Environment and Ecology 37 (4B) : 1478—1487, October—December 2019
ISSN 0970-0420

New Finding in the Activities of the South-West Zagros Orogeny Belt Mountain by Environmental Factor Case Study : Surmeh Mountain Fars Province, Iran

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Received 2 August 2019; Accepted 16 September 2019; Published on 17 October 2019

ABSTRACT

In this research, it was attempted to examine the impact of tectonic activities on Surmeh mountain to create the rupture. Surmeh anticline is the most important geological feature of the South-West Zagros orogeny belt in Fars province, Iran. The structure of the rock of Paleozoic-Mesozoic age is complex. Several levels of deformation are probably recognized in the Alpian orogeny. The Alpian orogeny produced folds, low angle thrust, numerous normal faults, a moderate graben and widespread fracture zones. The trend of most faults, folds and fracture zones is from north-west to south-east. In this county, the main fault is Surmeh thrust. Due to these effects, Dalan formation contains some clay minerals, Marl perch on Dalan formation and beneath it, perch Foraghan formation and Hurmoz series. At the following tectonic phase, the region creates an appropriate condition for salt diapirism, therefore, in the north county, two salt domes can be seen which are called Jahani dome. Although, the Earth scientists believe that in the South-West of Zagros organic belt, the surficial rupture cannot be seen. Due to soft formations such as Hurmoz, Faraghan and Pabdeh-Gurpi which lead to the damping potential of seismic waves, surficial rupture is rarely seen in the South-West of Zagros; that it has been seen in the 1999 Furg earthquake with 6.4 magnitude for the first time and the second rupture has been seen in Khurgu county in 1993 earthquake with 6.7 magnitude and the other place is Ghir, so the most significant factors affecting surficial rupture are : Development and growth of fold-thrust during earthquake, the number of earthquakes with high magnitude (more than 6.4 Richter), the revision of one of the limbs of the folds, being asymmetric folds.

Keywords Zagros, Fold, The Surmeh, Thrust, Earthquake.

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INTRODUCTION

The Earth scientists believe that the presence of soft materials such as salt, marble and shale in formations lead to the highest rank of energy absorbance from seismic waves, so enough energy is not provided to get fold-thrust to Earth's surface. Therefore, in the South-West of the Zagros orogeny belt, a surficial rupture cannot be seen (Ramsey et al. 2008). Only the earthquakes with 6.4 magnitudes are capable of cutting their sedimentary cover, on the other hand, the Qeshm earthquake occurred with 5.9 magnitude on September 10, 2008 and the Qeshm earthquake occurred with 5.8 magnitude on November 27, 2007 and Qeshm earthquakes occurred with 5 and 5.5 magnitude on March 25, 2006 have cut their sedimentary cover, but the Fin earthquake occurred with 6 magnitude on March 25, 2006 could not cut off the sedimentary cover, however, in the South-West of Zagros, the first failure (surficial rupture) has been seen in Darab'-Furg on the 1990 earthquake. To more precisely study of this area, the tectonic features were studied (Perotti et al. 2011). So, the factors causing the outcrop of rupture are something beyond what the Earth scientists have ever said, therefore, it seems necessary to do further study on South-West of Zagros specially Fars arc. In the present study, it has been tried to determine the main factors of the scarcity of surface failure for the first time based on the observations and documents obtained for the first time.

MATERIALS AND METHODS

The following actions have been carried out in order to study the tectonics of Surmeh County :

Preparing a geological map of Surmeh region, Determining the limits of the anticline of Surmeh in Google Earth and geological map,Geological survey, Extracting tensile joints in Surmeh region, determining the features and formations in the Surmeh mountainous county, Determining normal faults, Providing a cross section of the Surmeh Mountain in the Northeast-Southwest direction, Preparing stratigraphic column of Surmeh region.,Providing the status of the focal mechanism of the earthquake in the Surmeh region, Determine the state of the Surmeh fault respecting to the regions' formations, Entering all the information in GIS software.

Location and accessibility

Surmeh zinc-lead region is a wedge shaped area of 40 sq km in the Surmeh mountainous country, South Firoozabad and about south-east of the boundary of Farashband. It lies within a rectangular region bounded on north by lat : 28°34′. on the South by lat : 28°28′ on the East by long : 52°26′ and the West by long : 52°39′. The Surmeh area is located in a highly populated area. The only town that is located about 3 km to the region is Firozabad with the population about 121417 persons in 2015.

Physiogeography

Surmeh lead-zinc County lies within a broad long of the mountainous area. That is referred from Surmeh mountain. The first topographic feature of the Surmeh County is the anticline of Surmeh. It spreads from the South-East to the North-West limits of the area. The vally of the Surmeh County is broad. Its bedrock is largely covered by the sediments of Faraghan formation. As shown in Fig.1, in the area, the highest point is boundary ridge of 2239 m and the lowest point is along the banks of the Westward Faraghan formation. Surmeh mountainous area lies in a vast long belt of mountainous county that is variously referred to the Alpian System or the Zagros Range. The anticline of the Surmeh area is vast. Its bedrock is largely covered by Paleozoic and Mesozoic formations . The sediments occur as two Well-developed terraces at altitudes of 1500 and1700 m.

In the West of the area shown in Fig. 1, the slopes are steep and culminate several km distance in the mountains and attain altitudes of more than 2200 m . Initial region shown in Fig.1 in which the highest mountains lie in the north-eastern part, the highest point is boundary ridge, altitude of 2239 m, the lowest point is along the banks of the Northward flowing Dehram River, at the boundary of county, East of the Surmeh mountain. It has nearly 10—16 km wide. In this area, many hills of silt, sand and gravel are exposed during the periods of low water level. A recently constructed dam at Khoorab is high enough

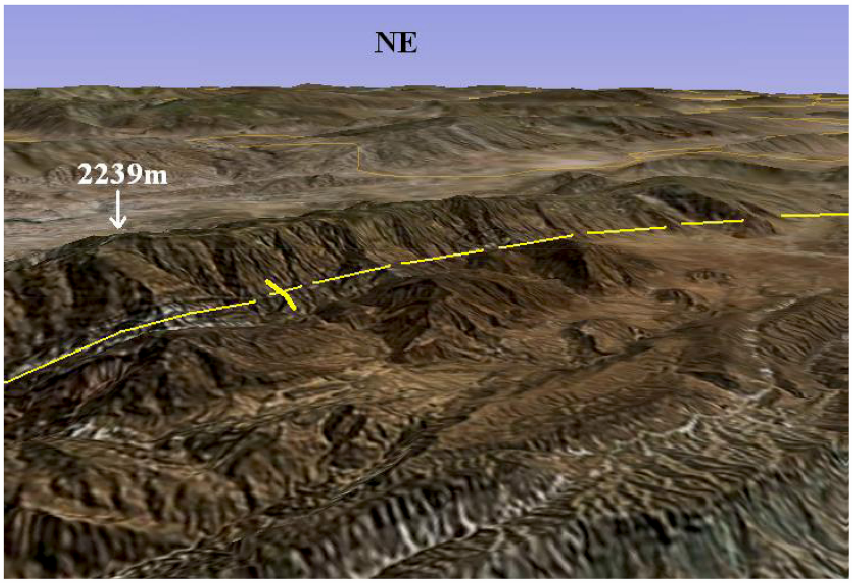

Fig. 1. View North-East across Surmeh anticline in the Surmeh mountain, SW, Shiraz, Iran, showing the highest elevation. The scale is indicated by the length of anticline.

to eventually form a lake that will bring back water to the county boundary.

RESULTS AND DISCUSSION

Field work

The principal field work on which this article is based was carried out during 2015-2017. The rocks in Surmeh region are in the age range from Cambrian to Permian. The Quaternary deposits include limestone, dolomite, salt, shade. The principal field work on which this report is based was carried on during the summers 2015-2017. The average field season was from the middle of June to the middle of September. The resulting maps, which ranged widely in scale from map to map, generally showed the outline of individual crop figures, the type of rock and the known or inferred faults. Little or no attempt was made to map bedrock pattern as determined from float fragments. In 2001, the situation was changed, permission to publish was granted by all major mine operators in the region. Some of the geologic units, structural features and interpretations incorporated in the present report were formulated. These maps were of great aid in the location of many crop figures and some parts of this early work are incorporated in the present report, as specifically credited.

Previous work

The most important international works done on the survey of surface rupture in the South-West of Zagros mountain belt are as follows : New views on earthquake faulting in the Zagros fold and thrust belt of Iran, The 2006 March 25 Fin earthquakes (Iran)-insights into the vertical extents of faulting the Zagros simply folded belt, Fold evalleyution and drainage development in the Zagros mountain of Fars province, SE, Iran basin (Ramsey et al. 2008), Locations of selected small earthquakes in the Zagros mountains, The structure and kinematics of the South-Eastern Zagros fold thrust belt (Molinaro et al. 2009), Crustal scale geometry of the Zagros fold thrust belt, Structural models of faulted detachment folds.

Tectonics setting

Principal features

The rocks in Surmeh mountain region are in the age range from Cambrian, or possibly older, to Tertiary (Motamedi 2008, Motamedi et al. 2012). The Quaternary deposits of surficial material mask large areas (Figs. 2–4). The formations of Paleozoic age include, in ascending order, Hurmoz formation (Cambrian ?), Faraghan formation (Ordovician), Nar

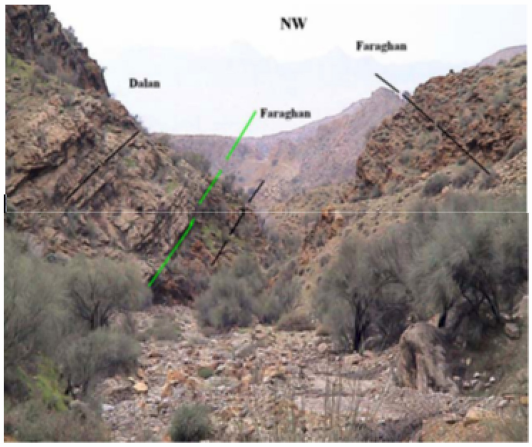

Fig. 2. Geological formation of Surmeh anticline in Surmeh anticline, SW , Shiraz, Iran, showing geological formation. The scale is indicated by the vegetation. North-West view of the Surmeh mountain. The scale is indicated by the vegetation.

member and Siahoo formation (Silurian) (Nagafi et al. 2012). The Quaternary deposits include silts and sands of lacustrine origin. Small deposits of alluvium occured in a few places. Igneous rocks are rare, although wide areas of the Jahani salt domes cropped

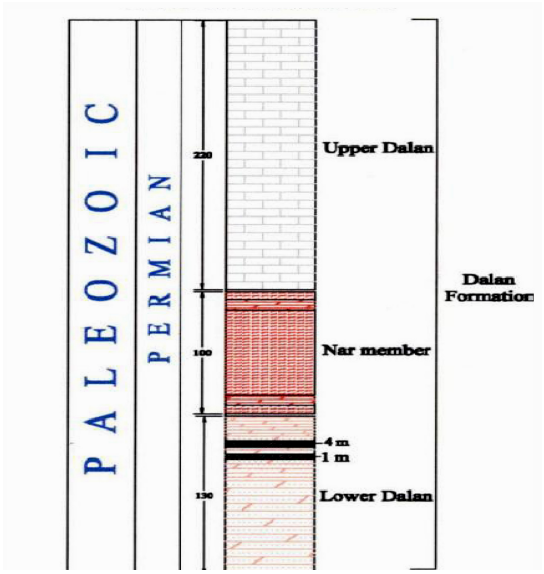

Fig. 3. Geological formation of the Surmeh mountain. Upper : Stratigraphy column. (1) Lower Dalan, (2) Bar member, (3) Upper Dalan. The scale is indicated by the thickness of the lower Dalan formation.

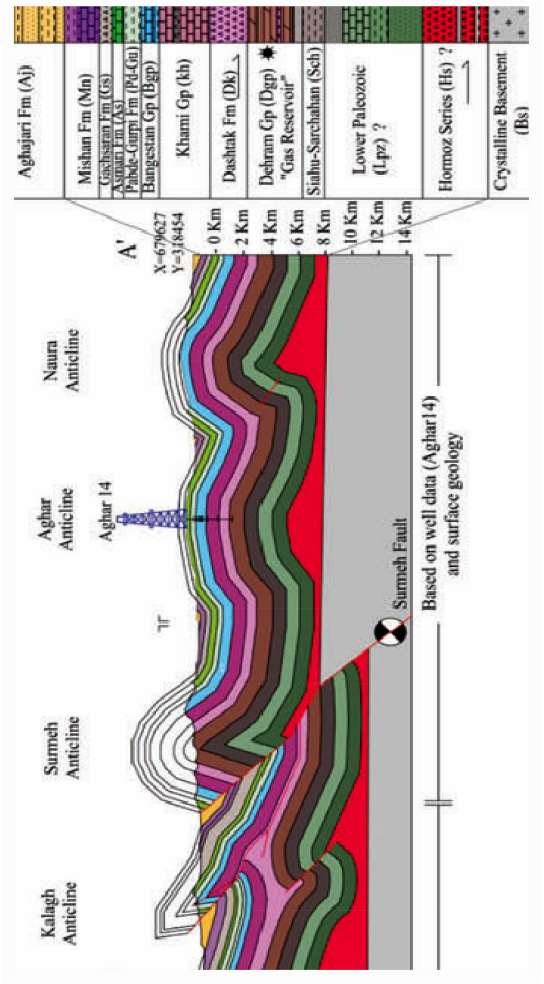

Fig. 4. Geological formation of the Surmeh anticline. Upper : Stratigraphy column. Lower Geological cross section. The scale is indicated by the depth of formations.

out a few kilometers distant. The geologic structures are generally moderately complex, although locally they are extremely complicated. Structures include folds, faults and widespread fracture zones with prevailing northeasterly trends. The dominant structure is a wedge-shaped Graben, the valley block or Graben which, along its western border, is marked by a fault with a stratigraphic throw of about 200 m. The stratigraphic throw of the fault that bounds the Graben on the east is not precisely known, although it is locally a minimum of 500 to 600 m. Several levels of deformation are recognized.

Lithology

The rocks in Surmeh region are in the age range from Cambrian, or possibly older, to Cretaceous. The Quaternary surficial deposits covered the entire region, they are chiefly sedimentary rocks relaed to Paleozoic-Mesozoic age. The formation of Paleozoic age includes, in ascending order, Hurmoz formation (infra Cambrian), Faraghan formation (Ordovician), Siahoo formation (Silurian-Devonian), earlier Dalan formation (lower Permian), Nar member formation (middle Permian), upper Dalan formation (upper Permian) ages (Fig. 3).

Paleozoic formations

The total thickness of a complete stratigraphic section of the Paleozoic formations surrounding the central region and expanding outward for several kilometers from the Surmeh mountain zinc-lead region is about 450 m. These figures are based on thicknesses obtained during the present investigation. The Paleozoic rocks described on the following pages include only those that lie within or on the border of the large Graben. Hurmoz of Cambrian, Ordovician, Silurian, and Devonian ages are represented principally by limestone, dolomite. Fossiliferous beds are, as a whole, rare and spaced at large stratigraphic intervals. In the area mapped in this report, only parts of Surmeh, Hurmoz and Dalan formations are present. However, detailed studies were made of Surmeh mountain limestone an irregularly dolomitized formation containing the main ore bodies, the overlying Silurian and Devonian rocks. Rocks of Silurian age had been known in this region. During the present investigation, a particular effort was made to show reliable sub-divisions in the Surmeh mountain limestone and in turn, to arrive at the thickness of the formation at various places throughout the mapped area. The sub-divisions that are recognized, and vary greatly in thickness, are described in a sub-sequent section. The total thickness of Surmeh mountain limestone in the region is roughly 320 m. They assigned a total thickness of 750 m to the Surmeh mountain in a section East of the Surmeh mountain falls. The present investigation shows that the Surmeh mountain limestone attains a total thickness of about 450 m.

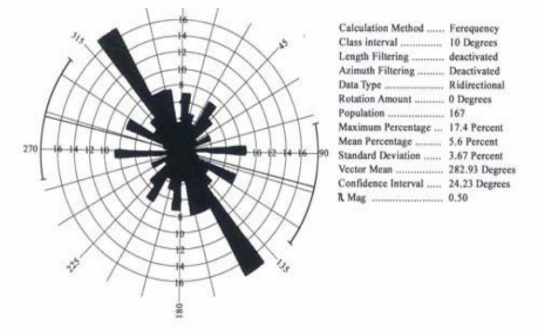

Fig. 5. Rose diagram related on Surmeh mountain.

Structure and tectonics

Fractures

The structure of the rocks of Surmeh region is complex. Several levels of deformation related to the Alpian orogeny, are recognized. These levels of deformation produced folds, low angle thrust, numerous of moderate to steeply dipping normal fault and a reverse fault, a large wedge- shaped Graben and intense local cracking (Fig. 5). At many places, deformation caused a recrystallization of carbonate rocks. Surmeh lead-zinc region is largely contained outstanding structural feature of the region, the simple folded belt, which is uplifted and rotated along its south-west border (mountain front fault). The principal tectonic structural settings are in the highly fractured ground between Sharoor, Shahrooz, A_1, A_2, A_3 faults. The Paleozoic-per Tertiary rocks of Surmeh region are folded into a series of anticline and syncline that are ranged in size from 10-16 km length. The geological map and accompanying sections clearly show that the dominant folds within Surmeh mountain are asymmetric, whereas main fold outside the mountain in the south limb of the anticline is rotated toward the South-West.

Folds

The Paleozoic-Mesozoic rocks of Surmeh mountain region are divided into a series of anticlines and synclines that are ranged in size. The geological map and accompanying sections clearly show the dominant folds within the Graben, or valley block, which is

broad and symmetrical, whereas some folds near the Firozabad and Surmeh fault are tight and in places, overturned. Therefore, within this range, fold axes are commonly interrupted and it is difficult to locate them precisely, especially in areas of sparse crop figures or where bedding planes have been obliterated by alteration, recrystallization, and shearing. Undoubtedly, many of folds with a length from a hundred to several hundred cm are shown on the geologic map. Recognizing them is more difficult than recognizing the major folds due to of the rarity of local horizon markers in addition to the reasons just mentioned. However, no certain criteria could be found in recognizing overturned beds rather than the general stratigraphic relations, where it seems that field evidence indicatea that a structure could be interpreted equally well as a fold or as a fault, a fault has been favored compared to a fault because the number of faults are greater than the number of the recognized folds. Most of the major folds are in the large area expanding from the south of the county boundary to Ghir. There are a series of anticlines and synclines plunge 25°—35°SW. The north-east plunging. Anticline and syncline are known to be present in the Mesozoic deposits in the North of Surmeh mine in the South Central part of Surmeh mountain region. These folds, both cut by many later faults, are recognized in Surmeh mountain. According to the data of a few drill holes in the north and north-east of this creek, main fold is detachment and has been cut and offset by later faults. Dragged folds show movement along bedding planes occured locally, especially in the lower strata near or beside to the Surmeh mountain limestone. It seems that the axial planes have no systematic arrangement, which may be inherent or due to the lack of sufficient data, but most fold axes trend north-east. A sharp syncline that can be traced for about 1.5 km, lies in the South-West of Surmeh mountain in the area (Fig. 6).

Faults

Faults are plentiful and widely spread in Surmeh mountain mining region. They are ranged in length from 100 cm or less to several kilometers, the most faults are moderate to steeply dip, but a few are nearly vertical. Their throw ranges are from a few meters or less to 4 m or more of them are the normal faults. Faults are especially plentiful in the mine workings. This abundance is partly the result of good exposures in the mine workings, and is due to the more intense shattering and faulting of the rocks in the mineralized areas. Some further ideas of this shattering can be realized from the fact that many distinct faults were observed in the core from drill hole over a vertical distance of 40 m. Also, other faults are likely to present in parts of the hole that did not yield core. Many faults have smooth and slick surfaces. At many places, the movement is indicated by an irregularly bounded zone of stratigraphy column. There is only a vague and generally unreliable relationships between the magnitude of displacement along faults and the degree of brecciation, grooving and polishing. The presence of slate squeezed into a fault zone rarely, but certainly not everywhere, shows moderate displacement, as determined from many such faults found in the mines. However, many weak-appearing faults, such

Fig. 6. SW view of the Surmeh anticline in Surmeh mountain, SW, Zagros, Shiraz, Iran. It shows the formations and Surmeh fault. (Su : Surmeh, Nz : Niriz, Dk : Dashtak, Kn : Kangan, Da : Dalan), the scale is indicated by the tree.

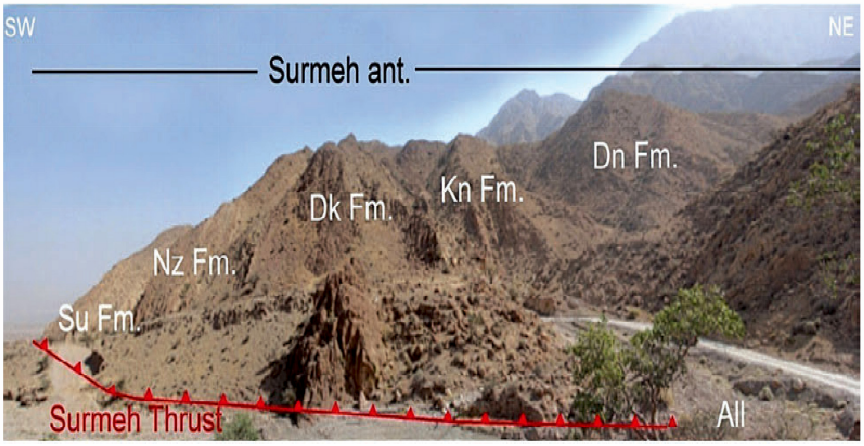

Fig. 7. South-West view of the Surmeh mountain, SW, Zagros, Shiraz, Iran. It shows Surmeh thrust, the scale is showed by the vegetation.

as the Surmeh fault that is exposed of Surmeh mine (Fig. 6), have fairly large displacements. Mineralized cavities and caves are accompanied with some faults. Only the principal faults are shown on the geological map (Fig.5). Many of them are based on anomalous stratigraphic relations or offsets, only a few of them are the fault surfaces exposed. The faults are divided into five groups : Thrust faults, faults that delineate the Graben ; principal faults within the Graben, major faults in the Surmeh mountain.

The Surmeh thrust

Surmeh thrust that its name derived from Surmeh mountain mine in which it is not exposed, is a low-angle fault along which Surmeh mountain limestone has been thrust over the Surmeh mountain. This fault, which formed at a relatively early period in the structural history of the region, is cut by many younger faults. Surmeh mountain thrust is entirely concealed at the surface under a thick covering of Dalan formation, although its upper part over thrust plate of limestone protrudes through the surficial deposits in the South-East of Surmeh mountain (Fig. 6). In Surmeh mountain mine, faulted segments of Surmeh mountain thrust are distributed over a distance of more than 4 km in a North-West direction from Surmeh anticline to plunging in a South -East direction. The fault are recognized at many places over a distance of about 2.5 km from the upper center of the Surmeh anticline. Surmeh mountain thrust is especially well exposed along the main haulage level of a few hundred cm (Figs. 7—13). There is the gentle and variable easterly dip of the thrust that can be seen along the sides of the drift and in the location of the fault plane, or sole of the thrust plate, it is strikingly exposed in the roof of

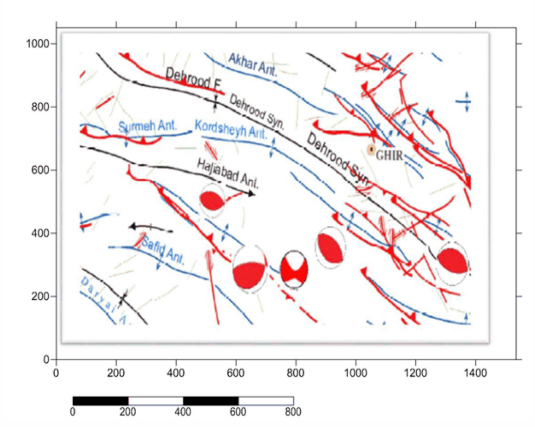

Fig. 8. Focal mechanism of earthquake in Surmeh mountain.

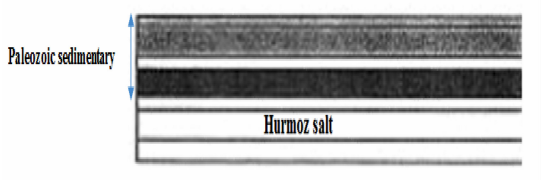

Fig. 9. A slime of sedimentary layers was deposited.

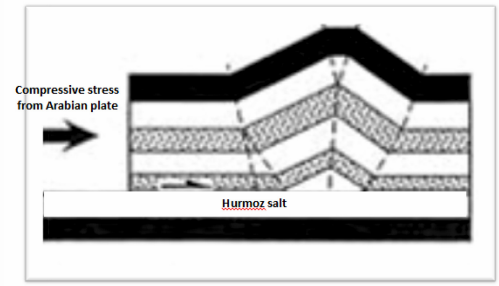

Fig. 10. An overview of the detachment folding in the Surmeh mountain, the South-West of Zagros area.

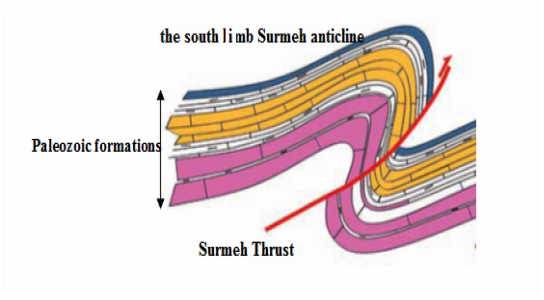

Fig. 12. The schematic of becoming asymmetry of folds in the valley formation process.

the tunnel where, locally, grooves are readily seen in the north-west part. A study of the markings and figures along the grooves failed to show clearly, whether the overlying limestone plate had moved north -west or south-east according to the underlying bedrock. Many diamond-drill holes, drilled from within the mine workings, show that the Surmeh mountain thrust has produced a highly complex fault zone in many places, especially in the south crosscut workings. Here sharp folds, repetition of strata, and wide zones cracks are common. The original area extent and the first attitude of Surmeh mountain thrust are referred to earlier Permian. Erosion has likely removed many segments in bordering areas and the mine workings or drill holes merely interrupted parts of this fault and their various strikes and dips probably do not show the original attitude of the thrust, but have resulted from movement along the younger faults that have displaced the thrust. However, the bearing of the few grooves seen along Surmeh mountain thrust is probably of no major structural significance because of the likelihood that the individual fault blocks were rotated during the later period of deformation pro-

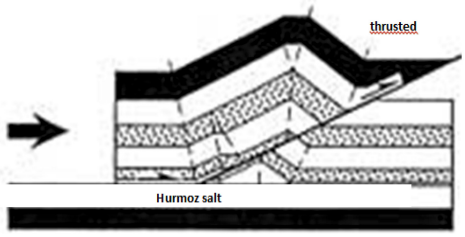

Fig. 11. How the detachment folds are thrust in the Surmeh mountain.

ducing the various segments. It is also probable that some segments of the thrust have not been recognized where older beds of the Surmeh mountain have been brought in the contact of fault with younger beds of Surmeh formation.

CONCLUSION

Firoozabad county is located in the simple folded Zagros section related to the salt dome formed in the Cambrian-middle Cambrian age. Its Sequence stratigraphic column represents a shallow sedimentary basin formed in the Permian age and in this basin, sedimentation has been continuous and consistent, only in the upper Permian, a shallow vapory sedimentary basin is created for creation vapory Nar member, the basement has been thrust by the Alpine. Orogenic phase can be seen clearly in cross-sections

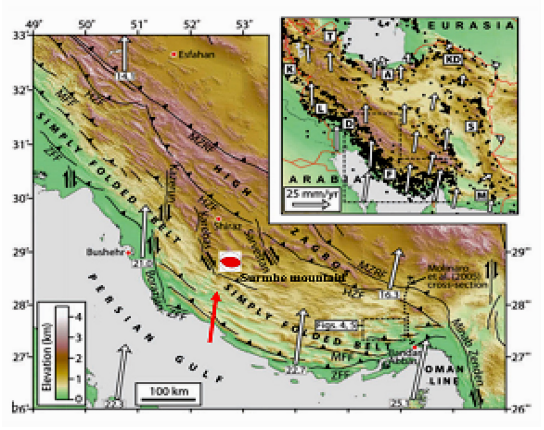

Fig. 13. Presentation of tectonic model of the Surmeh area and its conformance with tectonics regiment region.

along the NE-SW direction in the region (Fig. 4). The condition of the Surmeh mountain fault can be categorized in the main and sub-categories of faults and the main fault is thrust. Along the axis of Surmeh anticline, a series of normal faults can be seen such as shahrooz fault, sharoor fault and other several normal faults, in Dalan Carbonate formation, the faults have been created due to the possibility mineralization by creating a tension stress in this area. The results of the analysis of stretching system joint using the rose-diagram software shows the tensile stress which dominates along NW-SE and the compressive stress dominates along NE-SW which have affect Surmeh county, the tension prevailing in the region is the result of the encountering of Arabian plate to the Iranian plate, also the analysis of focal mechanism of seismic almost shows activity of the reverse fault in the area. Displacement in the lithology of Surmeh county is due to the activity of the basement inverse fault with the tensional joints and normal fault affected by the activities of the Alpine orogenic in the area. It has provided the perfect conditions for salt diapirism. Calcium Carbonate Dalan formation, Nar evaporate formation at the top of Dalan formation, marble in the central part of the core of Surmeh anticline, Hormuz salt diapirism along the fault system and perpendicular direction to the axis of anticline is created by the effect of compressive phase on the basement of Surmeh mountain, the intrinsic absorption properties of soft formations related to seismic waves contained in salt, Calcium Carbonate and evaporation member of Surmeh mountain intensity are interesting. The Earth scientists believe that in the South-West of Zagros, the surficial rupture cannot be observed because soft formations such as Hurmoz, Faraghan and Pabde-Gurpi-lead to the damping of seismic waves, but surficial rupture in the South-West of Zagros is rarely seen. First time, it was seen in the 1999 Furg earthquake, so, the factors affecting the surficial rupture are : Development and growth of fold-thrust during earthquake, the number of earthquakes with high magnitude, the revision of one of the limbs of the folds, asymmetric folds.

Tectonic pattern of South-West Zagros mountain belt

The layers deposited horizontally in sedimentary basins such as Hurmoz salt and this formation reduces friction.

The upper layers slip on this with the stress applied. The upper layers (including Faraghan formation, Siahoo formation, lower Dalan, Nar member, upper Dalan) are stuck in a spot while they are moving and they move upward and this point is the place for thrusting as shown in below figure. In this stage, right lateral strike slip faults have been formed at first, such as Kuzerun fault, Kare-bas fault, Sarvestan fault.

The rigid behavior of the Central Iranian plate, caused the folded part to rotate in the space between the Arabian plate and Central Iranian plate. This rotation resulted in asymmetric fold in the Surmeh county and the southern limb became closer to the ground surface and the northern limb went deep. The magnitude of the earthquakes in the areas that are closer to the focal conjunction was higher than other areas, such as Fars arc in the Surmeh mountain. The 1990 November 6 Furg earthquake formed a scarp on the southern limb of the Surmeh anticline at a height of 1 m and length of 15 km. As the 1972 Ghir earthquake, the largest earthquake, occurred with magnitude of 6.7 along the east-south-east-to-south direction at the Surmeh anticline at the terminus of the Kare-bas fault. But the most energy of earthquake on the northern limb transported the fold upward and forming strain and decreased the chance of outcrop of this limb caused by the fold. On the following, after Miosen-Eosen age, the reduction of the space between Arabian plate and Central Iranian plate caused the formation of thrust such as Surmeh fault.

REFERENCES

Molinaro M, Leturmy P, Guezou JC, Frizon de Lamotte D, Eshraghi SA (2009). The structure and kinematics of the South-Eastern Zagros fold-thrust belt, Iran : From thin-skinned to thick-skinned tectonics, Tectonics, 24, TC3007, doi : 10.1029/2004TC001633.

Motamedi H (2008) Structural Analysis of Bandar-e-Chiru-Khonj Region, Coastal-Interior Fars, Zagros Fold-Thrust Belt. PhD thesis. Beheshti University, Tehran, Iran, pp 158.

Motamedi H, Sherkati S, Sepehr M (2012) Structural style variation and its impact on hydrocarbon traps in Central Fars, Southern Zagros.

Nagafi M, Beamud E, Verges J, Yassaghi A, Sherkati S, Bahroudi A (2012) 3-D Structure of Permian Reservoir and Timing of Deformation in Frontal Fars, Zagros Fold Thrust

Belt. Presented at Daryush Conference, Evalleyution of the Zagros-Makran Fold Belts. 14-15 May 2012, Institute of Earth Sciences Jaume Almera, ICTJA-CSIC, Barcelona, Spain.

Perotti C, Carruba S, Rinaldi M, Bertozzi G (2011) The Qatar-South Fars Arch Development (Arabian Platform, Persian Gulf) : Insights from Seismic Interpretation and Analogue Modelling. In : Schattner U (ed). New Frontiers in Tectonic Research-At the Midst of Plate Convergence, pp 325—352.

Ramsey L, Walker R, Jackson J (2008) Fold evalleyution and drainage development in the Zagros Mountains of Fars province, SE Iran. Basin Res 20 : 23—48. doi : 10.1111/j.1365-2117.2007.00342.x.