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# Investigation and structural analysis of Dezful Shear Zone using remote sensing

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ABSTRACT
Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to in situ observation. The research aims were to determine in the exact boundaries of the Dezful shear zones, its Geometry, Evaluation of regional tectonic and Seismotectonic, and type of shearing in addition to its widths zones shearing. Dezful shear zone is an east-west trending which is located in the northern Dezful Embayment. Dezful shear zone is a left lateral shear zone which is 180 to 190 kilometers long and almost 45 kilometers wide. Its manifest a brittle behavior based on their location in folded Zagros. Its north border is actually the Balarood south border. The east border of Dezful shear zone is limited to Mountain Frontal Fault (MFF) and it is colliding Izeh shear zone in its southeast end. Kamestan anticline is the collision spot.

KEY WORD: Shear zones, shear zone of Dezful, Dezful Embayment, structural analysis, Remote sensing

## INTRODUCTION

Remote sensing is obtaining information about a thing, region or phenomenon through experience and analysis of data using a tool which does not have physical contact with the thing, phenomena or region. This major is accepted along with other sciences as a standard approach in lots of geological studies and land survey extensively and is increasingly progressing. It has high application in structural studies in arid and semi – arid regions that plants have not covered stone surfaces and soil. This approach also enabled us to identify morphological status and morphotectonic in order to evaluate young motions and it is so much cheaper than other approaches in addition to high degree of accuracy. Surface phenomenon such as grooves and linear cavities, detachments alongside the crests, color change in soil resulted from changing moisture level of soil, existence of springs, sink, linear protraction of plant cover and even changes in type and height of plants which are shown up linearly in surface, contribute largely in identification of lineaments of geologic structure in order to investigate the possibility of earthquake in a region. Lineaments, faults and folding are structural elements which are suitably investigated through remote sensing studies (Khalaj, M, 2012).

Lineaments are large direct and indirect topographic phenomena which are observable in remote sensing images, such as areal or satellite images or on topographic maps. Although it is possible for observers not to have agreement on a large lineament, usually in an image, similar general paths are found for such lineament. Lineaments usually show the path of fault regions or main joints.

Accordingly, the region is in the north of Dezful Embayment which is recently introduced as Dezful Shear Zone by Hamoodi Obaydi *et al* (figure1) (Hamoodi Obaydi *et al*, 2014).

*Methodology:*

At first, after introducing shear zone, we began investigating the region by using satellite images such as Landsat 7 images and georeference images. In using Google earth images we tried to georeference images to better identify the phenomena and more rationalize the audiences. These manipulations in satellite images seem to be approving for readers and explains the identification of structures and analysis of geological regions.

*Shear zones:*

Shear zone is a zone with continuous strain and this deformation or strain is larger compared to other near stones. Shear zones existing in deeps and faults which are located in their counterpoint, are local strain structures which both have parallel displacement with PDZ and have inclination to expand their dimensions along with displacement accumulation (Fossen, 2010). They exist in all scales from microscopic to crustal size. Deformation behavior limitations of these regions are varying from strongly brittle and fragment to completely ductile and continuous. In fact lots of faulty regions are shear zones (Poorkermani and Arian; 2006). According to Ramsy and Hobber (1987) shear zones can expand to semi parallel or even transverse (one left-lateral and one right-lateral).

Shear zones of any type, do not continue to infinity. In some of them, displacement is conveyed to other shear zone and in other cases shear zone is faded in a vast ductile deformation area.

*Dezful shear zone:*

Dezful shear zone is first introduced by Hamoodi Obaydi *et al* (Hamoodi Obaydi *et al*, 2014). One of the challenges we face in this research is vast agriculture in the Khouzestan province which has faded most of geological structures. Investigation and identification of geological structures of the region began with investigating and analysis of images by remote sensing. Because of vast agriculture in major part of Khouzestan province and extended flats, possibility of investigation and structural identification, we are not initially able to survey the path. According to these notes, we need images with high quality and accuracy to carry out geological studies in order to identify structures. Accordingly they introduce a new shear zone in north of Dezful Embayment that using remote sensing images such as google earth and Landsat 7 significantly contributed to their identification.

Dezful embayment was first defined by Grunau (Grunau, 1960). Dezful embayment is located in southwest thrust of Zagros which due to covering Asmari formation with Gachsaran evaporate composes major oil fields of Iran. Geological evidences show that this embayment is a separate structure unit which is located among three important structural elements. At the north of Dezful embayment there is a flexural zone named Balarood region that limits Dezful embayment with its east – west direction. At northeast border, there is another flexural named mountain front flexural (or MFF) which has NW- SE direction. Finally in east – southwest border, there is a complex flexural and fault zone named Kazeroon which has north – south direction (figure 2). Activity of these large fault zones control this embayment's sedimentation and subsidence (Sepehr & Cosgrove, 2005). Field observations show that Dezful embayment probably is similar to geo-structurally embayment zone that is related to Izeh shear zone and increasing sedimentation and erosion speed resulted from uplift. The amount of this difference is estimated nearly 4-5 km and more than 5 km (Talebian & Jackson, 2004; Sherkati & Letouzey, 2004; Safari *et al*, 2009).

This embayment, with abrupt slopes and increased thickness of neogene sediments indicates the possibility of faults (Graben type) or flexural structure (Rangzan 1993).

Amount of deformation in this sub zone decreases from northeast to southwest (figure2). This happens in a way that in more north eastern regions the amount of comminution and function of thrust faults are more evident and folds have lost their normal state and some of them have changed to kink anticlines. While throughout south east, the anticlines are simpler and rather cylindrical shaped (folds) and some others have become plainer. In north Dezful embayment, there are few east–west lines of which regions are contributed to strike – slip faults and very deep basement and are operated alongside the late cretaceous (Motiei, 1995).

Dezful embayment stratigraphically contains Sarvak, Gurpi, Pabdeh, Asmari and Gachsaran (Safari *et al*, 2009). In this embayment, Miocene sedimentations of Gachsaran are considered as middle uncomponent main detachment horizon. Its thickness changes quickly begin from several hundred meters to 2000m. The reason of thickness changes can be referred to faults, folding and diapirism after deposition and also syn-sedimentation with geo-structural phenomena in folding processes. These formations include salt in their basement which is covered with layers of Anhydrite, Marley and thin layers of carbonate (Sherkati & Letouzey, 2004).

In the field of case study, focal mechanism of most of earthquakes is a reverse fault or high slopes drifts (40-50 degree) with NW–SE direction (figure1). According to the investigations carried out we can see that most of earthquakes focus on special paths which are in fact stage fault borders separating morphotectonic units of the zone.

Dezful shear zone is left-lateral and has 180-190 km length and about 45km width (figure 1 and 2).

According to Hamoodi Obaydi *et al* (Hamoodi Obaydi *et al*, 2014), north border of Dezful shear zone is contiguous with southern border of Balarood region (figure 3 and 4). Accordingly we can study Balarood region not as a line but as a shear zone with east – west direction of which south border is shared with north border of Dezful shear zone and evidences of left-lateral direction is clear in it. Changes in axis folds alongside this border can indicate left-lateral motions and the severity of this deformation is different based on the emerging stone material.

The southern border of Dezful shear zone is considered as left-lateral fault and some evidences such as direction change in Karoon River, creation of left-lateral in Gachsaran sedimentations, creation of escarpment fault and changing the axis fold in Kamestan anticline are recorded (figure 3). So, Dezful shear zone has two north and south slip borders which affect navigation pattern and severity of fractures in geological units of this zone. Structural analysis of fracture sets in Dezful shear zone indicates two different types (figure1). One set is resulted from left-lateral motion of its north border (shared border between Dezful shear zone and Balarood region) which has east – west direction. Another set which is evident in this shear zone is observed at the eastern end of it. This region most possibly is the crashing zone of shear zone of Dezful and north end of Izeh shear zone which has a north – south pattern.

Remote sensing in east of Dezful shows several main fractures system which are along with different sub-fracture sets. As we see in figure 1, direction pattern of fracture paths along of Dezful shear zones and specially near to its east part (collision with Izeh shear zone) we can see longitudinal (R') and lateral (P) fractures in addition to other paths (such as north – south (X) motions and north east – south west (D,R) motions).

*Discussion:*

Tectonic and Seismotectonic investigations of the faults province show that the transformed region is under a pressure with north – north east trend (Hamoodi Obaydi *et al*, 2014). Interesting point in Dezful shear zone and specifically Dezful embayment is related to its earth quakes (figure 4). Some researchers believe there is no possibility of severe earthquakes related to strike slip faults in Dezful since strike slip faults including Balarood lineation cannot be regarded as a strike slip fault (Hamoodi Obaydi *et al*, 2014). Accordingly, paying attention to following subjects has great importance. Release of energy from the faults depends on three factors. The first factor is related to the genus and type of stones which have major role in energy attenuation. According to the extension of Gachsaran formation which shows plasticity behavior, surface faulting is to be avoided. Existing evaporative ductile layers in this zone cause earth quakes to show short return periods and as a result because of short halts between earth quakes, the accumulated energy is not such huge to create severe earth quakes. Hence, because of evaporative formations, no surface faulting happen and Zagros earth quakes are low in severity, medium and frequent. The second factor is return period of strike slip faults which are shorter compared to pressure (reverse or thrust) faults and decreases the time of energy release with their activities. The third factor is related to oil excavations. The rich zone mentioned has been the subject of excavation and exploration from long ago because of huge oil fields in order to extract this black gold. As you know, we need drilling mud in order to drilling oil and gas wells. So during long times and after drilling hundreds of wells in this region, huge volume of drilling mud is injected into the ground. This mud (fluid) will be absorbed to the ground where internal breaks or fracture, gaps or fault exist under-ground. This has happened recently in one of western faults of US. Nuclear wastage has fluid state and US had to inter it beneath the ground in order to protect environment. Injection nuclear wastage near the faults causes to facilitate the release of the stored energy and frequent weak earth quakes to happen. So in the region, we don't have to have severe earthquakes and this doesn't have to be interpreted as no strike slip faults in the region.

The final note in this study is related to the effect of strike slip faults on their morphology. It is now proved that stone basement structures have important effects on rivers' morphology (figure 3). Lineaments and basement structures with north – south path have important effects on structure paths on Zagros and inclination of rivers in this zone. But east – west paths have important effects on local and river Canal Zone changes and generally major part of Zagros Rivers' path follow North West – south east path (Barjasteh, 2003). With entrance of Karoon River to Izeh shear zone, this river's path was affected by north – south motion. Outflowing from this zone and at the beginning of its path to Dezful shear zone, this river is affected by its southern border and follows its path as a detoured river. In other words, going along a path in dezful's shear zone, finally it outflows from Shoushtar city and continues its path toward south.

*Conclusion:*

According to the notice mentioned, in the present study, we can present the important points as following:

Dezful shear zone shows brittle behavior and characteristics according to the nature of its position in the folded Zagros. This shear zone has an east – west direction which is located at the north part of Dezful embayment. This is left-lateral shear zone which is 180-190 km long and about 45km wide. It seems that north border of this shear zone is congruous with the northern border of Balarood region. We can mention to changes in axis folds located on this border according to surface structure evidences (figure4). The southern border of Dezful shear zone has recorder evidences such as Karoon River changes in path, left-lateral detours in Gachsaran's sediments, creation of escarpment fault and changes in axis fold in Kamestan anticline (figure 3). Dezful shear zone have collided the northeast end of Izeh shear zone at its southeast end. Collision spot is place of these two shear zones is Kamestan anticlines that is create a kind of refolding in this anticline. Generally the collision spot is place of these two shear zones has various structural complexities.

There are fractures and lineation on the ground surface proportionate to the forces imposed by these shear zones. Remote sensing studies in east of Dezful indicate that several main crack trends are along with multiple subsidiary ones. The direction pattern of the cracking trends along Dezful shear zone especially close to its east (where two shear zones collided) shows other trends (north – south or (X) and north east – south west (D,R)) in addition to longitudinal (R') and altitudinal (P) cracks. It should be noted that the existing cracks and lineation in Izeh shear zone has a right lateral movement which is manifested as left lateral behavior in Dezful shear zone.

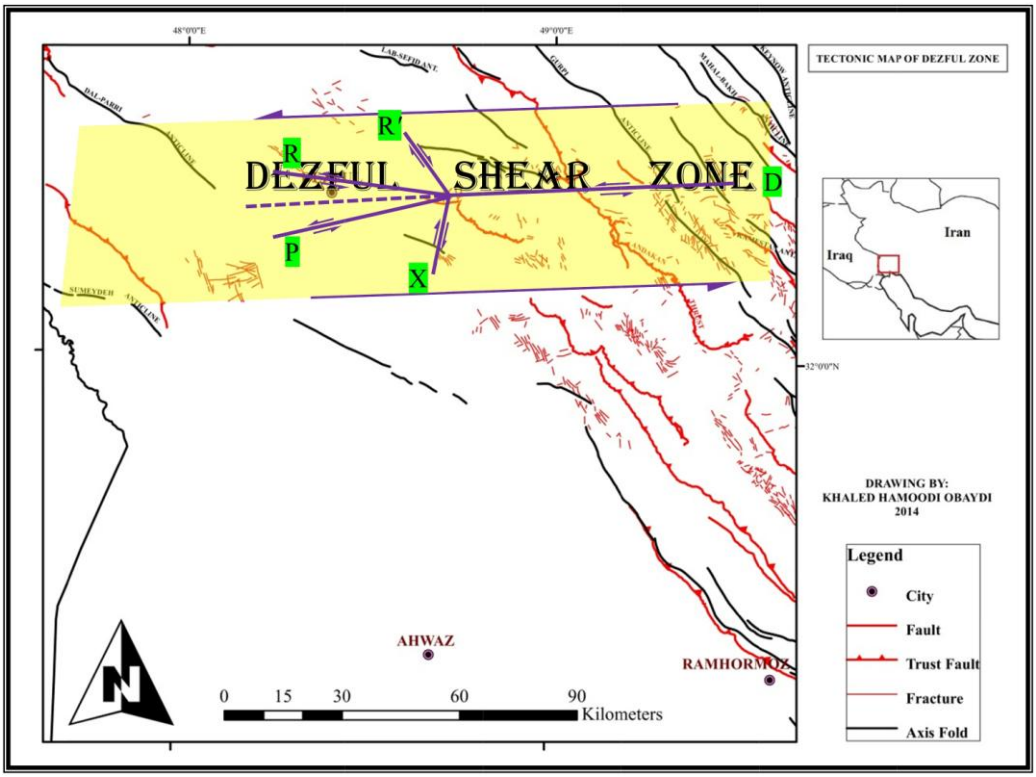


**Fig. 1:** This is the tectonic map of Dezful shear zone and its geographic location in Khouzestan province which is provided in GIS environment. In this image we can see the path of region's faults and also axis folds as NW–SE. fractures pattern in Dezful shear zone show two different kinds.

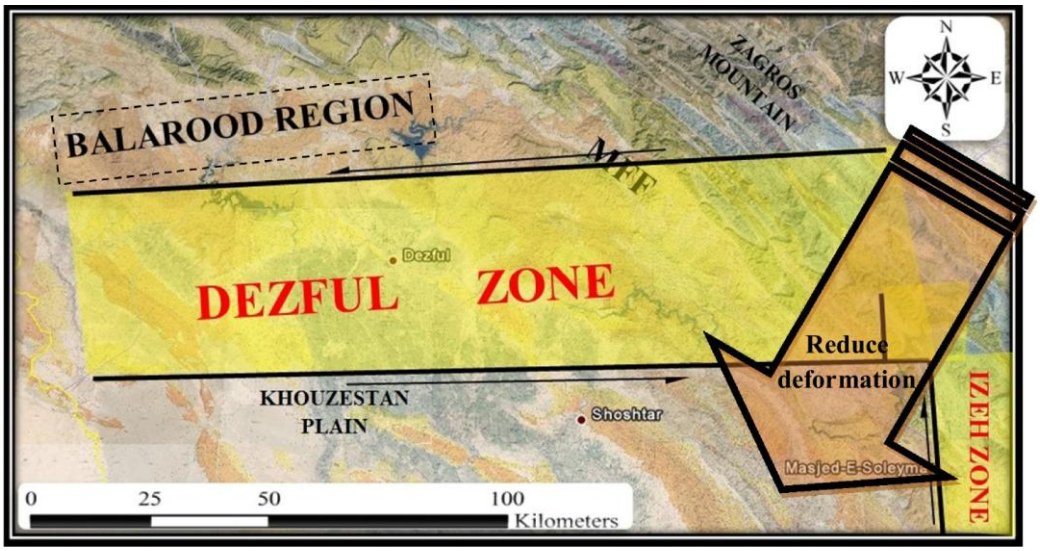


**Fig. 2:** Geo-reference map of Dezful shear zone. As we can see in this figure, Dezful shear zone which is located in north of Dezful Embayment, is surrounded by three structures: in north; Balarood region in north, Mountain Frontal Fault MFF in northeast and Kazeroon fault region in the east. The amount of deformation in this zone decreases from northeast to southwest. (With some manipulations: Hamoodi Obaydi *et al*.; 2014).

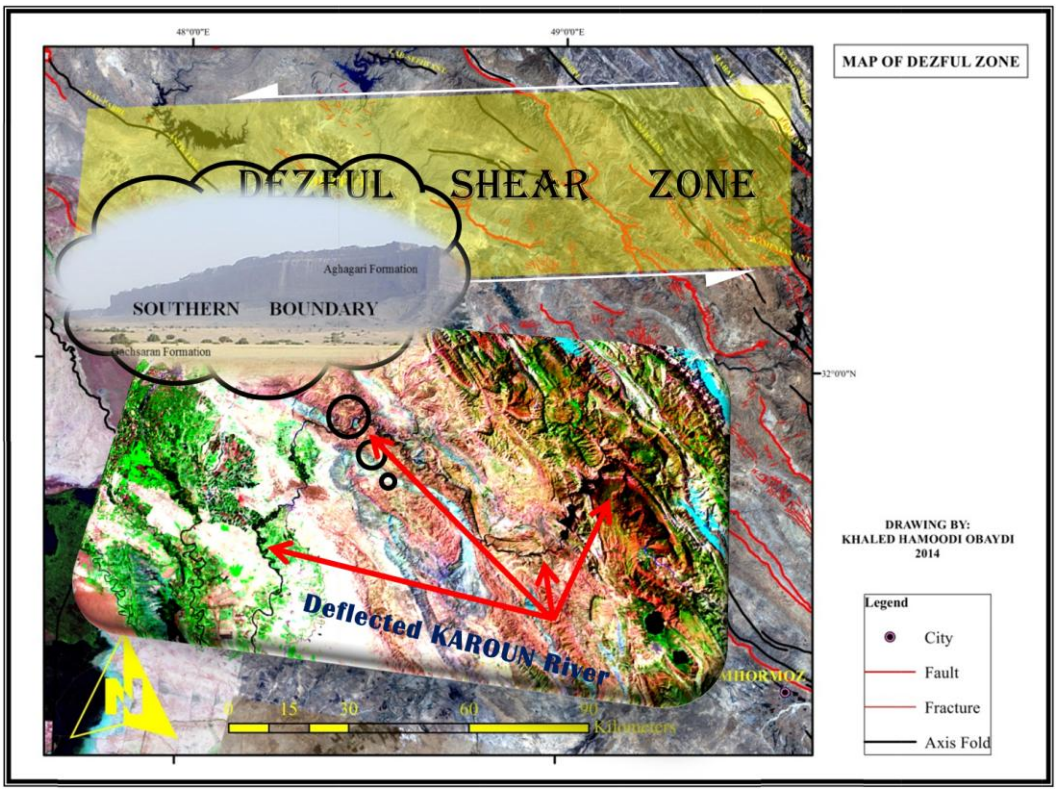


**Fig. 3:** Landsat 7 map of Dezful shear zone which is provided in GIS environment. The southern border recorded evidences such as changes in axis fold, creation of escarpments fault, changing in river path and left-lateral detours in structure of zone.

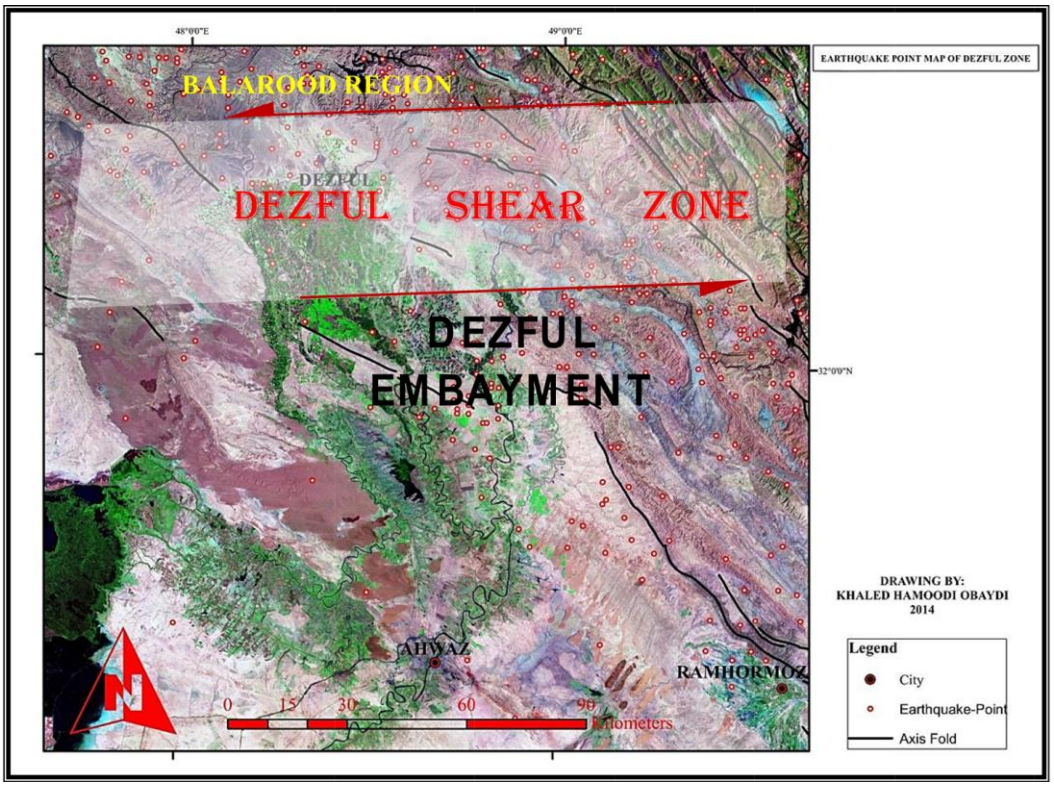


**Fig. 4:** Landsat 7 map by Mr. SID of Dezful shear zone which is provided in GIS environment. The north border of Dezful shear zone is congruous with southern zone of Balarood which has effects such as changing the axis folds of at its continue. Frequency of earthquakes is high in Dezful embayment and shear zone but their severity is low.

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