Folding Pattern in the Fars province, Zagros folded belt: Case Study on the Karbasi and Khaftar Anticlines, Interior Fars, Iran

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10 Abstract

Iran)

(Introduction:) The study area is located in the Zagros Simply Folded Belt of Iran and in the Fars province. The Karbasi and Khaftar anticlines are case study anticlines in the interior Fars sub-basin (Fassa area). The anticlines in the Fars region, which are located in the Zagros fold-thrust belt, are valuable because they possess several hydrocarbons. The geometry of anticlines in the Zagros fold- thrust belt are affected by the type of deformation and mechanical behavior of stratigraphic units specially detachment units.

17 (Aim:) The main aim of this paper is to determine of folding pattern anticlines in the Fars

18 province and define structural features affected on them, specially focused on the Karbasi

19 and Khaftar anticlines which they have been deformed by Nazamabad fault, too.

(Material and method:) Description of fold geometry is important because it allows comparisons within and between folds and allows us to recognize patterns in the occurrence and distribution of fold systems. This paper presents a part of the results of a regional study of Fars province in the Zagros Simply folded belt, based on satellite images, geological maps, and well data. In this research, we used Tectonics FP and Global Mapper Software for prepared some data in our study. In addition, we used the common classification of folds for our research.

(Results:) in the study area, the fold style elements of the anticlines have been suffered main changes. This change has shown especially in the Khaftar anticline by change of dip of axial planes in all parts and change of other fold style elements. These main changes have been confirmed the sinistral strike slip movement of the Nezamabad fault in the middle part. Also in another case study anticline, this fault has been affected specially in the western part of this anticline. On the other hand, the secondary fault that related to the Nezamabad fault has been affected on the folding style of the Karbasi anticline in E-E' and F-F' studied sections. 34 (Conclusion:) In the Interior Fars area, it seems that folding pattern is controlled by 35 structural elements such as the Nezamabad basement fault and Dashtak formation as 36 detachment unit. Except effect of detachment unit on the folding pattern in the study area, 37 the main fault as the Nezamabad fault has affected on the folding pattern specially on the 38 Karbasi and Khaftar anticlines.

39 Keywords: Karbasi anticline, Nezamabad fault, Folding style, Zagros, Iran

40 1. Introduction

41 The Zagros fold –thrust belt in Iran lies on the northeastern margin of the Arabian plate. This fold thrust belt with northwestern - southeastern strike extends from Tarus mountain 42 43 in the northeast of Turkey and Kurdistan in north of Iraq up to Strait of Hormuz in southwest of Iran (Fig.1). More than 65 percent (~107.5 billion cubic meters) of the remaining prove 44 oil resources (~159.6 billion cubic meters) and nearly 34 percent (~ 49.5 trillion cubic 45 meters) of the total gas resources (~146.4 trillion cubic meters) of the world are accumulated 46 in numerous giant and super giant hydrocarbon fields of the Middle East. Clearly, the 47 accumulation of hydrocarbons in the Middle East has been intricately related to the 48 49 stratigraphy and structural evolution of the Zagros fold-thrust belt (Alavi, 2007). As one of 50 the valuable oil-rich provinces, this belt provides approximately 2/3 of oil-resources and 1/3 51 of gas-resources of the world.

The anticlines in the Fars region, which are situated in the Zagros fold-thrust belt, are valuable because of possessing numerous hydrocarbons and this area is easily recognized by the NW-SE trending parallel anticlines that verge to the SW in a 6-12 km cover sequence (Colman-Sadd, 1978; Dehbozorgi, et al., 2010). According to the geological classification, this understudy area is located in the Interior Fars region (Fig.1).

So far, a large number of studies have been done in the study area based on stratigraphy and geophysical exploration, but no studies have been conducted based on folding geometry and folding style in order to indicate structural oil traps with emphasis on basement complexities and basement faults activity. On the other hand, a few studies should be done on understudy area based on kinematics pattern of folding in this fold –thrust belt.

Fold geometric form and mechanical stratigraphy evolution are affected by thickness, detachment unit's ductility, and stratigraphy sequence of formations. Moreover, fold geometric form and mechanical stratigraphy evolution depend on the above-mentioned cases (Ehsani and Arian, 2015; Arian and Aram, 2014; Qorashi and Arian, 2011; Alavi, 1994). Numerous studies have been conducted according to variation of structural style and effects of detachment folding on folding pattern (Sherkati& Letouzey, 2004; Sherkati et al.,
2005). These investigations mentioned above confirm the effects of mechanical stratigraphy
on folding geometry in Zagros but did not study the relationship of folding patterns with
middle detachment horizons in the Paleozoic horizons based on the relationship of
kinematics with main folds.

Other researchers such as O'Brien (1957) mentioned the effects of detachment layers on folding process for the first time. On the other hand, in the recent years, geologists have presented different types of geometric and mechanical models and the obtained results of these studies have increased researchers' information. Other researchers such as Jamison (1989) and Mitra (2002 & 2003) have presented papers which have brought about an increase in geologists' information about cases mentioned above.

Geometry of anticlines in Zagros is affected by type of deformation and mechanical behavior of stratigraphic units. Detachment units such as Dashtak formation in Zagros are important in controlling folding pattern especially in Fars region. Dashtak formation with Triassic age belongs to Kazeron group and this formation have evaporates units such as shale and dolomite. On the other hand, other detachment formations in this area are Kazdomi and Gachsaran formation.

Based on Maleki et al., (2014) the Khaftar anticline is an asymmetric structure and activity 84 of the Nezamabad sinistral strike slip fault has caused main changes to the fold style 85 86 characteristics in the study area. One of the case study anticlines in Fars region is Karbasi anticline. These anticlines have asymmetric structures and their stratigraphic units are 87 88 affected by many faults in this region. Some of these faults may affect the Dehram horizon in this region. As the result of the effects of these faults that exist in stratigraphic units, faults 89 activity may affect gas reservation in this horizon (based on geological map of the Karbasi 90 anticline,2001). Due to increasing complication of structural geometry in Fars region and 91 necessity to explore activities for deeper horizons especially the Paleozoic ones, the analysis 92 93 of fold style elements, which is known as one of the main parts in structural studies, seems necessary. 94

Specific features are important in describing folds and understanding how they develop
(Twiss and Moors, 1992). According to the cases mentioned above, we tried to analyze and
investigate the complications in the study area with fold element style analysis, structural
map, modified structural sections.

Description of fold geometry is important because it allows comparisons within and between
 folds and allows us to recognize patterns in the occurrence and distribution of fold systems.

The Karbasi and Khaftar anticlines are case study anticlines in the interior Fars sub-basin 101 102 (Fassa area). Because of the Khaftar, anticline has displaced by the Nezamabad fault in 103 middle part with 2.5 km displacement and the Karbasi anticline has rotation toward 104 Northwestern affect by mentioned fault, therefore has been chosen. In addition, this choice may be show that main fault has affected on the folding style in the study area. The main 105 aim of this paper is to determine of folding pattern anticlines in the Fars province and define 106 107 structural features affected on them specially focused on the Karbasi and Khaftar anticlines in the study area. 108

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110 2. Material and methods

This paper presents part of the results of a regional study of Fars province in the Zagros 111 Simply folded belt, based on satellite images, thin sections, geological maps, well data and 112 original fieldwork. Our fieldwork in the study area and some data such as geological maps 113 114 (Jahrom and Kushk, 2001) and geological regional data were prepared and provided by the National Iranian Oil Company (NIOC). In the study area, there are no seismic data provided 115 by Oil Companies in this region to analyze and discuss the structural features. All geological 116 reports have been studied and all the elements of fold style have been calculated and 117 118 analyzed. We used fold style elements analysis methods (description of folds) base on Twiss and Moors (1992), Rickard (1971), Ragan (1985) and Ramsay (1967). We used Tectonics 119 120 FP software to prepare and analyze stereoplots of the Karbasi and the Khaftar anticlines. In addition, we used Global Mapper Software to prepare 3D SRTM of the study area and 3D 121 122 Path Profile (along cross sections) based on Global Mapper Software. 3D SRTM has been prepared base on Digital Elevation Model (DEM) and geological map of study area (in scale 123 1:100,000, 1:250,000 and 1:1000,000-published by the National Oil Company and the 124 125 Geological Survey of Iran).

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127 3. Geological and geographical setting

In this paper, the Study area is located in the Zagros Simply Folded Belt of Iran and Fars region
(Fig. 1). The Zagros Fold-thrust belt is home to one of the largest petroleum producing reservoirs
in the world. Based on geological facies, Fars region consists of three sub-basins; Interior Fars,
Coastal Fars and Sub-Coastal Fars (Beydoun et al., 1992) and the study area is located in the
Interior Fars sub-basin. This area is easily recognized by the NW-SE trending parallel anticlines
that verge to the SW in a 6-12 km sedimentary cover sequence (Colman-Sadd, 1978). Most of

the anticlines have followed this trend in the Zagros folded belt. However, some of the
anticlines have affected from structural features. Therefore may be effects of these structural
features such as main faults, salt plug and shear zone has caused changes on the folding
style on specific anticlines. In the study area, may be fold style of the case study anticlines
have been affected by main fault in the study area.

In the Zagros fold-trust belt, the oldest stratigraphic unit with 2000-1000 meters thickness
related to Hormuz Series (Ala, 1974) and is exposed in the form of salt domes in Fars region.
Structures in this area have complications and the oldest stratigraphy unit that outcropped in the
Khaftar anticline on the surface belongs to Hormuz Series (salt plug). The age of Hormuz Series
is Pre- Cambrian- Cambrian (Fig. 2).

Anticlines which outcrop stratigraphic units in most structures in Fars region often include Upper Cretaceous stratigraphic units (Campanian to the present) and in the sub-coastal Fars region, includes the Lower Cretaceous stratigraphic units (Neocomian to the present). The youngest formations that outcrop in the study area are Aghajari and Bakhtiari and Razak formations. Also, in the study area, the oldest outcrop is Hormuz Series which are observed in the Khaftar, Kuh-e Qazi and Surmeh anticlines (e.g. Beydoun et al., 1992, Dehbashi Ghanavati, 2008).

151 The Khaftar and Karbasi anticlines are located in the Interior Fars region (Fasa area). Trend of 152 the Khaftar anticline has three orientations consisting North- Northeast, East- West and South-153 Southwest. This anticline is bounded from north by Kuh-e Qazi anticline, from north- northeast by Qutbabad anticline, from south- southeast by the Karbasi anticline and from southwest by 154 155 Sim anticlines (Fig. 1). The trend of the Karbasi anticline is N60°W. This anticline is bounded from south by the Chaghal, from southwest by the Noura, from north- northeast by the 156 157 Khaftar and from north- northeast by the Jahrom anticlines (Fig.1). The Karbasi anticline is 158 an elongated structure with 40 km length and 7.5 km width in the Asmari horizon. The Khaftar anticline is an asymmetric structure with 45 km length and 12.5 km width in the 159 Asmarihorizon on the surface (Fig. 3). 160

161 The Mund River flows towards a northern- southern path in this area and in the western part 162 of anticline; this river has changes in its flow path. By running towards the western part of 163 anticline, finally Mund River continues its path to south.

164 4. Structural setting

The Karbasi and Khaftar anticlines are an asymmetric structure (Fig.1). This anticline is located in Interior Fars province. This structure is an elongated structure. Eastern part of anticline ends to the city of Jahrom and in the western part ends to mountains. The oldest formation that outcropped on the surface of this anticline is Gurpi formation which exists in the Gurbid strait. In this anticline, some parts eroded on the surface and then caused the oldest formation such as Pabdeh- Gurpi to outcrop on the surface. In the southern flank of

the location which Asmari formation covered surface, some cliffs exist with vertical walls.

172 The highest part of The Karbasi anticline has an elevation of 2013-meters.

A large part of the surface of anticline is generally covered with Asmari- Jahrom formation. This anticline is an asymmetrical anticline in which the dip of southern flank is greater than that of the northern flank (Fig. 4). On the other hand, the plunge values in western part of anticline more than eastern part. Based on Setchell et al., 2007, Khaftar anticline is a detachment fold and in the middle part of southern flank of this anticline, salt diaper has cropped out.

The Structure of the Karbasi anticline has been complicated due to some faults with high lateral displacement. The activity of these faults could be divided into different parts. By activity of faults, western part of anticline has plunged to north. This anticline in the western part has a complicated structure but in the eastern part, the structure has a subtle change.

Because of Karbasi and Khaftar anticlines, have complicated structures, the analysis of element fold style is necessary. Then, for further studies in this structure, changes of fold style elements will be analyzed and investigated from east to west of anticline in the different structural cross sections.

187 5. Faulting in the study area

Fault system in the study area comprises two type of faults. One type is longitude fault and the other type is transverse fault. The longitude faults are located in the hinge line zone of anticlines in the study area. On the other hand, some longitude faults are located parallel with fold axis. Transverse faults are situated in a high angle to fold axis.

192 The Nezamabad fault is one of the strike slip faults with northeast- southwest trend in the Gavbandi High which has separated Gavbandi High from central Zagros (Setudehnia, 193 1978). This fault has 265 km length and sinistral displacement. Regarding the fact that, the 194 195 first time Barzegar (1992) introduced Nezamabad fault, he introduced this fault based on 196 satellite images. This fault has 2.5 km strike slip displacement and begins from the southern 197 flank of Shahini anticline to southeast of Neyriz. The major parts of displacement of the Nezamabad fault can be easily observed in the satellite image of the Khaftar anticline. This 198 fault has caused change and rotation of anticlines plunge (Dehbashi, 2008). The Nezamabad 199 200 sinistral strike slip fault is the main fault in this area which affected the western plunge of the Karbasi anticline. In addition, based on Maleki et al., (2014) activity of this fault has
caused main changes to the fold style characteristics of the Khaftar anticline.

203 According to fold style elements analysis results, it became clear that in the eastern part of 204 anticline the type of fold is horizontal and moderately inclined and in the western part it is upright moderately plunging, so west evaluation of anticline is affected by more 205 deformations. It seems that, the Nezamabad fault may be located between G-G' and F-F' 206 207 structural sections, moreover a second order fault introduced in relationship with the Nezamabad fault. In different parts of the Karbasi anticline, Dashtak formation, as a middle 208 209 detachment unit, plays an important role regarding folding geometry, which may be affected by the Nezamabad main fault and the second order fault. According to Maleki et al., (2014) 210 folding analysis of the Khaftar anticline, reveals that folding pattern in the study area may 211

- 212 be affected by Nezamabad.
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214 6. The Description of Folds in the study anticlines

Descriptions of fold geometries are important because they allow comparisons within and between folds and allow us to recognize patterns in the occurrence and distribution of fold systems. For example, orogenic belts contain characteristic fold systems: along their flanks are large fold and thrust belts, with little metamorphism, but underlain by décollements; and in core zones where intense folding has been accomplished, accompanied by high-grade metamorphism under high temperature and pressure.

Top formations tested in the analysis of folds are top formations of Kazeron group, i.e.
Neyriz-Dashtak formation, and also those of Bangestan group. According to given results,
limbs in The Karbasi anticline are of unequal length.

Twiss and Moors (1992) described the geometry of folded surface by specifying three style 224 225 elements: aspect ratio, tightness and bluntness. Based on these cases we will analyze the geometry of fold style of the Karbasi anticline. As some parts of anticline are affected by 226 faults and fault effects were observed on surface, we were not able to measure and calculate 227 228 some parameters in these parts. There are three chief descriptors of a folded surface: aspect 229 ratio: the ratio of the fold amplitude to the distance between two adjacent inflection points, 230 tightness: or the interlimb angle, bluntness: a measure of the curvature of the surface in the zone of closure. In this part, we mentioned methods of calculation and measurement of this 231 parameters in the studied area. Finally, given results are illustrated by comparable diagram 232 233 (Table 1).

235 7. Elements of Fold Style

The style of a fold is the set of characteristics that describe its form. Over years of working with folds, geologists have identified certain features as particularly useful in describing folds and understanding how they develop (Twiss and Moors, 1992).

Since the Karbasi anticline, has complicated structure, the analysis of fold style elements seems necessary. Therefore, for more studies on this structure the changes of fold style elements will be analyzed and investigated from east to west in the different parts of this anticline. As the Nezamabad fault may produce effects on the Karbasi anticline, we have evaluated and calculated elements of fold style in this structure. In this respect, cylindricity and symmetry have been evaluated in the geometry of axial plane and Folding Mechanism.

Folded surface forms a symmetric fold if in profile, the shape on one side of the hinges a 245 mirror image of the shape on the other side, and if adjacent limbs are identifiable in length 246 (Twiss and Moors, 1992) .Based on previous studies in the Karbasi and Khaftar anticlines, 247 these anticlines are asymmetric. The Karbasi anticline is an asymmetric anticline that the 248 dip of its southern flank is greater than the northern flank. Southern flank is changing from 249 15° to 75° and in northern flank dip value is changing from 3° to 57°. In the southern flank, 250 dip of layers is greater than the northern flank on the Asmari formation horizon. The 251 Southern flank layers have dip changes from about 60° to 88° and dip value in the northern 252 flank ranges from about 35° to 50° (Maleki et al., 2014). 253

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255 6.1. Aspect ratio

The aspect ratio P is the ratio of the amplitude A of a fold, measured along the axial surface, to the distance M, measured between the adjacent inflection points that bound the fold (Twiss, 1988). In the Karbasi anticline, aspect ratio (P) or ratio of amplitude is measured to half of fold wavelength in seven parts of structural cross section of this anticline.

According to calculated values of aspect ratio, this parameter varies from -0.847 to -0.322

for top of Bangestan group formations (table 1) and values of aspect ratio varies from -1.08

to -0.156. This variable result is obtained for tested top of folded surface from eastern part

- to western part. Based on aspect ratio, fold type in different parts of the Karbasi anticlinehas been defined in table 2.
- Based on logarithm P and description term of folds in the Karbasi anticline just between three parts of folds (E-E' to G-G') description term of fold is broad and in the other parts is wide for top of tested surface formations of Bangestan group. It seems that these changes

have affected some faults in the mentioned parts of anticline. As most changes observed in
the western part are the same as one domain of deformation (from E-E' to G-G' sections),
operation of the Nezamabad Fault in this area may be the same as fault zone that specific
states especially observed in top of tested surface formations of Bangestan group.

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273 **6.2.Tightness**

274 The tightness of Folding is defined by the Folding angle ($^{\circ}$) or the interlimb angle (I) (Twiss 275 and Moors, 1992). As the degree of folding increases, the folding angle increases and the interlimb angle decreases. Based on interlimb angle calculated in seven parts of fold from 276 277 A-A' to G-G' sections, the minimum of interlimb angle is 62° degree for western part of anticline which is located in the G-G' structural cross section (for top of tested surface 278 formations of Bangestan group). In addition, the maximum of interlimb angle is 136° for 279 Eastern part of anticline which is located in the A-A' structural cross section (for top of 280 tested surface formations of Bangestan group), (Table 2). The minimum of interlimb angle 281 for top of tested surface Nz-Dk is 84° degree for G-G' structural cross section in western 282 part and maximum of interlimb is 152° degree for A-A' structural cross section in eastern 283 284 part. Ramsey (1967) classified folds based on folding angle that is used in this paper and the given results are presented in Table 2. 285

According to the given results, based on folding angle, only in one part of the Karbasi anticline, fold type is close in G-G' structural cross section. In this part, fold type of anticline is rabbit ear fold (in southwest flank of rabbit ear fold). This complication of structure may be affected by operation of the Nezamabad Fault. In this area, it seems that faults affect folding style and complications of structures.

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292 **6.3. Bluntness**

The bluntness b measures the relative curvature of the fold at its closure. It is defined by Twiss (1988). In seven parts of fold from A-A' to G-G' sections b is calculated based on bluntness for tasted surface of Bgp formations (Ilam- Sarvak formations) and Nz- Dk formation this parameter. Given results showed that folds in different parts are angular, subrounded, rounded and blunt and just in E-E' section, fold is angular (Table 2).

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299 8. Geometry of axial plane

300 In the Karbasi anticline, it seems that geometry of axial plane is planner. In figure 5, based 301 on analysis and calculations of some parameters, given locations of axial plane in the seven structural cross sections of anticline are shown. Based on results, it seems that activity of 302 the Nezamabad fault is the same as fault zone. On the other hand, based on figure 6, The 303 Karbasi anticline is a horizontal fold. The given results and output of Tectonics FP software 304 305 for seven parts of Karbasi anticline, presented seven stereoplots that showed the location of axial plane (AP) and cylindericity (AC) for seven parts of the Karbasi anticline (Fig.6) (also 306 307 structural cross sections are shown in Fig.10).

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309 9. Results and discussion

In the eastern and western part of the Karbasi anticline rabbit ear folds are observed (G-G' and A-A' cross sections). In the western part most of changes are observed. In this part of fold there is a specific style which based on folding angle, fold has a close style. Probably the operation of the Nezamabad fault and some other faults in this anticline caused these changes. In the proposed pattern of folding model for the Karbasi anticline, we will represent changes in different parts of the Karbasi anticline.

316 Based on classification of Rickard (1971) in the Karbasi anticline, the type of fold is different (Fig.7 and Table 3). In the eastern part of anticline (A-A' section) the type of fold 317 318 is moderately inclined horizontally and in the western part of anticline (G-G' section) type of fold is moderately inclined moderately plunging. According to these results, it seems that 319 320 the western part deformed greater than the eastern part. Nezamabad fault may have affected this case. Based on classification of Ramsay (1967), in most parts of the Khaftar anticline, 321 axial plane of fold is upright but in D-D' and E-E' sections axial plane is steeply inclined. 322 323 According to Maleki et al (2014), the Khaftar anticline has been cut by sinistral displacement of the Nezamabad fault. 324

Some given results in the Khaftar anticline such as folding style analysis, position of Kuh e Khaftar salt plug in the middle part of Khaftar anticline, changes of fold type and main structural changes (rotation of fold axis and 2.5 km displacement in Khaftar anticline) show main changes in the middle parts of the Khaftar anticline. It seems that, these changes have been formed by activity of the Nezamabad fault and activity of this fault is just the same as a fault zone. Based on classification of Ramsay (1967) the orientation of fold in the Khaftar and Karbasi anticlines are evaluated for all profiles (Fig. 8). Results show the orientation of fold in the Khaftar anticline especially in the D-D' and E-E' parts are different from other parts. It is possible that Nezamabad fault has affected the orientation of fold in these parts (Maleki et

al., 2014).

In this research, model of the relation between folding and faulting has been prepared in the 336 337 Dehram horizon and Bangestan group with emphasis on the Nezamabad strike slip fault (Figs.9&10). The Dehram horizon and Bangestan group (Stratigraphic units) are of utmost 338 339 importance in hydrocarbon exploration in the Fars region. Based on given results and orientation of fold in the Karbasi anticline (Fig. 8) it seems that the Nezamabad fault is 340 located between G-G' and E-E' structural sections and this fault in this area operated the 341 342 same as fault zone. In the study area, Dashtak formation as a middle detachment unit, plays an important role in connection to folding geometry and it may be affected by the 343 344 Nezamabad main fault. The relation between the Nezamabad fault and the Karbasi anticline is modeled by 3D modeling based on structural cross section from A-A' to G-G' 345 346 (Figs.11&12).

Based on our investigation and map pattern of the Nezamabad fault related to surrounding
structures (Fig. 13) and focal depth of instrumental earthquakes (Fig. 14), it is an active
basement fault that has not yet completely visible at the earth surface.

350 10. Conclusion

In the Interior Fars area, it seems that folding pattern is controlled by structural elements such as strike slip Nezamabad fault and Dashtak formation. In fact, Dashtak formation, as a middle detachment unit, plays an important role in connection to folding geometry and fold style in the study area.

Some given results such as folding style analysis, position of Kuh-e Khaftar salt plug, changes of fold type, main structural changes in the study anticlines (such as rotation of fold axis of the Khaftar anticline and 2.5 km displacement in this anticline), show main changes in the middle parts of the Khaftar anticline and western part of the Karbasi anticline. Studied anticlines in these locations have greater deformation than other parts.

360 It seems that, these changes are brought about by the activity of Nezamabad fault and361 activity of this fault is just the same as a blind active basement fault zone.

Finally based on give results, it seems that orientation of fold and folding style in the study

area are controlled by main strike slip fault in the area.

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Table 1:Comparable diagrams 3D line chart and 3D Bar chart showed interlimb angle,
folding angle, amplitude and wavelength for tasted surface of Bgp formations(Ilam- Sarvak
formations) and Nz- Dk formation.





Table 2: Indicate style for tasted surface of Bgp formations (Ilam- Sarvak formations) and Nz- Dk formation.

		Top of Folded	Formation	Top of Bgp	Top of Bgp	Top of Bgp		Ton of	Folded	Formation	NZ-DK	NZ-DK	NZ-DK	NZ-DK	NZ-DK	NZ-DK	NZ-DK	NZ-DK					
		riptive Term	ased on b	tounded	tounded	b rounded	tounded	Angular	b an gul ar	b rounded	Blunt			riptive Term	ased on b	tounded	Blunt	b rounded	tounded	b rounded	Angular	b rounded	counded
		Desc	ri Pi	X	н Ш	Su			Su	Su				Desci	ġ s			Su	×	Su	7	Su	
0	1		Bluntnes	0.981	0.936	0.722	0.937	0.274	0.38	0.709	1.5				Bluntnes	0.914	1.02	0.653	0.971	0.738	0.171	0.502	0.894
ticline		;	ro (km)	5.3	4.7	7.2	6.4	6.2	6.3	5.5	2.5				61) (km)	~	6.6	5.2	3.5	6.5	6.2	$\frac{1}{2.9}$	3.8
asi An		1	ะ (เม	5.2	4.4	5.2	9	1.7	2.4	3.9	5.1	1	$\left \right $		er (km)	6.4	6.8	. 6 4	3.4	4.8	1.3	1.5	3.4 4
of Karba		Descriptive Term	bas ed on \$	Gentle	Open	Gentle	Gentle	Open	Open	Close	Open		Descrintive	Term	Das ed on 0	Gentle	Gentle	Open	Gentle	Gentle	Open	Open	Open
neters o			Folding Angle o	44	62	57	49	84	101	118	105			;	Folding Angle 0	50	28	62	51	55	69	90	96
y Paran			Interlimb	136	118	123	131	96	79	62	75				Interlimb	130	152	118	129	125	III	90	84
eometr		Descriptive Term	based on LogP	Wide	Wide	Wide	Wide	Wide	Broad	Broad	Broad		Descrimtive	Term	based on LogP	Wide	Wide	Broad	Wide	Broad	Broad	Broad	Equant
lated G			Log P	-0.815	-0.602	-0.785	-0.649	-0.847	-0.316	-0.397	-0.322		-		Log P	97	-1.08	-0.552	-0.619	-0.581	-0.301	-0.397	-0.156
Calcu			M (km)	3.25	2.8	3.6	4.45	3.5	3.1	Э	2.1		-		M (km)	7	72	2.5	2.5	3.05	4	1.5	2.15
			(km)	0.5	0.7	12	-	5	15	12	1	1			(km)	0.7	9.6	0.7	9.0	9.0	2	9.0	1.5
		itructural	Section	A-A'	B-B'	C-C	D-D'	E-E'	F-F'	0-0,	6-0,			itructural	Section	A-A'	A-A'	B-B'	رر ت	D-D'	E-E	F-F'	0' C'
		s	Row	1	0	en	4	s	9	2	8			s	Row	1	E4	रगः	4	s	9	3	æ

Table 3: In this table showed type of fold in seven sections of The Karbasi anticline. This

484	classification based	on classification	of Rickard	(1971)	and Ragan (19	9 85).
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		A-A' P:9/ 110 AP:117/ 73	B-B' P:3/ 286 AP:105/ 88	C-C' P:3/ 291 AP:111/ 83				
		Fold type: Moderately inclined horizontal	Fold type: upright horizontal	Fold type: upright horizontal				
	D-D' P:1/ 105 AP:106/ 66	E-E' P:2/ 303 AP:122/ 66	F-F' P:8/ 107 AP:129/78	G-G' P:42/ 086 AP:088/ 89				
	Fold type: Moderately inclined horizontal	Fold type: Moderately inclined horizontal	Fold type: upright horizontal	Fold type: Moderately inclined moderately plunging				
485 486 487 488 489 490 491 492 493 494 495 496	P: Plunge AP: Axial Plar	16						
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Figure.1: (a) shows location of the study area, (b) with white framework in the Middle East,

509 (c) 3D SRTM for the study anticlines (Karbasi and Khaftar anticlines).







of Jahrom, 2001).



Figure 4. View to the south-west that shows Northern limb of The Karbasi anticline and
syncline between The Karbasi anticline in northern limb and the Khaftar anticline in
southern limb.



Figure 5.a) Axial plane of the Khaftar anticline and b) axial plane of the Karbasi anticlinebased on gave results in cross sections.



Figure 6.Stereoplots showed axial plane (AP), cylindericity (AC) for seven sections of The

607 Karbasi anticline.





Figure 7. Triangle form diagram showed type of fold in seven sections of The Karbasianticline, based on Rickard (1971). This Diagram gave based on Rickard classification.

Type of fold in Part G (G-G' section) is different to other section completely



Figure 8. This figure showing the classification for orientation of the Khaftar and
 Karbasi anticlines based on Ramsay (1967)



Figure 9. Schematic model for relationship between folding and faulting for near top of Bangestan group and near top of Dehram horizon in C-C' part of the Karbasi anticline that observed fault rapture in surface. This modelling is based on information of C-C' structural cross section with 3D modelling software.



Figure 10. Structural cross sections of the Karbasi anticline (based on Geologicalmap of the Karbasi anticline, 2001).



Figure 11.(a) 2D model of longitude structural cross section of the Karbasi
anticline.(b) Forms of fold with location of longitude structural cross section. cRelationship between the Nezamabad Fault and the Karbasi anticline, 3D model
(based on structural cross section from A-A' to G-G').





Figure 12. These diagrams showing 3D path profiles of the Khaftar anticline

677 (location of these profiles is located along the cross sections A-A' to G-G' in the

- Figure 5. The horizontal axis and vertical axis showing distance (mile) and
 elevation (meter).
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Figure 14.The distribution map of epicenters and focal depths of instrumentalearthquakes along the Nezamabad fault.