Neotectonics Controls on the Migration of the Rivers by Using Remote Sensing Imagery - A Case Study from Tabas Area - Eastern Iran

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ABSTRACT: *Landsat TM data were used in the study of neotectonics of the Tabas region in eastern Iran to assess drainage pattern and migration model of rivers. Evaluation and inspection of active tectonic processes and their effects such as earthquakes is of great importance in earthquake hazard analysis in any area. Since most processes directly related to seismic risk are not expressed in ways measurable from ground or satellite observations, using morphotectonic indicators of active tectonics may be useful for identifying these events. In this paper, the focus lies on the changes in the drainage network and the migration of rivers to get a clear understanding of active tectonics in the area. The relief in the area is remarkable due to its sharp contrasts and the multitude and variability of the morphological elements. Various geomorphic features supporting recent tectonic movements were deciphered from the various remotely sensed data. These include: strike-slip faults, fault line scarps, triangular facets, uphill facing scarps, pressure-ridges, and abrupt changes in topographic slope angles along fault traces, offset drainage, truncated fans and beheaded drainage channels. Subsequently the focus of active deformation seems to have shifted northwest, and more precisely in an anti-clockwise direction, to where the most active zone of deformation is now buried in the desert of the Tabas plain.*

Keywords: Remote Sensing; Active Tectonics, Morphotectonic; Neotectonics; Tabas

1. Introduction

The surface expression of endogenous mechanisms driving the tectonic activity is always represented by relative movements such as uplift, subsidence and translation of the crust [1, 20]. In inaccessible regions, satellite imagery provides a useful tool for geomorphological and structural studies [15]. The most sensitive parameter to surface tilting and uplift is the drainage pattern and its relationship with structures controlling the river courses. Multi-sensor and multi-date remotely sensed data and advanced digital image processing techniques are extremely useful to observe the morphotectonic activities and migration of the rivers [11-12]. This approach attempts to identify and describe the current state of neotectonic manifestations to better understand the seismic risk of any region. Iran, located in the Alpine-Himalayan seismic belt, is a vulnerable country from the viewpoint of seismic hazards. Hence, any endeavor to assess earthquake hazard is of great value and could prevent excess damage to life and property. On the other hand, it is evident that a number of destructive events can not be anticipated using recent data or even by examination of the limited historic data. For example, numerous records of strong historical earthquakes located along some of Iran's great faults exist, even though these faults currently seem calm. Importantly, most civilizations do not have more than one or two centuries history, and considering the long repeat period for most great earthquakes, identification of their tectonic regimes can not be provided with historic earthquake data (earthquakes before 1900) [4]. In a number of such regions, especially the district at the internal parts of the intraplates such as Tabas region (the current case study), paleoseismology and geomorphic evidences are very helpful to define the seismic potential of the area.

In this way, the close relationship between the tectonic geomorphology of the area and the seismotectonics of the recent earthquake lead us to define relic, inactive, active, and new-born mountain fronts in the area. The role of such studies for the better understanding of tectonic activity and historical seismicity of the region is emphasized. Disregarding these studies in seismic hazard analysis can induce irretrievable damage. For instance, the Tabas area had been classified as a low-risk region before 1978, but, the 1978 Tabas earthquake (*Mw* = 7.4), striking after an 11-century without any instrumentally recorded earthquake, dramatically demonstrated that the area is active tectonically. The event in the evening of September 30th, 1978, completely destroyed the city of Tabas with a thrust-fault of 85*km* length rupturing the surface [4].

It was supposedly possible to present a better image from the active tectonics and seismic condition for the area through investigation of geomorphic indicators. Many of these active processes definitely can not be measured in short and limited period perceptions or even by historical observation [9-10]. Therefore, using the Quaternary geological parameters and geomorphic indications are very helpful to estimate seismic risk.

Monitoring of young tectonic movements, and assessing associated seismic risks, require complete understanding of the speed, nature, and configuration of these processes. Several authors have described the geomorphic expression of long-term fault-driven folding [19], the localised tectonic uplift [e.g. 6], and the forcing of surface deformation by discrete earthquake events [e.g. 5], but since almost all of these researchers focused their work on the fractured zone of the 1978 earthquake, the question remains whether the active deformation zone in the area is limited to the 1978 earthquake fractured zone or whether it extends further than the zone of deformation.

In order to attain an appropriate answer, the Landsat *TM* images, see Figure (1) and field observations were used to analyze and extract morphotectonic

Figure 1. Landsat ETM + Image of Tabas area, processed by Erdas 8.5 Software Package after combination bands No: 1, 2&3 assigned to RGB. The city of Tabas is located between the Shotori mountain to the east and the Tabas playa to the west.

indicators of active deformation, and geomorphologic studies of young mountain building. The attention was paid on the following features: fault scarps, fluvial traces, alluvial fans, and triangular mountain facets located on fault scarps as well as mountain fronts, beheaded drainage, and displacements of rivers. By combining observations of surface deformation and geomorphic indications of active deformation using satellite imagery, a simple and self-consistent picture of the neotectonics of the area was produced.

2. Geological Setting

The Tabas area is geologically part of central Iran [18], see Figure (2), which is a triangular region comprised of complicated geologic units. This complex was deformed by orogenic movements from the Precambrian to Triassic. Much of the area is covered by younger continental deposits of the Iranian platform. The rock types in the study area might be divided into three main units: 1- Shotori heights, which has been covered by limestone and dolomite units in east part of the Tabas, 2- The Kalmard mountains, west of the study area with almost similar units, and 3- The middle parts, that are covered by quaternary deposits, see Figure (2).

In more detail, it was found that the eastern rock units of Shotori mountain, ranging from Devonian to late Paleocene, include sandstone, limestone, dolomite, and conglomerate which were eroded into pediment surfaces. These folded deposits have been cut with several main or secondary faults. In the western part, rock units from Ordovician to Quaternary age outcrop around the Kalmard fault, and include limestone, shale, sandstone, dolomite and bauxite layers. Fold axes in the area show a regular geometric relationship with faults, suggesting that they are related. The most important faults of this region are the Kalmard and Shotori faults, which have strongly deformed their surrounding layers. Quaternary sediments cover nearly the study region. The most common Quaternary sediment include alluvial deposits and clay flats. Quaternary alluvial fan deposits reach low regions and their volume and size decrease away from the mountain fronts. Among the important phenomena in sediments, old alluvial deposits can be pointed out and river deposits in the intermediate part for at least four generations can be marked. Some of these alluvial fans have been either cut by the main faults or displaced by secondary faults, but some of their parts have been eliminated. The main objective in this paper is to assess the active tectonics in the center of this area.

3. Tectonic Setting

The active tectonics of Iran is driven by the northward motion of Arabian Plate with respect to Eurasia, and movement of the Indian plate to the northwest [17].

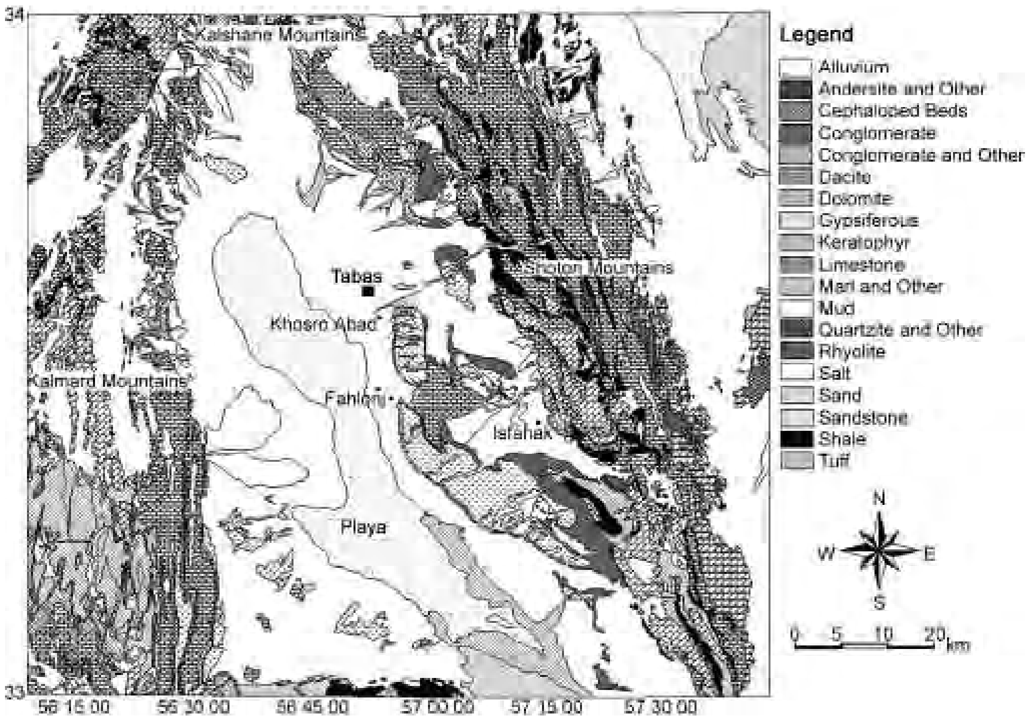

Figure 2. Geological map of Tabas area.

The Red Sea floor spreading is a response to the movement of the Arabian plate toward the north-east, as it pushes and squeezes Iran northward. This motion has caused crustal shortening in Iran, forming the folded-faulted region of the Zagros and Makran, and caused the movement of the central parts of Iran towards the northwest. On the other hand, the Indian plate moves in the direction of *N-NW* toward Iranian plate. The result of these two movements rotates Iranian plate relative rate [16], see Figure (3). At the area 25*mm/yr* of north-south shortening is accommodated across Iran [20]. Eastern Iran is a region of widespread active faulting. Right-lateral shear is taken up on several north-south right-lateral fault systems that surround the Lut desert. In the north, the right-lateral shear is seen as clockwise rotation of east-west left-lateral shear.

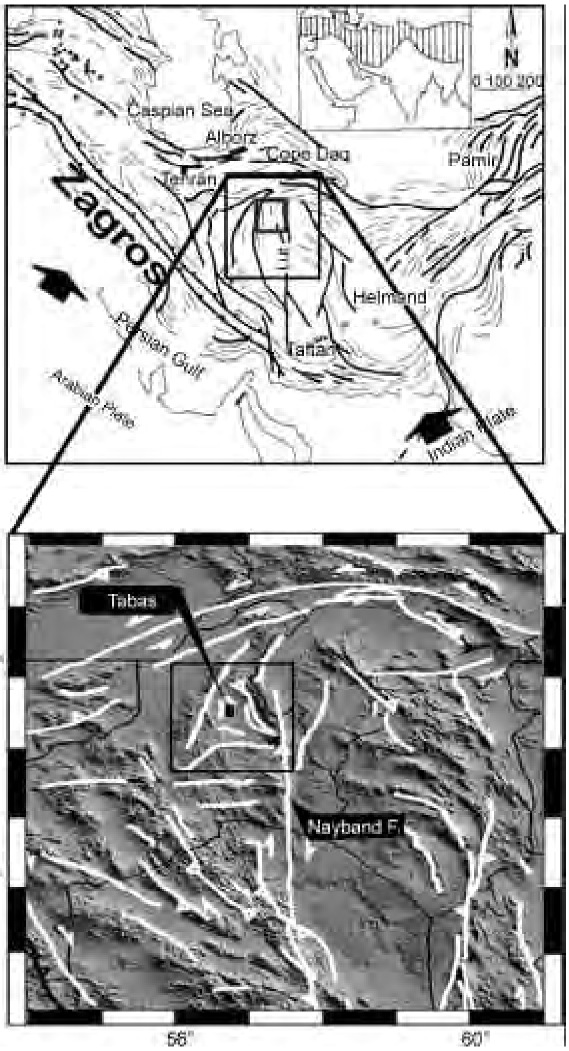

Figure 3. The active tectonics of Iran is shown in this figure. It is dominated by the northward motion of Arabian Plate with respect to Eurasia and the Indian plate to the northwest. Eastern Iran is a region of widespread active faulting. Right-lateral shear is taken up on several north-south right-lateral fault systems that surround the Lut desert.

Shortening components associated with the strike-slip faults resulted in widespread thrust faulting [17]. These thrust faults often fail to reach the surface (termed “blind” faults). The Shotori mountain range at northern end of the Nayband active fault is one of the east central Iranian ranges east of the city of Tabas, as shown in Figure (3), but the low rates of seismicity lead the parts of central Iran west of the Tabas area to be considered as relatively strong and non-deforming crustal blocks, in which few active faults have been mapped and few historical earthquakes are recorded [2]. However, there are clear indications of Quaternary fault movement in these areas. Many of these fault systems have been responsible for destructive earthquakes, and pose a serious seismic hazard to local populations. However, little is known of their evolution, development and rate of slip. The seismic activity in East Iran is characterized by the occurrence of large magnitude shallow earthquakes concentrated in limited regions on active fault zones around the Lut Block. Considering the pattern of seismicity around the Lut Block, it seems that there is an alternative occurrence of large destructive earthquakes on the northeast and southwest borders, the earthquake occurrences as well as a north to south migration of earthquake occurrence on fault zones bounding it in the west and east.

Borders between the blocks absorb some of the kinetic energy between the plates and create complex structures. Considering these facts, it is believed that the existent structures can not be justified by a simple tectonic regime. Numerous studies indicate that there are various models for the tectonic setting of the study area zone. Some suggest that the central Iran is formed as a result of suturing of sub-continents which were transformed to a sub plate and has faced transformations and rotations. Some others suggest that the central Iran consists of the plates which the right lateral movements have dissected into inter-continental basins, dependent structures and changes related with them. What is important is that the borders of these blocks consist of the main faults of the region. These faults are deep and more or less are indicators of infrastructure changes. Their kinetic inversion during compression-tensional phases indicates that the main faults have a deep expression and have witnessed a long geological history.

Some of them have been controlling the sedimentation regime and geometry of the old basins. Thus, the above mentioned zones can be considered as a collection of rigid blocks, which are moving and displacing beside each other, and those which have controlled the old basins have surrounded a large thickness of different sediments. The Shotori mountain range is one of the east central Iranian ranges in the east of Tabas city, see Figure (4).

Folds and faults are the most important structures in the area, especially in the eastern parts. The folds and faults show three main trends: *N-S*, *NW-SE* and *W-E*. The recent deformations have mostly acted brittle and with sudden movements have induced an incompatibility. Generally, structures of the main faults in the Shotori system have emerged only in right-lateral forms but the younger structures in the Tabas plain most often exhibit a left-lateral shape. All these evidences show complicated tectonic regime which is caused by the interaction of the regional stress field and the local stress field. The reason is that separate blocks which slide beside each other, are compressed or detached. Therefore, it is expected that right-lateral movements, although relatively inactive at the moment, can cause energy accumulation on the corner of the blocks and energy release along the smaller faults or their inductive movement. It also might create a disorder in the mechanism of structures. The local stress fields follow from the displacement of these blocks and their border situations. Actually these borders are the places for discharging energy or damping and most of the deformation happens at these borders. The distribution of the transformation mechanisms depends on the geometric shape and how the blocks are displaced. A glance at fault mechanisms, and the geometry and dispersion of folds all over the region, reveals the variety of tectonic processes dominating in each location, and their interaction. Based on this analysis, the mechanism of the center and east of Iran is right-lateral, but recent studies indicate that this mechanism is not comprehensive [3]. The faulted-folded belt in the south of Tabas indicates a *N-S* compressional regime, but the contractional structures have been constituted with a different pattern and a geometry unsimilar to the Shotori mountain. Study of river migration can help one to obtain a logical understanding of the modern tectonic regime in the area and it can be helpful to identify the active zones which are important for earthquake hazard assessment.

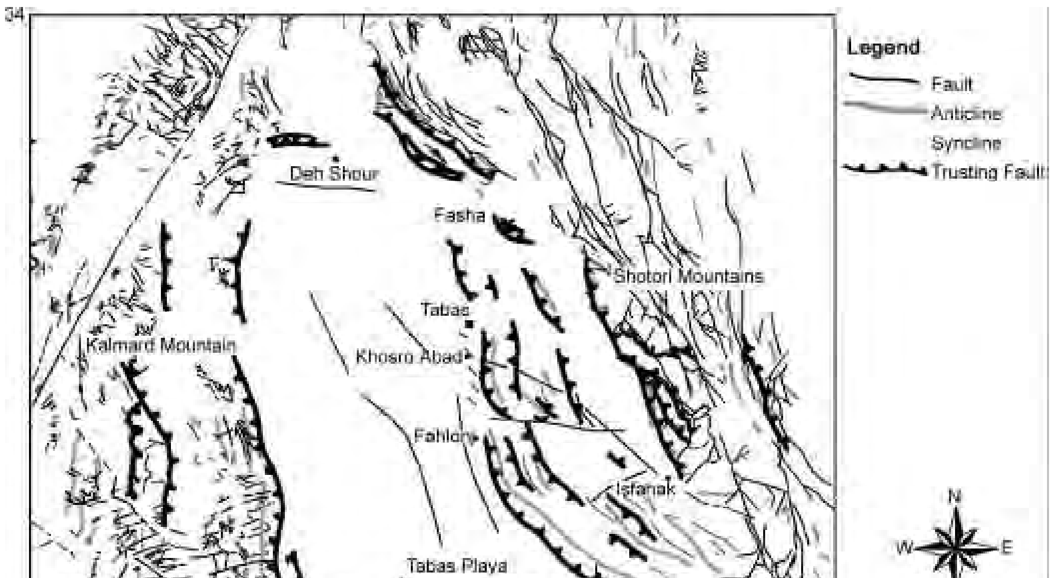

Figure 4. The map of structural geology of Tabas area in the east of Shotori mountains. The Shotori mountains on the west of the study area have emerged in a more or less compression regime, with a W-E trend and affected by devolvement model [4]. Folds and faults are the most important structures in the area especially in the eastern parts. The existent folds and faults have emerged in 3 trends: N-S, NW-SE and W-E.

4. Geomorphologic Indicators of Active Tectonics of the Study Area

Geomorphology of active fault zones often includes valuable information on the long-term development and evolution of the faulting, which is impossible to obtain by using seismology alone [14]. Processed data of Landsat *ETM+* has a super application to identify the morphotectonic evidence in desert and arid area, see Figure (1). In order to find out about the active zones in the study area, Landsat *ETM+* images were processed as the primary data source for the assessment of geomorphologic indexes. After obtaining the best possible resolution with a band combination of 2, 3 and 5 (to *RGB*) of the Landsat *ETM+* bands, the appropriate different filters such as Gaussian filter were applied to understand surface changes. Since there is no accumulated vegetation in the area, the geomorphologic evidence, including young structures, such as fault scarps, alluvial fans triangular facets, and the displacement of Quaternary sediments by faults are completely obvious and distinct by the processed satellite images. Finally, all the results were checked with field evidences which are expressed in detail. Although geomorphological transforms are gradually formed, but their effects are even more clear in the study area through decrease or increase of channel grade and deflection of sedimentation, meanders expansions, and braided pattern or incised channels of the rivers. All these indications are followed by the authors to understand the migration form of the rivers in order to get an acceptable understanding of the tectonic situation of the area. Therefore, the drainage pattern map for the study area was prepared by using satellite data and checking the 1/50,000 scale topographic maps, see Figure (5).

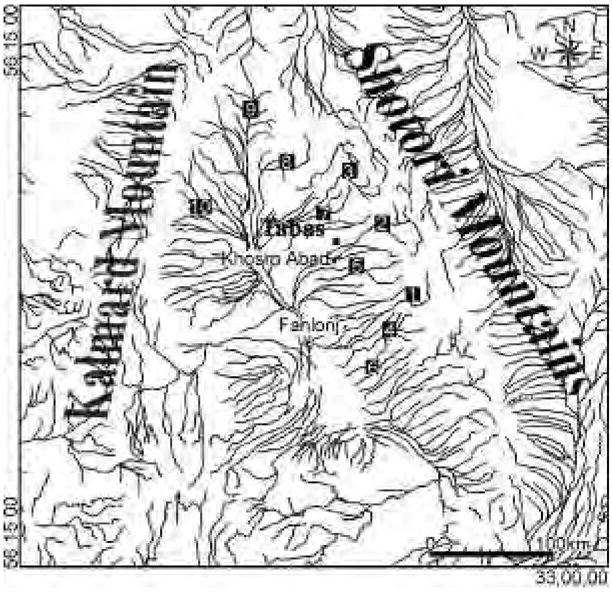

Figure 5. The drainage pattern map for the study area was prepared by using satellite data and checking with the toposheet at 1/50,000 scale. The map shows that the movements within the Shotori range include right lateral displacements but in the Tabas plain, especially the young movements contain left lateral activities.

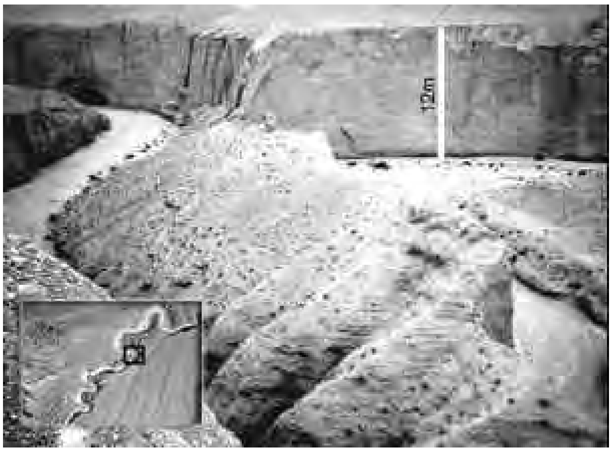

Figure 6. The photo shows Korit river bed, 68km south of the city of Tabas.

The recent study on the main rivers such as: 1) Korit, 2) Sardar, 3) Fasha, 4) Isfahak, 5) Khosro Abad, 6) Abbas Abad, 7) Kord Abad, 8) Shavalak, 9) Ezmeghan, and 10) Dehshour, indicate that the reaction of each of the mentioned river beds are different in response to the horizontal displacement effected from the sharing stress and even the vertical movements of the compression or tension components, see Figures (6) to (8).

For example, as a result of the horizontal shearing stress and deformation, the drainage pattern in south of the city of Tabas, the majority of streams at the Shotori mountain front such as, Korit and Sardar rivers have been deflected and as a result of compression- tension systems, are now a little far away from the Shotori mountain. Near the Dehshour village, deflection of rows of trees by a strike slip fault is evident, see Figure (9).

As it can be seen in Figure (9), the strike-slip fault laterally offsets the row of trees with a left-lateral movement, where trees on one side of the fault are displaced 25 to 35*cm* in an *W-E* direction. These trees have been growing for only 30 years in an agriculture organization, so the present rate of movement on the fault can be estimated. Additionally, the displacement of Quaternary surfaces by the fault allows us to place a broad limit on the minimum lateral component of the fault slip rate. Within the Shotori mountain front, offsets of the drainages incised into alluvium that was interpreted to be Holocene to latest Pleistocene in age and are used to place an estimate of the fault slip rate between 12 and 14*mm/year* for the faults with an *E-W* trend.

Figure 7. The photo shows Khosro -Abad river bed 6km south of the Tabas city. Increase or decrease of the hydraulic gradient caused by active tectonics in this river have been accompanied by the channels morphologic changes as channel excavation or sedimentation and when passing over the thrusting in the eastern of Tabas, suddenly have begun to expand their width, and by getting sinusoidal shapes in their path, the sediments have been deflected.

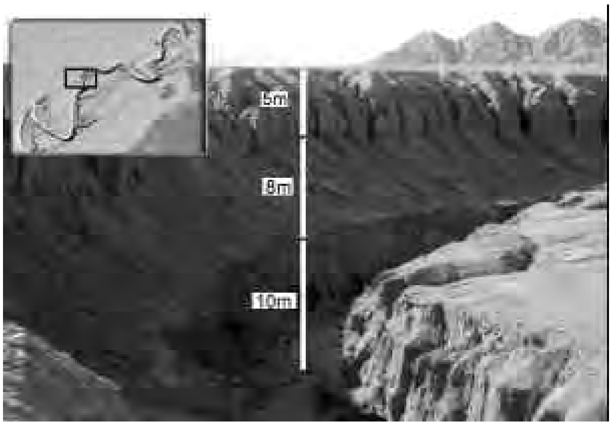

Figure 8. The photo shows Sardar river bed 8km east of the city of Tabas. The active tectonics via uplifting is the main reason that the river bed is incised by the river flow.

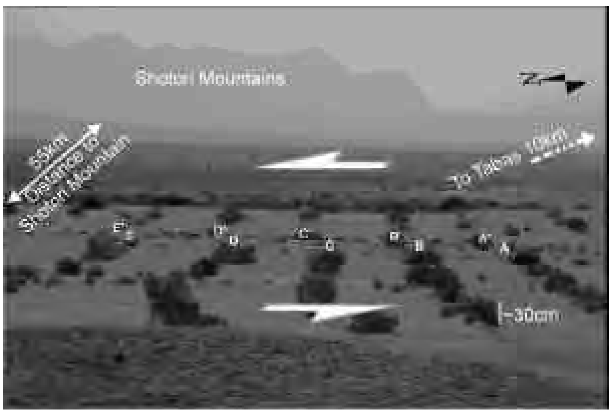

Figure 9. The field photo shows deflection of the rows of trees in west of Tabas near the Dehshour village.

Maintenance of the path of an antecedent river, meaning one that predates the structure through which it cuts - is favored by high stream power, a weak geologic sub-structure, a slow rate of uplift, and a low sediment flux. As the river incises through a growing structure, the relief between the channel and the surrounding topography will increase forming a water gap [13]. Satellite data and our recent field works show that in part of the area in southeast of Tabas, namely Shekaste Hezar-Ghach, active anticline has been formed, due to uplifting of a water gap. The action is the main cause to deflect streams in the east parts of anticline. The active anticline is rising upward, and propagation of the anticline out into the valley has pushed the north flowing stream in the area steadily eastward during the Quaternary, see Figure (10).

This water gap has been maintained, but a large wind gap to the west records an earlier path of one of the structures that was deflected by the growing anticline. In other parts of the region such as Fasha village, a short distance northwest of Tabas, it seems that frequent tilting and folding due to the faulting have caused large changes during the mountain making phase. The existence of young faults and folds in the region, considering the position of processed fault blocks relevant to the river stream may cause small or large waterfalls or sag-ponds on the river stream. Tilting in the northern parts of Fasha, and the existence of the right slide faults, have created small and cut alluvium from which beheaded streams emerged and indicated the strong activity, see Figure (11).

Figure 10. The photo shows a water gap southeast of Tabas near the Isfahak village namely Hezar-Ghach hills (No. 1). The formation of wind and water gap across a growing anticline can be seen in the photo. The larger stream can incise as quickly as the surface is rising up (No. 2). The smaller river has been deflected and has joined the river (No. 3). Between these three rivers, a water gap has been formed.

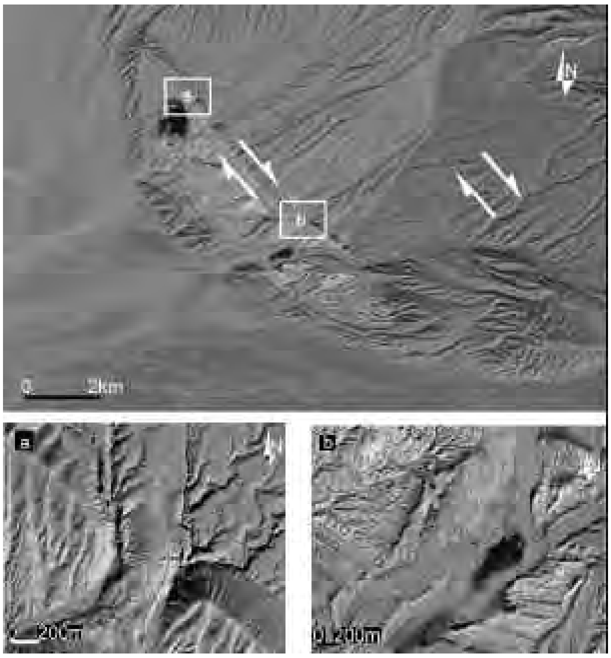

Figure 11. Landsat image of the Fasha sag pond. The folding is very clear, and the asymmetry of drainage incision, can be seen only toward the east of the fold. As it can be seen in the above satellite, image forms a deep notch through the structure "a" and "b" through the sag pond in the north part and since the steep dips are only found in the western margin of the fold, two waterfalls have been formed at the south west part of the sag pond.

Lateral displacement is of great importance for the river response, see Figures (12) to (15). Lateral shifts of an alluvial river can be detected by its asymmetrical position in a valley and by evidence for repeated channel avulsion or shifts in one direction. The recent field work was mainly along the segment of the main faults between Isfahak, south of the city of Tabas, and in Shirgesht heights, north of the city. Mapping of the displacement for the Sardar Fault disclosed that a facies contact within older alluvial fan deposits directed northeast from Sardar Ridge is left-laterally offset 2.5*km* along the Sardar fault, see Figure (12), No. 1. The age of the fan deposits is Holocene at their western edge, southwest of the Sardar, and they are perched 100*m* above the floor of Sardar river. Northeast of the fault, the fan was deposited upon a moderately eroded surface developed on essentially coeval mid-Pleistocene units. This is one of the most obvious lateral impacts on a river in the region and it is the result of active strike-slip faulting in the front of Shotori mountains. But along the Baraf fault, sediments have been displeased sinistrally, see Figure (12), No. 2.

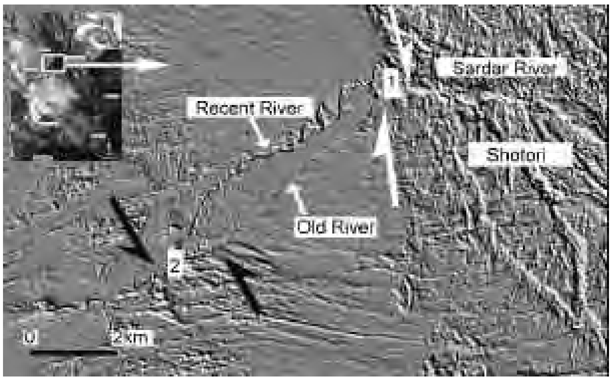

Figure 12. Sardar right-lateral strike-slip faults, cutting alluvium and displacing river systems along the western margin of the Shotori mountains. Sardar river incises a very narrow gorge up to 100m deep. The Sardar gorge exits the Shotori mountain range to the Tabas plain. The satellite image shows a pattern of left-lateral shifting of Sardar river in relation to uplifting with strike-slip component. The arrow shows the trend and stages of directional shifts from old to present condition. This indicates a migration of activity away from the range front where it is also inferred to have migrated away from the main range-front, presumably in response to stresses generated by topography.

Figure 13. The Landsat TM image shows Korit river south east of Tabas. The river meanders are displaced with a right-lateral strike-slip offset, displacing river courses and alluvium within the Shotori mountains from the north west to south east .The satellite image shows drainage displaced by almost 1.7km at the north west of the south east. The faulting cuts young deposits in beds and continues along the western margin of the Shotori mountains. As it can be seen, a new active front is rising between the Isfahak plain and Shotori mountain, and the existing meanders are in back thrusting with a reverse grade.

The geometry of river, as shown in Figure (12), and channels crossing active strike-slip faults are quite variable depending on their location, local morphology, lithology and the movement of the fault itself [7-8]. Although the analysis of drainage patterns is generally not enough to provide evidence of fault

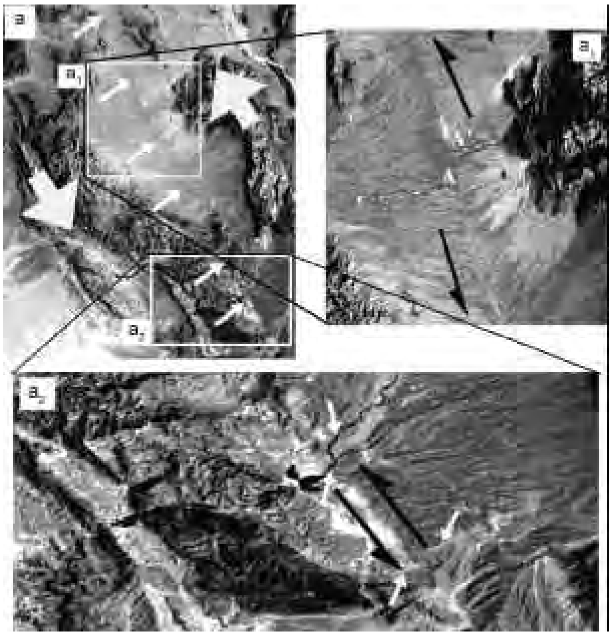

Figure 14. Left-lateral strike-slip faulting, displacing Ezmeghan river courses and alluvium within the Kuhe Sefid height in the north of Shotori mountain from north west to the south east. (a1) view of drainage is displaced by 3km near Ezmeghan. (a2) 2.5km shows displacement of alluvial gravels and drainage near the Geshn village in the north east of Tabas. A majority of the displacement along the Shotori mountain in the right-lateral shape was found, but in this area a very strong left lateral strike-slip has deflect the Ezmeghan river by 2.5km in trend NW-SE.

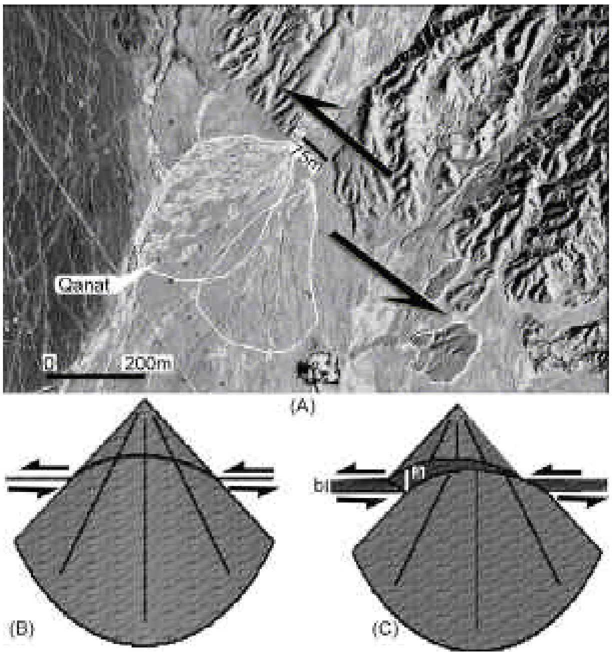

Figure 15. (A) Composite scarp in the south of Tabas near the village of Fajlonj. The scarp has a height of 15m. The real vertical displacement is 1.2m, with a left-lateral displacement of 75m. (B) Diagram of an alluvial fan was deposited across the trace of the fault. (C) Diagram of the effect of strike-slip movement on creating large apparent vertical offsets. The lateral displacement of topography at the margin of the fan produces vertical scarps with apparent heights (a) which are much larger than the true vertical displacement (b).

movement and to quantify it, the consideration of the drainage pattern can provide information on the faulting activity. To support these conclusions, the relocated earthquake epicenters prepared by the International Institute of Earthquake Engineering and Seismology (*IIEES*) was used for the area. The results proved to be acceptable and indicated a close relationship between the river migration and active faults in the area.

In addition, morphology deformation along the Korit river in southeast of Tabas was studied. The river meanders and is flanked by a wide, frequently inundated floodplain. The river carries a high suspended - sediment load, and deposits fine sand and gravel as channel bars on the floodplain. The river crosses a zone of uplift that is further deformed by extensional faulting on the axis of the uplift, see Figure (13).

Geomorphic expressions of the uplift and faulting includes the deformation of terrace profiles, tilting of paleochannels, truncation of paleochannels and faulting of fault-line scarps. The satellite image shows a right lateral displacement of this zone, see Figure (13). One includes right-lateral offsets of stream channels, apparent truncation of probable upper Pleistocene alluvial fan deposits, and a 2.5*km* horizontal offset. In exploratory trenches excavated along topographic breaks in slope, the fault offsets stream terrace deposits and colluvium, suggest possible Holocene displacement, but what is important is the changes which exist along the Korit meanders, in a manner that a new front is raising and the existing meanders are in back thrusting with a reverse grade, see Figure (12). The movement of this river to east has let the river cut the older channels. Such tilting has emerged in the north and north-east of study area and has actively incised or deflects their lateral streams.

In some parts of the study area such as the Fahlonj Uplift south of Tabas, where anticlines are growing, the apparent vertical displacement across the fault along the Shotori mountain front basin is often greater than the real vertical displacement. Closely spaced streams flow westward from the hills of the Fahlonj uplift into the Tabas playa. Each stream has deposited a small gravel fan along the eastern margin of the hills, resulting in a gently undulating topography, see Figure (15A).

The Fahlonj fault incises through each fan close to its apex, see Figure (15B). If the fault has a small dip-slip component of motion, distance (b) in Figure (15C), then the lateral displacement of topography across each fan will generate large apparent vertical offsets across one margin of the fan, distance in Figure (15C), and much smaller vertical offsets at the other edge of the fan. The right-lateral motion across the fan in Figure (15A) is 75*m*, which is similar to values measured across many other displaced alluvial fans along the fault.

5. Conclusions

Phenomena such as sedimentation displacement and horizontal excavation of the river have emerged in many rivers of the Tabas plain. Morphotectonic studies in the studied region indicate that tectonics has a direct effect on occurrence and evolution of the regional morphology; and the consistency between the structural pattern and mountains and fields, rivers, and complexity of the areas around the faults, indicate the direct role of tectonic motions. Studying the morphotectonic elements including streams, alluvial deposits, meanders, rivers, shapes, streams asymmetry, channel patterns, tectonic sag ponds in mountain front, V-shape valleys, and triangular facets in mountain fronts, all indicate the strong activity of the studied region. Seismic actions are not limited to the 1965 earthquake fractured zone, and generally these regions have the potential of seismic hazard. Our observations show that the Shotori Mountain front fault zone is a major and active structural element accommodating shear in the area. Because the fault shows principally strike-slip motion on the Tabas plain, the strike of the fault (*N* 25_*W*) can be used to locally define the azimuth of maximum shear accommodation. The azimuth is significantly more westerly than other major strike-slip faults within the area.

Mapping in the Tabas plain clarifies the Holocene and right-lateral nature of slip along the Shotori Mountain fault zone and left lateral nature for the Tabas plain, especially associated with the younger movements. Within Shotori mountain, the fault shows primarily right-lateral motions within an intermountain valley. The range front fault traverses northwestward and majority of the faults acquire a component of reverse motion in addition to the right lateral strike-slip. However, the similarity of the values is consistent with the idea that the slip rate has been relatively constant since the inception of the fault. The occurrence of the displacement of Holocene deposits shows the recent nature of deformation and is suggestive of a relatively frequent earthquake recurrence time. An approximate estimate of the average recurrence time of earthquakes can be made, if the displacements recorded on single-event scarps are used.

The recent estimations indicate that most of the activity is related to the immediate parts of the mountain front and the Sardar river bed has been strongly affected by these activities. The importance lies in the changes that exist along the meanders, in a manner that a new front is rising and the existing meanders are in back thrusting with a reverse grade.

Each of these surfaces, or a complex of active faults is segregatable. Seismic evidence and the recorded earthquakes for the past 100 years indicate that most of the recorded earthquakes have occurred near these edges. Therefore based on the geomorphic evidence, it is not easy to justify the claim that the studied region has been relatively inactive during the past eleven centuries, and the result of this study indicates the previous activities in this region. It is not possible to consider the machine data or historic data as the only basis for seismicity analysis and the necessity of including assessments of the neotectonics in risk analysis in an area is necessary and important for determining the seismic risk of the region. Seismic risk analysis without neotectonic and morphotectonic studies for each region is not reliable. We conclude that all the major parts of this interpretation can be inferred directly from the landscape, illustrating that if the signs to look for are known, the zones of active thrust faulting can be identified, even if they have not experienced any recent earthquake activity, and even if no discrete fault scarps are reported at the surface. Long-term folding and uplift produce a simple and self-consistent picture of the faulting at Tabas. Indications of active faulting and folding as well as drainage incision are presented in the landscape across the entire plain of Tabas. Modern satellite imagery enhances the ability to see the subtle patterns of uplift and drainage incision.

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