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FORELAND PROPAGATION OF FOLDING AND STRUCTURE OF THE MOUNTAIN FRONT FLEXURE IN THE PUSHT-E KUH ARC (ZAGROS, IRAN)

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Chapter 5

SUMMARY

5. SUMMARY

Concentration of the oil and gas fields in Zagros mountain belt makes this chain interest of the oil industry and exploration as well as the scientific attention. During the last decade it has been started using the new geology application as well as the GIS, different applications of cross section construction and dating technique in order to develop the knowledge about the Zagros mountain belt. However there are numerous problems regarding to the evolution of this mountain belt, which has to be solved. The main objective of this work was to use multidisciplinary methods to better understand the structural geometry, kinematics of the deformation and time of the folding across the Pusht-e Kuh Arc. In this study we applied a multidisciplinary approaches; proper cross section construction using constant thickness method, the sand box modeling and magnetostratigraphy dating to the Pusht-e Kuh Arc in NW side of the Zagros fold and thrust belt.

5.1 Fold shape analysis and structural interpretation of Zangul anticline

We analysed the folding characteristic in an area of about 824 km^2 of the northeastern Pusht-e Kuh Arc where two different sets of folds coexist. The relatively large Zangul anticline crops out at the level of upper Cretaceous limestone of Ilam Formation and smaller anticlines formed by Oligo-Miocene Asmari Formation at both ends of the Zangul anticline. The analysis has been supported by the construction of 11 cross-sections across structures and 3 longitudinal sections along the major folds. These form the basis for the 3D geometry of the region that helps to understand the complex merges and bifurcations among structures.

The Zangul anticline is a four closures anticline, with an open box folding shape and slightly verging to the SW. Its amplitude is of about 1.5 km and its half wavelength is ~4.5 km. The aspect ratio amplitude / half wavelength of the Zangul anticline is of 0.38±0.05 at the level of top of Ilam Formation. The smaller anticlines at both terminations of the anticline show slight vergence to the SW and some of them are cut by a SW-directed thrust that normally flattens at the Paleocene Amiran shales. These Asmari folds show amplitudes of few hundred meters and half wavelength of less than 2 km. Their aspect ratio is about half of the one by the Zangul anticline and of about 0.21.

The geometric construction of cross-sections, showing a regular position of the anticline axial traces intersections, indicates that the Triassic Dashtak evaporites may represent one of the major detachment levels in the Mesozoic sedimentary pile. In addition, the shales of the Amiran would also represent a minor detachment level below the limestones of the Asmari Formation These two detachment levels have been already documented in other folds of the Pusht-e Kuh Arc as proved in previous works.

One significant result is the grouping of Asmari folds in synforms (SE termination of the Zangul anticline) and antiforms (NW termination) that can be important for oil exploration since they may represent significant closures at the level of top Bangestan. A more regional study must be accomplished to determine the exact position and size of such culminations.

5.2 Structure of the Mountain Front Flexure along the Anaran anticline

The Anaran anticline on top of the Mountain Front Flexure represents the most external fold of the Pusht-e Kuh Arc. This anticline is asymmetric with a long and gently dipping backlimb and a very steep forelimb. However, the most characteristic tectonic feature is the large amount of normal faults that cut the crestal and forelimb domains of the anticline. We proposed a geometric and evolution model for the Anaran anticline with the help of sand box models and growth strata ages. We also studied the potential effects of erosion and sedimentation coeval to folding in the development of the Anaran anticline.

By the help of analogue modelling the deeper geometry of the Anaran anticline has been reconstructed. The models indicate that the forelimb of brittle units (Competent Group) is mostly subvertical and does not follow the gentler dip of younger stiff units (Passive Group) separated by an intermediate detachment level (Upper Mobile Group). Syntectonic deposition to folding has a strong impact in controlling the geometry of the forelimb against which growth strata are impinged. These variations are the verticalization and lengthening of the growing anticline forelimb. Erosine of the units during the deformation had the similar effects than syntectonic sedimentation in our experiments.

By integrartion of the experiment result to the other numerical and analouge models we therefore proposed the evolution of the Anaran anticline as follows: an initial folding episode as detachment anticline linked to the suite of folds cropping out in the present

Pusht-e Kuh Arc. Agha Jari growth strata in the Changuleh growth syncline indicate that this folding initiated at 7.65 Ma. Regional uplift of the Pusht-e Kuh Arc above a low-angle crustal thrust probably took place later although ther is no precise temporal constraint. The fine-grained Lahbari Member could be related to this basement blind thrusting since 5.5 Ma to the end of the Bakhtyari deposition at 2.5-1.5 Ma. Since the end of Bakhtyari deposition, uplift is recorded by river incision, anticline gravitational collapses and recent basement seismic activity.

5.3 Magnetostratigraphy and timing of deformation

The magnetostratigraphy dating technique applied to the syntectonic detritical sediments of the Agha Jari Formation in two locations across the NW of the Zagros. The first location is the Afrineh syncline in the center part of the folded belt displaying field evidence of the growth strata in upper most part of the Agha Jari Formation. The second section is located in front of the High Zagros Fault across the Chaman Goli syncline with the same stratigraphy as in Afrineh syncline. The magnetostrigrphy dating technique in this study provides us the age of the sedimentation of the Agha Jari units and permits to constrain the sequence of the folding associated to growth strata across this particular part of the Zagros fold belt.

5.3.1 Afrineh syncline

The section in Afrineh syncline covered the 850 m preserved thickness of Agha Jari outcrops and 350 m of uppermost part of the Ghachsaran Formation. A total 128 sites were sampled along the total thickness of about 1200 m in southern flank of the Afrineh syncline. The average distance was about 10 m for each site.

The correlation with GPTS is largely base on a best-fit solution; the correlation is controlled by the similar overall pattern of our magnetic stratigraphy to GPTS (Cande and Kent 1995 and 1995; Gradstein et al., 2004). Two correlations are presented in this study for Afrineh section, option 1 and option 2. The option 1 shows better correlation while the option 2 is less evidenced because of the weak fit to the GPTS.

5.3.2 Chaman Goli syncline

The Agha Jari Formation in this area shows dominate succession of the coarse grain and conglomeratic units characteristic of the proximal lithology of the fluvial deposits while in Afrineh syncline is very fine to fine grain sediments without any conglomeratic units showing distal characteristics. A total 107 samples have collected along the 1300 m thickness of the Agha Jari Formation across the two separate sections. It is corresponded to 12.5 m distance per sample site. The correlation of the Chaman Goli result to the GPTS shows discontinuity for the lower 320 m of the section, the polarity result from this part of the section dos not support for the correlation. However, the middle part of the section from 320-850 m shows continues and good sample coverage. The best correlation is occurred for this part of the VGP latitude.

In Afrineh syncline by assuming continues sedimentation through the transition Ghachsaran to Agha Jari formations the contact in sequence will be determined at ~13.9 Ma in Afrineh and ~17.2 Ma in Chaman Goli synclines**.** The extrapolation to the base of the Bakhtyari Formation resulted to ~12.4 Ma in Chaman Goli syncline.

The extrapolation of the base growth from field evidences to the VGP latitude and correlation to the GPTS shows the base of the growth in Afrineh will be dated at about 11.8 Ma. That is about 6 Ma earlier than folding in front of the Pusht-e Kuh dated by Homke et al. (2004). It is idicating that the ages of the folding is become younger toward the foreland and therefore implying a forward sequence of deformation that started at 12 Ma, reached to the frontal folds in mountain front at about 7.6 Ma, and continued to slightly 2.5-1.5Ma.

Regarding to the oil exploration the study of new magnetostratigrphy successions will help to better understanding the deformation sequence provides better knowledge to further understanding of the structural development and trap generation across the Zagros mountain belt.

5.4 Future work

The type of the analogue modeling used in this study gives the idea about the using different configuration and kinematic model, which can help to better understand the process of the deformation and evolution of the structures, using the similar procedure of modeling could be a very good tool for testing the accepted kinematics models for any structure in Zagros or other mountain chain.

The mangetostratigraphy of the Agha Jari deposit shows that fortunately the lithology of this Formation in Zagros is appropriate for this kind of dating technique. It is recommended to apply this dating to other exposed Agha Jari Formation in Zagros fold and thrust belt. The expanded dating result over the Zagros will help to better understand the latest movement and deformation sequence in Zagros. It is the important key point in source rock maturation and oil trap generation for further hydrocarbon exploration in Zagros folds and thrust belt.