine compressive deformation characterized by a shortening axis NW–SE to N–S (Jauzein, 1967; Rouvier, 1977; Turki,

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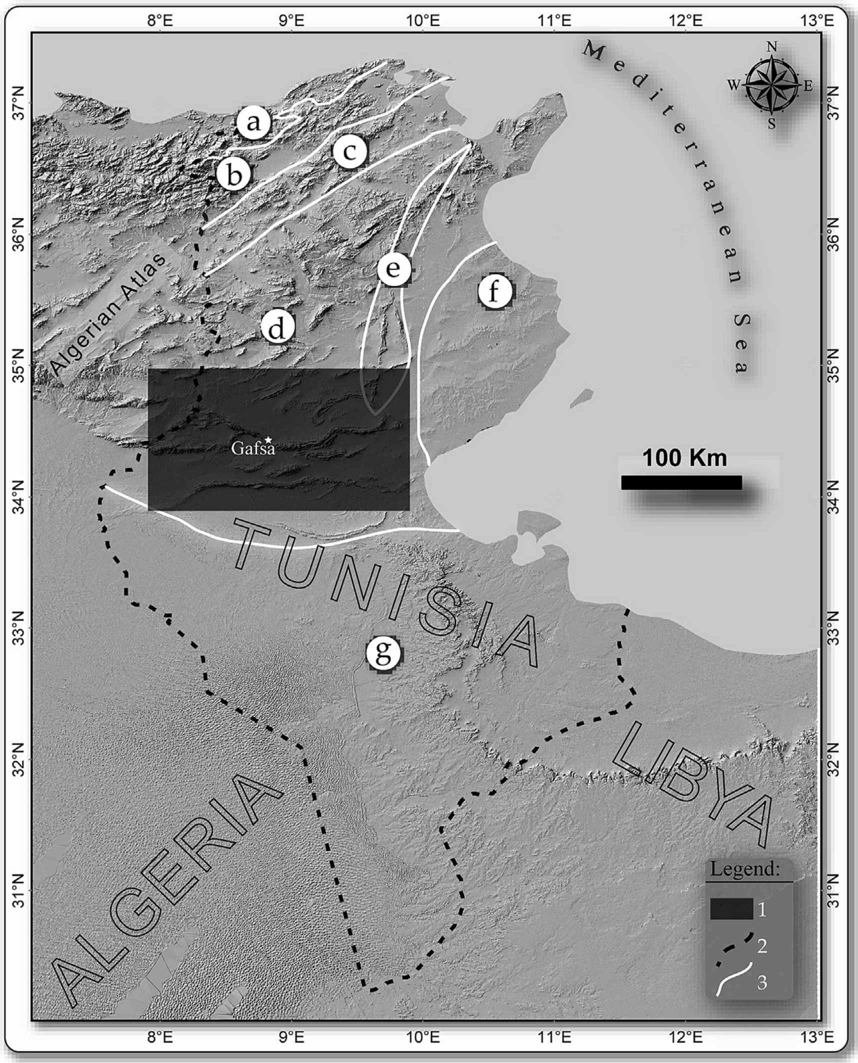

Fig. 1. Location of the Gafsa study area (dark rectangle) and major structural areas of Tunisia (after Ben Ayed, 1986, modified): 1: Study Area, 2: Boundary of Tunisia, 3; Tectonic domain (a: Tellian Atlas, b: Imbrication zone, c: Diapir zone, d: Atlas of Tunisia, e: North–South axis, f: structural block of Sahel, g: Saharan platform) – Shading parameters of the SRTM DEM: Azimuth = N315° E, elevation = 45°, Exaggeration of relief = ×5.

1985; Zargouni, 1985; Ben Ayed, 1986; Bouaziz, 1995; Bouaziz et al., 2002; Nocquet and Calais, 2004).

Usually, erosion is a complex parameter that is strongly influenced by tectonics, climate, morphology, and lithology. Thus, the creation of a relief, after a tectonic event, is accompanied by erosion. In the Palaeogene, southern and central Tunisia emerged and compressional deformations occurred. Thus, during the Neogene and Quaternary, intense processes of erosion took place and caused the deposition of thick syn-orogenic series of silts and molasses in the morphologic depression (Hlaiem, 1999).

The tectonic setting with the contribution of erosion phenomena has deeply changed the landscape of the region, sculpting four major mountain ranges (Fig. 2): the Gafsa chain, the Moulares one, the Metlaoui one and the North Chotts chain. In addition to these four chains, the study area contains many isolated massifs: the Jebel (J.) Sehib, J. Berda, J. Chemsi, and J. Bel Kreir. These elongated and high reliefs correspond to folded structures (Zargouni, 1985) with cores mainly occupied by carbonate and calcareous clay lithological lower Cretaceous series (Swezey, 1996).

3. Quantitative geomorphometric analysis: data, methods and results

Geomorphology considers the interactions between geological (lithological and tectonic setting) and surface erosion phenomena. Thus, the geomorphology reflects interactions of sedimentation, tectonics and erosion (Legier, 1977; Tapponnier and Molnar, 1979; Deffontaines, 1990; Burbank and Pinter, 1999; Kühni and Pfiffner, 2001; Slama, 2008). One of our objectives is to highlight the signal of active tectonics.

A universal set of geomorphometric indices useable in all geomorphological and structural studies does not exist. It is rather the local context (the phenomenon studied, characteristics of the study area, initial data, etc.) that determines the choice of the best indices to achieve the objective (Speight, 1974; Evans, 1979; Deffontaines, 1990; Monier, 1997; Wilson and Gallant, 2000; Dupéret and Deffontaines, 2004).

As other authors (e.g. Ehsani and Quiel, 2009; Drăguţ and Eisank, 2011; Prasannakumar et al., 2011; Ślęszyński, 2012), we used the DEM SRTM (Shuttle Radar Topography Mission) for the