Influence of Pre-Existing Late Cretaceous Extensional Faulting and Foredeep Basin Geometry on the Origin and Extent of a Pliocene-Age Triangle Zone in the Zagros Mountain Belt of S.E. Kurdistan

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Summary

Geological field mapping in SE Kurdistan (2009 and 2011) has outlined the presence of a Pliocene-Age Triangle Zone in the High-Fold Belt of the Zagros Orogen. In the Baranan, Qara Dagh and Bazian blocks, decoupling between hinterland-verging structures developed in Tertiary mixed carbonate-siliciclastic units, from foreland-verging thrust sheets and antiformal stack in Mesozoic carbonates, occurs within a regional Upper Detachment zone in Paleocene shale-dominated units (Kolosh Formation) and Late Cretaceous marlstones (Tanjero Formation). The Upper Detachment emerges at the base of the Baranan Range. Southwest of the Qara Dagh and Bazian Ranges, all structures in Tertiary units of the Foreland-Foothills Belt are foreland-verging, whether rooted from detachment levels in the Paleocene shales (i.e. Kurdamir-Topkhana ramp anticlines) or the Mid-Miocene anhydrites (large frontal emergent Kalar and Shakal thrusts). The regional Upper Detachment of the Triangle Zone and the large frontal thrusts cutting through the Pliocene clastics (i.e. above Kirkuk, Jambur, Pulkhana fields) were also folded during the latest stage of shortening, with foreland propagation of the Mesozoic carbonates fault imbricates. The SW extent of the Triangle Zone and its associated hinterland-verging structures coincides with an abrupt and significant thickness increase in the Late Creatceous Tanjero Formation, along the foreland side of the Qara Dagh and Bazian Ranges.

Introduction

The Kurdistan Region of northern Iraq lies within the Kirkuk Embayment of the Zagros Orogen, which resulted in the closure of the Thetys Ocean from the Middle Cretaceous to present time. Field geological mapping was carried out in the Baranan, Qara Dagh and Bazian mountain ranges area in 2009 and 2011. The area of interest is dominated by NW-SE trending broad open synclines and narrow anticlines, where Miocene- to Pliocene-age shallow marine mixed siliciclastic units (Fars to Baktiari Fms.) and Eocene-age lagoonal facies carbonates (Pila Spi Fm.) outcrop respectively. Northeast of the Baranan Block, Mesozoic carbonaceous units were involved in megascopic-scale folding, dominating the hinterland physiography, such as the Pira Magrun and Azmar anticlines.

Field mapping and ties to the regional structural story

Previously published geological maps in SE Kurdistan show little information about the vergence of surface anticlines/thrusts and their associated detachment levels. Field mapping observations in the Baranan, Qara Dagh and Bazian blocks, complemented by seismic data in the High-Fold Belt, show that Tertiary (Paleocene to Pliocene) units are invariably involved in hinterland-verging (i.e. NE) folds and thrusts, rooted off shales of the Paleocene Kolosh Formation. This contrasts further to the SW in the Foreland-Foothills Belt, where an earlier phase of deformation (Phase 1 at 15 Ma) was responsible for foreland-verging ramp anticline folding of Oligocene and Eocene carbonates, restricted between the

regional Paleocene-level detachment and a Mid-Miocene unconformity (e.g. Topkhana & Kurdamir structures). Phase 1 deformation is also seen in the Aj Dagh mountains area.

Phase 2 deformation was initiated in the Uppermost Miocene to Early Pliocene (at < 3 Ma), with structural thickening of the Mesozoic carbonates, below the regional Paleocene level of detachment. In the Foreland-Foothills Belt, disharmonic folding of Miocene and early Pliocene units above a Mid-Miocene Lower Fars Fm. anhydrite detachment took place during the early stages of structural thickening in the Mesozoic carbonates. Seismic data show that deformation above the Mid-Miocene anhydrite detachment evolved from a detachment fold first, then a fault-propagation fold, before being truncated by the large-scale frontal faults (i.e. Shakal and Kalar thrusts), above hydrocarbon fields such as Pulkhana, Kirkuk, Kor Mor and Jambur. Growth in structural relief of either the thick thrust sheets (i.e. Qara Dagh and Aj Dagh mountains) or antiformal culmination (i.e. under the Baranan Range) of Mesozoic carbonates were responsible for the passive folding of the regional Paleocene level Upper Detachment and exhumation of the High-Fold Belt, as well as folding of the Mid-Miocene detachment in the Lower Fars anhydrites. Recently acquired seismic data in the Baranan Block confirmed the presence of a Triangle Zone as mapped in the field, where deformed Tertiary units have been passively modified during the latest stage of Mesozoic carbonates shortening. The deflection in the Baranan Range, the SE plunge of the Darbandikhan Synclinorium, presence of minor normal faulting and the 4-way surface closure of the Kalosh Mountain NE-verging detachment anticline are genetically-linked to the subsurface extent of seismically-defined culminations of thrusted Mesozoic carbonates with lateral ramping along-strike terminations. The geological map pattern and structural evolution in the Baranan Block is similar to that documented in the area of Limestone Mountain and Williams Creek area, in the Central Alberta Foothills, with a major lateral ramp in the Brazeau Thrust. On a regional scale, the SW limit of the Triangle Zone, with its hinterland-verging structures, coincides with an abrupt and substantial increase in thickness of the Late Cretaceous foredeep basin Tanjero Formation (marlstone-dominated section), from less than 100 m in the SW to over 800 m, located approximately along the foreland side of the Qara Dagh and Bazian ranges. It is believed that an extensional fault active during the foredeep basin evolution was responsible for the extra accommodation space and deposition of the much thicker Tanjero Formation. Inversion of this foredeep basin fault during the Pliocene-age compression of the Mesozoic carbonates would have acted as a buttress, forcing the hinterland vergence of folds and thrusts in Tertiary units from above a detachment zone in the Paleocene Kolosh Fm. shales, possibly too in the uppermost Tanjero Fm. marlstones.

Conclusion

Field mapping in SE Kurdistan has revealed the presence of an extensive Triangle Zone, where a canopy of deformed Tertiary units is detached from underlying foreland-verging thrust-fold belt imbricates of Mesozoic units. Mechanical stratigraphy within the Paleocene and Mid-Miocene detachment levels was critical for structural decoupling during the Mid-Miocene and Pliocene. But it is the presence of a Late Cretaceous foredeep basin extensional fault, during its Pliocene-age inversion, which controlled the origin and extent of the Triangle Zone in the High Fold Belt of the Zagros Orogen in SE Kurdistan.

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