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Structural style variation and its impact on hydrocarbon traps in central Fars, southern Zagros folded belt, Iran

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ABSTRACT

The Fars area is the main target for Permian gas exploration in the Zagros fold belt. It contains approximately 15 percent of the world's proven gas reserves. The geometrical characteristics of the folded structures change dramatically across the N–S trending Gavbandi High. We used seismic profiles, well data, magnetic survey information and field observations to show that thickness variation of the sedimentary pile inherited from basement geometry is the main reason behind structural style variation in this area which occurred during the Zagros folding. Differences in thickness were more significant in Early-Middle Paleozoic time and decreased considerably upward in time. The total thickness of the Lower Paleozoic succession in the eastern side of the Gavbandi High is approximately 40–50% thicker than on the summit of this basement high. Sedimentary pinch-outs through Cretaceous and Tertiary times indicate that the activity of the basement faults decreased but did not stop. The impact on hydrocarbon traps of the pre-folding basin architecture and the differences in the behavior of the sedimentary cover after Miocene folding is discussed and documented.

1. Introduction

The influence of lateral facies and thickness variations in a sedimentary overburden on the geometry and style of folding has been addressed in many mountain belts (Currie et al., 1962; DeSitter, 1964; Bally et al., 1966; Ramsay, 1967; Dahlstrom, 1970; Price, 1981; Woodward and Rutherford, 1989; Mountjoy, 1992; Stockmal, 2001; Spratt et al., 2004; Sherkati and Letouzey, 2004; Sepehr et al., 2006). Moreover, the importance of intermediate decollement levels in shaping the variable geometry of the folds of the Zagros has been demonstrated in the NW Zagros fold belt (i.e. Lurestan region, Casciello et al., 2009; Farzipour-Saein et al., 2009; Vergés et al., 2011).

An understanding of the fold pattern is crucial in any attempt to improve hydrocarbon exploration and production activities.

The central Fars is a typical area in which lateral variations in the surface geometry of folds is observed. This variation is expressed by considerable variation in the wavelengths of folds over a short distance (Fig. 1). This area is also the main province of the giant Permo-Triassic gas reserves of the Zagros fold belt. Drilled wells in this area show success rates for gas exploration right across the region (Fig. 1).

In this paper we used balanced geological cross sections constructed on the basis of recent field observations, 2D seismic profile interpretations and well data to demonstrate that variation in sedimentary thickness can influence the style, scale and closure of the individual structures or exploration targets in this part of the Zagros fold-thrust belt.

We also discuss the nature of the inferred sedimentary transition which is interpreted to reflect a pre-contractional configuration of the Pan African basement structure and its influence on hydrocarbon system evolution.

2. Geological framework

The Zagros fold-thrust belt of Iran lies within the central part of the Alpine-Himalayan system, which extends from the NW Iranian border to SW Iran, up to Strait of Hormoz. This fold-thrust belt formed as a result of the Neo-Tethys closure and Late Miocene continent–continent collision between Arabia and Eurasia (Takin, 1972; Haynes and McQuillan, 1974; Stocklin, 1974; Ricou et al., 1977; Agard et al., 2005).

The studied area is located in the southern part of the Zagros belt, in the Fars geological province (Fig. 1). The NW–SE trend of the structures in the northwestern part of this belt (e.g. the Lurestan

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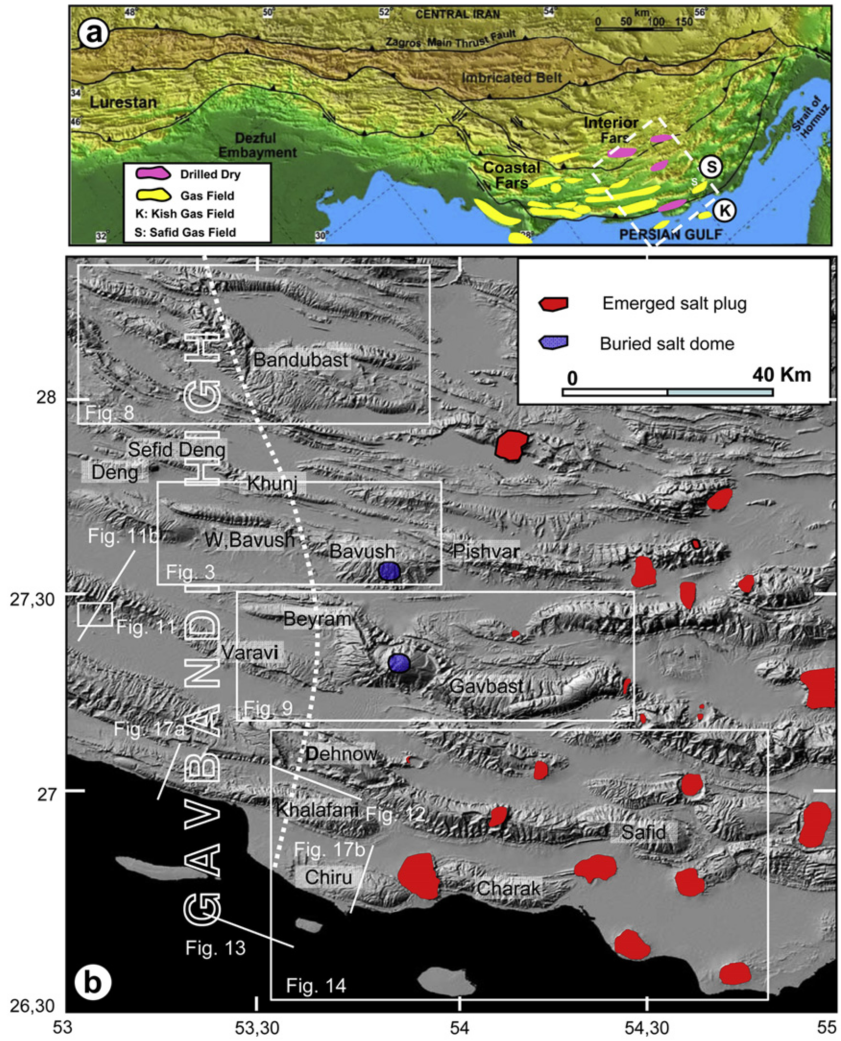

Fig. 1. a) Geological framework of study area in the southern part of the Zagros fold-thrust belt. The location of Permo-Triassic gas fields and the dry structures over the Gavbandi High (the dashed white rectangle) are also shown. b) Digital elevation model (DEM) of the study area showing evident surface geometry variation of folded structures. The dotted line corresponds to boundary between variations in anticline wavelengths.

and Dezful embayment), swing into an E–W orientation in the southeastern end of the Fars province or Fars arc.

The sedimentary succession of the Zagros fold-thrust belt is composed of an approximately 8–12-Km thick section of Lower Cambrian through Pliocene rock units without significant angular unconformities (Stocklin, 1968; Falcon, 1969; Colman Sadd, 1978). During the final extension phase of the Pan African events in the Late Precambrian–Early Cambrian, a number of evaporitic basins developed in an extensional pull-apart setting over a large area along the northern margin of the Arabian platform. However, they did not occur in the Qatar arc and its northward continuation toward Iran, a region known as the Gavbandi High or Fars High on which evaporites are generally absent or thin. (Fig. 1, Beydoun, 1993; Talbot and Alavi, 1996). The Hormuz salt and its equivalent series were deposited in an evaporite basin during the Neo-Proterozoic–Early Cambrian (Motiei, 1993). Coeval salt basins formed in Central Iran as well as Oman, Qatar, and Pakistan (Stocklin, 1968; Talbot and Alavi, 1996; Edgell, 1996; Al-Husseini, 2000; Konert et al., 2001; Jeroen et al., 2003).

During the Early-Late Paleozoic, the Zagros was a part of the stable passive margin of Gondwanaland. During the Cambrian to Permian, the Hormuz salt was overlain by 6–10 km of sandstone, shale, and dolomite deposits. The absence of a large part of the Paleozoic sequence on some paleo-highs indicates that either later uplift in the Carboniferous, possibly related to the Hercynian event (Fig. 2), resulted in the sequence being eroded away or that the highs were present during the deposition of these sequences which resulted in the sequences not being deposited in these areas. The entire Permo-Triassic to Upper Cretaceous succession consists of a thick sequence of competent platform carbonates deposited in a passive margin setting. The Triassic evaporites and shales (the Dashtak Formation) is thought to be the most important intermediate decollement level in the simply folded belt especially in the costal Fars region (Sepehr et al., 2006). The evaporites of the Dashtak Formation grade laterally to Dolomites of the Khaneh Kat Formation toward the inner parts of the belt (Szabo and Kheradpir, 1978).

The emplacement of the ophiolites (the remains of the Neo-Tethys Ocean) which occurred along the northeastern margin of the Arabian continent marked the initial stage of collision probably took place during the Campanian–Maastrichtian (Kazmin et al., 1986; Alavi, 1994). During the Paleocene-Oligocene, shelf type sediments, dominantly carbonates were deposited (the Asmari and Jahrum Formations). Instability of the margin in Lower Miocene

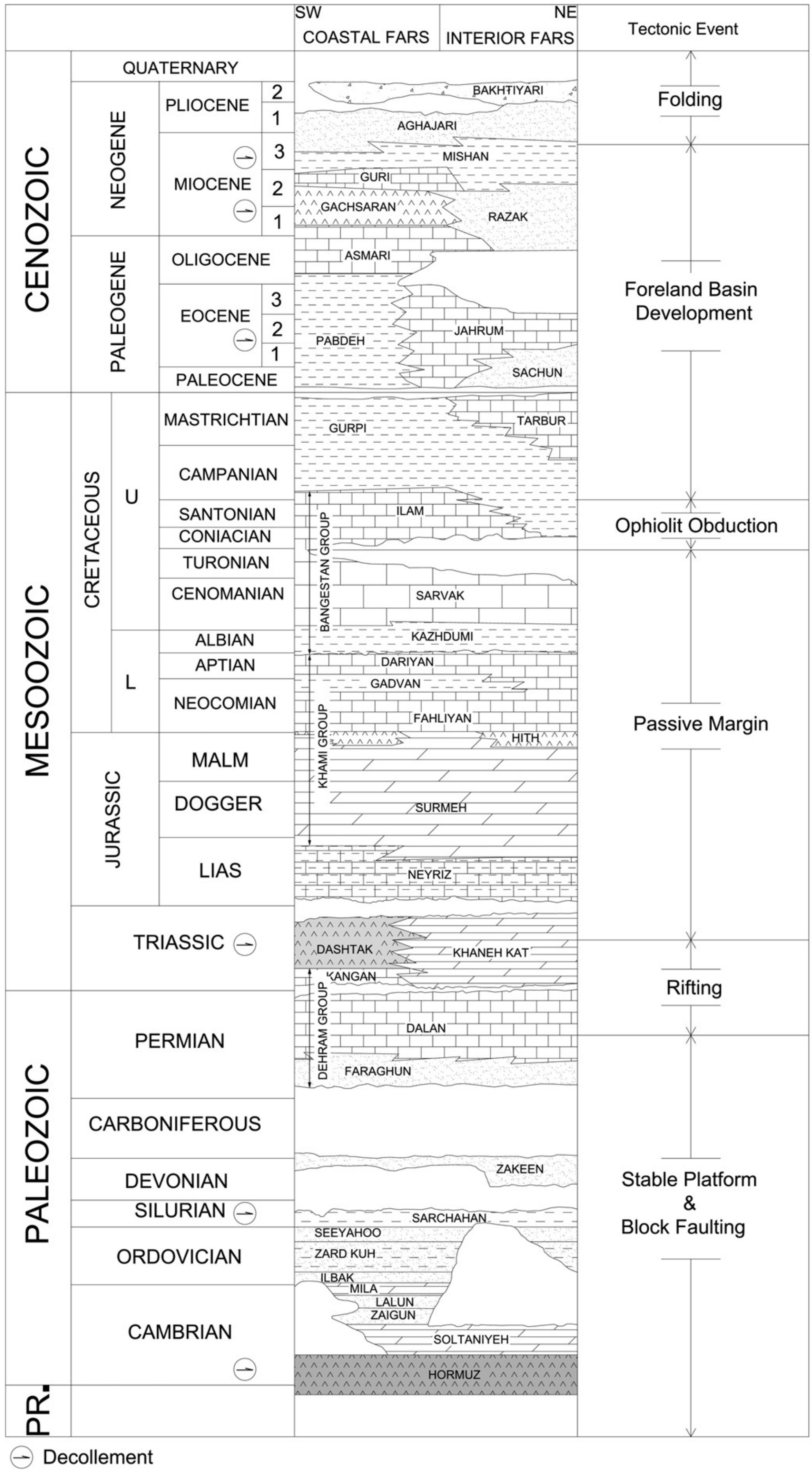

Fig. 2. Stratigraphic correlation chart of the Fars region showing lateral facies changes from the inner part of the basin (Interior Fars) to outer part of the belt (Coastal Fars). The gray color indicates the main known decollement levels. Other possible minor decollement horizons also are shown on the table. Modified after James and Wynd (1965), Motiei (1993) and Stocklin (1968).

Table 1
Comparison of the wavelength, amplitude and wavelength-amplitude ratio of the folded structures above and to the east of the Gavbandi High, measured on the top of the Oligo-Miocene Asmari Formation. See Fig. 1b for the location of the anticlines.

Anticline		Wavelength λ (Meters)	Amplitude D (Meters)	λ/D
East of Gavbandi High	Chiru	15,580	1500	10.38
	Charak	17,130	1550	11.05
	Dehnow	21,127	3600	5.86
	Khalafani	13,680	2400	5.70
	Bavush	19,950	2981	6.69
	Gavbast	24,658	4780	5.15
	Pishvar	13,007	2800	4.64
Gavbandi High	Beyram	14,718	3817	3.85
	Varavi	15,528	3434	4.52
	Khunj	10,620	2700	3.93
	Deng	6630	2220	2.98
	Sefid Deng	7778	2170	3.58
	West Bavush	10,361	2800	3.70

times is marked by a regional deposition of the Gachsaran Formation and its lateral equivalent in the inner part of the belt namely the Razak Formation, a gypsiferous red marl containing lenses of sandstone and conglomerates.

Sedimentation in the Zagros during the Middle Miocene was strongly controlled by the initial phases of the collision and the development of a foredeep basin over the Arabian margin. The Mid Miocene and younger rocks in the section include gypsum, limestone, sandstone, shale and conglomerate (Fig. 2).

3. Folding style

Inspection of the central Fars region indicates that the surface geometry of folds above the Gavbandi High varies significantly from that of those formed to the side of this uplift (Fig. 1 and Table 1). Folded structures over the Gavbandi High are typically short wavelength folds whereas on the eastern side of the paleohigh the folds have a much larger wavelength and display a whale back geometry. Table 1 shows the wavelength, amplitude,

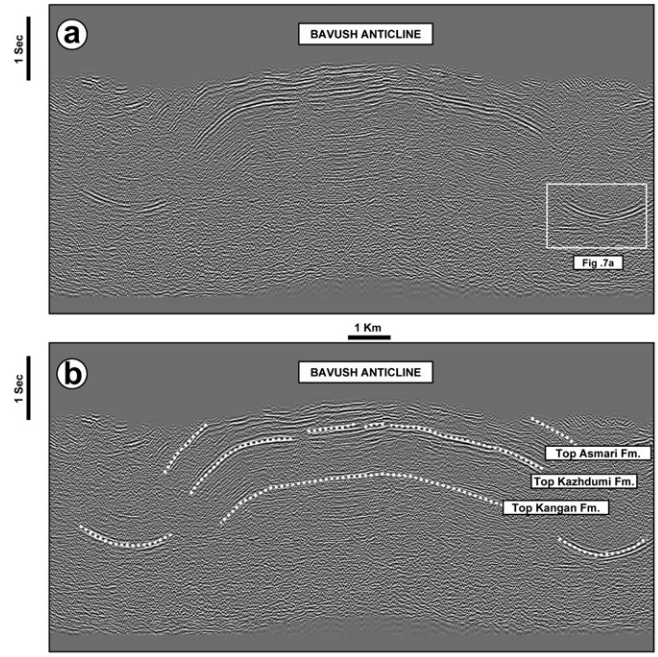

Fig. 4. a) Time seismic profile and b) interpretation of (a), showing box form geometry of the Bavush anticline. The interpreted horizons are the Oligo-Miocene Asmari Formation, the Albian Kazhdumi Formation and the Middle Triassic Kangan Formation (for location of the seismic line see Fig. 3, Seismic line courtesy of the National Iranian Oil Company).

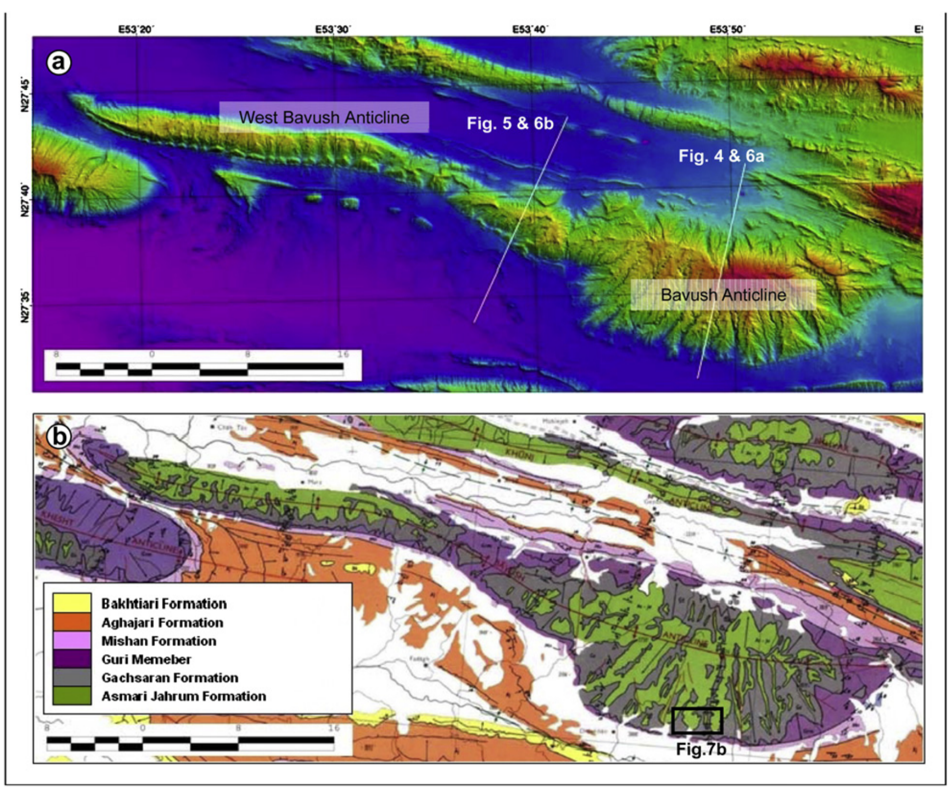

Fig. 3. a) Digital elevation model and b) geological map of the broad Bavush anticline and its western continuation over the Gavbandi High showing evident difference in geometry and wavelength. For location see Fig. 1b.

and wavelength-amplitude ratio of the folds in the study area measured from the geological cross sections through the top of the Oligo-Miocene Asmari limestone.

One of the best examples of the variation in structural style across the Gavbandi High is the Bavush anticline and its western continuation over the Gavbandi High (Fig. 3). The Bavush anticline is a wide gentle fold and its wavelength is controlled by the Oligo-Miocene Asmari limestone, the resistant unit that controlled the characteristic morphology of the folds in the region. Toward the west it narrows abruptly as it passes onto the Gavbandi High to form a tight fold and continues westward as a narrow fold as can be clearly seen on the geological map (Fig. 3).

The 2D seismic lines of the Bavush anticline and its western continuation over the Gavbandi High confirm this significant variation of geometry along the structure (Figs. 4 and 5). The Bavush anticline is a symmetric box form anticline limited by tight synclines (Fig. 4) whereas the west Bavush anticline has an asymmetric anticlinorium style. The tight geometry of the anticline at the surface represents the central culmination of this complex formed by detachment folding on an intermediate decollement level, the Dashtak Formation (Fig. 6b). Thrusts appear to have formed on both limbs of this fold. Furthermore, the presence of an active intermediate decollement level can be deduced from the divergence between the Albian and Lower Triassic seismic reflectors (see solid arrows in Fig. 5b) which is interpreted to be the result of thickening of the Dashtak Formation in the core of the fold. This weak, intermediate decollement horizon allows the decoupling of the deformation above it from the deformation below allowing the folding above it to become highly localized compared to the broad fold structure beneath the Dashtak horizon. The faulting in the fold limbs is thought to be secondary and linked to strain accommodation during the late stages of fold development. The geological cross sections constructed on the basis of the seismic profiles (Fig. 6) indicates that the Bavush anticline (Fig. 6a) is a uniform box fold in which all the sedimentary units above a basal decollement level are folded without any internal complexity. Only minor complexity occurs probably linked to the development of fold accommodation faults such as out-of-synclines faults or wedge-limb faults (Mitra, 2002) which possibly formed to facilitate the progressive shortening (Fig. 7). The geometry of the West Bavush anticline is influenced by slip on the Triassic evaporites (Dashtak Formation) which acted as a local intermediate decollement horizon during the fold development.

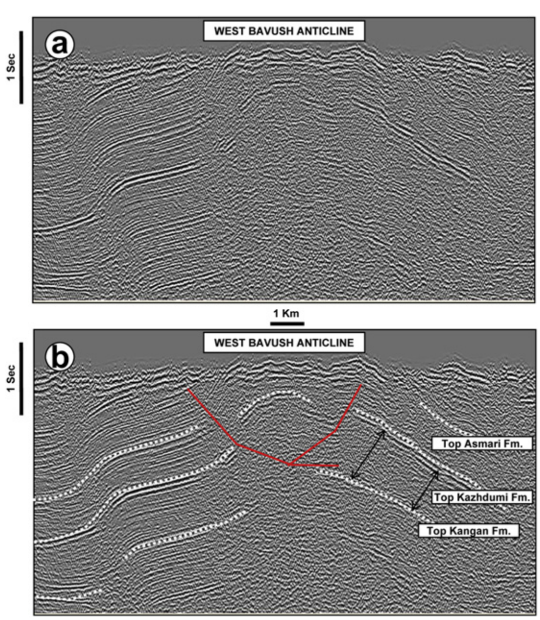

Fig. 5. a) Time seismic profile and b) interpretation of (a) showing the tight geometry of the West Bavush anticline. The interpreted horizons are the Oligo-Miocene Asmari Formation, the Albian Kazhdumi Formation and the Middle Triassic Kangan Formation, (for location of the seismic line see Fig. 3, Seismic line courtesy of the National Iranian Oil Company).

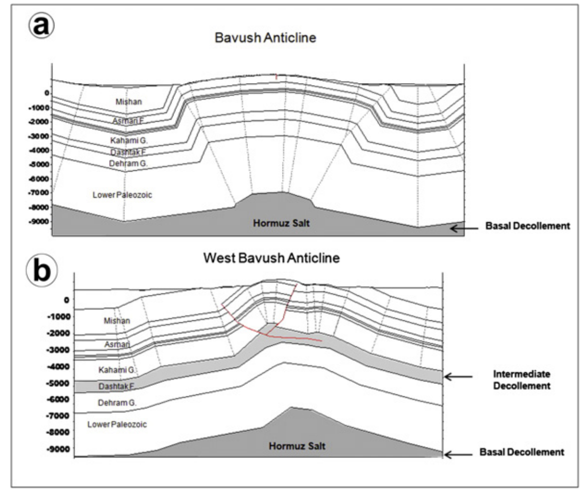

Fig. 6. Geological cross sections constructed on the basis of the 2D seismic profiles over the a) the Bavush and b) West Bavush anticlines. The cross sections clearly show the different folding style. Note the change in geometry of the anticline in b) above the Triassic Dashtak Formation while both sections show an approximate equal wavelength at depth.

Similar lateral geometry variations from an open to a tight fold are very common across the central Fars area (Fig. 8).

The Gavbast and Beyram anticlines form another well defined example which clearly show the lateral variation in fold geometry across the strike of the Gavbandi High (Fig. 9). The Gavbast anticline is a huge whale back structure with a high central circular dome. This is probably related to a buried salt dome. A study of the Oligo-Miocene carbonates shows that the fold plunges toward the west. The Beyram anticline is a short wavelength anticline which can be traced as the western continuation of the Gavbast anticline toward the Gavbandi High (Fig. 9a). Fig. 9b shows the geological profiles through the top of the Oligo-Miocene Asmari Formation, based on the constructed geological cross sections. The large wavelength of the Gavbast anticline is only compatible with a deep level of decollement whereas the short wavelength of the Beyram anticline implies the probable activation of a secondary shallow decollement during the folding.

The geological cross section through the Beyram anticline (Fig. 10) suggests that the asymmetric tight geometry of the Beyram anticline has been formed above a decollement horizon represented by the Triassic evaporites and marls of the Dashtak Formation.

Other geometrical features caused by the influence of an active intermediate decollement layer over the Gavbandi High can be distinguished in field as well as seismic profiles (Fig. 11).

Fig. 11 shows a seismic profile passing through the Varavi anticline (see Fig. 1b). The seismic profile indicates that a shearing along the intermediate decollement horizon has resulted in development of convergent drag folds associated with small thrusts "rabbit ear" structure (Letouzey et al., 1995) on the southern flank of the major anticline.

4. Stratigraphic thickness variation

Despite the lack of supporting data, the absence of salt structures over the Gavbandi High, whether emergent or buried (see Fig. 1) is attributed to the role of the Pan-African relief in controlling

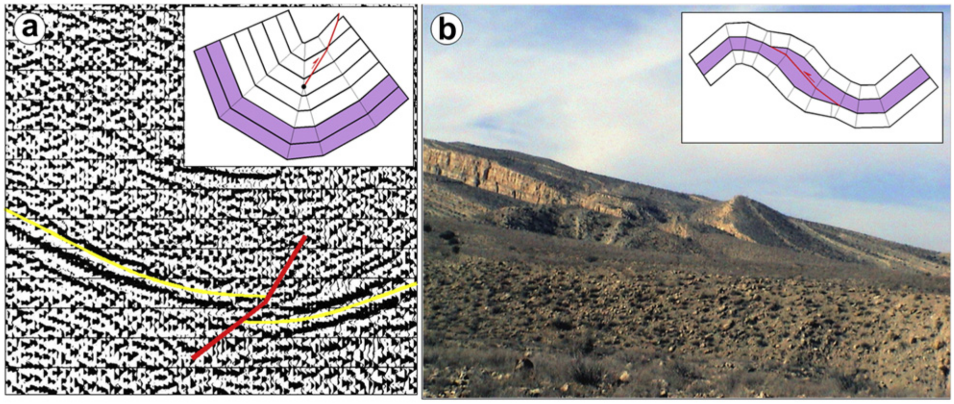

Fig. 7. Examples of fold accommodation faults in the Bavush anticline. a) Part of seismic profile showing the development of an out-of-syncline fault, for location see Fig. 4a. b) Field photo showing development of limb wedge thrust in limestones of the Oligo-Miocene Asmari Formation on the southern flank of the Bavush anticline, insets from Mitra (2002). For location see Fig. 3b.

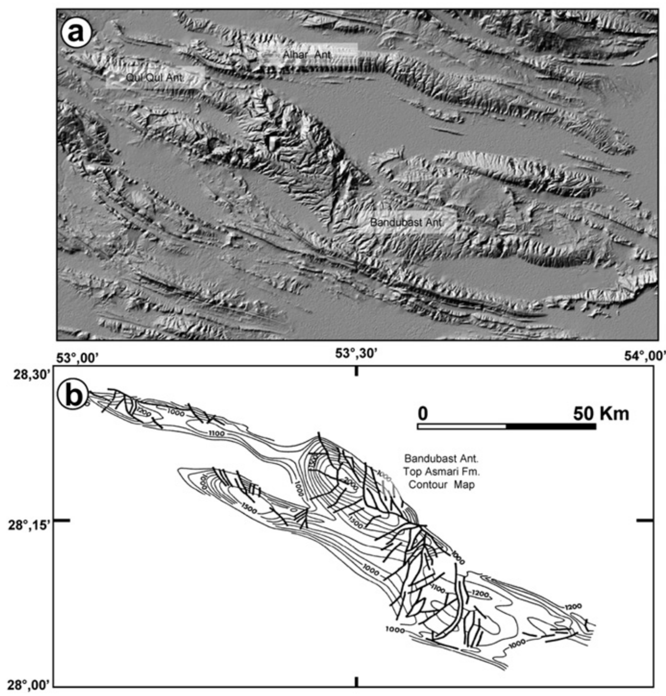

Fig. 8. a) Digital Elevation Model and b) contour map on the top of the Oligo-Miocene Asmari limestone in the Bandubast anticline showing a large wavelength anticline narrowing to a tight fold over the Gavbandi High toward west. For location see Fig. 1b.

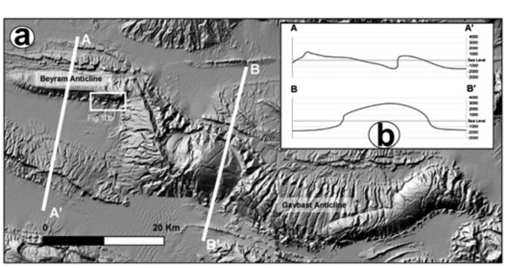

Fig. 9. a) Digital elevation model of the Gavbast and Beyram anticlines showing the significant variation in the surface wavelengths of the folded structures that occur in the central Fars area. b) The constructed cross section over the Gavbast and Beyram anticlines based on the top of the Oligo-Miocene Asmari Formation. The line of the cross sections is shown on (a). For location see Fig. 1b.

the distribution of the Hormuz salt during the Early Cambrian (Bahroudi and Talbot, 2003; Callot et al., 2007). For the first time this paper uses seismic data to demonstrate the variation in thickness of the Early Paleozoic strata in the central Fars area.

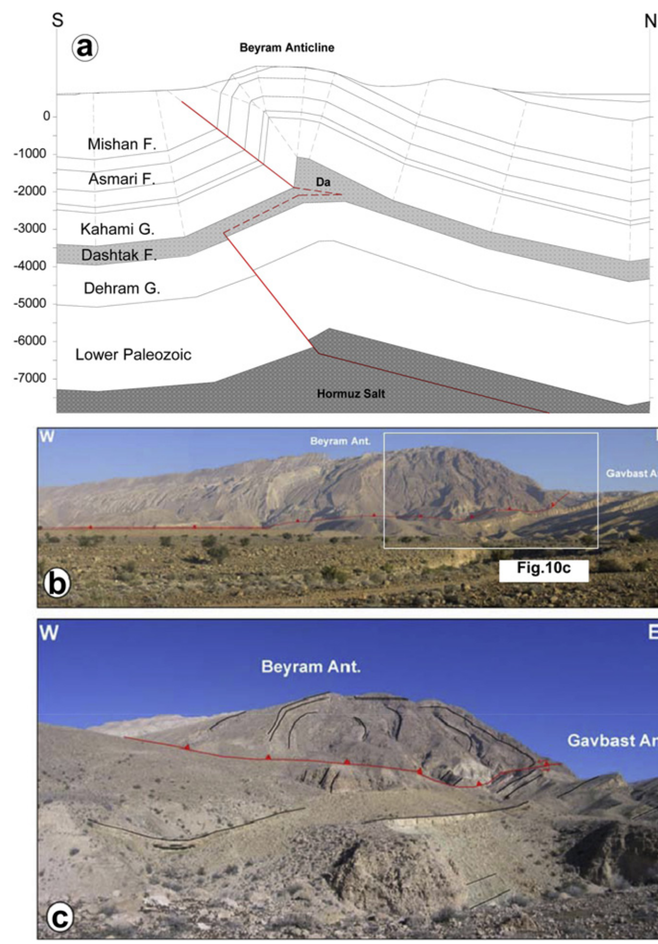

Fig. 10. a) Geological cross section through the Beyram anticline (see Fig. 9) showing possible involvement of an intermediate decollement horizon (Da: Dashtak Formation) in the development of "multi decollement folding" over the Gavbandi High. It is associated with forelimb steepening above this secondary decollement horizon. b) Field photo showing the southern flank of the Beyram anticline and c) close view of the southeastern pericline of the Beyram anticline showing the eastward dragging of the Oligo-Miocene limestone (Asmari Formation) over the Gavbast anticline which might be related to the interpreted thrust fault in Fig. 10 a.

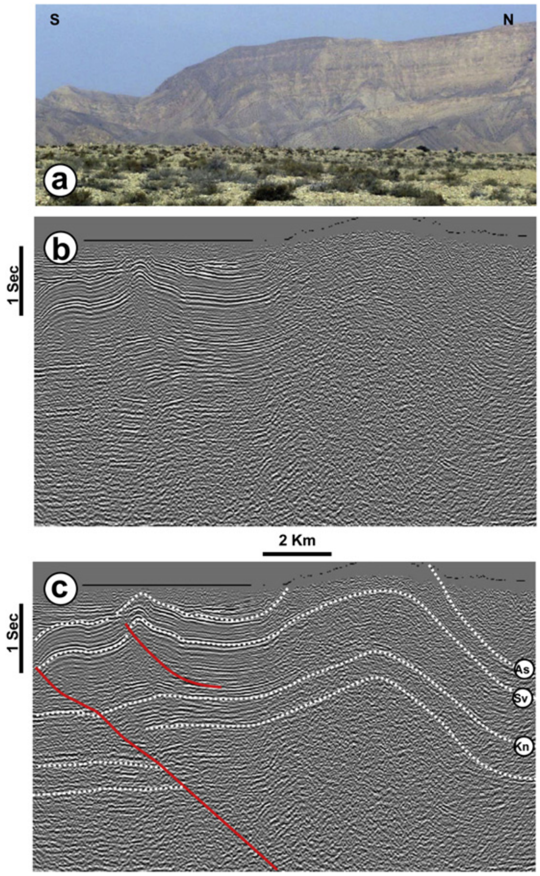

Fig. 11. a) Field photo showing the development of the auxiliary folds on the southern flank of the Varavi anticline see Fig. 1b for location. b) Time migrated seismic profile and c) interpretation of (b) showing of development a rabbit ear structure on the southern flank of the major anticline due to influence of an active shallow decollement horizon. As: Oligo-Miocene Asmari Formation, Sv: Upper Cretaceous Sarvak Formation, Kn: Middle Triassic Kangan Formation. (For location see Fig. 1b, Seismic line courtesy of the National Iranian Oil Company).

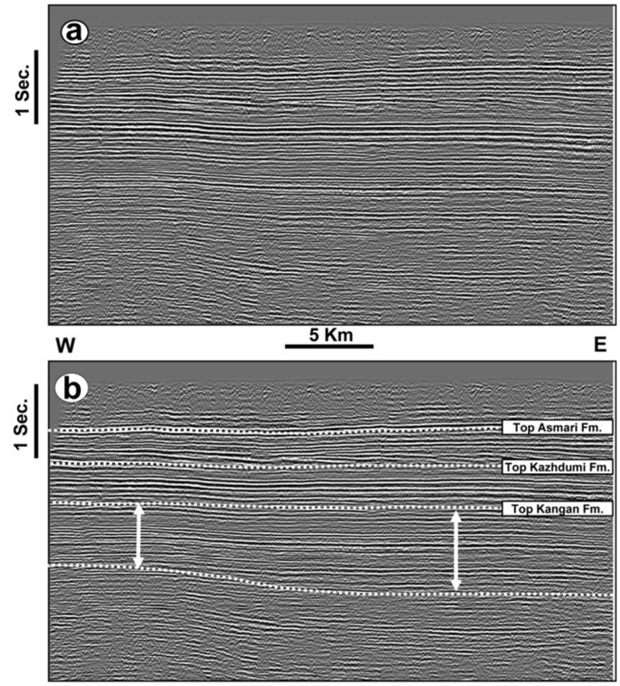

Fig. 12. a) Time migrated seismic profile and b) interpretation of (a) crossing the eastern boundary of the Gavbadi High indicating evident thinning of the Lower Paleozoic succession over this Pan African high. The interpreted horizons are the Oligo-Miocene Asmari Formation, the Albian Kazhdumi and the Middle Triassic Kangan Formations. The lowermost interpreted reflector indicated a tentative horizon in the Paleozoic. (For location see Fig. 1b, Seismic line courtesy of the National Iranian Oil Company).

Fig. 12 shows a 2D seismic section which crosses the eastern limit of the Gavbandi High. It shows that beds above the Triassic maintain a nearly constant thickness whereas in those below the sedimentary successions thicken considerably toward the east. Although in the absence of a deep penetrating well it is impossible either to pick the reflectors in the Lower Paleozoic sequence or the top of the Hormuz salt, the Lower Paleozoic sequences show a significant thinning toward the Gavbandi High.

A similar pattern can be seen in offshore Persian Gulf seismic lines (e.g. Fig. 13) which shows thinning of the sedimentary succession toward the Gavbandi High, so that the total sediment thickness on the eastern side of the Gavbandi High is approximately 40–50% thicker than on the summit of this basement high.

The results of the magnetic survey of the central Fars (Fig. 14) images a number of north-south trending linear magnetic anomalies which are spatially co-incident with the line of the thickness changes in Figs. 12 and 13. This indicates the importance of structural inheritance and pre-existing basement fabrics on the distribution, orientation and geometry of the sedimentary basin and sediment accommodation and accumulation during the Early Paleozoic.

5. Discussion

The stratigraphic thickness variation of the sedimentary cover is a critical factor in determining the structural style in the central Fars area. The greater thickness of the sedimentary succession in the eastern side of the Gavbandi High explains the larger crustal width of the folded structures in this region. Fig. 15 shows a geological scenario constructed on the basis of the seismic profiles in Figs. 12 and 13. The inherited Pan African Gavbandi High

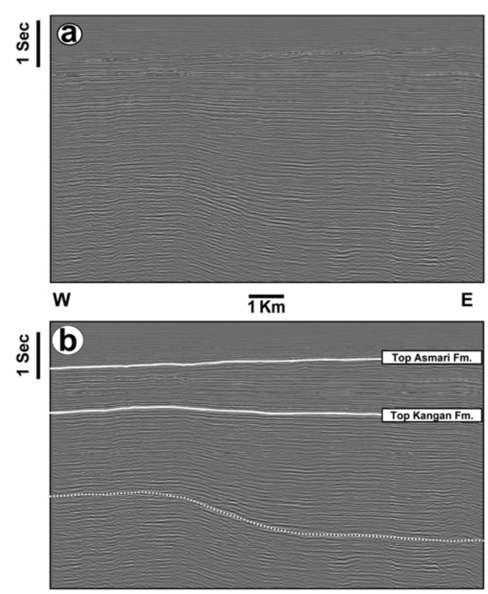

Fig. 13. a) Time migrated seismic profile and b) Interpretation of offshore time migrated seismic profile crossing the eastern boundary of the Gavbandi High. The interpreted horizons are Oligo-Miocene Asmari Formation and middle Triassic Kangan Formation. The lowermost interpreted reflector indicated a tentative horizon in Paleozoic. (For location of the seismic line see Fig. 1b, Seismic line courtesy of the National Iranian Oil Company).

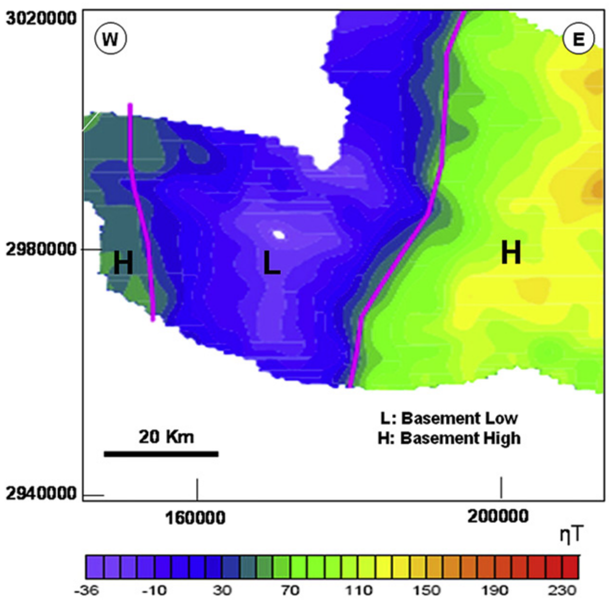

Fig. 14. Total magnetic intensity map showing a negative magnetic anomaly due to a basement low east of the Gavbandi High. See Fig. 1 for location (Magnetic map courtesy of the National Iranian Oil Company).

marked a significant basement step during the Early Paleozoic controlling the depositional thickness of Cambrian Hormuz salt as well as the Early Paleozoic succession. The thin Hormuz salt over the Gavbandi High also explains the lack of the breached or buried salt domes in this area. Although in other parts of the Zagros Fold and thrust belt the known N–S trending basement structures experienced significant Cretaceous activity and were also rejuvenated during the Zagros orogeny (Abdollahie Fard et al., 2006), the variation of sedimentary thickness linked to the reactivation of the Gavbandi High indicate that very little activity has occurred on this structure since the Late Paleozoic (Fig. 15).

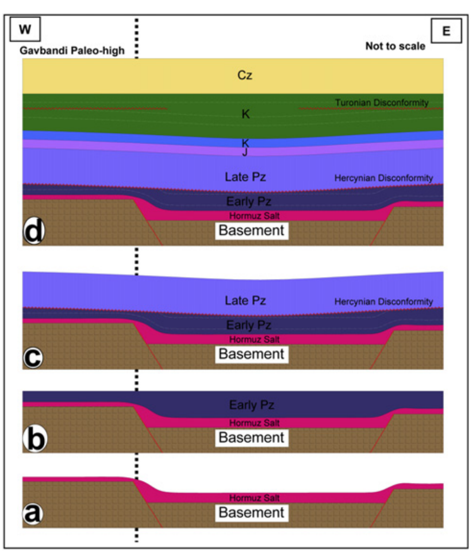

Fig. 15. Schematic scenario for the geological evolution of the eastern Gavbandi area. a) and b) the Gavbandi basement high was a prominent high during the deposition of the Hormuz salt and the Early Cambrian succession and controlled the depositional thickness during this time interval. c) and d) show the Late Paleozoic to Tertiary stratigraphy. During this time almost the same thickness of the sedimentary sequence was deposited across the whole area. Pz: Paleozoic, Tr: Triassic, J: Jurassic, Cz: Cenozoic.

This proposed model of varying basement geometry and Lower Paleozoic sedimentary thickness is presented as evidence which can be used to explain the variation in wavelength of the folds. The thickness variation in the Hormuz salt related to the underlying basement geometry probably controlled the observed differences of folding style in the central Fars area. On the eastern side of the Gavbandi High, the greater thickness of the Hormuz series increased its efficiency as the basal decollement during the folding. Almost all of the shortening was accommodated by the evacuation of this mobile unit from the synclinal areas to the cores of the adjacent anticlines. As a result, all of the other possible decollement layers in the sedimentary sequence remain inactive and the whole succession of the sedimentary layers deformed as a buckled fold with minor thrusting either in the back limb or forelimb of the folds.

In contrast, over the Gavbandi High, where the basal decollement layer was very thin or absent, welding of the sedimentary pile and the basement in the synclinal areas occurred much earlier during the fold evolution compared to the evolution of the folding that occurred to the east of the high. In this situation, the secondary (higher) decollement levels in the sedimentary cover (e.g. the Dashtak, Gachsaran and Mishan Formations, see Fig. 2) were activated. Decoupling of the sedimentary pile above the Triassic evaporites and shales gave rise to formation of the short wavelength anticlines above this shallow depth decollement layer. The activation of this intra-level decollement also accounts for the greater complexity of the fold geometry above the Gavbandi High compared to the folded structure adjacent to it (see following section).

Barzegar (1989) using satellite images interpreted the changes in the geometry and style of deformation across the Gavbandi High as produced by a deep strike slip fault with an N–S trend, 230 km of length and named the Razak Fault (Fig. 16). This fault has been addressed by other authors (Hessami et al., 2001a; Bahroudi and Talbot, 2003) and the distortion of the fold axes in the central Fars area is attributed to the left lateral movement along this fault.

Our study in this paper indicates that the Razak fault is a passive fault formed only as a result of variation in the folding style caused by changes in thickness of the folded strata as it moves onto the

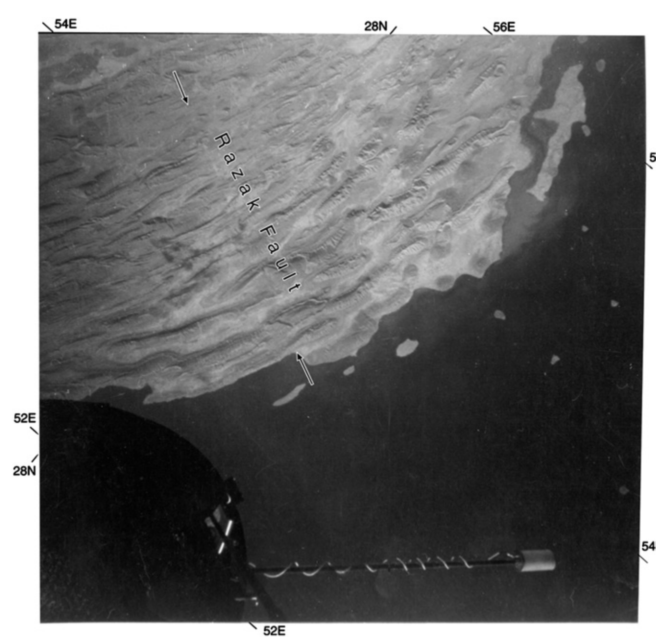

Fig. 16. Gemini satellite image of the Razak Fault. (After Hessami et al., 2001a.)

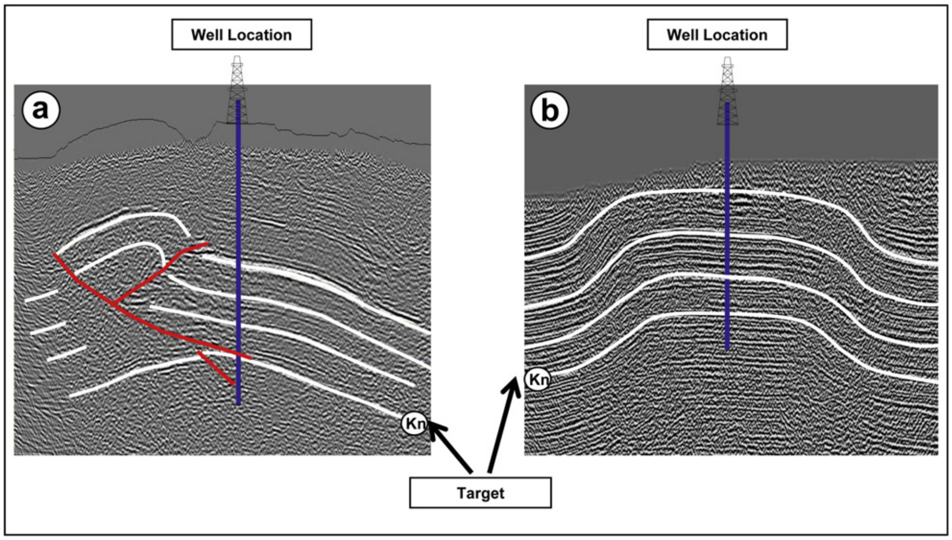

Fig. 17. Interpreted time migrated seismic profile through a) a structure over the Gavbandi High with complicated geometry above the intermediate shallow decollement. The top of the Triassic Kangan Formation (Kn) marks the top of the main exploration target. b) A fold structure to the east of the Gavbandi High with parallel geometry. Since the intermediate decollement horizons remained inactive, the geometry of the structure remained constant with depth. (For location see Fig. 1b, Seismic line courtesy of the National Iranian Oil Company).

basement high across this lineament. According to the seismic profiles the main activity along this basement lineament was during the Early Paleozoic.

6. Implications for hydrocarbon exploration

More than 1500 trillion cubic feet of gas reserves have been discovered in the Permo-Triassic carbonates sealed by thick Triassic anhydrites in the Zagros Fold belt (SW Iran), the southern part of the Persian Gulf and Saudi Arabia. Silurian organic-rich shales are regarded as the main source rock (Bordenave, 2008). The Gavbandi High is associated with most of the onshore super-giant/giant gas reservoirs in the Permo-Triassic succession (the Dehram Group). In recent years, the results of exploration activities in the Permo-Triassic Dehram group indicate that the success rate over the Gavbadi High is greater than in the area to the east of the paleo-high (Fig. 1).

Bordenave (2002) showed that the Silurian shales in the Zagros were expelled in the Late Cretaceous time i.e. before the Zagros folds had been formed and when the Gavbandi High had an essential role in gas entrapment. The magnetic survey shown in Fig. 14 indicates the presence of other minor basement highs to the east of the Gavbandi High and recent exploration wells discovered commercial gas in the Safid and Kish structures (Fig. 1) i.e. in an area that has been abandoned for more than 35 years. It is concluded that recognizing and studying paleo-highs is important in order to maintain a successful exploration in the Fars region in general and along the eastern flank of the Gavbadi high in particular.

The activation of the Triassic evaporites (the Dashtak Formation) as an intermediate decollement horizon, affected the style of the folding over the Gavbadi High, which resulted in the complexity in geometry and variations in the superficial and subsurface folding style of the anticline traps. From an exploration perspective, knowledge of thickness variations in the strata below a reservoir unit is important for estimating the potential size of structural targets. Fig. 17a shows seismic profiles of a structural prospect over the Gavbandi High, which indicates a shift in the crestal position in the surface anticline and reservoir target. As a result, in order to drill the reservoir target in an appropriate position, the proposed location well is selected on the flank of the surface anticline, which increases the drilled thickness of the formations. In contrast, the anticline structure in Fig. 17b is situated about 70 km from anticline 17a, to the east of the Gavbandi High. It shows concentric folds with nearly constant bed thicknesses. Therefore improvement in seismic imaging is essential in order to identify future exploration targets and production activities over the Gavbandi High.

7. Conclusion

The observed variation in structural style in the central Fars area is found to be related to variations in the thickness and distributions of the major tectono-stratigraphic units. As a result of these variations, the same unit responds differently in different places to the same compression event.

Over the Gavbandi paleo-high, the Triassic evaporites of the Dashtak Formation are identified as the main intermediate decollement horizon and in this region was generally activated during the Neogene folding. It is suggested that the activity of this detachment horizon reflects the relatively thin Hormuz salt which forms the basal detachment to much of the folding. The thinning of the Hormuz salt over the paleo-high decreases its efficiency as the basal decollement. As a result multi-decollement folding developed in this part of the region which is marked by short wavelength anticlines at surface accompanied by complex geometry at depth. To the east of the Gavbadi paleo-high the thickness of the Hormuz series is much greater. It acted more efficiently as a basal decollement which decoupled the sedimentary cover from the crystalline basement during the Neogene Zagros orogeny. Progressive shortening during fold development was accommodated by migration of salt from the synclinal areas into the core of the adjacent large wavelength anticlines which have parallel geometry.

Although the measured wavelengths of the folds at the level of the Oligo-Miocene Asmari Formation varies significantly across the central Fars area (see Table 1), below the weak layer of Triassic evaporites, they lie within a systematic range from 15 to 19 km, i.e. the fold wavelength in the lower competent unit is fairly constant. Using restoration of the balanced cross sections which are mainly based on 2D seismic profiles, we obtained approximately the same amount of shortening (8.5%) for all the anticlines which lie across the eastern margin of the Gavbandi High.

On the basis of this study, it is concluded that the Razak fault is a passive fault formed only as a result of variation in the folding style caused by changes in thickness of the folded strata as it moves onto the basement high across this lineament. The main activity along this basement lineament was during the Early Paleozoic.

A recently explored gas field over the minor basement high east of the Gavbandi paleo-high supports the conclusions of this paper namely that an understanding of basement geometry is likely to be a key factor for future exploration activities along the eastern side of the Gavbandi High.

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