



Research paper

Evolution of the Nourooz anticline (NW Persian Gulf) deciphered using growth strata: Structural inferences to constrain hydrocarbon exploration in Persian offshore anticlines

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ARTICLE INFO

Article history:

Received 27 October 2014

Received in revised form

22 June 2015

Accepted 30 July 2015

Available online 4 August 2015

Keywords:

Growth strata

3D geological model

Sequential restoration

Fold amplification

Persian Gulf

ABSTRACT

The structural features and kinematic evolution of the Nourooz anticline, an oil producing structure located in the NW Persian Gulf, are unravelled based on the interpretation of a seismic profile grid and well data, construction of a 3D depth model and sequential restoration of a 2D geological section. The Nourooz anticline is a kilometre-scale, slightly asymmetrical fold that comprises pre-growth and growth strata. The main stratigraphic feature is an Upper Cretaceous unconformity. The amplification of the Nourooz anticline from Upper Cretaceous to present-day probably took place by hinge migration with minor contribution of limb rotation assuming that the structure resulted from horizontal compression and maintained constant bed length. The estimated average fold-shortening rate is 0.002 mm/a, assuming that the structure resulted from horizontal shortening, and the average fold-uplift rate calculated is 0.019 mm/a, although the fold amplification rates decreased with time. The anticline does not seem to be related to a detachment at depth and its growth may have been caused by motion along a basement fault, that favoured movement of deep evaporite bodies underneath the anticline, and buckling caused by propagation of the Zagros belt deformation into the foreland basin. The processes involved in the formation of this anticline coincide with those documented for an adjacent structure and seem to be the main processes that controlled the structural style in the Persian Gulf basin.

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1. Introduction

The Persian Gulf basin is an elongate sedimentary basin located along the eastern subducting margin of the Arabian plate (Fig. 1). It is bounded by the Arabian shield to the SW and by the Zagros fold and thrust belt to the NE. Significant discoveries since 1960 proved that there is great oil potential in the Persian Gulf (e.g., Konyuhov and Maleki, 2006), and in particular the Iranian sector has been the subject of numerous seismic studies from 2000. However, there is still a notable unexploited potential (Soleimany, 2010), which makes the structures developed in this area, and the Persian Gulf in general, a geologically interesting site to be analysed in detail from both economical and scientific point of view. One of the largest structures that hosts several Iranian and Saudi Arabian oil fields in the Persian Gulf is the Nourooz anticline (Abdollahie Fard et al., 2006), whose name comes from the Nourooz oil field. This

anticline is an approximately 300 km long, NE–SW trending structure located in the NW portion of the Persian Gulf within the Mesopotamian foreland basin (Fig. 1). This gentle anticline involves a thick and almost complete stratigraphic series, and exhibits well-developed growth strata associated with it and a very distinctive angular unconformity.

The most recent works focussed on this anticline and neighbour regions relevant to the analysis presented here are the ones conducted by Abdollahie Fard et al. (2006), Soleimany (2010), Soleimany and Sàbat (2010) and Soleimany et al. (2013). All these authors interpret the Nourooz anticline as an Arabian-type structure whose growth started in Late Cretaceous and was reactivated during Tertiary as a result of the Zagros orogeny. However, Abdollahie Fard et al. (2006), who call the Nourooz anticline as the Hendijan High, concluded that the anticline grew uninterruptedly from Late Cretaceous to present-day with two main pulses: one during Late Cretaceous and another one during Tertiary. Alternatively, according to Soleimany and Sàbat (2010) and Soleimany et al. (2013) two main folding phases (one during Late Cretaceous and another from Middle Miocene to present-day) took place separated by a Palaeocene to

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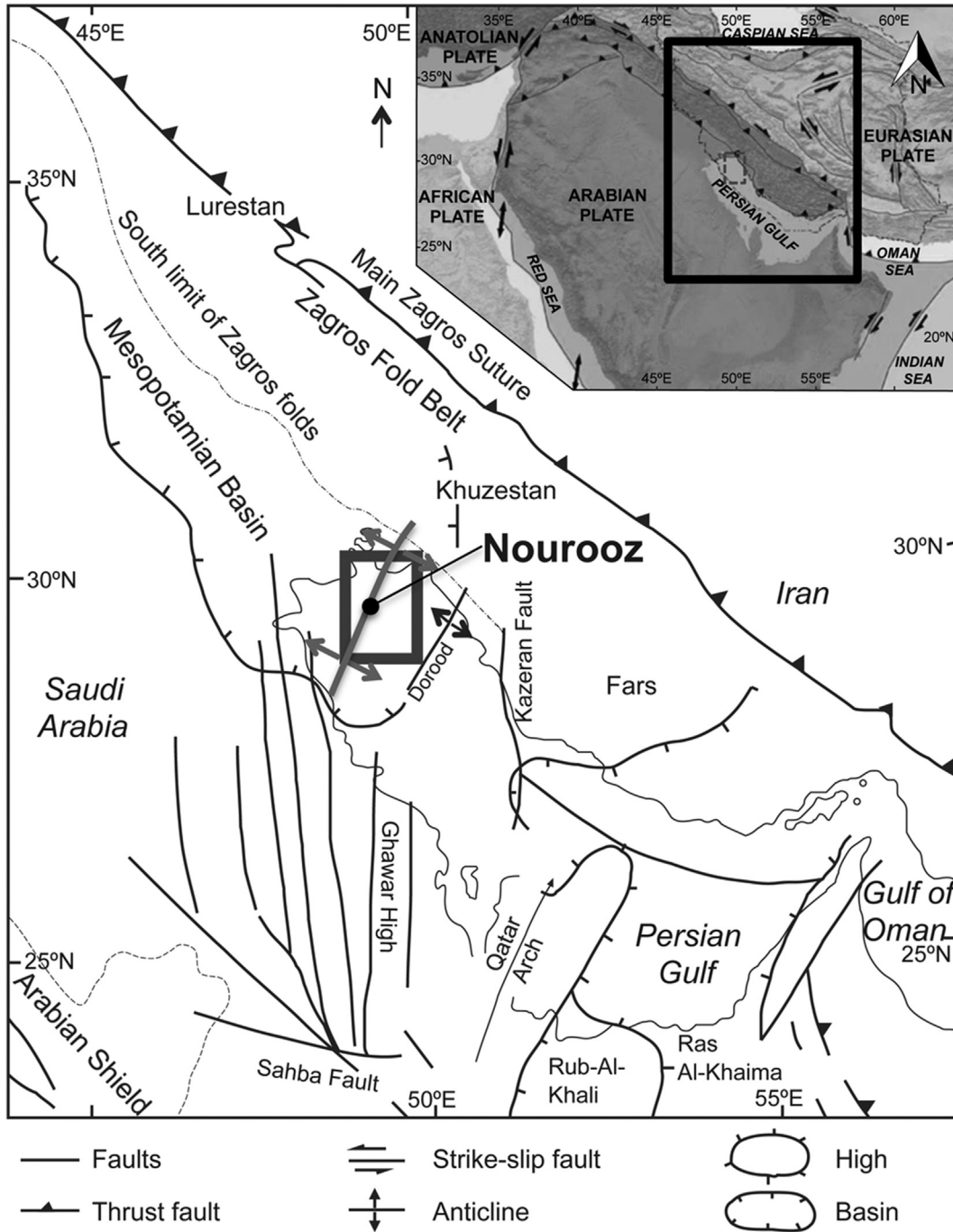


Fig. 1. Structural sketch of the Persian Gulf region. The axial trace of the Nourooz anticline is depicted within the study area (dashed rectangle). Modified from [Konyuhov and Maleki \(2006\)](#).

Middle Miocene period of tectonic quiescence. In order to solve this timing issue a detailed analysis of the Nourooz anticline has been carried out. In addition, the purpose of this study is to compare the origin and evolution of the Nourooz anticline with those of adjacent structures and acquire a larger-scale picture of this portion of the Persian Gulf. Finally, the knowledge of the main characteristics of the Nourooz anticline could help to better understand similar structures present in this region and to improve strategies of exploitation of the hydrocarbons stored in this structure.

Thus, this study aims to establish the structural features, tectonics–sedimentation relationships, timing, origin and kinematic

evolution of the Nourooz anticline, using an excellent imaged seismic survey plus well information property of the National Iranian Oil Company (NIOC). Techniques such as geological interpretation of a 2D seismic network, construction and visualization of a 3D depth model, sequential restoration of a 2D geological cross section, depth to detachment estimations, and analysis and quantification of the kinematic evolution of the anticline have been used.

2. Geological setting

The Persian Gulf basin is an approximately 2600 km long and

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