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Wrench structural deformation in Ras Al Hilal-Al Athrun area, NE Libya: a new contribution in Northern Al Jabal Al Akhdar Belt

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Abstract Al Jabal Al Akhdar is a NE/SW- to ENE/WSW-trending mobile part in Northern Cyrenaica province and is considered a large sedimentary belt in northeast Libya. Ras Al Hilal-Al Athrun area is situated in the northern part of this belt and is covered by Upper Cretaceous–Tertiary sedimentary successions with small outcrops of Quaternary deposits. Unmappable and very restricted thin layers of Palaeocene rocks are also encountered, but still under debate whether they are formed in situ or represent allochthonous remnants of Palaeocene age. The Upper Cretaceous rocks form low-lying to unmappable exposures and occupy the core of a major WSW-plunging anticline. To the west, south, and southeast, they are flanked by high-relief Eocene, Oligocene, and Lower Miocene rocks. Detailed structural analyses indicated structural inversion during Late Cretaceous–Miocene times in response to a right lateral compressional shear. The structural pattern is themed by the development of an E–W major shear zone that confines inside a system of wrench tectonics proceeded elsewhere by transpression. The deformation within this system revealed three phases of consistent ductile and brittle structures (D_1, D_2, and D_3) conformable with three main tectonic stages during Late Cretaceous, Eocene, and Oligocene–Early Miocene times. Quaternary deposits, however, showed at a local scale some of brittle structures accommodated with such deformation and thus reflect the continuity of wrenching post-the Miocene. D_1 deformation is manifested, in Late Cretaceous, via pure wrenching to convergent wrenching and formation of common E- to ENE-plunging folds. These folds are minor, tight, overturned, upright, and recumbent. They are accompanied with WNW–ESE to E–W dextral and N–S sinistral strike-slip faults, reverse to thrust faults and pop-up or flower structures. D_2 deformation initiated at the end of Lutetian (Middle Eocene) by wrenching and elsewhere transpression then enhanced by the development of minor ENE–WSW to E–W asymmetric, close, and, rarely, recumbent folds as well as rejuvenation of the Late Cretaceous strike-slip faults and formation of minor NNW–SSE normal faults. At the end of Eocene, D_2 led to localization of the movement within E–W major shear zone, formation of the early stage of the WSW-plunging Ras Al Hilal major anticline, preservation of the contemporaneity (at a major scale) between the synthetic WNW–ESE to E–W and ENE–WSW strike-slip faults and antithetic N–S strike-slip faults, and continuity of the NW–SE normal faults. D_3 deformation is continued, during the Oligocene-Early Miocene, with the appearance of a spectacular feature of the major anticline and reactivation along the E–W shear zone and the preexisting faults. Estimating stress directions assumed an acted principal horizontal stress from the NNW (N33°W) direction.

Keywords Wrench system · Transpression · Structural inversion · Structural analysis · Al Jabal Al Akhdar · Libya

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