Available online at: www.geo-dynamica.com

ISSN 2345 - 4997

Vol. (I) - No. 02- (Special Issue on Intra- Plate Earthquakes) Feb.2014
4th Article- P. 36 to 41

GRIB
Geodynamics Research
International Bulletin

A Study of Drainage Pattern Responses to Active Tectonics in Tadvan Region, SW Iran

Mehrdad Pazhoohan (Pourzarghan)[1], Mehran Arian[2], Manochehr Ghorashi[3], Khosro Khosrotehrani[4]

[1] Department of Geology, Faculty of Sciences, Science and Research Branch Islamic Azad University, Tehran, Iran.
[2] Department of Geology, Faculty of Sciences, Science and Research Branch Islamic Azad University, Tehran, Iran.
[3] Geological Survey of Iran (GSI), Tehran, Iran.
[4] Department of Geology, Faculty of Sciences, Science and Research Branch Islamic Azad University, Tehran, Iran.

*Corresponding Author (Dr.Pazhoohan@yahoo.com)

Article History: Received: Feb. 01, 2014 Reviewed: Feb. 06, 2014
Revised: Feb. 09, 2014 Accepted: Feb. 10, 2014 Published: Feb. 14, 2014

ABSTRACT

Tectonic plates are constantly moving. Thus, determining the location of the regions with earthquake potential has always been the geologists challenge. One of the new methods which follow observations of tectonic movements and earthquakes is the application of the knowledge of tectonic geomorphology. Studying and measuring landscapes and forms made by active tectonics is one of the objects of morphologic science. Active tectonic movements in a region are recorded in the morphology of rivers, drainages, alluvial fans and mountain fronts. The rivers respond to active tectonic movements, so the study of these phenomena can have an important role in locating the active tectonic regions. Ghareh Aghaj River originates from North East of Kazeroon in Fars province and flows into Persian Gulf while passing Bushehr province. This river is in the folded Zagros zone. Tadvan region in the South West of Iran has responded to ongoing tectonic deformation and has shown some geomorphological features. Due to Arabian–Eurasian collision the uplift and lateral tilting occurred in the study area, and they are manifested in avulsion, truncated streams and oriented drainage network. Such geomorphic features have been identified on the satellite images and interpreted through DEM and field observations. The fluvial features in the study area show uplift in one side of Ghareh Aghaj River which has caused lateral tilting in the area.

Keywords: Uplift, Avulsion, Truncated Streams, Drainage Network.

1. INTRUDOCTION

With the advancement of tectonic geomorphological science, it seems that active tectonic processes can influence the form and function of the river. (Holbrook and schumm, 1999, Schumm et al, 2000). Structural geology has greatly helped tectonics geomorphology. Fundamental development in our understanding of the tectonic geomorphology, often comes from combining multiple fields and disciplines. (Morisawa & Hack, 1985, Burbank and Anderson, 2001). A frequent change in the Earth's climate during the Quaternary period has visible impact on some landscape such as rivers (Bull, W., And McFadden L., 1977). Moderate and large inner crust torsions can have many reasons, but the result of these torsions is tilting of the earth's surface. Rivers are sensitive to changes in their grade causedby tectonic tilting. One of the tectonic tilting is lateral tilting which is normal to floodplain orientation (Holbrook and Schumm, 1999), and can be recognized with the related indicators. Geomorphic anomalies have been used as a powerful tool to delineate tectonically influenced landscapes. In the study area due to Arabian–Eurasian collision the uplift and lateral tilting occurred and they are manifested in avulsion, truncated streams and oriented drainage network (Fig. 1).

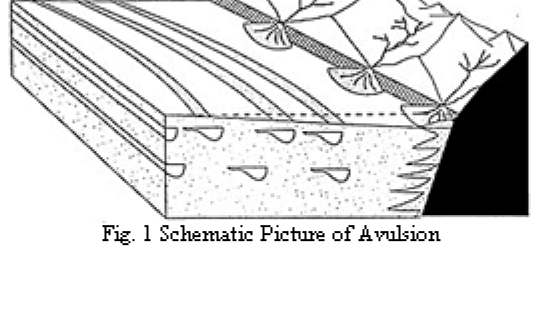

Fig. 1 Schematic Picture of Avulsion

Numerous studies in the Iranian plateau have shown ongoing convergence and active tectonic in this area (Jackson et al. 2002; Allen et al. 2003; Allen et al. 2004). Zagros is a fold-and-thrust belt in southern Iran that accommodates roughly half of the 25mm year-1 convergence between the Arabian and Eurasian plates (Fig. 2; e.g. Tatar et al., 2002; Blancetal, 2003). The study area is located on Simple Folded Belt in Fars region of the SW Zagros (Fig. 2), Tadvan region (Fig. 3). This paper presents the influences of active tectonic in making active deformations via detection and characterization of geomorphic anomalies in Ghareh Aghaj River and related drainage network. In the following sections, we describe the Geology and tectonics, stratigraphy and structural geology of Zagros Mountains.

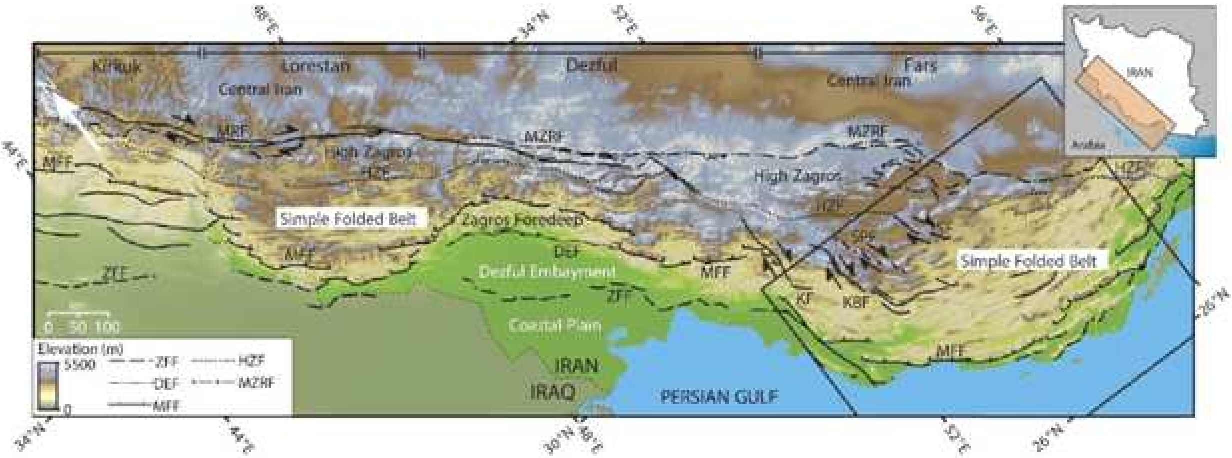

Fig 2. Topography and major structures of Zagros Mountains as discussed by Berberian (1995) (90m SRTM topography, Mercator projection, rotated anti- clockwise by 401). All major fault planes are inferred to dip to the NE (DEF, Dezful Embayment fault; HZF, High Zagros fault; MFF, Mountain Front fault; MZRF, Main Zagros Reverse fault; ZFF, Zagros Foredeep fault). Note the contrasting topographic expressions of the Dezful Embayment and Fars regions.

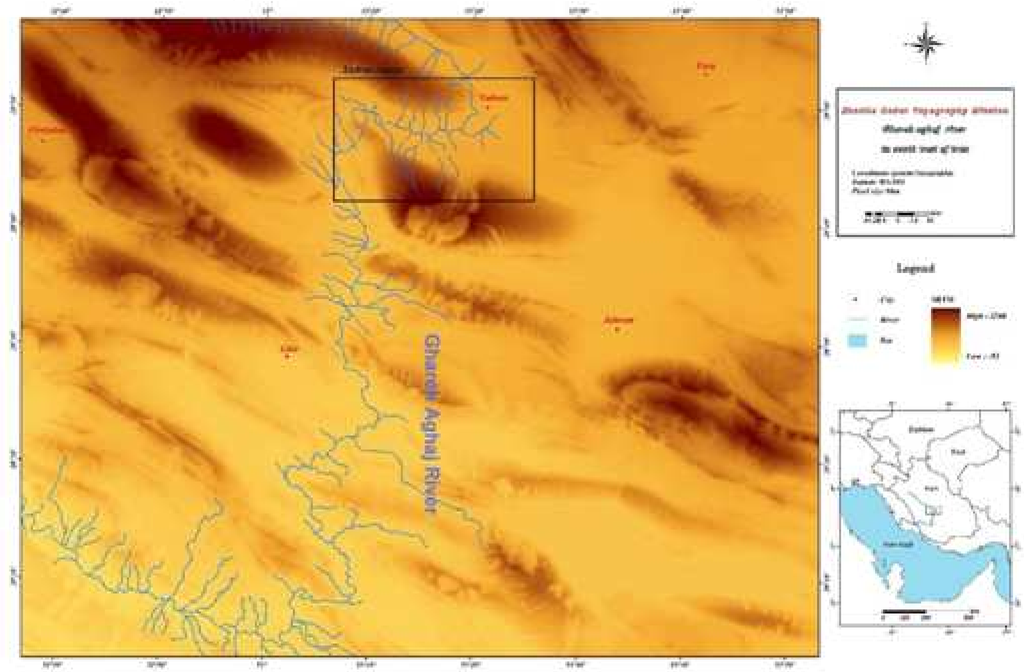

Fig 3. DEM of the study area (USGS/SRTM data) illustrating Simple Folded Belt in Zagros structural zone in SE Iran. Inset shows DEM of Iran with location of the study area.

2. THE STUDY AREA

2. 1. GEOLOGY AND TECTONICS

Active deformation in Zagros is caused by the northward motion of Arabia with respect to Eurasia, which occurs at a rate of 25mmyear-1 at longitude 561E (Sella et al.,2002;Tatar et al., 2002;Vernant et al., 2004;Walpersdorf et al., 2006). Almost half of the Arabia-Eurasia shortening is accommodated in Zagros Mountains of southern Iran (Talebian & Jackson, 2002; Tatar et al., 2002; Blanc et al., 2003).

The age of initial collision between Arabia and Eurasia is poorly constrained and is possibly diachronous from NW to SE (Stoneley, 1981).

The minimum age of continental collision is estimated at 16-23Ma from structural and sedimentation records (Robertson, 2000) to no later than 10Ma from a reconstruction of plate motions (McQuarrie et al., 2003). Before the onset of subduction in the LateCretaceous (Falcon,1974; Berberian &King, 1981; Alavi 1994), Zagros formed a passive continental margin on the northeastern margin of present-day Arabia, with seafloor-spreading in the Neo-Tethys ocean to the NE. Earlier still, Zagros shows evidence of Permian-Triassic rifting (Stocklin, 1968, 1974), and some of the present- day north-dipping thrust faults may be reactivated normal faults from this time (Jackson 1980; Koop & Stoneley 1982; Berberian 1995; Sattarzadeh et al., 2000).

2. 2. STRATIGRAPHY

The Zagros Phanerozoic cover is estimated to be up to 12-13 km thick or more in places (Colman-Sadd, 1978; Alavi, 2004) and exposes a series of limestones, marls, sandstones and salts, typical of a passive continental margin sequence (Fig. 2).The stratigraphic sequence was originally separated into five structural divisions defined by their mechanical behaviour (O'Brien, 1950, 1957).Two horizons that are known to influence the structure are the Pre-Cambrian Hormuz salt and the Miocene Gachsaran evaporite sequence, which make up the lower and upper mobile groups, respectively, and which form the major decollement levels. Both decouple the sedimentary sections above and beneath themvary in thickness from NWto SE (Sepehr&Cosgrove, 2004; Sherkati et al., 2005).

The competent Asmari and Bangestan limestones are continuous across the fold belt, although the thickness of the Asmari decreases to the SE and is gradually replaced by an increasing thickness of highly variable siliciclastics that form part of Razak Formation (IOOC 1969; Alavi 2004; Sepehr & Cosgrove 2004).

2. 3. STRUCTURE

Berberian (1995) suggested that the Zagros belt could be split into five morphotectonic units picked out on the basis of topography, seismicity and exposed stratigraphy, each with their own characteristics and deformation style. These five units are the High Zagros Thrust Belt, the Simple Folded Belt, the Zagros Foredeep, the Zagros Coastal Plain and the Persian Gulf-Mesopotamian lowland (see Fig. 2).

As there are few direct constraints on faulting at the Earth's surface, present-day activity on any of the individual basement faults is difficult to ascertain. However, the distribution of seismicity suggests that faulting active at the present day is concentrated in the SW of the range. In central Zagros, the surface folds are not continuous along the belt for more than 100 km. Instead, they are interrupted by a series of right-lateral strike-slip faults, including Kazerun, Karehbas and Sarvestan fault systems (Fig. 2), that accommodate along-strike extension in the central part of Zagros (Talebian & Jackson, 2004; Authemayou et al., 2006).

3. MATERIALS AND METHODS

For the identification of tectonically controlled geomorphological features, we used topographic maps at scale 1: 25,000, geological maps at scale 1:100000 and satellite images. GIS software was used to identify oriented drainage network in the study area and the drainage is extracted from Topographic maps and Digital elevation model (DEM).

Fig 4. Annotated Land- sat image depicting truncating streams implies the uplift in the area

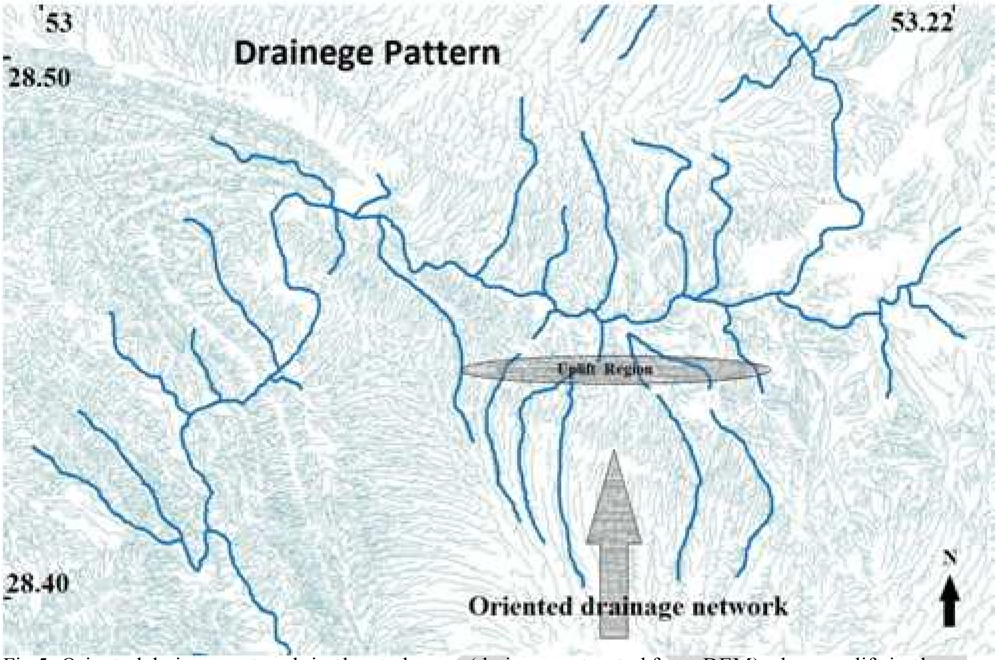

Fig 5. Oriented drainage network in the study area (drainage extracted from DEM), shows uplift in the area.

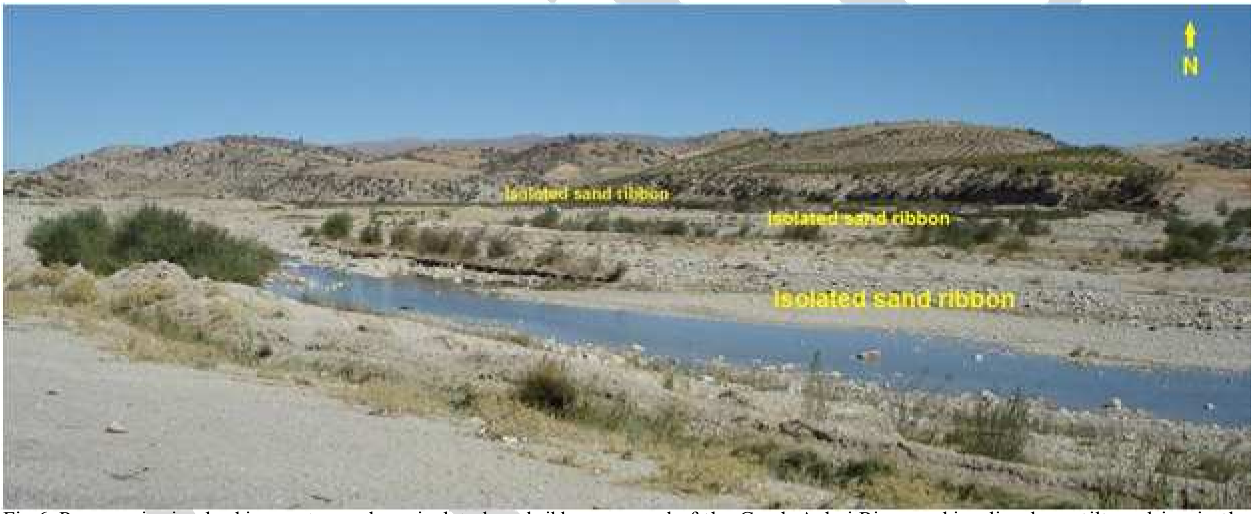

Fig 6. Panoramic view looking upstream shows isolated sand ribbons around of the Gareh Aghaj River and implies down-tilt avulsion in the study area.

3. 1. TOPOGRAPHIC MAPS AND DIGITAL ELEVATION MODEL (DEM)

In this study we have used 10-m grid cell DEM. Its projection was the Datum WGS84 Pixel SIZE 90m. 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 representation of structural zone of the study area.

3. 2. GEOLOGICAL MAPS

The geological maps of Sarvestan, Koshk, Ghir, and Firozabad at scale 1:100000, provided by Geological Survey of Iran, are used for the determination of the types of rocks in the area.

3. 3. 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 study area.

4. RESULTS AND DISCUSSION

Detection of geomorphic anomalies has provided an additional tool for recognizing the subtle tectonic movements. Conventional methods such as seismic data analysis and fault plain solutions of earthquake data are not sufficient to relate active tectonic movements to any specific fault. The integrated approach using remote sensing data and digital elevation models coupled with repeated field observations provide information on the nature of active tectonic of the study region (Jain & Sinha, 2005).

In tectonically active regions, the drainage network shows the interaction between surface processes and tectonic processes, so that variation in the style of the bed rock deformation, due to uplift, causes perturbations in the drainage network. Generally, active tectonics causing tilting that trigger channel avulsion tends to produce isolated sand ribbons in one side of the river cross-valley (Fig. 6), because tilting will generally force rivers to avulse toward the down-tilted side of the flood plain. The alluvial features in Tadvan region are avulsion, truncated streams (Fig. 4) and oriented drainage network (Fig. 5). In the study area, both the truncated streams and the oriented drainage network show that the course of surface waters is changed due to uplift in the area. The mentioned features have been detected on the satellite images and maps, commented through DEM and field observations indicate uplift and lateral tilting in the area.

5. CONCLUSION

1. The fluvial features in Tadvan region show uplift in one side of the Ghareh Aghaj River which has caused lateral tilting in the area.

2. The Ghareh Aghaj River has responded and adjusted to slow and subtle active tectonic movements. These adjustments can be recognized using the fluvial features.

3. The responses of Ghareh Aghaj River and the related drainage network to uplift zone are different, and include avulsion, truncated streams and oriented drainage network.

REFERENCES

Alavi, M. (1994) Tectonics of the Zagros Orogenic Belt of Iran: New Data and Interpretations. *Tectono- physics*, 229, 211-238.

Alavi, M. (2004) Regional Stratigraphy of the Zagros Fold-Thrust Belt of Iran and its Proforeland Evolution. *American Journal of Science*, 304, 1-20.

Allen, M.B, Jackson, J.A. & Walker, R. (2004) Late Cenozoic reorganization of the Arabia-Eurasia collision and the comparison of short-term and long-term deformation rates. *Tectonics*. 23, TC2008, doi: 10.1029/2003 TC001530.

Allen, M.B., Ghasemi, M.R., Shahrabi, M. and Qorashi, M. (2003), Accommodation of Late Cenozoic Oblique Shortening in the Alborz Range, Northern Iran. *Journal of Structural Geology*, 25, 655-672.

Authemayou, C., Chardon, D., Bellier, O., Malekzadeh, Z., Shabanian, E. & Abbassi, M.R. (2006) Late Cenozoic partitioning of oblique plate convergence in the Zagros fold and-thrust belt (Iran). *Tectonics*, 25, TC300.

Berberian, M. & King, G. (1981) Towards a palaeo-geography and tectonic evolution of Iran. *Canadian Journal of Earth Sciences*, 18, 210-265.

Berberian, M. (1995) Master Blind Thrust Faults Hidden Under the Zagros Folds: Active Basement Tectonics and Surface Morphotectonics. *Tectonophysics*, 241, 193-224.

Blanc, E.J.P., Allen, M.B., Inger, S. & Hassani, H. (2003) Structural Styles in the Zagros Simple Folded Zone, Iran. *Journal of the Geological Society of London*, 160, 401-412. doi: 10.1144/0016-764902-110.

Bull, W. & McFadden, L. (1977) *Tectonic Geomorphology North and South of the Garlock Fault, California, Geomorphology in Arid Regions*. D. O. Doehring, ed., Publications in Geomorphology, State University of New York at Bingamton, 115 – 138.

Burbank, D.W. & Anderson, R.S. (2001) *Tectonic Geomorphology*. Blackwell Science Malden, MA, USA.

Colman-Sadd, S.P. (1978) Fold Development in Zagros Simple Folded Belt, Southwest Iran. *American Association of Petroleum Geologists Bulletin*, 62, 984-1003.

Falcon, N.L. (1974) *Southern Iran: Zagros Mountains, In: Mesozoic- Cenozoic Orogenic Belts* (Geological Society, London, Publication, Edite By A.M. Spencer), 4: 199-212.

Holbrook, J. & Schumm, S.A. (1999) Geomorphic and Sedimentary Response of Rivers to Tectonic Deformation: a Brief Review and Critique of a Tool For Recognizing Subtle Epeirogenic Deformation In Modern And Ancient Settings. *Tectono- physics*, 305, 287- 306.

Iranian Offshore Oil Company (IOOC), 1969*, Geological Map of South-West Iran*.1:1000 000, Tehran, Iran.

Jackson, J.A. (1980) Reactivation of Basement Faults and Crustal Shortening in Orogenic Belts. *Nature*, 283, 343-346.

Jackson, J.A., Priestley, K., Allen, M.B. & Berberian, M. (2002) Active tectonics of the South Caspian Basin. *Geophysical Journal International*, 148, 214- 245.

Jain, V. & Sinha, R. (2005) Response of active tectonics on the alluvial Baghmati River, Himalayan foreland basin, Eastern India. *Geomorphology*, 70, 339–356.

Koop, W.J. & Stoneley, R. (1982) Subsidence history of the Middle East Zagros Basin, Permian to recent. *Philosophical transactions of the Royal Society of London*, 305, 149-168.

Mc-Quarrie N., Stock J.M., Verdel C. & Wernicke B.P., (2003) Cenozoic Evolution of Neotethys and Implications for the Causes of Plate Motions. *Geophysical Research Letters*, 30, 2036.

Morisawa, M. & Hack, J.T. (1985) *Tectonic Geomorphology* Boston, Union Hyman.

O'Brien, C.A.E. (1950) *Tectonic Problems of the Oilfield Belt of Southwest Iran*. In: 18th International Geological Congress, Proceedings, and Great Britain.

O'Brien, C.A.E. (1957) Salt diapirism in South Persia. *Geology Mijnbouw*, 19, 337-376.

Robertson, A.H.F. (2000) *Mesozoic-Tertiary Tectonic-Sedimentary Evolution of a South Tethyan Oceanic Basin and Its Margisn in Southern Turkey. In: Tectonics and Magamtism in Turkey And The Surrounding Area* (Ed. by E.Bozkurt, J.A.Winchester & J.D.A. Pipier). Geological Society London Special Publications, 173, 97-138.

Sattarzadeh, Y., Cosgrove, J.W. & Vita-Finzi, C. (2002) *The Geometry of Structures in the Zagros Cover Rocks and Its Neotectonic Implications. In: The Tectonic and Climate Evolution of the Arabian Sea Region* (Ed. by P.D. Clift,D. Kroon, C. Gaedicke & J. Craig), Geological Society London Special Publications, 195, 205-217.

Schumm, S.A., Dumont, J.F., Hol-brook, J.M. (2000) *Active Tectonics and Alluvial Rivers*. Cambridge.

Salvany, J.M. (2004) Tilting Neotectonics of the Gualiamor Drainage Basin, SW Spain. *Earth Surface Process and Landforms* 29, 145-160.

Sepehr M. & Cosgrove J.W., 2004, Structural Framework of the Zagros Fold-Thrust Belt, Iran. Marine and Petroleum Geology, 21: 829-843.

Sherkati, S., Molinaro, M., Frizon de Lamotte, D. & Letouzey, J., (2005) Detachment Folding in the Central Zagros Fold-Belt (Iran): Salt Mobility, Multiple Detachments and Late Basement Control. *Journal of Structural Geology*, 27, 1680-1696.

Stocklin, J. (1968) Structural History and Tectonics of Iran: a Review. *American Association of Petroleum Geologists Bulletin*, 52, 1229-1258.

Stocklin, J. (1974) *Possible Ancient Continental Margins In Iran, In: Geology of Continental Margins* (Ed. byC. Burke& C. Drake), Springer-Verlag NewYork, 873-877.

Stoneley, R. (1981) The Geology of The Kuh-E Dalneshin Area of Southern Iran and Its Bearings on The Evolution of Southern Tethys. *Journal of Geology Society*, 138, 509-526.

Talebian, M. & Jackson, J. (2004) A Reappraisal of Earthquake Focal Mechanisms and Active Shortening in the Zagros Mountains of Iran. *Geophysical Journal International*, 156, 506-526.

Talebian, M. & Jackson, J.A. (2002) Offset on the Main Recent Fault of NW Iran and Implications for the Late Cenozoic Tectonics of The Arabia- Eurasia Collision Zone. *Geophysical Journal International*, 150, 422 - 439

Tatar, M., Hatzfeld, D., Martinod, J., Walpersdorf, A., Ghafori-Ashtiany, M. & Chery, J. (2002) The Present Day Deformation of the Central Zagros from GPS Measurements. *Geophysical Research Letters*, 29, 1927.

Vernant, P., Nilforoushan, F., Hatzfeld, D., Abbassi, M.R., Vigny, C., Masson, F., Nankali, H., Martinod, J., Ashtiani, A., Bayer, R., Tavakoli, F. & Chery, J. (2004) Present- Day Crustal Deformation and Plate Kinematics in The Middle East Constrained by GPS Measurements in Iran and Northern Oman. *Geophysical Journal International*, 157, 381-398.

Walpersdorf, A., Hatzfeld, D., Nankali, H., Tavakoli, F., Nilforoushan, F., Tatar, M., Vernant, P., Chery, J. & Masson, F., (2006) Difference in the GPS Deformation Pattern of North and Central Zagros Iran. *Geophysical Journal International*, 167, 1077-1088.