Development and folding of the NW Zagros foreland basin, Lurestan Povince, SW Iran

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Summary

It is crucial for exploration in fold-and-thrust belts to get robust understanding of foreland basin evolution and deformation, in order to constrain the timing of hydrocarbon generation, migration and trap formation. Although it is widely accepted that the main phase of deformation in the Zagros belt occurred in the Miocene and Pliocene, recent field studies have demonstrated that folding started in the NW Zagros (Lurestan Province) as early as the Late Cretaceous and Paleocene.

The objective of this work is to constrain the timing of the development and folding of the NW Zagros foreland basin, on the base of accurate dating of the Amiran, Taleh Zang and Kashkan syntectonic foreland formations at different places through Lurestan Province. A multidisciplinary approach has been used, combining benthic foraminifera biostratigraphy, calcareous nannoplankton biostratigraphy, palynostratigraphy and strontium isotope stratigraphy.

Dating results show that the Amiran-Kashkan clastic wedge prograded south-eastward in the NW Zagros foreland basin between the late Cretaceous and the early Eocene. The dating of associated syn-depositional folding structures permits to establish that an early folding of the NW Zagros foreland basin progressed south-westward during the same period.

Introduction

For successful exploration in foreland fold-and-thrust belts it is crucial to establish a robust understanding of foreland basin evolution and fold growth, in order to constrain the timing of hydrocarbon generation, its migration and trap formation. The region of Khorram-Abad, in the Zagros range (Lurestan Province, SW Iran) (**Fig. 1**), is an excellent natural laboratory for understand these issues.

It is widely accepted that the main phase of deformation that shaped the present Zagros belt occurred in the Miocene and Pliocene. However, recent field studies have revolutionized the understanding of foreland basin and fold development, showing that folding started in Lurestan Province as early as the Late Cretaceous and Paleocene ([Blanc et al., 2008](#); [Homke et al., in press](#)) (**Fig. 2**). This result has a major impact on modelling of the petroleum system.

The objective of the work is therefore to constrain the evolution and folding of the Zagros foreland basin in the Khorram-Abad area. This is achieved through the determination of the timing of the foreland basin development and of the timing of fold growth, on the base of extensive detailed dating of the syntectonic foreland succession at different places of the studied area.

Studied sedimentary succession

In northeast Lurestan, the exposed Mesozoic-Cenozoic stratigraphic column consists of about 4-5 km of pre-orogenic strata and about 4-5 km of syn-orogenic deposits. The Mesozoic pre-orogenic succession is mainly composed of passive margin carbonate units. The overlying syn-orogenic deposits include, from bottom to top, the Amiran-Taleh Zang-Kashkan succession, the Shahbazan-Asmari shallow-marine carbonate platform, the evaporitic Gachsaran Formation, and the siliciclastic Agha Jari and Bakhtyari formations ([James and Wynd, 1965](#)).

Deposition of the Amiran Formation on top of the Gurpi Formation marks the transition from deep-marine carbonate to foreland siliciclastic sedimentation in the NW Zagros basin. The Amiran flysch Formation, the Taleh Zang carbonate formation, and the Kashkan siliciclastic formations formation constitute a shallowing

upward succession that infill the early foreland basin developed in the Lurestan province in relation with the Late Cretaceous obduction event. The Amiran and Kashkan formation are mostly sourced by the erosion of the radiolarite-ophiolite Kermanshah complex. The Amiran-Kashkan foreland succession forms a southwestward-thinning wedge that pinches-out around the SW flank of the Chenareh anticline and that grades laterally into the Pabdeh Formation ([Fakhari and Soleimany, 2003](#); [Alavi, 2004](#); [Homke et al., in press](#)).

In order to accurately determine the timing of foreland basin development and folding in Lurestan Province, twelve sections encompassing the Amiran, Taleh Zang, Kashkan, Shahbazan and Asmari formations have been logged and sampled through the Lurestan Province (**Fig. 1**). Sediment dating has been achieved using a multidisciplinary approach, combining benthic foraminifera biostratigraphy, calcareous nannoplankton biostratigraphy, palynostratigraphy and strontium isotope stratigraphy.

Development and folding of the NW Zagros foreland basin

Detrital sedimentation started in the NW Zagros basin during the Late Cretaceous, with deposition of a massive conglomeratic fan (Gilbert) delta in the most proximal parts of the basin (Late Cretaceous Conglomerates of [James and Wynd, 1965](#); Amiran conglomerates of [Alavi, 2004](#)). This fan delta is mainly constrained to the NE of the Khorram-Abad Anticline, whereas the Amiran Formation deposited to the SW of the anticline is only made of distal and deep-water turbiditic deposits. The Amiran-Kashkan clastic wedge prograded toward the SE in the foreland basin, reaching the Amiran anticline (central part of the flexural basin) during the middle Danian (early Paleocene), the NE flank of the Rit anticline in the early Selandian (middle Paleocene), the SW flank of the Sultan anticline in the late Selandian, and the NE flank of the Chenareh anticline during the Ilerdian (early Eocene) (**Fig. 3**).

The Amiran-Kashkan foreland succession presents multiple evidences of syn-deposition folding (growth strata, angular unconformity, fold-scale thickness and age variations, sediment facies distribution). Several growth structures (non-dated) have already been described within the Amiran-Kashkan succession in the SE part of the Lurestan Province ([Blanc et al., 2008](#)) (**Fig. 2**).

To the NE of the Khorram-abad Anticline, the Shahbazan Formation unconformably covers the Amiran-Kashkan succession, with in some areas a complete lack of the Taleh Zang and Kashkan formations. This angular unconformity, together with the geometry of the conglomeratic fan delta complex mostly constrained to the NE of the Khorram-Abad Anticline, give evidence for a Late Cretaceous fold growth in the internal part of the NW Zagros basin. To the SE of the Khorram-Abad Anticline, variations in sediment age, facies, and thickness through the Pusht-e Jangal and Amiran anticline give evidences for a Maastrichtian to Middle Paleocene folding in the central part of the Amiran basin. More to the south, similar sediment thickness and age variations between the two flanks of the Rit Anticline suggest a late Paleocene to early Eocene folding near the south border of the Amiran basin.

These dating results evidence an early phase of folding in the NW Zagros related to the emplacement onto the NE Arabian passive margin of the Kermanshah radiolarite-ophiolite complex. The deformation progressed in the Amiran flexural basin toward the SE between the Late Cretaceous and early Eocene times. Identification of the early folding event has a major impact for the timing of development of hydrocarbon structural traps in the NW Zagros fold-and-thrust belt.

This early period of folding is post-dated by the deposition of the Shahbazan-Asmari carbonate succession, which covered the entire region after a long period of non-deposition/erosion that encompassed part of the middle and late Eocene. The main folding event that shaped the present Zagros fold-and-thrust belt started during later during the Miocene, reaching the front of the belt (Anaran anticline) during the late Miocene at 7.7 ± 0.5 Ma ([Homke et al., 2004](#)).

Fig. 1. Satellite view of the studied area. Studied stratigraphic sections are located by red pushpin icons.

Fig. 2. Growth strata within the Kashkan formations on the SE flank of the Dariagiveh anticline (Picture from E. Blanc).

Fig. 3. Simple lithostratigraphic correlation.

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