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A REVIEW OF POP-UP STRUCTURES IN ZAGROS FOLD THRUST BELT

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Abstract:

Many orogenic belts (Zagros, Alps, Pan-African, Pyrenees) are characterized by divergent thrusts and folds, so that the structures face in opposite directions on opposite sides of the orogenic belt, often with upright structures in-between called Pop-up structures. Zagros Fold-Thrust Belt therefore shows a good example of divergent tectonics, and this structural pattern has sometimes been interpreted as due to intraplate, dominantly autochthonous tectonics. Pop-up structures developed in compression zones along large shifts, where compression and extension structures alternate.

Keywords: *Tectonic, Pop-up Structures, ZFTB.*

Introduction

Introduction:

An SW-verging orogen, the ZFTB extends from the eastern part of Turkey to the Makran area over a distance of around 2000 km (Sarkarinejad and Goftari, 2019; Bigi et al., 2018; Ballato et al., 2011; Karasozen et al., 2019). Large crustal-scale thrusts and folds are a feature of the Zagros Fold-Thrust Belt. The Neotethys Ocean subducted northward, causing a collision between central Iran and Arabia plates during the Neogene period, which produced this belt. Several of the peaks in the belt reach elevations of more than 4,000 meters (Pascale and Cecile, 2010). According to Regard et al. (2010), it consists of a sedimentary pile (6-15 km thick) covering a Precambrian metamorphic substrate.

A protracted and intricate history of tectonic convergence between the Eurasian and Arabian plates produced the ZFTB. The onset of the compressional phase falls between the Late Cretaceous and Early Pliocene, according to the many studies conducted on the geodynamics of the Zagros. This belt's average shortening is 45 ± 13 km, and it varies from east to west between approximately 75 and 30 km (Sembroni et al., 2024).

In orogenic mountain belts, such as the Zagros, where it originated at the collision zone, pop-up construction is frequently employed (Bhattacharya, 2022). A pop-up structure is defined by Elliott (1981) as a "hanging wall block that develops between a back-thrust and a frontal ramp".

Literature review:

The Afro-Arabian continent colliding with the Iranian microcontinent is what caused the deformation of the Zagros orogenic belt. The potential for oil and gas resources in this belt has been studied (Ghanbarian and Sarkarinejad, 2014).

In the sedimentary cover, Mouthereau et al. (2006) proposed two ideas on brittle deformation. The first suggests that the thickening of the cover due to deformation above the Harmuz salt is the primary factor forming the regional topography. In this idea, the Eocene salts were broken by a thin-skinned thrust wedge formed of weak sedimentary rocks. The folding observed at the surface may be isolated from the subsurface brittle deformation at a weak layer located between the cover layers, according to another theory. Thrust ramps cause deformation in the sedimentary layer's bottom region, while buckling, thrust, and reversal faults—also referred to as "pop up" structures—can eventually construct the local topography. A second intermediate decoupling element between an upper and a lower competent group is needed to support this idea. If such a layer is present, it should be located between the Cambrian Hormuz salt and the Cretaceous strata, which are exposed in several of the Zagros' anticlines.

According to Molinaro (2004), the front almost thrust fault in the Jain structure is thought to match with the High Zagros Fault's (HZF) real surface emergence. The tectonic style and geometric linkages of the surrounding structures of the HZF and Jain region are depicted in a precise field section. Rocks of the Eocene to Devonian ages have been transported over a narrow syncline in the north of the Agha Jari and Mishan formations, which comprise the heart of the significant south-verging Baghan Thrust. A north-dipping frontal thrust fault—which is thought to correlate with the development of the HZF—and a south-dipping back thrust bring Jurassic to Cretaceous shelf limestone to the surface in the south. Thus, a "pop-up" structure constructed from strongly folded and distorted rocks that extend in age from the Cretaceous to the Jurassic is demarcated by these two faults.

Pop-up structures grow early in the deformation process and are passively carried along with the structure as it evolves. The granular materials utilized in the models' mechanical properties determine how these structures evolve. Back thrusting is less common in the Zagros structures. The rheology of carbonate rocks may be to blame for this, as it prefers folding to fracturing and diffusive mass transfer (pressure solution) (Sherkati et al., 2006).

Fard et al. (2006) cited the Pabdeh Formation, which has marl and shale deposits and transitions laterally to the Jahrum shelf, as an example of a facies transition. Moreover, the northern basinal shale of the Kazhdumi Formation gives place to the Albian Burgan Formation with shallow delta clastics in the SW of the Abadan Plain. Rocks of the Miocene-Pliocene have been identified as having back-thrusting and pop-up structures, which may be explained by the previously described changes in layer-mechanic resistance to fore-thrusting. Thus, shifting layer mechanics caused by lateral facies modifications are likely to have impacted the region's structural style to some extent.

When Di Cuia and Pace (2017) analyzed the Zagros Thrust Belt, they noted that it mainly consisted of long, linear thrust-related anticlines that trended from Noth West-South East to East-West and from South East to North East. These anticlines responded to the diverse mechanical stratigraphy by being doubly plunged and changing vergence regionally along the strike due to a variety of folding processes and repeated detachments. The compressional subsurface geometries are reconstructed by combining well data, seismic interpretation, and surface geology in order to better understand the relationships between surface exposures and deep structures. Structures can have a variety of morphologies, including folds connected to fault-bend and fault-propagation thrust, inversion anticlines, pop-up, and flower structures. This suggests that different fracture patterns will emerge, which will have a significant impact on the distribution and occurrence of hydrocarbon accumulations. During tectonic inversion, these inherited extensional traits have resulted in the localization of thrust ramps and the reactivation of reverse normal faults.

Behyari and Mohajjel (2009) proposed a hypothesis on the geometry of colliding plates in the Zagros suture zone, namely that the Neothetyse along the suture zone's length was not sealed simultaneously. Instead, the Cenozoic sediments have been able to accumulate because the Neothetyse basins around the deflexion positions of clashing plate borders have remained mostly open. The Cenozoic sedimentary basins closed as a result of a transpressive tectonic regime brought forth by the Arabia plate's constant migration. Structural evidence indicates that the structure created in the area is a pop-up structure that originated from the reactivation of a high-angel reversal fault.

According to Aflaki and Mohajjel (2009), the Laibid pop-up structure formed and evolved by a continuous deformation process that turned the material from ductile to brittle. Subsequent motions caused the material to separate and form the pop-up structure.

For the purpose of regional scale fold-thrust belt style assessment (Maystrenko et al., 2003) and hydrocarbone trap occurrence (Morley et al., 2011), pop-up structure identification is significant. Pop-up structure growth is influenced by a variety of factors, including rheological differences, stratigraphy, décollement type, deformation processes, and rates of thrust/fold propagation (Fabbi and Smeraglia, 2019).

According to Shihab and Al-Obaidi (2016), the Perat anticline faults may be considered back-thrusts. This model explains why a continuous fold-thrust sequence of tectonic deformation affected the studied area and is consistent with the pop-up and triangle zone models. The upper sediments situated above the detachment fault up against the Lower Triassic sequence, are squeezed in this model. The morphology of the Alpine thrust region may be related to the many folds and thrusts' varying orientations.

Based on bed length, Al-Obaidi and Al-Moadhen (2015) separately balanced the duplex. These duplexes were arranged to generate the topography of the duplex and the bends of the thrust sheets over it. The ensuing problem caused the front part of the duplexes to rise as a Pop-Up structure and the rear thrusts to rotate in the opposite direction. All of these evidences-pop-up structures, long flats, short ramps, hinterland sinking duplex, and beds which have acted as separation surfaces found in the research region corroborate thin skin tectonic concept.

Because deformation did not spread outward during the final phases, Jiménez-Bonilla et al. (2022) proposed that the resultant ZFTB exhibits both a low protrusion level and a comparatively small frontal fold thrust belt. Pop-up structure make up the ensuing fold-thrust belt at the arc limbs, while gravitational deposits consisting of slumping sand associated with silicone, which were later added to the belt, cover the frontal fold-and-thrust belt.

Hasan et al. (2023) assessed the 2-dimensional seismic section of the Maqlob structure to ascertain the structural type. The seismic section and depth structural maps show the existence of (5) thrust faults in the region. Additionally, it is clear from the depth contour maps and the interpreted seismic section that these faults are thrust and back thrust faults, which produced pop-up structures. Based on the analysis of the seismic data, the structure is composed of pop-up anticline and triangular zone as a result of compression stress.

Conclusion:

In thrust belts, pop-up structures and back thrusts are often observed. In the context of orogenic mountain belts, such as the Zagros, where it forms at the collision zone, the phrase "pop-up structure" is frequently employed. An elevated block constrained by a back thrust that verges into the hinterland and a thrust ramp that verges into the foreland may produce the Pop-up structures. This kind of structure typically occurs in fold-thrust belts, which are defined by thin-skinned tectonics, weak décollement, and multilayered sedimentary succession (alternating competent and incompetent rocks). These structures are visible in Zagros belt, such as Bekhair, BardaRash, Taq Taq, Perat, Maqlob, and Miran anticlines.

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