Seismotectonic kabir kooh fault, zagros

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Abstract

folded belt and thrust of zagros is an active structure which sets the present border between the Arabic plate at the south and west of the central Iran continent at North East. The folded Zagros basin (south of Pole-Dokhtar) includes a thick sequence of sediments from the Jurassic to the Pliocene periods which the compress ional deformation along the NE-SW bearing has caused its folding and faulting. The general alignment of the corrugations is NW-SE. This folded assemblage has been cut off by numerous faults. The main fault in the region as an activated structure has had the major role in the deformation of this terrance. The structure of the dextral and sinistral lateral slip faults which are positioned in the western Jouth and Eastern south of Pole-Dokhtar respectively have a significant impact on the neotectonic movements. Kabir Kooh fault plain includes the group of dextral strike-slip faults with a bearing of North West – South West. This plain's faults are mostly tectonically active. The Kabir Kooh fault as the most important fault of this plain having the highest level of displacement is the most known feature in this collection. The division of the deformation pattern, which usually is present in the lateral slip structures, can be observed along the bearing of this fault as strike-slip movements along the fault and dip-slip movements (thrust) at the fault terminal. The Quaternary and Neogene juvenile sediment deformation in the plain near Pole-Dokhtar can be the result of the thrust faulting at the Kabir Kooh main fault terminal. The division of the deformation at other plain faults, including mountain-front fault is detectable to the south of the eastern region.

Introduction

The folded Zagros plain as a geo-structural unit and a seismotectonic province is situated in the south west of the country in the form of a folded belt and thrust. Post-Cretaceous compressional deformations have lead to the formation of the structural condition of the folded Zagros in the form of corrugations and faulting. These deformations are still extant at the present. The lateral-slip faulting has happened in a large area of the southern plain of the Pole-Dokhtar. The main Kabir Kooh fault as an activated structure inside the basin controls the deformation patterns. The structure of the dextral and sinistral lateral-slip faults plays an important role in the tectonic movements. The dextral lateral-slip faults which affect a significant portion of the surveyed region, are juvenile phenomena and understanding and identifying the activity and the features produced by them is of significant importance in identifying and understanding the neotectonic and seismotectonic structures. In this article, we discuss the structural characteristics of the strike-slip faults in Kabir Kooh. Also, the drift change in the lateral-slip fault terminal will be investigated and introduced as a factor explaining their mechanism of change.

The Geological Position of the Surveyed Terrane

Zagros folded belt and thrust with a post-Cretaceous age is an active structure. The surveyed area which is situated at the south of Pole-Dokhtar is demarcated in the north by Maleh-Kooh anticline, and in the south and west by Ilam Province (the city of Dare-Shahr), and in the east by Khuzestan Province. This region included a thick sequence of the Jurassic-Pliocene sediments which was formed after the orogenic movements of the middle Seymarain (??),i.e. at the time of the marine closing of the neotethys. This sedimentary sequence is placed on the older layers as a disconformity. The region is covered with Mesozoic and Tertiary sedimentary units. The thickness of these sedimentary units at some areas amounts to 3000 meters. The post-Miocene compressional deformation has been the cause of extensive corrugation of the North West - South East to East West. A balanced cross section with the length of 100 km with a North West- South East bearing shows a 30 percent shortening via corrugation. 20 percent of the calculated shortening is due to the pure compressional component at a bearing of 045 N degrees and the other 10 percent is due to the pure dextral component at a bearing of 110N degrees for the East.

The convergence rate for a 6-million year period is about 1-1.2 cm/year. This convergence rate is equal with the relative motion of the 2.7 on the Iran-Arabic plate. The present 2700 meter height of the Pliocene sendiments to the south west of Pole-Dokhtar also indicates an uplift equal to 0.45-0.65 mm/year which shows the crust accretion is the result of the convergence of the Iran-Arabia blocks. In general, the aforementioned region has a bearing of 145 degrees N. The general alignment of the corrugations in this folded assemblage is cut off by numerous faults which can be divided into two groups. The first group consists of the basement faults which were active during the sedimentation and played a crucial role in the face change in the rock units and sedimentary gaps (breaks). This group of the faults which are widespread in the south western part of the area and include three faults with a general drift (trend) of north west – south east. These faults have been active in the recent orogenic phases, and with a reversal of the mechanism, have caused a thrust faulting and corrugation with a northward slope.

The second group includes faults which were activated during the Alpine orogenic phase and act as strike-slip faults and are active at the present and have an important role in the neotectonic movements. This group can further be divided into two subgroups: The first subgroup includes the system of the dextral lateral-slip faults with a NNW-SSE drift which are present at the eastern and central area (around Dare-Shahr). The second group consists of the system of sinistral lateral-slip faults with a NE-SW drift (trend) which are present at the western area. These two groups of strike-slip faults are part of the region’s main fault system (Mountain-Front Fault) which are formed under the Riddle (??) arrangement. The evidence shows that the presence of the Kabir Kooh fault as an activated system at the boundary of the basin controls the deformation pattern.

1. The system of the strike-slip and thrust faults (f1):

Mountain front fault (MFF) limits the Zagros simple folded belt and the Eocene-Oligocene outcrops to the south and south west. MFF is a buried, fragemental, thrust radical lateral-slip fault with important structural, topographic, geomorphologic, and seismotectonic characteristics. It is important to note that in places where thick sequences of the Gachsaran

Miocene evaporations have precipitated (settled), no Eocene-Oligocene formation outcrops or Mesozoic rocks to the south west of this radical topographic-moprphological feature on the front slope of Zagros have been observed. From the erosion of the uplifted mountains of Zagros (the simple folded belt and the raised Zagros) in the north east of MFF, destructive material has been produced which has settled in the frontal slope region of Zagros in the south west of MFF. The slumping of the frontal slope of Zagros and the Dezful depression together with the accretion of the Post- sediments (the Neogene vaporizations in Gachsaran and the mollase simultaneous with the orogenesis in Aghajari-Bakhtiari) provides some evidence regarding the relative movement along MFF and the Dezful fault slumping during the early Miocene. The geological evidence based on the current location of the upper Eocene-Oligocene which has been collected from stratigraphical, seismic, and borehole information, demonstrates a vertical displacement of more than one kilometer along this thrust. Because of the vertical movement along MFF, the southern edge of the simple folded belt of Zagros, especially along the lower MFF, has uplifted and the asymmetrical frontal surface corrugations have been placed on it.

Additionally, some evidence has been provided by the terraces produced by the burrowing river system. The Karoun river terraces have reached observable heights above the current level of the river flow. The major factor causing the observable burrowing and the change in the river curvature and the slope produced by Karoun and the other major rivers which pass through the rock-bed structures, is the reverse active movements and the uplifting along MFF. MFF is a combination of the assemblage of discontinuous thrust blocks with the length of between 15 to 115 km and the total length of 1350 km in Iran. Fault blocks in depth together with the asymmetrical folds adjacent to them are separated from each other by gaps and steps in the surface topographical and morphotectonic features. These fault blocks form two expansive arcs in Fars (shouth east of Zagros) and Lorestan (North West of Zagros) and are arranged as in a covering left and right stepping en echelon to the east and west of these two arcs respectively. Because the majority of the observed frontal asymmetrical surface folds which bury (hide) the blocks adjacent to MFF have a length of less than 115 km, are not prone to the creation of large earthquakes (M =8).

MFF is a radical topographic feature which is characterized by a 500 meter contour line on the surface in the east by the Kazeroon-Borazjan reverse fault in the Fars Province and in the west by Kabir Kooh in the Lorestan Province. MFF continues the 1000 meter contour line to the south of the Bakhtiari heights (to the north of the Dezful depression) between the active Kazeroon-Borazjan fault towards the east and the Kabir Kooh anticline in the west. MFF often forms large topographic steps and follows the reverse and sheared amplitudes to the south west of the asymmetrical anticlines on the south west edge of the Zagros simple folded belt. The core of these anticlines is revealed by this same fault. MFF has been dextrally displaced for 140 km by the transverse and active fault of Kazeroon-Borazjan. This displacement has changed the height of the surface outcrops for about 500 meters (500 meters eastward and 1000 meters westward towards the active strike-slip Kazeroon-Borazjan fault). Surveying the masroseismic areas with the earthquakes having the magnitude of medium to large along the different MFF blocks shows that the surveyed earthquakes have been concentrated in the successive fractures of folds on the surface. This means that earthquakes whose sources (origins) are near the gaps or spacings of the basal faults along different MFF blocks control these sequences and folds. For example, we can mention the following earthquakes: ……

Apparently, the source of these ruptures is near the gaps and spacings; That is, the hypocenter and the ruptures originate from the proximity of the gaps and spreads from there. In general, the depth mechanism of earthquakes along MFF shows a thrust fault with nodal planes almost parallel to the region's geological structures and MFF. The mechanism in the nodal planes correspond with the north-south and north east-south west drift (trend) and the MFF slope which have been calculated based on morphotectonic and structural data. Block lengths become shorter from the north west to the south west respectively. Each fault block at south east end has bent towards a fault plane with a bearing of NNW-SSE and expands into the mountain range. Therefore the block between the two ranges of Jologir and Mazhin bends towards a fault plane near the south east of the Seimareh plain. A narrow and longitudinal basin with a bearing of NW-SE which separates Dareh-Shahr from the Maleh-Kooh mountain ranges is called the Dareh-Shahr – Maleh-Kooh lineation. This basin is almost parallel to the main Kabir Kooh fault and indicates a radical basement rock structure (of the normal fault type), which is clearly visible on the aerial geophysical maps.

2. The System of Transverse Strike-Slip Faults

The corrugations of the Kabir Kooh mountain range have been cut off and displaced by a post-Alpine fault system. These lateral-slip faults are called the diagonal fault system which basically consists of dextral faults with a bearing of NNW-SSE and sinistral faults with a bearing of NE-SW and are accompanied by peripheral E-W thrusts at some points.

The NNW-SSE dextral faults with an average bearing of 40 N degrees north are situated in the Eastern parts of KAbir Kooh and can be seen individually or in the form of fault plains with a length of about 120 km and in the south east terminal bend toward the Jologir-Mazhin (east) lineation. This characteristic can express the structural dependence of these faults on the aforementioned fundamental elements. The flexure of these faults in the south east terminal toward east causes a change in their mechanism from strike-slip to thrust. The function of these faults causes a displacement in the in the corrugations in an expansive plain. The most important among these faults in terms of length and the amount of displacement, are located at the Pole-Dokhtar – Dareshahr plain which both in terms of structure and seismicity are among the major elements of the folded Zagros range. The Pole-Dokhtar – Andimeshk fault plain is located at a region with a width of 70 km with a north west – south east drift to the north of Andimeshk up to the south of Pole-Dokhtar. The length of this plain in Iran is about 65 km. This plain consists of about 7 strike-slip dextral faults which with a bearing of north – north west are parallel to each other and cause the displacement of the fold axis.

This plain's faults which were activated after or almost at the same time as the corrugation, have displaced the western block in comparison with the east, for about 29 km toward north west. Falcon (??) (1935), too, using a north west-south east narrow and long syncline, at the core of which the Ilam formation has been preserved, calculated this plain's displacement as being 21 km. Therefore, if we consider the time of the faulting to be 45 million years ago, the average displacement rate in this plain would be 2-5 mm a year and the highest level of displacement has happened along the alignment of the region's major fault and at about 7 to 8 km.Figure.

The deformation pattern in the strike-slip faults and the formation of a thrust at the fault terminal.

The Kabir Kooh fault is one of the most important faults in the Pole-Dokhtar plain. The length of this fault is about 150 km. This fault's alignment is visible as a quite clear lineation on satellite and aerial images and photos. The Kabir Kooh fault has cut off many streams and ridges along its path. As a result of the Seimareh earthquake, all the length of this fault has been affected by failure. This failure hasn't show a clear sign of strike-slip movement and only the north eastern part has been affected by stand-up in comparison with the south west. The southern end of the Kabir Kooh fault in the Abdanan plain has not continued in a straight line and it seems as if it has changed its path toward the south east. This change in direction causes a change in mechanism from strike-slip to thrust and vice versa. This kind of fault terminal, is a necessary consequence of the strike-slip faults which can clearly be seen in other lateral-slip systems including in the eastern parts of Iran. In the majority of the cases, these faults exist as buried thrusts. The displacement of the thrust faults which branch out from the strike-slip faults, is reduced with an increase in distance, for example, a thrust can be mentioned that branches out from the northern F2 dextral fault terminal toward the north west.

The elevation and tilt of the Neogene sediments at the end of the F2 fault can be connected to the function of the thrust that has branched out from it. This elevation and tilt creates peripheral basins among the structural reliefs. Also another branched fault could exist at the continuation of the F2 fault toward the south, that is, at a place where new sediments have been affected by tilting and folding again. The presence of some branched thrust faults can express a longitudinal growth in the lateral-slip fault with the passing of time. Considering the role of the lateral-slip intracontinental faults at the convergent location which one of them is a division of the oblique convergence to the lateral-slip and thrust components, the presence of these structures in this part of the active F3 belt is not considered improbable.

The macroseismic plain of the aftershocks exactly corresponds with the location of thrust faults. This issue explains this point that the occurrence of these earthquakes is related to a movement along the thrust or buried thrust faults. The possibility of the occurrence of a deformation as a lateral-slip and thrust faulting in the terminal exists in the other faults of the Seymareh plain. The F3 plain is another major fault in the Seymareh plain which is located to the east of the F2 fault. This fault has also cut off a large part of the Seymareh plain but has a smaller displacement in comparison with the F2 fault. The F4 fault with a length of more than 21 km is positioned at a distance of 2 km from the surveyed region and shows a thrust mechanism with a listric plane and the historical Seymareh earthquake has been attributed to this fault.

The juvenile and present-day activity of the faults in the Seymareh plain, given the structural and morphological reasons and also the occurrence of numerous earthquakes, is definite. The important point is that this activity is neotectonic which knowing and understanding it shows a high level of significance. In this case, the continuation of the studies seems necessary in order to help with gaining a more exact knowledge of the details and the functioning modes of these structures.

Conclusion

The Seymareh (Pole-Dokhtar) plain is an active fault plain with special neotectonic and seismotectonic characteristics. The evidence shows that a main part of the major faults in this region are active and have a high seimogenic potential. The division pattern of the deformation along these faults, like other similar lateral-slip systems, is in the form of a strike-slip movement along the fault and thrust at the fault terminals. The study and investigation of the deformation of the new sediments and the accompanying geomorphological phenomena, clarifies the patterns and factors related to the deformations. The presence of deformation in the Neogene and Quaternary sediments of the Seymareh plain, indicates that the activity of the thrust fault in the major strike-slip fault terminals. It is possible that thrusts exist under a deformed sedimentary covering in a buried form. Thrusts like these, as we have noticed in other parts of the country especially in the south east of Iran show a great potential in seismicity. Correctly understanding the characteristics, the mechanism of activity and the functioning mode of these active structures depends on the exact and complete knowledge we can gain about them and is of paramount im**.**

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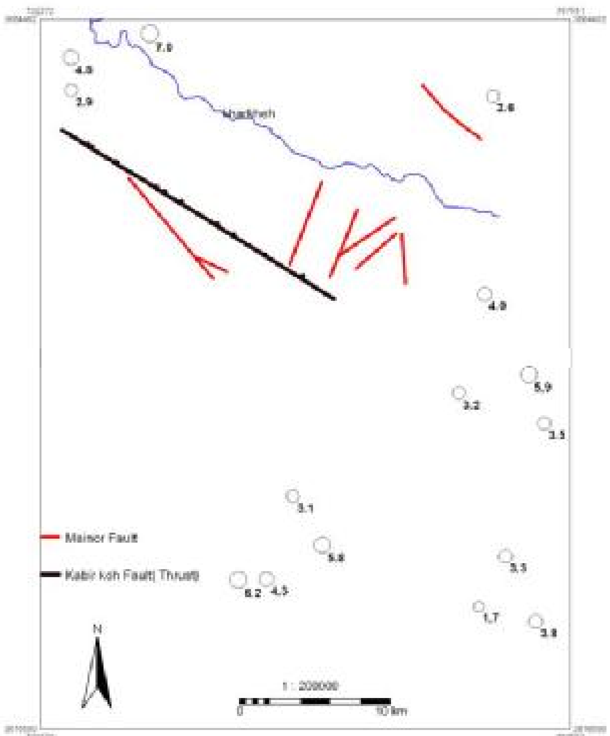
Characteristics of the major faults in the surveyed range

Row	Fault name	Fault length	The nearest distance to the surveyed region	Maximum Seimicity Magnitude	Mechanism
1	F1	150	15	6.8	Reverse fault
2	F2	8	8	4.2	Thrust fault
3	F3	12	7	3.8	Thrust fault
4	F4	21	2	6.7	Reverse fault

Pictures of the big landslide in Seymareh



The major fault in Kabir Kooh