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Research Article
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Controversy Coseismic Surface Faulting in the Zagros Orogenic Belt of Iran: Evidence from Tracking the Mining Pollution Indicators

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Abstract

The Zagros Orogenic Belt of Iran accommodates roughly one third of 25mm -1 north – south convergence between the Arabian and Eurasia plates. There is a strong belief that due to the presence of incompetent layers at the base or within the sedimentary covers, earthquake faults in the Zagros Orogenic Belt of Iran do not intersect the Earth's surface. Geological field works and tracking of the mining pollution indicators have revealed that contrary to what was widely believed before cosciesmic faults of the moderate – sized (up to M W 5-6) earthquakes in this region extend to the Earth's surface provided, They have sufficient system energy to power rupture propagation. It seems that lack of coseismic surface rupture in the Zagros Orogenic Belt is due to insufficient strain energy released during smaller events.

Keywords: Zagros; Fold; Iran; Thrust; Earthquake; Fault; Rupture

Introduction

The Zagros Orogenic Belt in south-western Iran is about 1500 km long and more than 2400 km wide, extending northwest – southwest from Turkey and northern Iraq to the strait of Hormuz Mount Dena with an elevation of 4410 is located in the middle of the Orogenic Belt [1]. The Zagros Orogenic Belt accumulate roughly one – third of the total rate of convergence between the Arabian and Eurasian plates [2]. In the Zagros Orogenic Belt, an on-going debate concerns coseismic surface rupture and whether earthquake slip at depth propagation to the surface producing scarp preserved through the Quaternary rocks and sediments. Some researches claim that in the Zagros region the presence of several incompetent stratigraphic units, such as Hormuz and lower Fars evaporitic series prevent fault movement from being expose at the Earth's surface. This is an important issue to resolve, as it plays a significant role in utilizing active fault traces for the assessment of earthquakes hazard in the region. Although many fault scarps are well exposed throughout the region, it is debated in the related to papers whether, they should be related to active faults forming due to coseismic slip or inactive and formed by geomorphological process [2]. The results obtained in this research from the study of field observations (balanced cross–sections) indicate that contrary to what is claimed before, a numless of faults that displaced the younger rock units. Within the sedimentary cover of the Zagros region could have reached the Earth's surface, provided sufficient strain energy was available to power the coseismic rupture propagation. This further reveals that coseismic faults in the Zagros region could indeed displaced the younger sedimentary rock layers and extend to the Earth's surface provided in the earthquakes have sufficient strain energy to power rupture propagation.

Methods

The following actions were carried out for the study of the tectonics of Surmeh County:

1- Prepare geological map of Surmeh region.

2- Determine the boundary of Surmeh's anticline in Google Earth and geological map.

3- Geological Survey.

4- Extracting tensile joints in Surmeh region, determine features and formations in Surmeh Mountain County.

5- Determination and removal of normal faults.

6- Providing a cross section of the Surmeh Mountain in the direction of the northeast to the southwest.

7- Preparation of stratigraphic column of Surmeh region.

8- Providing the status of the focal mechanism of the earthquake in the Surmeh region.

9- Determine the state of the Surmeh fault relative to the region's formations.

10- Implementation all of information in GIS software.

Location and accessibility

The Surmeh lead- zinc region a wedge shaped area of 40 square km is in Surmeh mountain country, south Firozabad and about south east of the boundary Farashband (Figure 1). It lies within a rectangle 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 in a highly populated area. The only a town about 3 km near the region, area Firozabad, with population in 2015 of about 121417 respectively.

Physiogeoghraphy

The Surmeh lead-zinc county lays a broad long belt of mountainous area. That is referred to as Surmeh Mountain. The initial of topographic

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feature of the Surmeh County is the anticline of surmeh. It spreads from the southeast to the northwest limits of the map area. The vole of the Surmeh County is broad. Its bedrock floor is largely covered by sediments of Faraghan formation. Aboard the region shown on Figure 2 the highest point is boundary ridge 2239 meters. The lowest point is along the banks of the westward Faraghan formation. The surmeh mountain area lies in a vast long belt of mountainous country that is variously referred to as the Alpian System or Zagros range. The anticline of the surmeh is vast. Its bedrock floor is largely covered by Paleozoic and Mesozoic formations. Sediments that occur as two well-developed terraces at altitudes of 1500 and 1700 meters. (Beyond and above the higher terrace level the bedrock rises into partly dissected highlands).

West of the area shown on Figure 2 the slopes are steep and culminate several kilometers distant in mountains that attain altitudes of more than 2200 meters. Initial the region shown on Figure 2 the highest mountains lie in the northeastern part; the highest point is boundary ridge, altitude 2239 meters; the lowest point is along the banks of the northward-flowing Dehram River at the interval or locally boundary. East of Surmeh mountain it is nearly 10 -16 kilometres wide. In this area many bars and islands of sand and gravel are exposed during periods of low water level. A recently constructed dam at Khoorab is of sufficient height to eventually form a lake that will back water to the locally or interval boundary.

Fieldwork and tectonic setting

The principal fieldwork upon which this article is based was carried on during 2015-2017. The principal fieldwork upon which this report is based was carried on during the summers of 2015-2017. The average field season was from the middle of June through the middle of September. The resulting maps, which ranged widely in scale from map to map, generally showed the outline of individual crop Figurengs, 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. Some of the geologic units, structural features, and interpretations incorporated in the present report were formulated. The rocks in the Surmeh region range in age from Cambrian to Permian. The Quaternary deposits include limestone, dolomite, salt, shale are seen. These maps were great aid in the location of many crop Figurengs, and some of this early work is incorporated in the present report, as specifically credited.

Previous Work

One of the most important international works done on the survey of surface rupture in the southwest of the Zagros Autonomous Belt is:

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 evolution and drainage development in the Zagros mountain of Fars province, SE, Iran basin [3], locations of selected small earthquakes in the Zagros mountains, The structure and kinematics of the southeastern Zagros fold thrust belt [4], Crustal scale geometry of the Zagros fold thrust belt, Structural models of faulted detachment folds.

Tectonics setting

Principal features

The rocks in the surmeh mountain region range in age from Cambrian, or possibly older, to Tertiary. Quaternary deposits of surficial material mask large areas (Figures 3 and 4). The formations of Paleozoic age include, in ascending order, the Hurmoz Formation (Cambrian?), Faraghan formation (Ordovician), Nar member, Siahoo formation (Silurian), Dalan formation (Permian). Small areas of poorly consolidated rock of the Mishan Formation of Tertiary age occur locally. The Quaternary deposits include silts and sands of lacustrine origin. Small deposits of alluvium occur at a many places. Igneous rocks not seen, although wide areas of the Jahani salt domes out crop a few kilometres distant. The geologic structures are generally moderately complex, although locally they are extremely complicated. Structures include folds, faults and widespread fracture zones with prevailing north-westerly trends. The dominant structure is a wedge-shaped Graben the valley blocks or Graben which along its western border is marked by a fault with a stratigraphic throws about 200 meters. Several stages of deformation on this region are recognized.

Lithology

The rocks in the surmeh region range in age Cambrian, or possibly older, to Cretaceous. The Quaternary surficial deposits covered the entire region; they are chiefly sedimentary rocks Paleozoice-Mezozoic age. The formation of Paleozoic age include, in ascending order, the Hurmoz formation (infracamberian), the Faraghan formation (Ordovician), the Siahoo formation (Silurian-Devonian), the earlier Dalan formation (lower Permian), the Nar member formation (middle Permian), the upper Dalan formation(upper Permian) age (Figure 3).

Paleozoic formations

The total thickness of a complete stratigraphic section of the Paleozoic formations in the region centering around and expanding outward for several kilometers from the surmeh mountain lead-zinc

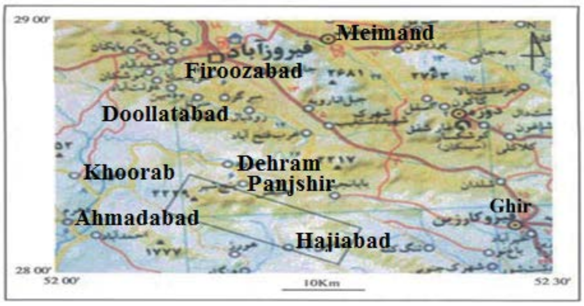

Figure 1: Map showing the location of surmeh, and the area discussed in this paper.

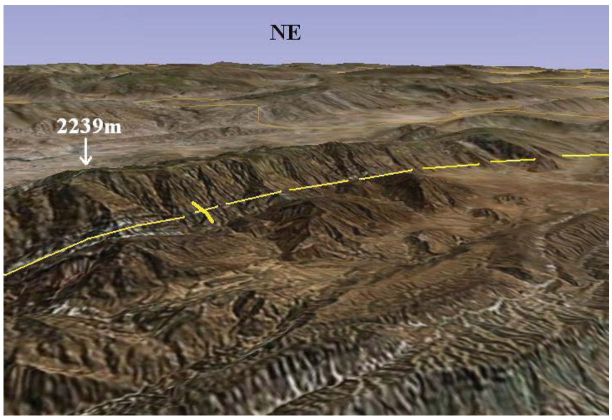

Figure 2: View Northeast across the Surmeh anticline in Surmeh mountain, SW, Shiraz, Iran. Showing the highest elevation. The scale is indicated by the length of anticline.

region is about 450 meters. These figures are based upon thicknesses obtained during the present investigation. The Paleozoic rocks described on the following pages include only those that lie within or border the large graben. Hurmoz of Cambrian, Ordovician, Silurian, and Devonian ages are represented principally by salt, limestone and dolomite. In the area mapped for these report only parts of the surmeh, Hurmoz and Dalan Formations are present. However, detailed studies were made of the surmeh mountain Limestone an irregularly dolomitized formation containing the main ore bodies the overlying the Silurian and Devonian rocks. Rocks of Silurian age had heretofore been known in this region. During the present investigation particular effort was made to establish reliable subdivisions in the surmeh mountain limestone and, in turn, to arrive at the thickness of the formation at various places throughout the mapped area. The total thickness of the surmeh mountain limestone in the region is proximally 320 meters. They assigned a total thickness of 750 meters to the Surmeh Mountain in a section east of Surmeh mountain falls. Work of the present investigation indicates that the surmeh mountain Limestone attains a total thickness of about 450 meters (Figure 5).

Structure and tectonics

The structure of the rocks of the surmeh region is complex. Several stages of deformation related to the Alpian orogeny, are recognized. These stages of deformation produced folds, low angle thrust; number us of moderate to steeply dipping normal fault and a reverse fault, a large wedge –shaped geraben and intense local fracturing (Figure 5). At many places deformation caused a recrystallization of carbonate rocks.

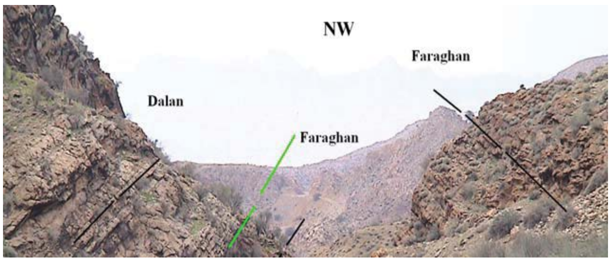

Figure 3: Geological formation of Surmeh anticline in Surmeh anticline, SW, Shiraz, Iran showing geological formation. The scale is indicated by the vegetation. View Northwest across the Surmeh mountain.The scale is indicated by the vegetation.

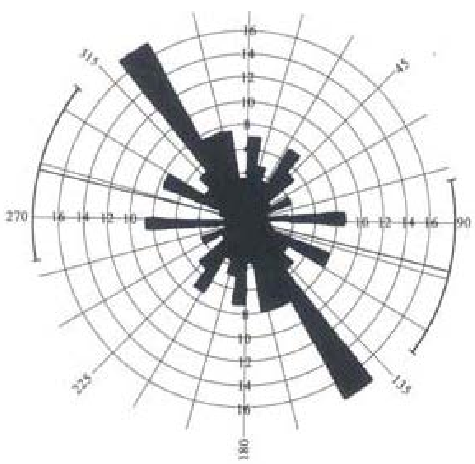

Figure 4: Rose diagram of the connects of the Surmeh mountain.

The surmeh lead-zinc region in largely contained in the outstanding structural feature of the region, simple folded belt which is uplifted and rotated along its southwest border (mountain front fault).

Fractures

One of the most important structures in surmeh region is fracture. The fractures divided to tensional and compressive system. The fractures can be seen abundance in this county. After survey, the fractures implementation in rose diagram software. According to below figure, the tensional fractures follow from Zagros' trend. The principal fractures are in highly between Sharoor, Shahrooz, A1, A2, A3 faults.

Folds

The Paleozoic-Mesozoic rocks of the surmeh mountain region are folded into a series of anticlines and synclines that range in size several kilometres across. The geological map and accompanying sections show clearly that the dominant folds within the Surmeh Mountain are asymmetrical, whereas main fold outside at mountain the south lam of the anticline is rotated toward southwest. The geologic map and accompanying sections show clearly that the dominant folds within the graben, or valley block, are broad and roughly symmetrical, whereas some folds outside adjacent to the Firozabad and surmeh fault is tight and, in places, overturned. Within this range consequently fold axes are commonly discontinuous and difficult to locate precisely, especially in areas of sparse crop Figurengs or where bedding planes have been obliterated by alteration, recrystallization, and shearing. Undoubtedly, many more folds measuring a hundred to several hundred meters across are present than are shown on the geologic map; they are even more difficult to recognize than the major folds because of the rarity of local horizon markers in addition to the reasons just mentioned. Moreover, no certain criteria could be found for recognizing overturned beds other than the general stratigraphic relations. Where field evidence seemed to indicate that a structure could be interpreted equally well as a fold or as a fault. Most of the major folds are in the large area expanding from the interval boundary south to Ghir. There are series of anticlines and synclines plunge 25°-35° SW. A northeast-plunging anticline and syncline are known to be present under the Mesozoic deposits north of the surmeh mine in the south central part of the surmeh mountain region. These folds, both cut by many later faults, are recognized in the Surmeh Mountain. Complete data obtained from a few drill holes located north and northeast of this creek indicate that main fold is detachment and have been cut and offset by later faults. Drag folds that indicate movement along bedding planes occur locally, especially in the lower strata near or adjacent to the surmeh mountain limestone. The axial planes appear to have no systematic arrangement, which may

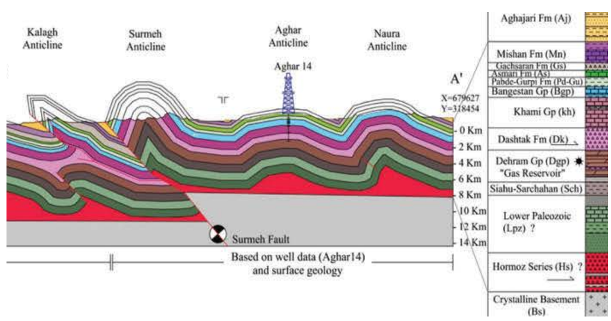

Figure 5: Geological formation of Surmeh anticline, Upper: Stratigraphy column. Lower Geological crosses section. The scale is indicated by the depth of formations.

be inherent or due to lack of sufficient data, but most fold axes trend northwest. A sharp syncline that can be traced for about 1.5 kilometres lies southwest of the Surmeh Mountain in the area (Figure 6).

Faults

Faults are abundant and widely distributed in the surmeh mountain mining region. They range in length from 100 cm or less to many kilometres, most faults are moderately to steeply dip Figureng, but a few faults are nearly vertical. Their throw ranges from a few meters or less to 4 meters or more on the normal fault. Faults are especially abundant in the mine workings. This apparent abundance is partly the result of good exposures in the mine workings and also is due partly to the more intense shattering and faulting of the rocks in the mineralized areas. Some further idea 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 meters moreover, other faults are likely present in parts of the hole that did not yield core. Many faults have smooth and slick surfaces. At many places movement is indicated by an irregularly bounded zone of stratigraphy column. Only vague and generally unreliable relationships exist between the magnitude of displacement along faults and the degree of brecciation, grooving, and polishing. The presence of slate squeezed into a fault zone commonly, but certainly not everywhere, indicates moderate displacement, as determined from many such faults found in the mines. However, many weak-appearing faults, such as the surmeh fault where exposed of the surmeh mine (Figure 6), have fairly large displacements. Mineralized cavities and caves are along some faults. Only the principal faults are shown on the geologic map (Figure 7). Many of these are based upon anomalous stratigraphic relations or offsets; only rarely are fault surfaces exposed. Largely for convenience of description 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.

Surmeh thrust

The surmeh thrust, named from the surmeh mountain mine in which it is not exposed, is a low-angle fault along which Surmeh mountain Limestone has been thrust over 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 the upper part of one over thrust plate of limestone protrudes through the surficial deposits southeast of the Surmeh Mountain (Figure 6). In the surmeh mountain mine, faulted segments of the surmeh mountain thrust are distributed over a distance more than 4 kilometers in a north-westerly direction from the surmeh anticline to plunging in a south-easterly direction the fault is indicated at many places over a distance of about 2.5 kilometres from the upper central of surmeh anticline (Figure 6). The surmeh mountain thrust is especially not well exposed along the main haulage level (Figure 6). There the gentle and variable easterly dip of the thrust can be seen along the sides of the drift, and in places the fault plane, or sole of the thrust plate, is strikingly exposed in the roof of the tunnel where, locally, grooves that bear northwest are readily seen. A study of the markings and figures along the grooves failed however to show clearly whether the overlying limestone plate had moved northwest or southeast relative to the underlying bed rock. Many diamond-drill holes, drilled from within the mine workings, show that the surmeh mountain thrust has produced a highly complex fault zone at many places, especially in the south crosscut workings. Here sharp folds, repetition of strata, and wide zones fractures are common. The original area extent and the initial

Figure 6: View SW across the Surmeh anticline in Surmeh Mountain, SW. Zagros, Shiraz, Iran. Showing formations and Surmeh fault. (Su: surmeh, Nz: Niriz, Dk: Dashtak, KN: Kangan, Da: Dalan), the scale is indicated by the tree.

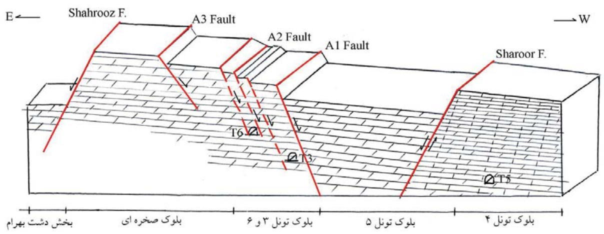

Figure 7: View South across the normal faults in Surmeh anticline, SW, Zagros, Shiraz, Iran. Showing normal faults. The scale is indicated by the movement on fault plane.

attitude of the surmeh mountain thrust are referred to earlier Permian. Erosion has likely removed many segments in bordering areas and the mine workings or drill holes disclose merely discontinuous parts of this fault, whose various strikes and dips probably do not indicate the original attitude of the thrust, but rather have resulted from movement along the younger faults that have displaced the thrust. Moreover, the bearing of the few grooves seen along the surmeh mountain thrust are probably of no major structural significance because of the likelihood that the individual fault blocks were rotated during the later period of deformation that produced the various segments. It is also probable that some segments of the thrust have not been recognized where older beds of Surmeh Mountain have been brought in fault contact with younger beds of the same formation.

History of earthquake in the southwest of zagros mountainous belt in the fars arc county

The earthquakes of the device have been identified in the southwest of the Zagros Mountain since 1976.1.1 to 2016.1.1 are used in order to determine the significance and extent of the activity of the Surmeh Mountain in this belt (Figure 8). In the sequel earthquakes from the thrust fault activity were located by GIS software. The following is presented below.

The centroid mechanism of correlate to the depth of soft layers in this county (Figure 9). Some focal mechanism of earthquakes in southwest of Zagros mountain are shown in Figure 9.

Search Criteria

Start date: 1976/1/1 End date: 2016/1/1

28 <=let<= 30 52 <=long<= 54

0 <=depth<= 1000 -9999 <=time shift<= 9999

0 <=mob<= 10 0<=MS<= 10 0<=Mw<= 10

0 <=tension plunge<= 90 0 <=null plunge<= 90

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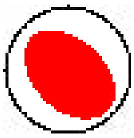
042276A SOUTHERN IRAN



Date: 1976/ 4/22 Centroid Time: 17: 3:10.6 GMT

Let= 28.49 Lon= 52.08

Depth= 15.0 Half duration= 1.6

Centroid time minus hypocenter time: 2.7

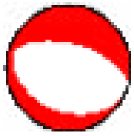
Moment Tensor: Expo=24 3.770 -1.830 -1.940 -0.630 0.060 1.550

Mw = 5.6 mb = 6.0 Ms = 5.5 Scalar Moment = 3.66e+24

Fault plane: strike=141 dip=41 slip=98

Fault plane: strike=310 dip=49 slip=83

020285B SOUTHERN IRAN



Date: 1985/ 2/ 2 Centroid Time: 20:52:34.5 GMT

Lat= 28.22 Lon= 53.48

Depth= 21.6 Half duration= 2.0

Centroid time minus hypocenter time: 0.8

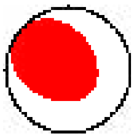
Moment Tensor: Expo=24 -1.644 1.450 0.194 0.821 -0.110 -0.496

Mw = 5.4 mb = 5.1 Ms = 5.2 Scalar Moment = 1.83e+24

Fault plane: strike=114 dip=32 slip=-81

Fault plane: strike=284 dip=58 slip=-95

050286A SOUTHERN IRAN



Date: 1986/ 5/ 2 Centroid Time: 3:18:40.1 GMT

Lat= 28.03 Lon= 53.02

Depth= 15.0 Half duration= 2.3

Centroid time minus hypocenter time: 3.0

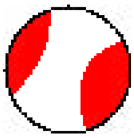
Moment Tensor: Expo=24 2.144 -1.307 -0.837 0.628 1.039 0.991

Mw = 5.5 mb = 5.4 Ms = 5.0 Scalar Moment = 2.39e+24

Fault plane: strike=107 dip=47 slip=57

Fault plane: strike=331 dip=52 slip=121

010693C SOUTHERN IRAN



Date: 1993/ 1/ 6 Centroid Time: 22:51:46.2 GMT

Lat= 29.31 Lon= 52.02

Depth= 15.0 Half duration= 1.4

Centroid time minus hypocenter time: 0.2

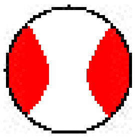
Moment Tensor: Expo=24 -0.491 -0.763 1.254 -0.034 -0.397 1.044

Mw = 5.4 mb = 5.5 Ms = 5.3 Scalar Moment = 1.49e+24

Fault plane: strike=248 dip=76 slip=0

Fault plane: strike=339 dip=90 slip=-166

030194A SOUTHERN IRAN



Date: 1994/ 3/ 1 Centroid Time: 3:49: 4.9 GMT

Lat= 28.75 Lon= 52.42

Depth= 17.0 Half duration= 2.8

Centroid time minus hypocenter time: 3.6

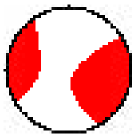
Moment Tensor: Expo=25 -0.312 -1.210 1.521 -0.102 -0.031 0.046

Mw = 6.0 mb = 5.8 Ms = 6.0 Scalar Moment = 1.37e+25

Fault plane: strike=136 dip=85 slip=-176

Fault plane: strike=46 dip=86 slip=-5

033094D SOUTHERN IRAN



Date: 1994/ 3/30 Centroid Time: 19:55:43.9 GMT

Lat= 28.96 Lon= 52.60

Depth= 33.0 Half duration= 1.3

Centroid time minus hypocenter time: -0.2

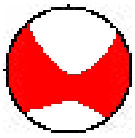
Moment Tensor: Expo=24 -0.144 -1.256 1.399 -0.343 -0.436 0.674

Mw = 5.4 mb = 5.5 Ms = 5.3 Scalar Moment = 1.58e+24

Fault plane: strike=148 dip=71 slip=177

Fault plane: strike=239 dip=87 slip=19

040394B SOUTHERN IRAN



Date: 1994/ 4/ 3 Centroid Time: 6:51:58.4 GMT

Lat= 29.01 Lon= 52.72

Depth= 33.0 Half duration= 1.1

Centroid time minus hypocenter time: -1.5

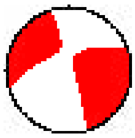
Moment Tensor: Expo=23 -0.416 -7.016 7.432 -3.273 1.145 1.201

Mw = 5.2 mb = 5.1 Ms = 4.8 Scalar Moment = 8.07e+23

Fault plane: strike=47 dip=69 slip=-11

Fault plane: strike=142 dip=79 slip=-159

062094A SOUTHERN IRAN



Date: 1994/ 6/20 Centroid Time: 9: 9: 6.7 GMT

Lat= 29.06 Lon= 52.44

Depth= 15.0 Half duration= 2.1

Centroid time minus hypocenter time: 2.7

Moment Tensor: Expo=24 -0.718 -3.948 4.665 1.356 -2.774 6.033

Mw = 5.9 mb = 5.9 Ms = 5.7 Scalar Moment = 8.05e+24

Fault plane: strike=251 dip=67 slip=-5

Fault plane: strike=343 dip=85 slip=-157

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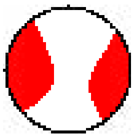
050699H SOUTHERN IRAN



Date: 1999/ 5/ 6 Centroid Time: 23: 0:58.3 GMT

Lat= 29.34 Lon= 52.03

Depth= 17.4 Half duration= 3.5

Centroid time minus hypocenter time: 5.2

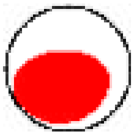
Moment Tensor: Expo=25 -0.516 -2.061 2.577 -0.397 0.381 0.590

Mw = 6.2 mb = 5.9 Ms = 6.3 Scalar Moment = 2.47e+25

Fault plane: strike=52 dip=76 slip=-6

Fault plane: strike=143 dip=84 slip=-165

030100E SOUTHERN IRAN



Date: 2000/ 3/ 1 Centroid Time: 20: 6:32.2 GMT

Lat= 28.40 Lon= 52.85

Depth= 15.0 Half duration= 1.0

Centroid time minus hypocenter time: 4.2

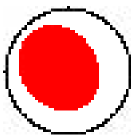
Moment Tensor: Expo=23 2.975 -1.875 -1.100 -3.035 0.625 -0.917

Mw = 5.0 mb = 5.1 Ms = 4.7 Scalar Moment = 4.03e+23

Fault plane: strike=49 dip=26 slip=55

Fault plane: strike=267 dip=69 slip=106

102403B SOUTHERN IRAN



Date: 2003/10/24 Centroid Time: 5:58:24.8 GMT

Lat= 28.34 Lon= 53.91

Depth= 33.0 Half duration= 0.8

Centroid time minus hypocenter time: 3.3

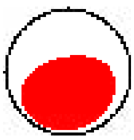
Moment Tensor: Expo=23 4.300 -2.060 -2.240 0.362 1.600 1.020

Mw = 5.0 mb = 5.2 Ms = 0.0 Scalar Moment = 4.01e+23

Fault plane: strike=128 dip=39 slip=70

Fault plane: strike=333 dip=54 slip=105

112803D SOUTHERN IRAN



Date: 2003/11/28 Centroid Time: 23:19:52.4 GMT

Lat= 28.19 Lon= 53.66

Depth= 33.0 Half duration= 0.7

Centroid time minus hypocenter time: 2.5

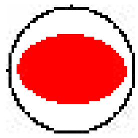
Moment Tensor: Expo=23 2.570 -1.100 -1.460 -3.180 -0.356 -0.505

Mw = 5.0 mb = 5.1 Ms = 0.0 Scalar Moment = 3.78e+23

Fault plane: strike=43 dip=19 slip=60

Fault plane: strike=255 dip=74 slip=100

121503B SOUTHERN IRAN



Date: 2003/12/15 Centroid Time: 22:57:27.7 GMT

Lat= 28.39 Lon= 53.86

Depth= 15.0 Half duration= 0.8

Centroid time minus hypocenter time: 5.0

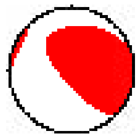
Moment Tensor: Expo=23 5.070 -4.610 -0.460 0.256 -0.005 0.111

Mw = 5.1 mb = 5.0 Ms = 4.2 Scalar Moment = 4.85e+23

Fault plane: strike=272 dip=43 slip=90

Fault plane: strike=92 dip=47 slip=90

200508090509A SOUTHERN IRAN



Date: 2005/ 8/ 9 Centroid Time: 5: 9:23.7 GMT

Lat= 28.90 Lon= 52.52

Depth= 16.1 Half duration= 0.9

Centroid time minus hypocenter time: 2.9

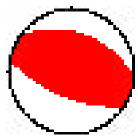
Moment Tensor: Expo=23 2.560 -3.430 0.872 2.150 -3.790 1.360

Mw = 5.1 mb = 5.1 Ms = 0.0 Scalar Moment = 5.5e+23

Fault plane: strike=257 dip=30 slip=31

Fault plane: strike=139 dip=75 slip=117

200805052157A SOUTHERN IRAN



Date: 2008/ 5/ 5 Centroid Time: 21:57:52.6 GMT

Lat= 28.19 Lon= 53.99

Depth= 12.4 Half duration= 0.9

Centroid time minus hypocenter time: -1.2

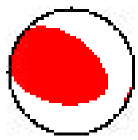
Moment Tensor: Expo=23 6.340 -5.940 -0.400 1.900 -0.914 2.650

Mw = 5.2 mb = 5.4 Ms = 0.0 Scalar Moment = 7e+23

Fault plane: strike=290 dip=36 slip=88

Fault plane: strike=113 dip=54 slip=92

201210101656A SOUTHERN IRAN



Date: 2012/10/10 Centroid Time: 16:56:34.6 GMT

Lat= 29.11 Lon= 52.56

Depth= 14.9 Half duration= 0.7

Centroid time minus hypocenter time: 1.6

Moment Tensor: Expo=23 2.210 -2.010 -0.200 0.256 1.050 1.020

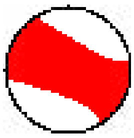
Mw = 4.9 mb = 5.2 Ms = 4.8 Scalar Moment = 2.58e+23

Fault plane: strike=93 dip=47 slip=57

Fault plane: strike=316 dip=52 slip=120

Citation: Sepasdar A, Zamani A, Yazdjerdi K, Poorkermani M, et al. (2018) Controversy Coseismic Surface Faulting in the Zagros Orogenic Belt of Iran: Evidence from Tracking the Mining Pollution Indicators. J Geol Geophys 7: 339. doi: 10.4172/2381-8719.1000339

201410280819A SOUTHERN IRAN



Date: 2014/10/28 Centroid Time: 8:19: 3.8 GMT

Lat= 28.32 Lon= 52.91

Depth= 18.9 Half duration= 0.8

Centroid time minus hypocenter time: 1.1

Moment Tensor: Expo=23 2.640 -3.600 0.958 0.447 0.349 2.760

Mw = 5.0 mb = 0.0 Ms = 4.9 Scalar Moment = 3.95e+23

Fault plane: strike=325 dip=53 slip=135

Fault plane: strike=86 dip=56 slip=47

Search criteria:

Start date: 1976/1/1 End date: 2016/1/1

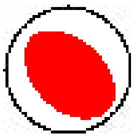
28 <=let<= 30 52 <=long<= 54

0 <=depth<= 1000 -9999 <=time shift<= 9999

0 <=mob<= 10 0<=MS<= 10 0<=Mw<= 10

0 <=tension plunge<= 90 0 <=null plunge<= 90

042276A SOUTHERN IRAN



Date: 1976/ 4/22 Centroid Time: 17: 3:10.6 GMT

Let= 28.49 Lon= 52.08

Depth= 15.0 Half duration= 1.6

Centroid time minus hypocenter time: 2.7

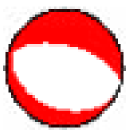
Moment Tensor: Expo=24 3.770 -1.830 -1.940 -0.630 0.060 1.550

Mw = 5.6 mb = 6.0 Ms = 5.5 Scalar Moment = 3.66e+24

Fault plane: strike=141 dip=41 slip=98

Fault plane: strike=310 dip=49 slip=83

020285B SOUTHERN IRAN



Date: 1985/ 2/ 2 Centroid Time: 20:52:34.5 GMT

Lat= 28.22 Lon= 53.48

Depth= 21.6 Half duration= 2.0

Centroid time minus hypocenter time: 0.8

Moment Tensor: Expo=24 -1.644 1.450 0.194 0.821 -0.110 -0.496

Mw = 5.4 mb = 5.1 Ms = 5.2 Scalar Moment = 1.83e+24

Fault plane: strike=114 dip=32 slip=-81

Fault plane: strike=284 dip=58 slip=-95

050286A SOUTHERN IRAN

Date: 1986/ 5/ 2 Centroid Time: 3:18:40.1 GMT

Lat= 28.03 Lon= 53.02

Depth= 15.0 Half duration= 2.3

Centroid time minus hypocenter time: 3.0

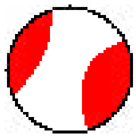
Moment Tensor: Expo=24 2.144 -1.307 -0.837 0.628 1.039 0.991

Mw = 5.5 mb = 5.4 Ms = 5.0 Scalar Moment = 2.39e+24

Fault plane: strike=107 dip=47 slip=57

Fault plane: strike=331 dip=52 slip=121

010693C SOUTHERN IRAN



Date: 1993/ 1/ 6 Centroid Time: 22:51:46.2 GMT

Lat= 29.31 Lon= 52.02

Depth= 15.0 Half duration= 1.4

Centroid time minus hypocenter time: 0.2

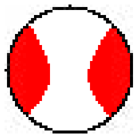
Moment Tensor: Expo=24 -0.491 -0.763 1.254 -0.034 -0.397 1.044

Mw = 5.4 mb = 5.5 Ms = 5.3 Scalar Moment = 1.49e+24

Fault plane: strike=248 dip=76 slip=0

Fault plane: strike=339 dip=90 slip=-166

030194A SOUTHERN IRAN



Date: 1994/ 3/ 1 Centroid Time: 3:49: 4.9 GMT

Lat= 28.75 Lon= 52.42

Depth= 17.0 Half duration= 2.8

Centroid time minus hypocenter time: 3.6

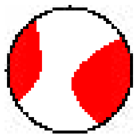
Moment Tensor: Expo=25 -0.312 -1.210 1.521 -0.102 -0.031 0.046

Mw = 6.0 mb = 5.8 Ms = 6.0 Scalar Moment = 1.37e+25

Fault plane: strike=136 dip=85 slip=-176

Fault plane: strike=46 dip=86 slip=-5

033094D SOUTHERN IRAN



Date: 1994/ 3/30 Centroid Time: 19:55:43.9 GMT

Lat= 28.96 Lon= 52.60

Depth= 33.0 Half duration= 1.3

Centroid time minus hypocenter time: -0.2

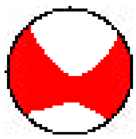
Moment Tensor: Expo=24 -0.144 -1.256 1.399 -0.343 -0.436 0.674

Mw = 5.4 mb = 5.5 Ms = 5.3 Scalar Moment = 1.58e+24

Fault plane: strike=148 dip=71 slip=177

Fault plane: strike=239 dip=87 slip=19

040394B SOUTHERN IRAN



Date: 1994/ 4/ 3 Centroid Time: 6:51:58.4 GMT

Lat= 29.01 Lon= 52.72

Depth= 33.0 Half duration= 1.1

Centroid time minus hypocenter time: -1.5

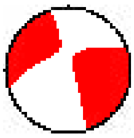
Moment Tensor: Expo=23 -0.416 -7.016 7.432 -3.273 1.145 1.201

Mw = 5.2 mb = 5.1 Ms = 4.8 Scalar Moment = 8.07e+23

Fault plane: strike=47 dip=69 slip=-11

Fault plane: strike=142 dip=79 slip=-159

062094A SOUTHERN IRAN



Date: 1994/ 6/20 Centroid Time: 9: 9: 6.7 GMT

Lat= 29.06 Lon= 52.44

Depth= 15.0 Half duration= 2.1

Centroid time minus hypocenter time: 2.7

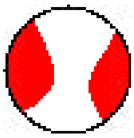
Moment Tensor: Expo=24 -0.718 -3.948 4.665 1.356 -2.774 6.033

Mw = 5.9 mb = 5.9 Ms = 5.7 Scalar Moment = 8.05e+24

Fault plane: strike=251 dip=67 slip=-5

Fault plane: strike=343 dip=85 slip=-157

050699H SOUTHERN IRAN



Date: 1999/ 5/ 6 Centroid Time: 23: 0:58.3 GMT

Lat= 29.34 Lon= 52.03

Depth= 17.4 Half duration= 3.5

Centroid time minus hypocenter time: 5.2

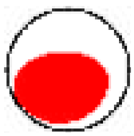
Moment Tensor: Expo=25 -0.516 -2.061 2.577 -0.397 0.381 0.590

Mw = 6.2 mb = 5.9 Ms = 6.3 Scalar Moment = 2.47e+25

Fault plane: strike=52 dip=76 slip=-6

Fault plane: strike=143 dip=84 slip=-165

030100E SOUTHERN IRAN



Date: 2000/ 3/ 1 Centroid Time: 20: 6:32.2 GMT

Lat= 28.40 Lon= 52.85

Depth= 15.0 Half duration= 1.0

Centroid time minus hypocenter time: 4.2

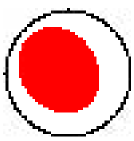
Moment Tensor: Expo=23 2.975 -1.875 -1.100 -3.035 0.625 -0.917

Mw = 5.0 mb = 5.1 Ms = 4.7 Scalar Moment = 4.03e+23

Fault plane: strike=49 dip=26 slip=55

Fault plane: strike=267 dip=69 slip=106

102403B SOUTHERN IRAN



Date: 2003/10/24 Centroid Time: 5:58:24.8 GMT

Lat= 28.34 Lon= 53.91

Depth= 33.0 Half duration= 0.8

Centroid time minus hypocenter time: 3.3

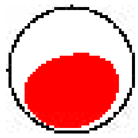
Moment Tensor: Expo=23 4.300 -2.060 -2.240 0.362 1.600 1.020

Mw = 5.0 mb = 5.2 Ms = 0.0 Scalar Moment = 4.01e+23

Fault plane: strike=128 dip=39 slip=70

Fault plane: strike=333 dip=54 slip=105

112803D SOUTHERN IRAN



Date: 2003/11/28 Centroid Time: 23:19:52.4 GMT

Lat= 28.19 Lon= 53.66

Depth= 33.0 Half duration= 0.7

Centroid time minus hypocenter time: 2.5

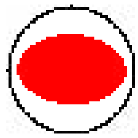
Moment Tensor: Expo=23 2.570 -1.100 -1.460 -3.180 -0.356 -0.505

Mw = 5.0 mb = 5.1 Ms = 0.0 Scalar Moment = 3.78e+23

Fault plane: strike=43 dip=19 slip=60

Fault plane: strike=255 dip=74 slip=100

121503B SOUTHERN IRAN



Date: 2003/12/15 Centroid Time: 22:57:27.7 GMT

Lat= 28.39 Lon= 53.86

Depth= 15.0 Half duration= 0.8

Centroid time minus hypocenter time: 5.0

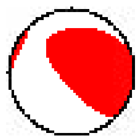
Moment Tensor: Expo=23 5.070 -4.610 -0.460 0.256 -0.005 0.111

Mw = 5.1 mb = 5.0 Ms = 4.2 Scalar Moment = 4.85e+23

Fault plane: strike=272 dip=43 slip=90

Fault plane: strike=92 dip=47 slip=90

200508090509A SOUTHERN IRAN



Date: 2005/ 8/ 9 Centroid Time: 5: 9:23.7 GMT

Lat= 28.90 Lon= 52.52

Depth= 16.1 Half duration= 0.9

Centroid time minus hypocenter time: 2.9

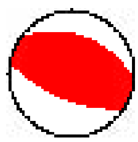
Moment Tensor: Expo=23 2.560 -3.430 0.872 2.150 -3.790 1.360

Mw = 5.1 mb = 5.1 Ms = 0.0 Scalar Moment = 5.5e+23

Fault plane: strike=257 dip=30 slip=31

Fault plane: strike=139 dip=75 slip=117

200805052157A SOUTHERN IRAN



Date: 2008/ 5/ 5 Centroid Time: 21:57:52.6 GMT

Lat= 28.19 Lon= 53.99

Depth= 12.4 Half duration= 0.9

Centroid time minus hypocenter time: -1.2

Moment Tensor: Expo=23 6.340 -5.940 -0.400 1.900 -0.914 2.650

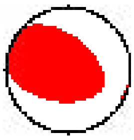
Citation: Sepasdar A, Zamani A, Yazdjerdi K, Poorkermani M, et al. (2018) Controversy Coseismic Surface Faulting in the Zagros Orogenic Belt of Iran: Evidence from Tracking the Mining Pollution Indicators. J Geol Geophys 7: 339. doi: 10.4172/2381-8719.1000339

Mw = 5.2 mb = 5.4 Ms = 0.0 Scalar Moment = 7e+23

Fault plane: strike=290 dip=36 slip=88

Fault plane: strike=113 dip=54 slip=92

201210101656A SOUTHERN IRAN



Date: 2012/10/10 Centroid Time: 16:56:34.6 GMT

Lat= 29.11 Lon= 52.56

Depth= 14.9 Half duration= 0.7

Centroid time minus hypocenter time: 1.6

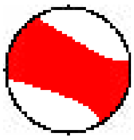
Moment Tensor: Expo=23 2.210 -2.010 -0.200 0.256 1.050 1.020

Mw = 4.9 mb = 5.2 Ms = 4.8 Scalar Moment = 2.58e+23

Fault plane: strike=93 dip=47 slip=57

Fault plane: strike=316 dip=52 slip=120

201410280819A SOUTHERN IRAN



Date: 2014/10/28 Centroid Time: 8:19: 3.8 GMT

Lat= 28.32 Lon= 52.91

Depth= 18.9 Half duration= 0.8

Centroid time minus hypocenter time: 1.1

Moment Tensor: Expo=23 2.640 -3.600 0.958 0.447 0.349 2.760

Mw = 5.0 mb = 0.0 Ms = 4.9 Scalar Moment = 3.95e+23

Fault plane: strike=325 dip=53 slip=135

Fault plane: strike=86 dip=56 slip=47

The pollution of the soil and water in the surmeh mine

If is accepted that due to presence of incompetent layers at the basement or within layers the surficial ruptures cannot seen in the southwest of Zagros simple folded, so the faults younger than incompetent Hormuz salt should not exist at the hole of this belt. For this reason and also due to the faults properties, It is accepted that attention to lithology its soil and water tobe polluted such as Anguran, Zehabad, Mahdiabad mines. So several points of the soil and water for testing selected. Their results have given by diagrams and tables at below (Figures 10-18).

The status expression of pollution lead and zinc mines (Anguran, Zehabad, Mahdiabad)

The Mahdiabad lead and zinc mine is formed in Sangestan, Taft, and Abkuh formations to Cretaceous age. Dolomite, limestone, and chert rocks are chiefly lithology in this county. The Tapehsiah normal fault is a significant fault in this mine. According to some researchers on this mine revealed that the Mahdiabad lead and zinc mine has high environmental pollution [5]. As Anguran mine is another lead and zinc mine that it has formed in Takab formation, the important components rocks in it are Schist, Tuff, Genies, and Amphibolite. Anguran mine consider the most pollution mine in Iran [6]. In another hand, the Zehabad lead and zinc mine has formed in Karaj formation to Eocene age. The analyses show that it has pollution higher than standard level [7]. So according to above passage and attention to comparison

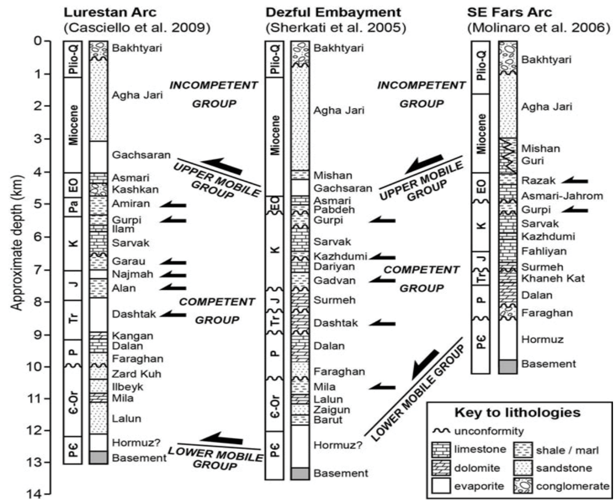


Figure 8: The location incompetent formation relation to other layers in Surmeh County.

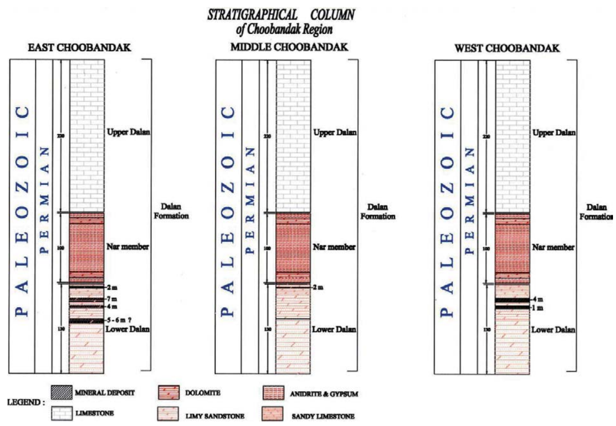


Figure 9: Geological formation of Surmeh Mountain.
Upper: Stratigraphy column.
(1) Lower Dalan, (2) Nar member, (3) upper Dalan.
The scale is indicated by thickness of lower Dalan formation.

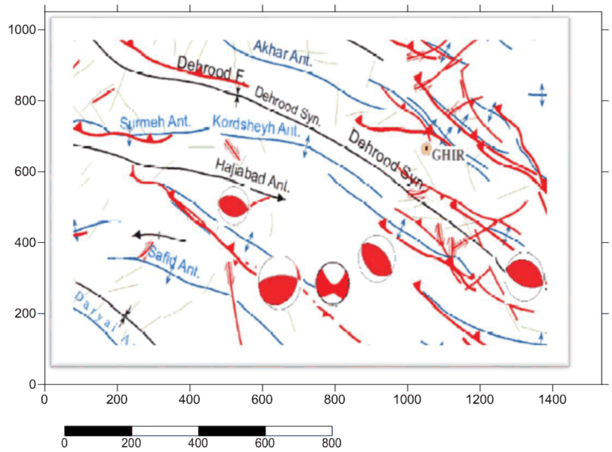


Figure 10: Focal mechanism of earthquake in Surmeh Mountain.

to pollution of the surmeh mine to other active lead and zinc mines (such as Anguran, Zehabad, Mahdiabad), the surmeh mine shows environmental pollution lower than the standard level, (Figures 11-18).

Conclusion

The geological structures outcrop in Alborz Mountain and Central of Iran, so they study very easily by satellite images. But they are hidden in the southwest of Zagros Mountain. Therefor they should study by indirect method such as solid solution of focal mechanism. In other hand, almost of the earth's scientists such as Cambridge university believe that due to be hidden the geological structures in this county to be existence the soft layers such as salt and marl, but by many more study on this region are showed several surficial rupture such

Figure 11: Water sampling stations of the S W of Zagros.

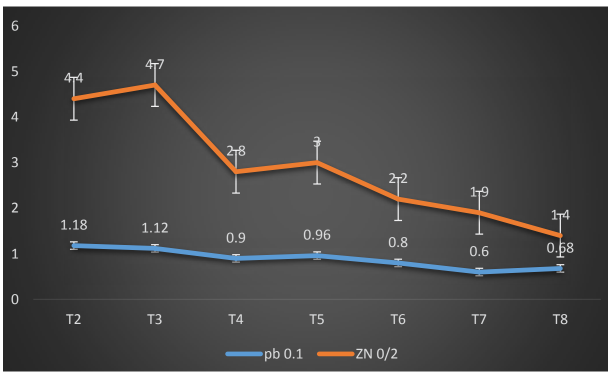


Figure 12: The variations diagram of the lead and zinc in the water of the SW of Zagros.

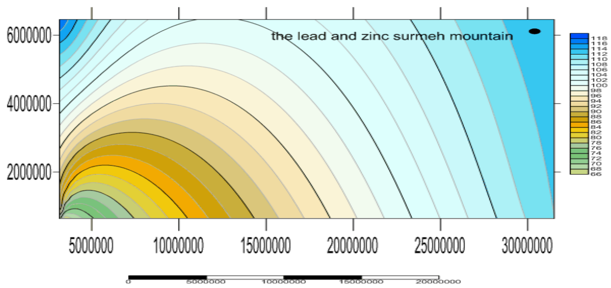


Figure 13: Lead emissions diagram in water of the SW of Zagros.

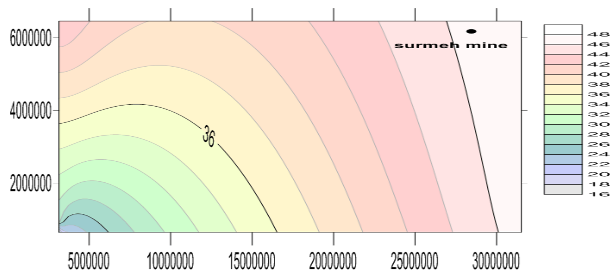


Figure 14: The zinc emissions diagram in water of the SW of Zagros.

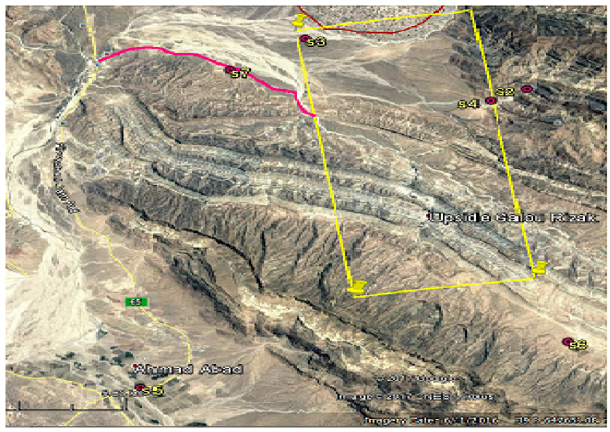


Figure 15: Soil sampling stations of the S W of Zagros.

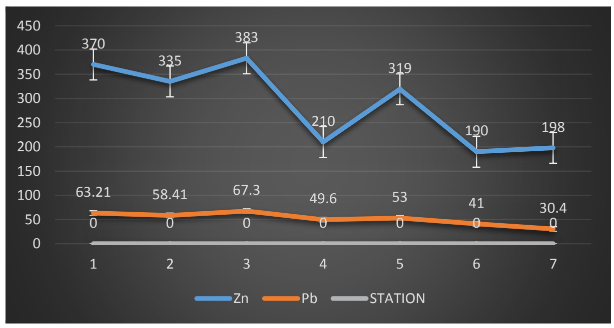


Figure 16: The lead and zinc variation diagram in soil of the Surmeh mine of SW of Zagros.

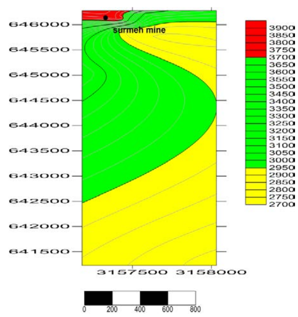


Figure 17: The zinc emissions diagram in soil of the SW of Zagros.

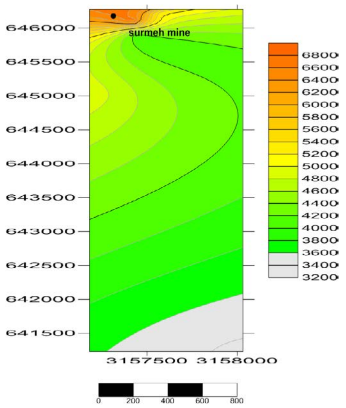


Figure 18: The lead emissions diagram in soil of the SW of Zagros.

as Furg earthquake in 1990 with 6/7 magnitude, Ghir earthquake in 1972 with 6/7 magnitude, Qeshm earthquake in 2005 with 6 magnitude, lar earthquake and recently earthquake in Kermanshah with 7.3 magnitude. As these scientists believe that rarely takes place earthquakes with magnitude more than 6 in this county, and to be the enviromental pollotion lead and zinc surmeh mine less than other lead and zinc mines in Iran show that due to these events in the southwest of Zagros Mountain has/have case or other cases. So, first, for better recognize these challenges consider a structure pattern of the southwest of Zagros Mountain is necessary.

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