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DETERMINE THE ZARNOSHEH FAULT SITUATION , SANANDAJ-SIRJAN ZONE, IRAN

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Abstract
In the past few years, construction extended extraordinarily to the northeast of Arak, Iran, where is an active sedimentary plain in the view of seismicity . The existence of active fault zone represents a hazard for such new urban areas. Therefore, it is important to know the size and position of fault zones before Building or reconstruction development. Recently, detecting fault zone using geophysical surveys has become common. In this paper, both geoelectric-resistivity using a schlomberger array and structural geology have been applied to the Arak plain . These studies revealed that the zarnosheh fault zone has dip-slip component (normal) in addition to having sinestral strike-slip component.

Keywords: Geoelectric; Resistivity method; Geophysics; Fault; Iran.

I. Introduction
Geoelectrical methods are used extensively in tectonics for investigation of subterraneous layers , the condition of alluvium and detecting the faults.

A geoelectrical measurement is carried out by recording the electrical potential arising from current input into the ground with the purpose of achieving information on the resistivity structure in the ground. In a homogeneous ground (halfspace) the current flow radially out from the current source and the arising equipotential surfaces run perpendicular to the current flow lines and form half spheres. In the common situation with both a current source and a current sink the current flow lines and the equipotential surfaces become more complex. In reality the current flow lines and the equipotential lines will form an even more complex pattern as the current flow lines will bend at boundaries, where the resistivities change, [1] .

Tozlogol basin is located 260 km far from southwest of Tehran at northeast of zagros mountain. It is between (286144, 3831232) and (500406, 3757647). This basin has a north-south trend and surround by mountains. Its vast is 2165494 hectare. Nine basins of studied area belong to Namak Lake the second order basin that it is belong to central Iran basins (Fig.1).

Fig.1. Location of the study area in a map of Iran

The studied area is in Markazi province in the view of politic deviation. Geographic limit of this area is: crest line of Saveh ,Qom , Kashan mountains in east, crest line of Nobaran, Hamedan and Razan mountains in north, crest line of Langroud , Astaneh, Shahre Miyan mountains in west and crest line of Muteh , Golpayegan mountains in south.

It is located at northwest of central Iran plateau, between two structural zone called central Iran and Sanandaj-Sirjan whereas the south and west region of it located in Sanandaj-Sirjan zone. This boundary is not abrupt, it is transitional zone. The strike of geology structures and main faults are northwest-southeast. Structural position of this area caused the sedimentation and lithostratigraphic sequence is variable. So that, the age and properties of formations and rock unites are different at different point of studied area.

The study area is covered by young alluvial of quaternary age that it has been covered the geological structure and fractures. The climate of the area is temperate mountain. The average annual rainfall of the area is more than 320 mm.

Hardness, mainly calcareous deposits and igneous unites and Erodible sediments form highlands and Lowlands of basin. There are many formation in this area such as Qom ,Tizkuh , upper red and lower red, Karaj, Shemshak, Nayband, Kazhdomi, Lalun, Mila, Darreh-Zanjir, Kahar formations. It includes a wide range of rock from sedimentary to igneous rocks, [2].

The gole of this investigation is finding the location of subsurface faults under the quaternary deposits. If the basement of Arak plain is displaced, it is determined as displacement in Geoelectrical zones. In fact, the Geoelectrical survey shows changes of the apparante resistivity in subsurface layers. The main objective of this paper is to apply both geoelectric-resistivity and geology to investigate the fault zones at Arak plain.

II. Materials and methods

Equipments, Techniques and Measurements

The Geoelectrical method is capable of mapping both low and high resistive formations.

Vertical electrical sounding, VES, is used to determine the resistivity variation with depth. Single VES should only be applied in areas, where the ground is assumed to be horizontal layered with very little lateral variation, since the sounding curves only can be interpreted using a horizontally layered earth (1D) model, [1].

A VES is typically carried out in Schlumberger array, where the potential electrodes are placed in a fixed position with a short separation and the current electrodes are placed symmetrically on the outer sides of the potential electrodes (Fig.2). After each resistivity measurement the current electrodes are moved further away from the centre of the array. In this way the current is stepwise made to flow through deeper and deeper parts of the ground. The positions of the current electrodes are typically logarithmically distributed with at least 10 positions per decade.

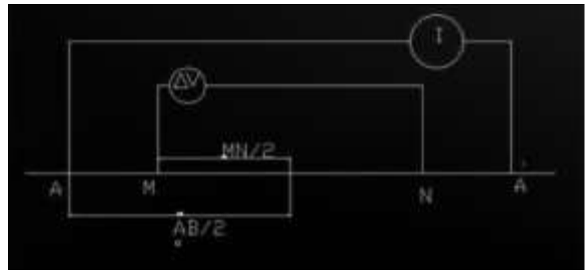


Figure 2. Electrode configurations for the Schlumberger array for resistivity surveys, [3].

The distance of the potential electrodes is increased to ensure that the measured voltage is above the noise level and the detection level in the instrument For large distances between the current electrodes. For a VES in schlumberger array, the distance between the current electrodes should be about 250 m to detect a resistivity layer boundry in the depth of 50 m, [1].

Forty seven (47) Schlumberger vertical electrical soundings (VES) were conducted across the study area using a maximum current electrode separation (AB) of 500m. Resistivity measurements were made with a digital resistivity meter (PASI – 16GL) which allows for readout of current (I) and voltage (V). Figure (3) indicates the picture of mentioned device.

Figure 3: it indicates the geophysical device PASI whose model is 16GL.Contribute a better translation.

The field curves were interpreted through partial curve matching [4] with the help of master curves [5] and auxiliary point charts [6,7]. From the preliminary interpretation, initial estimates of the resistivity and thickness of the various geoelectric layers at each VES location were obtained. These geoelectric parameters were later used as starting model for a fast computer-assisted interpretation, [8]. The program takes the manually derived parameter as a starting geoelectric model, successively improved on it until the error is minimised to an acceptable level.

Therefore, we attach much importance to geophysical and, more specifically, to geoelectric studies of the Earth's crust and upper mantle.

In the mid-1990s, during a great economic depression, Geoelectric surveys in many regions were dramatically reduced; however, it seems that the worst times are past. Nowadays we observe a steady increase in the number of geoelectric field groups using domestic and imported equipment of the latest generation and applying the most recent developments in interpretation technology, [9].

The Site selection of survey points has been done for determining of approximate location of fault line by geo electric (resistivity) notice to viewed feature of fault in the field in the studied region, then we achieved the coordinate system of desired location using GPS, we implemented coordinate system of obtained points using a laptop machine armed ARC GIS software, in which satellite images implemented, geological and topographical maps that they has been geo referenced in it ,then desired points corrected by created DEM images in ARC SCENE software, then survey of geophysical data has been done by 5 points for creating profile with arrays whose the length of each one is 3000 m in the northern and southern region of Zarnosheh fault ,respectively. Figure 4 shows the region three-dimensional DEM is created by topographic lines with 30 meter precision of desired region in different views. We used faultkin5 and SSWIN for drowing and studying fault plane solution and rose diagram, respectively, [10,11].

Figure4: The view of passing region of Zarnosheh fault on DEM image. (View north)

III. Results and discussion

Despite the sites of survey should be flat and lack of intense of topography difference in a wide range of mentioned fault caused that there were many restrictions for performance of geophysical operations so that the range of AB points were limited to 3000 meters in maximum and 100 in minimum for sounding in the region .The UTM coordinate of the sites of survey on satellite image of region has been shown in Table (1) and Figure (5,6),respectively. Then, using IPI2WIN software relevant data were investigated and their cross sections related to the fault zone were drawn that it is given in the forms of english letters (Fig.7). There were drilling log in some wells at arak plain for controlling the results.

Table 1. The coordinate system of the sites of survey data

The name of Profile	The name of soundages	UTM	
		X	Y
B	B1	390200	3771700
	B2	388700	3772600
	B3	387000	3773100
	B4	385100	3769000
	B5	383700	3774700
	B6	380700	3776300
	B7	378300	3776700
	B8	376100	3777500
	B9	374700	3778300
	B10	373000	3779000
	B11	371100	3779600
	B12	369500	3780200
	B13	392300	3771000
	K1	392300	3773000

k	K2	399000	3774400
	K3	388500	3775300
	K4	387000	3776300
	K5	384500	3777600
	K6	382600	3778700
	K7	380700	3780000
	K8	379000	3781000
	K9	375000	3783700
	K10	373300	3784600
	K11	369700	3787000
	M3	377000	3782000
C	C1	372300	3790700
	C2	374400	3789000
	C3	376000	3787700
	C4	378000	3786100
	C5	379200	3785200
	C6	381200	3784000
	C7	393000	3782700
	C8	384800	3781100
	C9	387200	3779000
	C10	389500	3778200
	C11	391000	3770000
	C12	394700	3775000
	C13	396500	3773500

L	L1	369700	3782500
	L2	370500	3784000
	L3	371500	3786000
	L4	373000	3787500
T	T1	376500	3774200
	T2	379200	3778000
	T3	380700	3780000
	T4	382000	3781600
	T5	384000	3784000

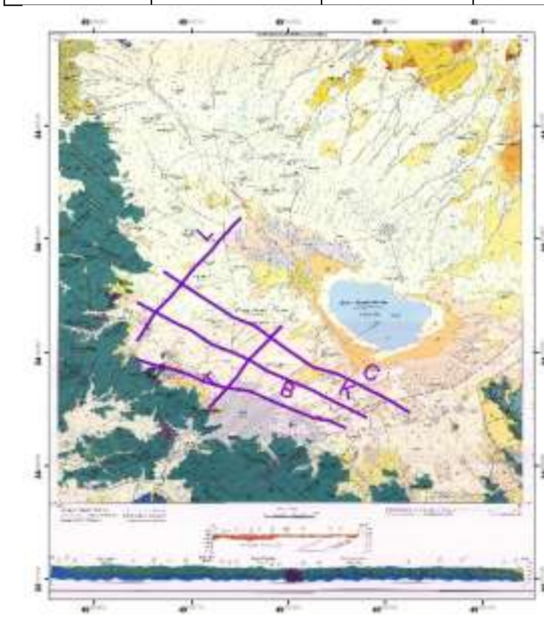


Figure 5: The geo electrical survey profiles on geological map, [12].

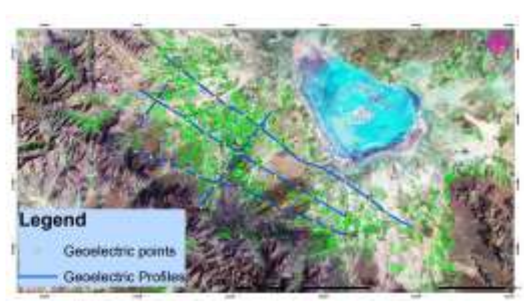
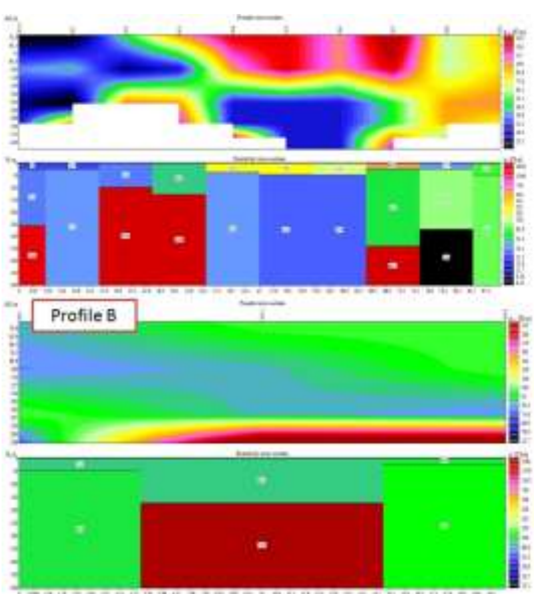


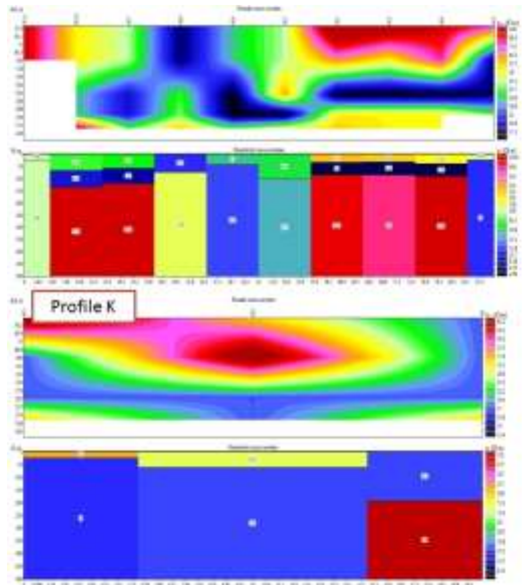
Figure 6: The geo electrical survey profiles on satellite image

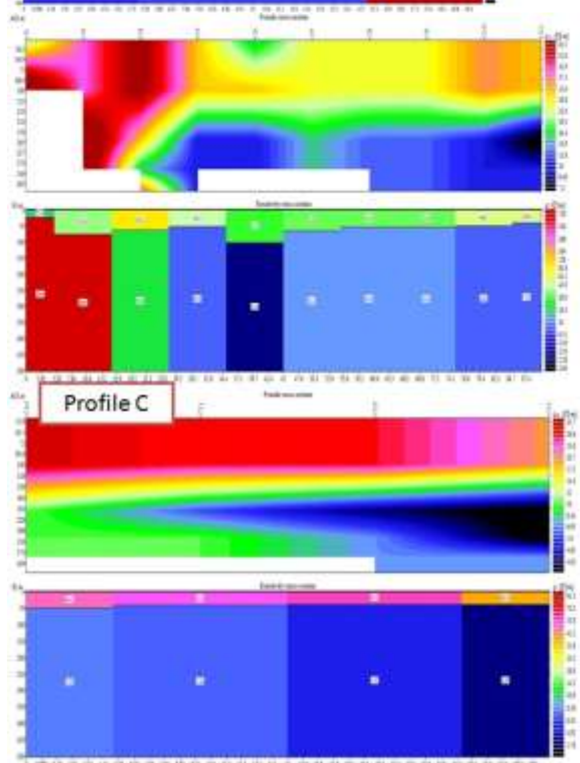
We have picked 5 profiles in the name of B,K,C, L, and T. Profiles B,K and C have a NW-SE trend with 2473.7,2663.2, and 3303.3 meter length and 13,12, and 13 soundings, respectivly.whereas two profiles (T and L) are perpendicular to other profiles. They have a NE-SW trend with 3666.2 and 1259.1 meter lenghth and 5 and 4 soundings. (Fig. 5, 6) apparent resistivity is low except in surface layers that it is maybe because water in all of profiles and apparent resistivity is high in the depth becase of different litology in the most of soundings. The fault zone was investigated by increasing humedity and decreasing the resistivity in region. There is a fault zone in B3 to B10 and K3 to K6 and C4 to C11 according to the obtained data from geophysical surveys and drawn profiles. The variation of apparent resistivity (12-57 Ωm) is vertically generally, in profile B.Profiles show the depth of basement is different according to soundings. The depth of basement in 13, 1, 2 and 3 ,4, 5 and 6 is 150 , 70 ,100 ,185, 295, 285 meter ,respectively at profile B. In general, basement is depth in 4, 5 and 6 soundings where are in the middle of profile.

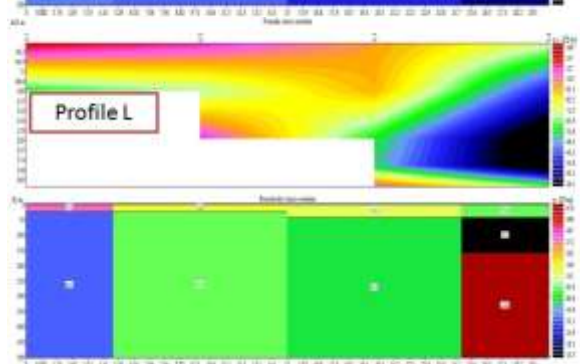
The basement of Arak plain is relatively variable. It is changing in the profile K whereas it is 145, 120,150 and 70 meter in soundings (K1,K2) , (K3,K6,M3,K9) ,K10 and K11. In the profile C and T, it changes between 50 - 100 meter and 60-70 meter, respectively.

The profile L is consists of 4 soundings that apparent resistivity is decreasing with increasing the depth in it. The depth of basement is almost fixed in this section. It is estimated 50 meter. Fault evidence did not indicate at this profile.









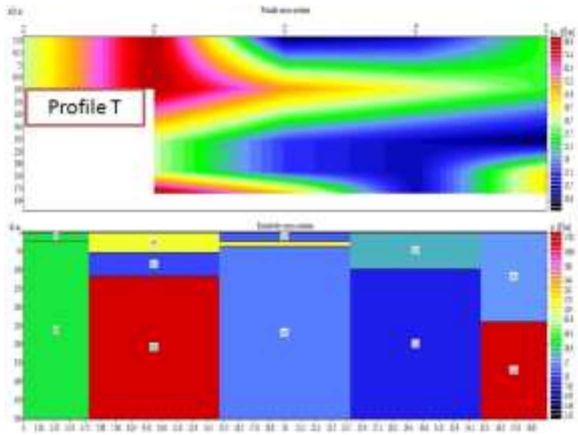


Figure 7: The pseudo cross section of profiles, the vertical axis shows the depth and the horizontal axis indicates the distance between soundings.

We found the passages of Zarnosheh fault zone by geoelectrical method at Tozlogol sedimentary basin in the Arak plain. Although the most extent of this fault was hidden under alluvial we probed the surface evidents. We analysed the joints data in 4 points (Fig.8) and obtained the data of slikensides in 5 points (Fig. 9) and therefore we haw drawn the fault plane solution, (figures 10 , 11). Other obtained evidents are indicated in figures 12 to 15.

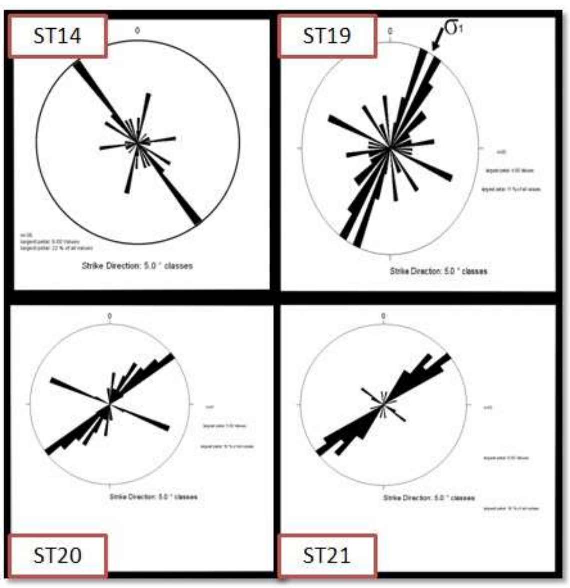


Figure 8: the rosse diagrams for joints in the length of Zarnosheh fault

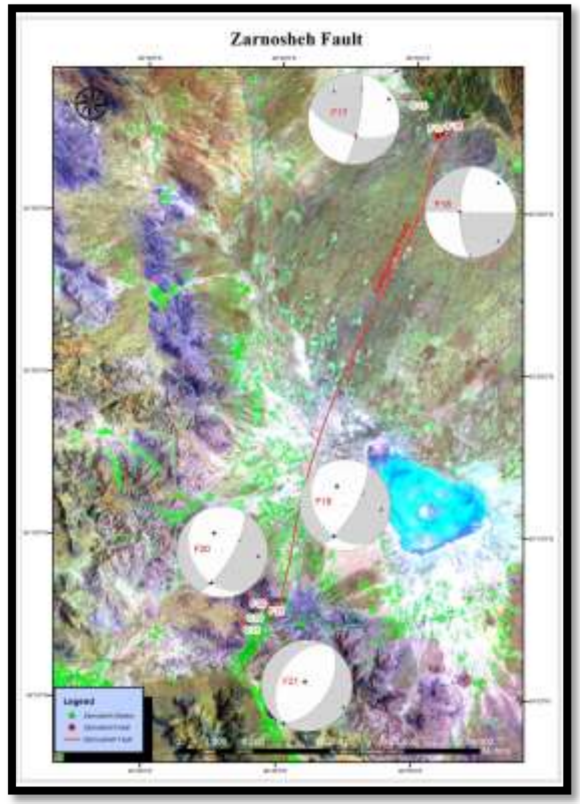


Figure 9: the position of obtained slickenside dataand joint data in the length of Zarnosheh fault

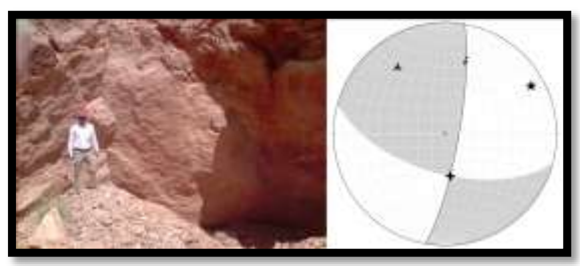


Figure 10: obtained fault plane solution (17) in the length of fault (view 20°)

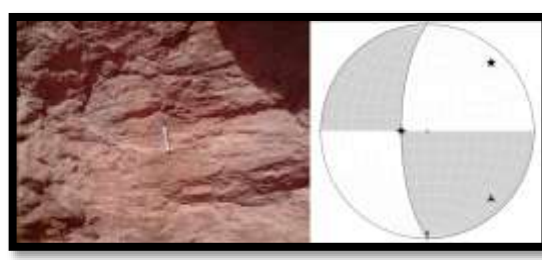


Figure 11: obtained fault plane solution (18) in the length of fault (view 160°)

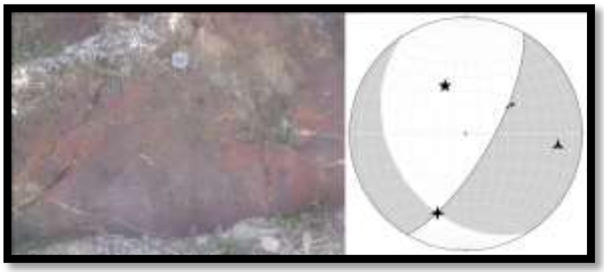


Figure 12: obtained fault plane solution (19) in the length of fault (view 300°).

According to the rose diagrams two main trends was seen at st14 and st19. These trends are 145° , 10°at st14 and 35°, 325° at st19 . The first trend has dextral and the second trend has tention component at st14 whereas it is in contrast to the st19. The second trend is parallel to Zarnosheh fault at st14 and the joints with first trend are parallel to it at st19. The station called st20 is at the bending of Zarnosheh fault, so that the changing the fractures trends is logical at it. The joints of this station have NE-SW and NW-SE trends. The main trend of joints is NE-SW at st21 because it is at the bending site of Zarnosheh fault such as st20.

Figure 13: obtained fault plane solution (20) in the length of fault (view 310°)

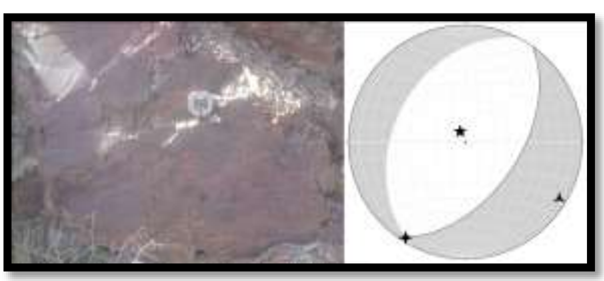


Figure 14: obtained fault plane solution (28) in the length of fault (view 335°)

Figure 15: The faulting trace at Cretaceous limeston unites and its folding at the west of Arak (view 300°).

Figure 16: sinestrial displacement at alluvial fan has been created by Zarnosheh fault zone at the south of zarnousheh village.

IV. Conclusion

According to the obtained general trend of fault, surface features, DEM models and satellite images, the general trend of fault has interpolated. The general trend of Zarnosheh fault zone is NNE-SSW in Arak plain as shown in figure 17. Its dip direction is SE . We found the length of 63.6 km for it from the north of Zarnosheh village to the west of Arak city.

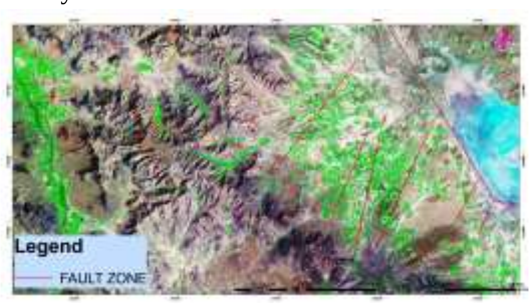


Figure 17: The general trend of faultzone at Arak plain on Google Earth

The graphical geo electric Profiles around of fault zone in the plain state tectonics movements in the mentioned region. Profiles show that the depth of basement is relatively variable in this area.

The operation of Zarnosheh fault has been moved the alluvial fan at the south of Zarnosheh village. This sinestrial displacement is 800 meter. The changing of force direct and the changing of Zarnosheh fault trend has been recorded at st21.we observed foure fault generations in this place. These generations has been shown in figure 13 from up to down. All of them have normal mechanism. The first generation has dextral strike-slip and otherones have sinestrial-strike-slip.

The results of morphotectonics and structural geology evidence and Geoelectrical surveys indicated what the Zarnosheh fault zone as a normal fault has sinestral strike-slip component in addition to having normal dip-slip component.

V. Acknowledgements

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