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Recognation of Geomorphic Anomalies in the Ghezel Ozan River Basin, NW Iran

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Abstract: The Ghezel Ozan River in NW of Iran shows association of geomorphic anomalies viz. sudden changes in river flow direction, anomalous sinuosity variations, straightening of river course, knick point in longitudinal profiles and distribution of overbank flooding. Such fluvial anomalies have been recognized on the satellite images and interpreted through DEM and field observations. Through this the nature of vertical movements and active structures in the area have been known. Most of the structures in the Ghezel Ozan River basin have caused the geomorphic anomalies in length of the river and the most active structures in the Ghezel Ozan River basin are surface and sub-surface faults and folds with trends of NW-SE and NE-SW.

Key words: Ghezel Ozan River · Active tectonics · Structures · Geomorphic anomalies

INTRODUCTION

Iran terrene is one of the most tectonically active regions of the world because the Arabian–Eurasian collision has been occurred. The moderate to large magnitude earthquakes and tectonically controlled geomorphic signs indicate to ongoing tectonic activity in this terrene. Numerous studies in the Iran have shown ongoing convergence and active tectonic in this area [1, 2, 3].

This paper presents the results of investigations from the Ghezel Ozan River basin in northwest of Iran. The area is characterized by numerous surface and subsurface faults and folds. Due to thick alluvial cover, current methods have failed to identify the style of surface deformation caused by the known seismogenic active faults for example Rudbar fault which was caused Rudbar earthquake of June 20, 1990. The geological investigations indicate that the earthquake occurred on a previously unrecognized fault [4]. Although fault plane solutions have determined nature of movement in a particular area affected by an earthquake; however, in very case to relate the movement with any particular fault is difficult. In this paper, we have endeavored to identify the surface deformation pattern along the surface and subsurface faults and folds with the help of data such as geomorphological anomalies and fluvial processes. This study focus on the response of longitudinal tilting on the Ghezel Ozan River system. We use a series of satellite images, geology maps and field investigations coupled with aeromagnetic and topography maps to show that the Ghezel Ozan River has responded to tectonic movements and thus, to reconnoiter the surface deformation pattern in the area.

Regional Setting: The Ghezel Ozan River flows on three structural and sedimentary zones [5] namely, Sanandaj - Sirjan, Centeral Iran and Western Alborz zones (Figure 1).

In view of regional tectonic, Sanandaj – Sirjan and Centeral Iran zones are located in Turkish-Iranian plateau [3]. It extends from eastern Anatolia to eastern Iran and typically has elevations of 1.5-2 km. Volcanic and turbidite rocks there is in this plateau, which is overlain in central Iran by the Lower Red Formation containing terrestrial clastics, evaporites and volcanic rocks of Oligocene age [6]. In across much of central Iran exists carbonatic marine deposition of the largely lower Miocene Qom Formation. The Qom Formation is overlain by Upper Red Formation with age middle Miocene which including terrestrial clastics. Based on seismicity [1] and GPS data it deduce that exist little crustal shortening over most of the plateau.

The Western Alborz zone situated in central portion of Alpine-Himalayan System and suffered shortening and uplift during Tersiary [7]. Sedimentary and volcanic rocks of different ages are involved in oblique shortening onto range-parallel left-lateral strike-slip and thrust faults and hypocentres at depths of,12 km are coeval with surface ruptures [2]. Igneous rocks and volcano-sedimentary rocks of Eocene Karaj tuff crop out in large part of the area. Incised river terraces and coastal marine terraces show there is recent uplift in the Alborz [8].

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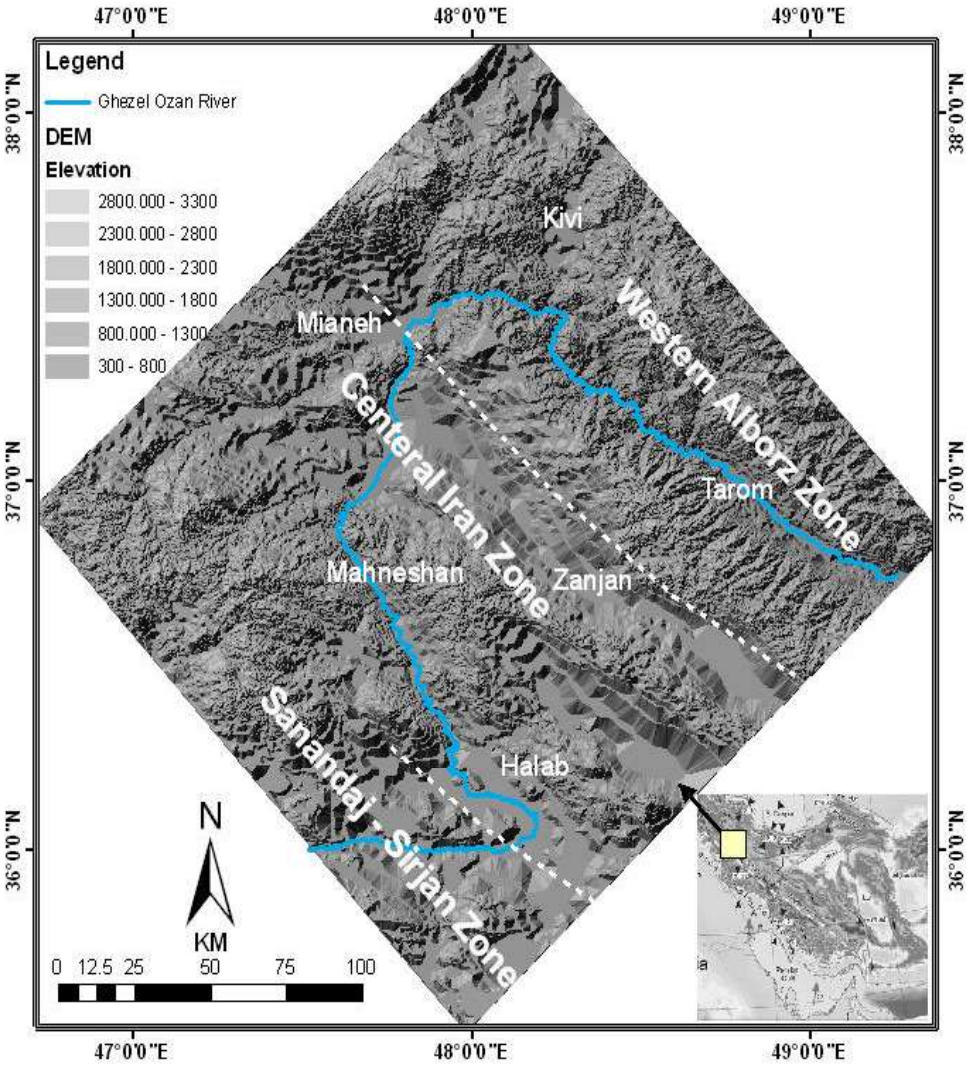

Fig. 1: DEM of the study area (USGS/SRTM data) illustrating structural and sedimentary zones marked by dashed lines and some urban points in NW Iran. Inset shows DEM of Iran with location of the study area

MATERIALS AND METHODS

Rivers are sensitive to changes in their grade caused by tectonic tilting. Tectonic warping may result in longitudinal tilting of alluvial river profiles [9]. The identification of longitudinal tilting in the Ghezel Ozan River is accomplished via: (1) sudden change in the flow of the river (deflection), (2) abnormal changes in sinuosity of the river, (3) knick points in the longitudinal profile of the river, (4) straightening of the river course and (5) distribution of overbank flooding.

For the identification of tectonically controlled geomorphological features, we used topographic maps at scale 1: 25,000, geological maps at scale 1:100,000, aeromagnetic maps at scale 1:250,000 and satellite images.

Topographic Maps and Digital Elevation Model (DEM): In this study we have used 10-m grid cell DEM. Its projection was the UTM zones 38 and 39 N. The DEM was derived from the contour lines of the 1: 25,000 topographic maps provided by Iranian Survey Organization (ISO) with 10 m contour intervals. The DEM is employed for the preparation of longitudinal profiles of the Ghezel Ozan River.

Geological Maps and Structural Mapping: The geological maps at scale 1:100,000 provided by Geological Survey of Iran are used for the determination of the type of rocks in the area and production of structural map via digitizing all the faults and folds in the geological maps.

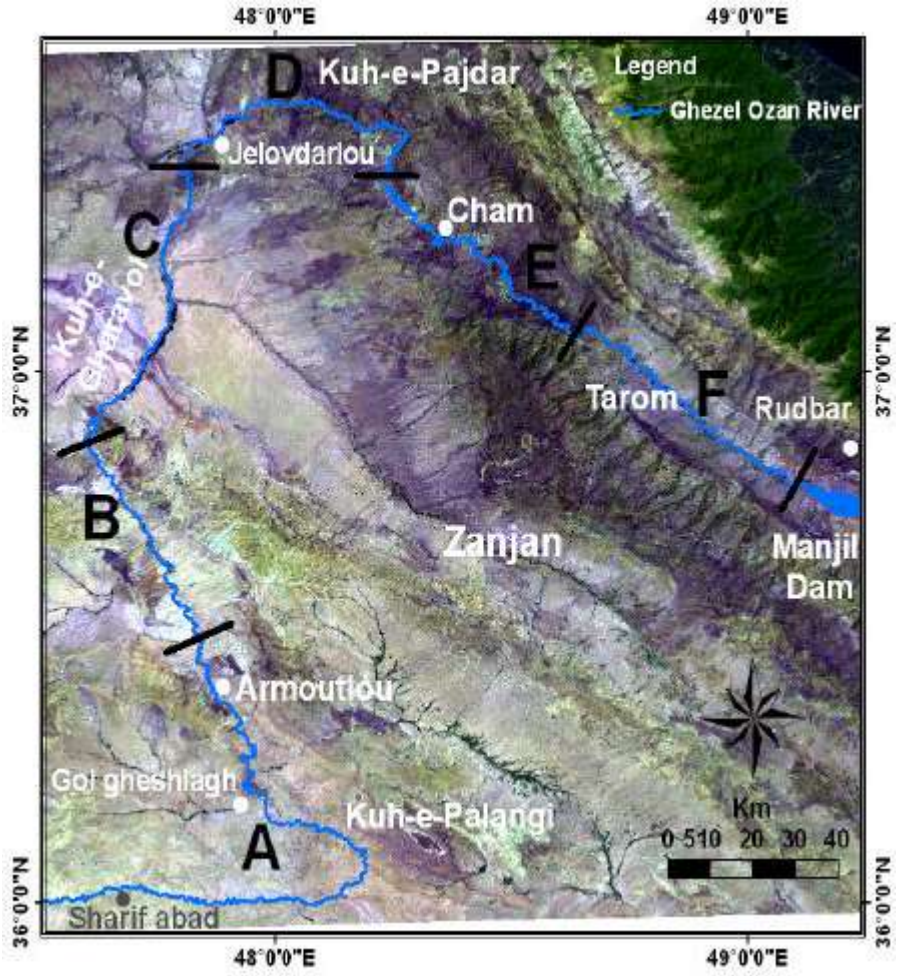

Fig. 2: Annotated Landsat image depicting the situation of segments (A, B, C, D, E and F) of the Ghezel Ozan River and key geographical regions of the study area

Aeromagnetic Maps and Lineaments Mapping: The aeromagnetic maps at scale 1:250,000 provided by Geological Survey of Iran are used for the production of lineaments map via digitizing all the magnetic lineaments in the aeromagnetic maps and the determination of the depth of the basement.

Satellite Images and Field Verifications: The Landsat ETM images with resolution of 28.5 m and by subsequent field verification are used for the recognition of the geomorphic anomalies in the length of Ghezel Ozan River. In order to collect data, first the Ghezel Ozan River is segmented into several distinct segments. The segmentation is done on the basis of orientation of the river, dispersal of streams and abundance of structures in the course of the river. In this way, the Ghezel Ozan River from upstream to downstream is segmented into 6 segments respectively A, B, C, D, E and F (Figure 2).

RESULTS

The results of remote sensing and fieldwork in various segments of the Ghezel Ozan River are as follows:

The Geomorphic Anomalies in Segment A of the Ghezel Ozan River: The Ghezel Ozan river in this segment first flows toward the east and then prolongs toward the northwest and flows thoroughly on the alluvial bed. The geomorphic anomalies and tectonic structures in this segment are shown in Figure 3. The structures creating the fluvial anomalies are: (1) faults with trends of NW-SE, NE-SW and E-W, (2) folds with trend of NW-SE and (3) lineaments with trend of NW-SE.

The Geomorphic Anomalies in Segment B of the Ghezel Ozan River: The Ghezel Ozan river in this segment flows toward the northwest and flows thoroughly on

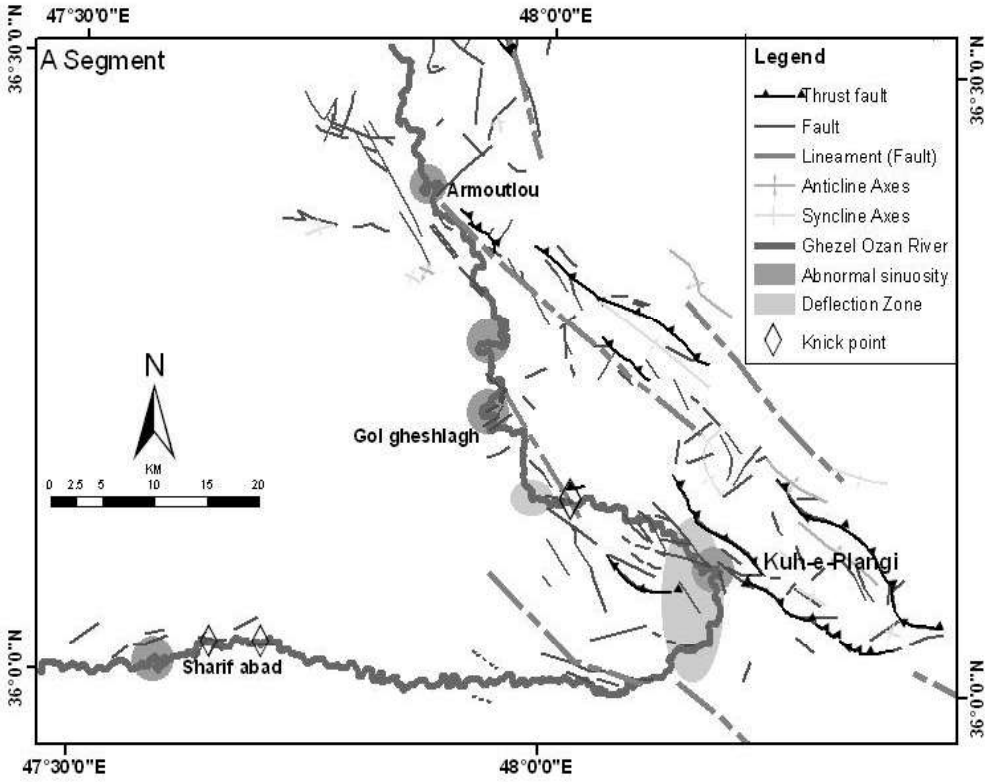

Fig. 3: Structural map illustrating the role of structures in creation of fluvial anomalies in Segment A of the Ghezel Ozan River

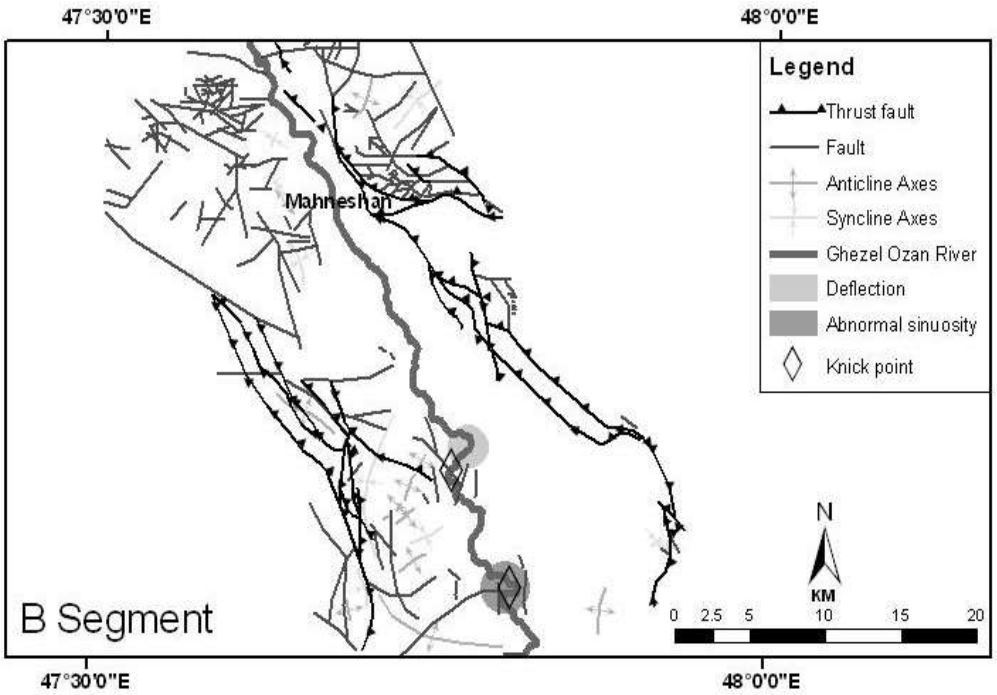

Fig. 4: Structural map illustrating the role of structures in creation of fluvial anomalies in Segment B of the Ghezel Ozan River

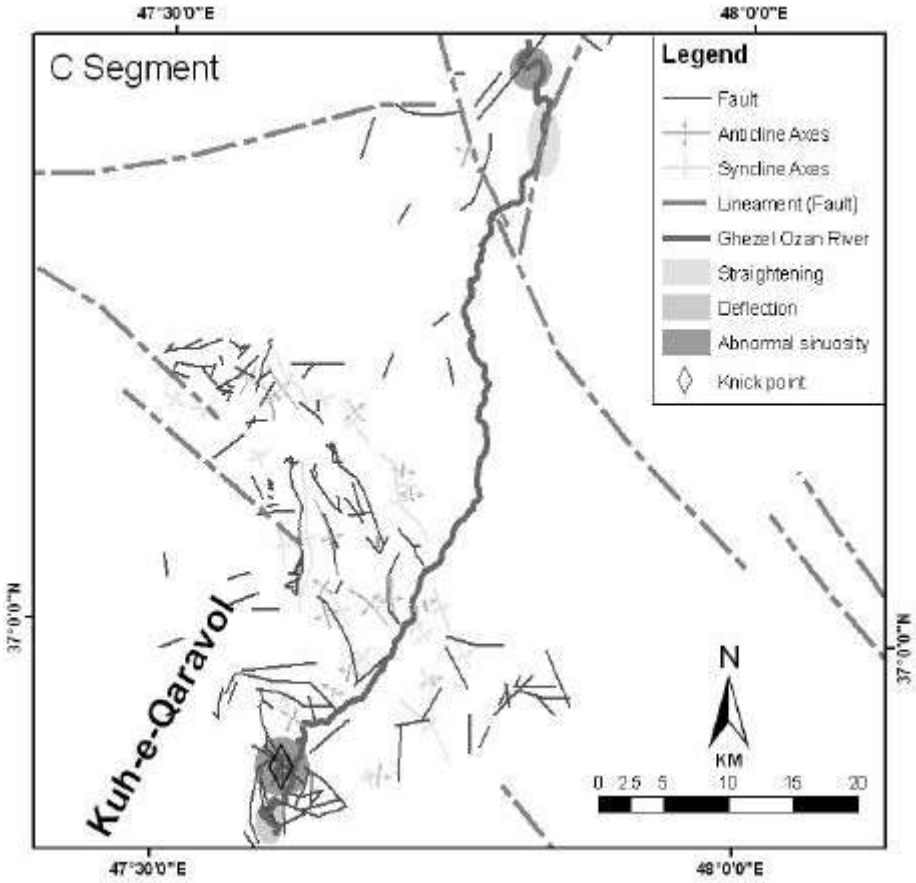

Fig. 5: Structural map illustrating the role of structures in creation of fluvial anomalies in Segment C of the Ghezel Ozan River

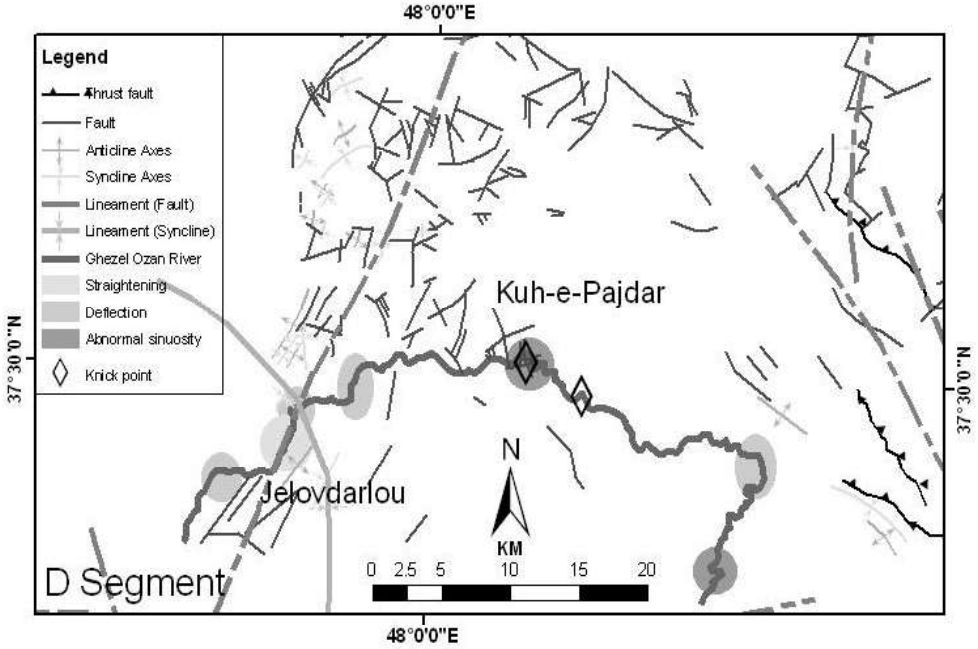

Fig. 6: Structural map illustrating the role of structures in creation of fluvial anomalies in Segment D of the Ghezel Ozan River

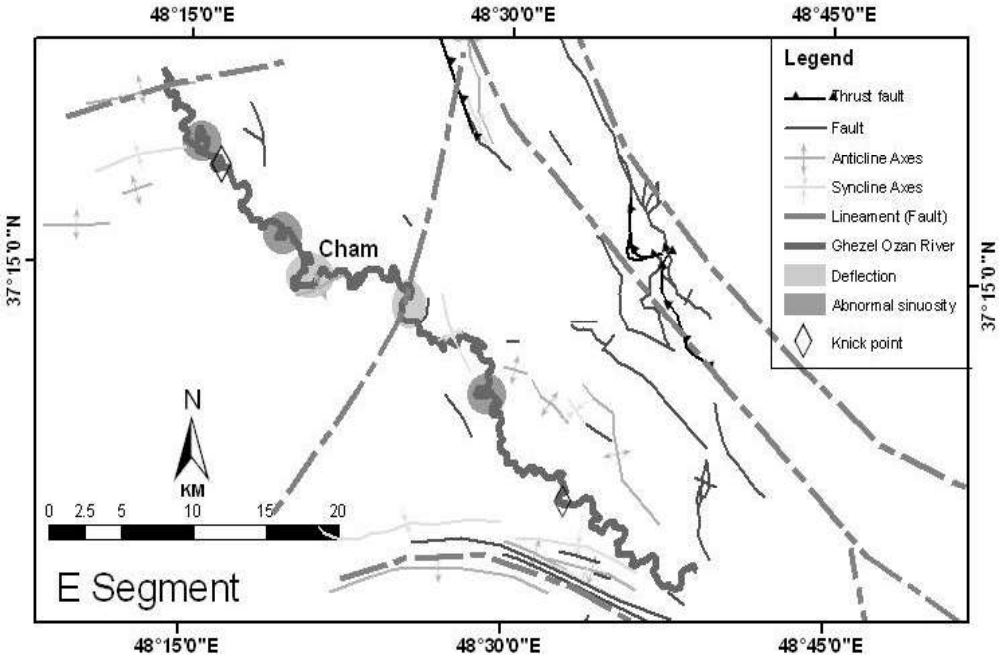

Fig. 7: Structural map illustrating the role of structures in creation of fluvial anomalies in Segment E of the Ghezel Ozan River

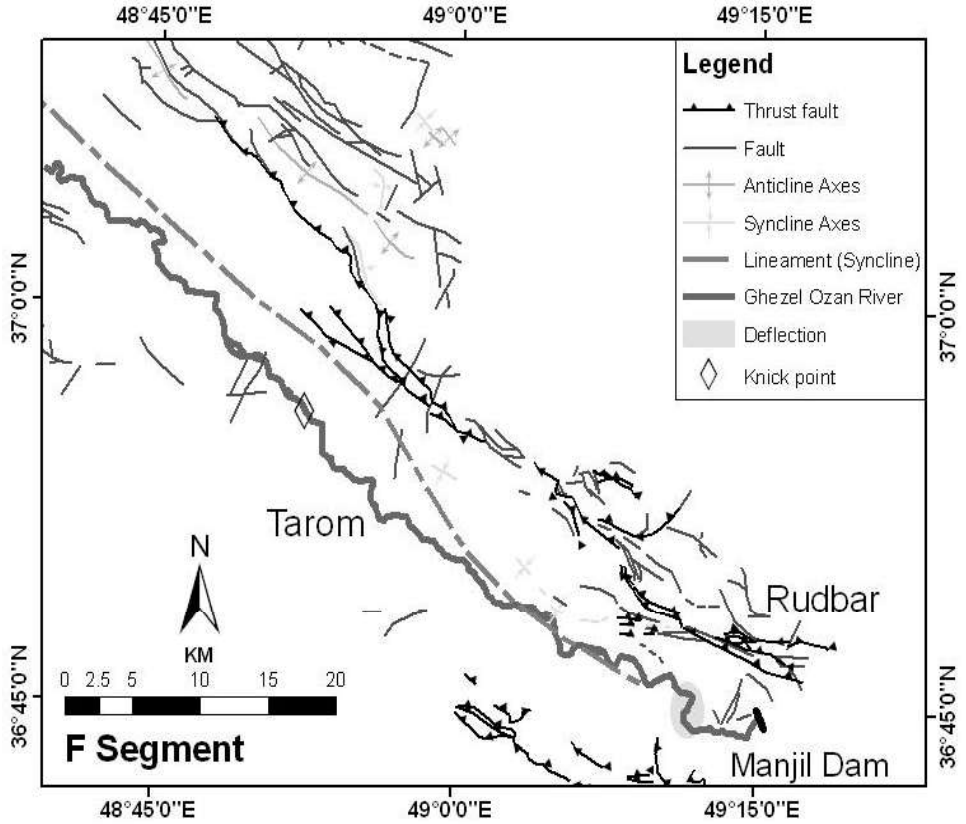

Fig. 8: Structural map illustrating the role of structures in creation of fluvial anomalies in Segment F of the Ghezel Ozan River

Table 1: The effective structures in creation of geomorphic anomalies in the Ghezel Ozan River basin

	A segment	B segment	C segment	D segment	E segment	F segment
Deflection	Faults *(NW-SE)* Folds *(NW-SE)*	---	Faults *(NW-SE)* Faults *(NE-SW)*	Lineament *(NW-SE)* Folds *(NW-SE)* Folds *(NE-SW)*	 Lineament *(NE-SW)* Folds *(NE-SW)*	---
Abnormal Sinuosity	Faults *(NE-SW)* Faults *(NW-SE)*	Faults *(N-S)*	Faults *(NE-SW)* Faults *(NW-SE)*	Faults *(NW-SE)* Faults *(NE-SW)*	Folds *(NE-SW)*	---
Knick point	Faults *(NE-SW)* Faults *(E-W)* Faults *(NW-SE)* Lineament *(NW-SE)*	Faults *(N-S)* Faults *(NW-SE)* Faults *(NE-SW)*	Faults *(NW-SE)* Faults *(NE-SW)*	Faults *(NW-SE)* Faults *(NE-SW)*	---	---
Straightening	---	---	Lineament *(NE-SW)*	Lineament (NE-SW)	---	---
Overbank Flooding	Faults *(NW-SE)* Lineament *(NW-SE)*	---	Lineament *(NW-SE)* Faults *(NW-SE)*	---	---	Faults *(NE-SW)*

the alluvial bed. The geomorphic anomalies and tectonic structures in this segment are shown in Figure 4. The structures creating the fluvial anomalies are faults with trends of N-S, NW-SE and NE-SW.

The Geomorphic Anomalies in Segment C of the Ghezel Ozan River: The Ghezel Ozan river in this segment flows toward the northeast and flows thoroughly on the alluvial bed. The geomorphic anomalies and tectonic structures in this segment are shown in Figure 5. The structures creating the fluvial anomalies are: (1) faults with trends of NW-SE, NE-SW, (2) lineaments with trend of NE-SW.

The Geomorphic Anomalies in Segment D of the Ghezel Ozan River: The Ghezel Ozan river in this segment flows toward the east and flows on the alluvial and rock bed. The geomorphic anomalies and tectonic structures in this segment are shown in Figure 6. The structures creating the fluvial anomalies are: (1) faults with trends of NW-SE, NE-SW, (2) folds with trends of NW-SE, NE-SW and (3) lineaments with trends of NW-SE, NE-SW.

The Geomorphic Anomalies in Segment E of the Ghezel Ozan River: The Ghezel Ozan river in this segment flows toward the southeast and flows thoroughly on the rock bed. The geomorphic anomalies and tectonic structures in this segment are shown in Figure 7. The structures creating the fluvial anomalies are: (1) folds with trend of NE-SW and (3) lineaments with trend of NE-SW.

The Geomorphic Anomalies in Segment F of the Ghezel Ozan River: The Ghezel Ozan river in this segment flows toward the southeast and flows thoroughly on the alluvial bed. The geomorphic anomalies and tectonic structures in this segment are shown in Figure 8. The structures creating the fluvial anomalies are faults with trend of NE-SW.

The whole of structures which have created the fluvial anomalies are summarized in Table 1.

DISCUSSION

In the Ghezel Ozan River basin, most of the faults and lineaments are cutting across the river channel and affected the fluvial processes. The differential movements along the faults and lineaments have produced longitudinal tilting in the area. In general, deflection of the river course, abnormal sinuosity and compressed meanders, straightening of the river course, knick point in longitudinal profile and overbank flooding are some of the geomorphic indicators of active tectonics in the Ghezel Ozan River basin. In order to omit the effects of resistance of rocks, only the fluvial anomalies are considered in places where the lithology is similar.

The important point which emerges from this study is the difference in tectonic setting within the Ghezel Ozan River basin. The various segments of the Ghezel Ozan River exhibit different fluvial anomalies, so that variety of geomorphic anomalies is more in primary segments of the river. Regarding the effective structures in the creation of fluvial anomalies it is specified that structures with trends of NW-SE and NE-SW are the most active structures in the area, while NE-SW trends are predominant in the east of the area and NW-SE trends are prominent in the west of the area.

CONCLUSION

- Most of the surface and sub-surface faults and folds in the Ghezel Ozan River basin are presently active and have produced distinctive response cleared as fluvial anomalies.

- The most active structures in the Ghezel Ozan River basin are surface and sub-surface structures with trends of NW-SE and NE-SW.
- The effect of NW-SE structures on the Ghezel Ozan River is more remarkable on the west of the area, while the effect of NE-SW structures on this river is more prominent on the east of the area.

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