



## Gravity analysis of the Precambrian basement topography associated with the northern boundary of Ghadames Basin (southern Tunisia)



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### ABSTRACT

Gravity data were analyzed to determine the structural development of the northern boundary of the Ghadames Basin in southern Tunisia. The Ghadames Basin which also occurs in eastern Algeria and northwestern Libya is one of the most prolific hydrocarbon producers in North Africa with several of the largest oil fields occurring along its northern boundary. The Ghadames Basin was formed during a series of tectonic events ranging from the Early Paleozoic to the Early Cenozoic. These tectonic events produced a basin in southern Tunisia that has a complex basement configuration which is not completely known. A residual gravity anomaly map constructed using polynomial trend surfaces, and vertical and horizontal gravity derivative maps indicate that the northern boundary contains a series of maxima and minima anomalies that trend in two prominent directions: northeast–southwest and east–west. The horizontal and vertical derivative gravity anomaly maps indicate that the width of the basement structures range between 10 and 20 km in width. Three-dimensional (3D) Euler deconvolution and 3D forward modeling constrained by well data, one seismic reflection profile and remote sensing data confirm the width of the basement structures and indicates that the depth of basin varies between 1.5 and 5 km, with deeper sections in general more numerous in the southern sections of the boundary. The gravity analysis constrained by the seismic reflection profile and well data implies that the basement topography may have been formed during the Pan African and/or late Mesozoic rifting. However, additional seismic reflection and well data are needed to confirm this conclusion. The discovery of the numerous basement structures suggests that there may exist additional hydrocarbon traps within the northern boundary of the Ghadames Basin.

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### 1. Introduction

The Ghadames Basin is a large sedimentary encompassing over 350,000 km<sup>2</sup> located in southern Tunisia, eastern Algeria and northwestern Libya (Fig. 1) (Echikh, 1998; Gauthier et al., 2003). The Ghadames Basin is one of a series of sedimentary basins formed on the early Paleozoic passive margin (Saharan Platform) that stretches from Morocco to Egypt (Boote et al., 1998). While the Ghadames Basin has previously been considered to be an intracratonic sag basin (Echikh, 1998; Klett, 2000), recent detailed studies of the structures within the basin suggest that the basin has a far more complex formation history involving a series of compressional and extensional tectonic events (Gauthier et al., 2003).

The earliest formation of the basin involved the Pan African orogeny in the Late Precambrian where Cambrian and Ordovician sediments were deposited within small-scale rift basins formed along a suture

zone between formed during the Pan African orogeny. During the Middle to Late Paleozoic, a series of collisions (Taconic, Caledonian and Hercynian orogenies) occurred between Africa and Laurentia that influenced the structural development of the basin (Echikh, 1998; Gauthier et al., 2003). The most important of these tectonic events were two phases of the Hercynian orogeny during the late Paleozoic where large scale thrusting aided in deepening the basin through flexural depression (Bishop, 1975; Echikh, 1998). During the early Mesozoic, rifting was associated with the opening of the Tethyan Ocean and this led to the development of a series of en echelon normal faults and tilted blocks with the subsequent deepening of portions of the basin (Echikh, 1998). During early Aptian time, deformation caused localized uplifts and strike-slip faulting (Rossi et al., 2002). Renewed subsidence occurred in the late Aptian that resulted in the deposition of carbonates and evaporates (Boote et al., 1998). The Alpine orogeny which caused large scale deformation to the north of the Ghadames Basin, only

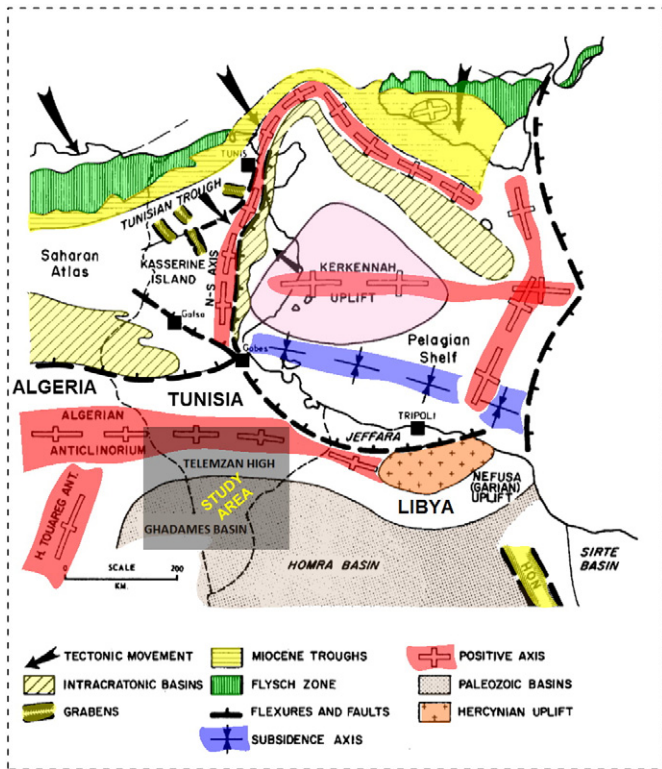


Fig. 1. Tectonic elements within Tunisia, eastern Algeria and northwestern Libya (adapted from Bishop, 1975). Also shown is the location of the Ghadames Basin and the study area.

produced subtle folding of the sediments within the Ghadames Basin (Rossi et al., 2002). The combination of the above tectonic events in the Ghadames Basin region resulted in a series of fault-bounded

structural highs (e.g., Telemzane High (Fig. 1)) surrounding a central depression that contains over 6000 m of Paleozoic and Mesozoic sediments (Klett, 2000).

This study concerns the basement structure of the northern sections of the Ghadames Basin in southern Tunisia and its relationship to petroleum exploration. The northern boundary of the Ghadames Basin in Tunisia consists of the Telemzane High (Fig. 1) which is a basement uplift. The Telemzane High is distinguished by gently dipping Paleozoic strata truncated by the Hercynian unconformity overlain by Mesozoic strata (Fig. 2) (Ben Ferjani et al., 1990). Previous studies using well and magnetic data within the northern boundary have shown this region to consist of a series of normal faults that controlled the subsidence of the basin (Acheche et al., 2001; Gabtni et al., 2006; Gabtni et al., 2012).

The goal of this work is to use detailed gravity data constrained by geological and remote sensing data to determine the basement structure and to locate Precambrian basement topography irregularities. These features are then related to petroleum exploration in terms of petroleum migration paths and the location of petroleum traps. A preliminary gravity analysis showed that all the major oil and gas fields along the northern boundary of the Ghadames Basin are located on positive gravity anomalies (Gabtni et al., 2012). A variety of enhancement techniques including upward continuation, polynomial trend surfaces, 3D Euler deconvolution and 3D forward modeling will be used to accomplish the above goals.

## 2. Geopetroleum setting

The Ghadames Basin is one of the largest petroleum producing basins in Tunisia, Algeria and Libya where over 3.5 billion bbl of recoverable oil has been discovered (Acheche et al., 2001; Galeazzi et al., 2010). Within Tunisia, the largest oil and/or gas fields include the El Borma, Debbech, Larich, Makhrougha, and Chouich es Saida (Fig. 3) where the recoverable reserves are located mainly in middle Triassic

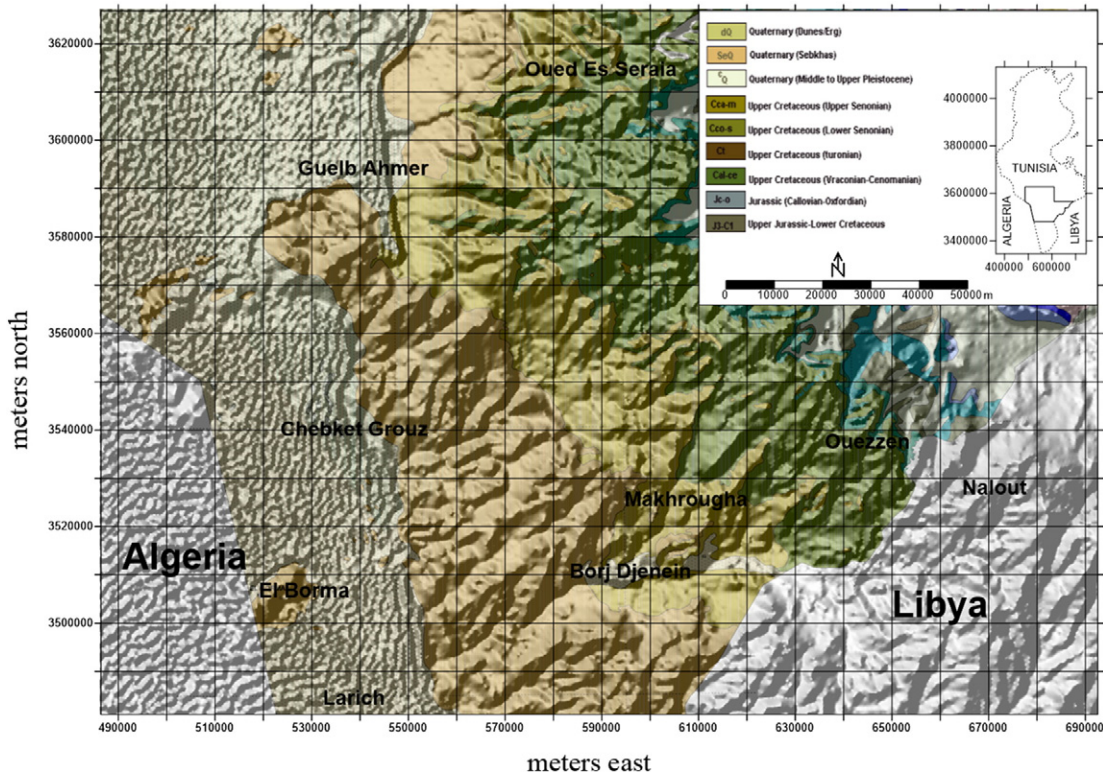


Fig. 2. Geological map of the study area superimposed over a shaded elevation relief map (adapted from Ben Ferjani et al., 1990). Major cities are shown and these cities are shown in subsequent maps. The inset shows the location of the study area within southern Tunisia. The remaining maps cover the same study area as the inset. The coordinate system is UTM zone 32N using the WGS84 datum and is used for all the maps.

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