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Syn- to post-collision role of Izeh transverse fault zone in deformation of the Zagros fold-thrust belt

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Abstract: The SE-trending Izeh fault zone is one of the main transverse faults that cross cut the major structures of Zagros belt in which deformations of the fault are overprinted on the major structures. Several restraining zones with en echelon pattern were mapped along the fault zone. Geometric and kinematic analysis of structures within the restraining zones suggest that the fault activity started on its northern side synchronously with continental collision of the Arabian Plate and central Iran in Late Cretaceous and continued towards the south until present time. Therefore, most of the recent earthquakes are occurring along its southern portion.

Keywords: syn-collision, post-collision, deformation, Izeh Transverse Fault Zone, Zagros Fold-Thrust Belt.

The Zagros Fold-Thrust Belt (ZFTB) is one of the youngest mountain belts, located in the middle part of the Alpine mountain system. The NW-SE trending belt developed during the collisional stage between the Arabian Plate and Central Iran in late Cretaceous (Ricou *et al.*, 1977). The belt has been grouped into different structural subzones including the High Zagros, the Zagros Simply folded belt and the Dezful embayment zones (Berberian, 1995) from NE to SW. The High Zagros zone, known as Imbricate Zone, marks the northeastern part of the orogenic belt. This zone is separated from the Iranian plate along the Zagros orogeny suture zone (Main Zagros Thrust). The Zagros Simple Folded zone, known as Izeh zone in the studied area, has major folds and thrust faults parallel to the ZFTB.

Thrust faults and related folds are the main structural elements of the belt. These major structures of ZFTB are transversely cross cut by two sets of subsurface fault zones developed during the late Alpine Zagros orogeny (Falcon, 1969; Furst, 1990; Ameen, 1992; Barzegar, 1994; Hessami *et al.*, 2001; Yassaghi, 2006).

The first set oriented NNW-SSE shows right-lateral strike-slip movement such as the Izeh, Kazerun, Sabzpushan and Sarvestan fault zones. The second set, NE-SW-oriented, has left lateral strike-slip movement such as Balarud, Nezamabad, Firuzabad and Razak fault zones (Fig. 1a).

The SE-trending Izeh transverse fault zone has influence on the structures of the entire Zagros subzone, i.e. the High Zagros zone, the Izeh simply folded zone and the Dezful embayment zone, from north to south, respectively (Fig. 1). The purpose of this paper is to document deformations along the Izeh fault zone and recognition of the fault pattern on the surface. The manuscript is also aimed at determining geometric and kinematics variations of structures along the Izeh fault zone for better understanding the effect of the fault zone on structural development of the ZFTB.

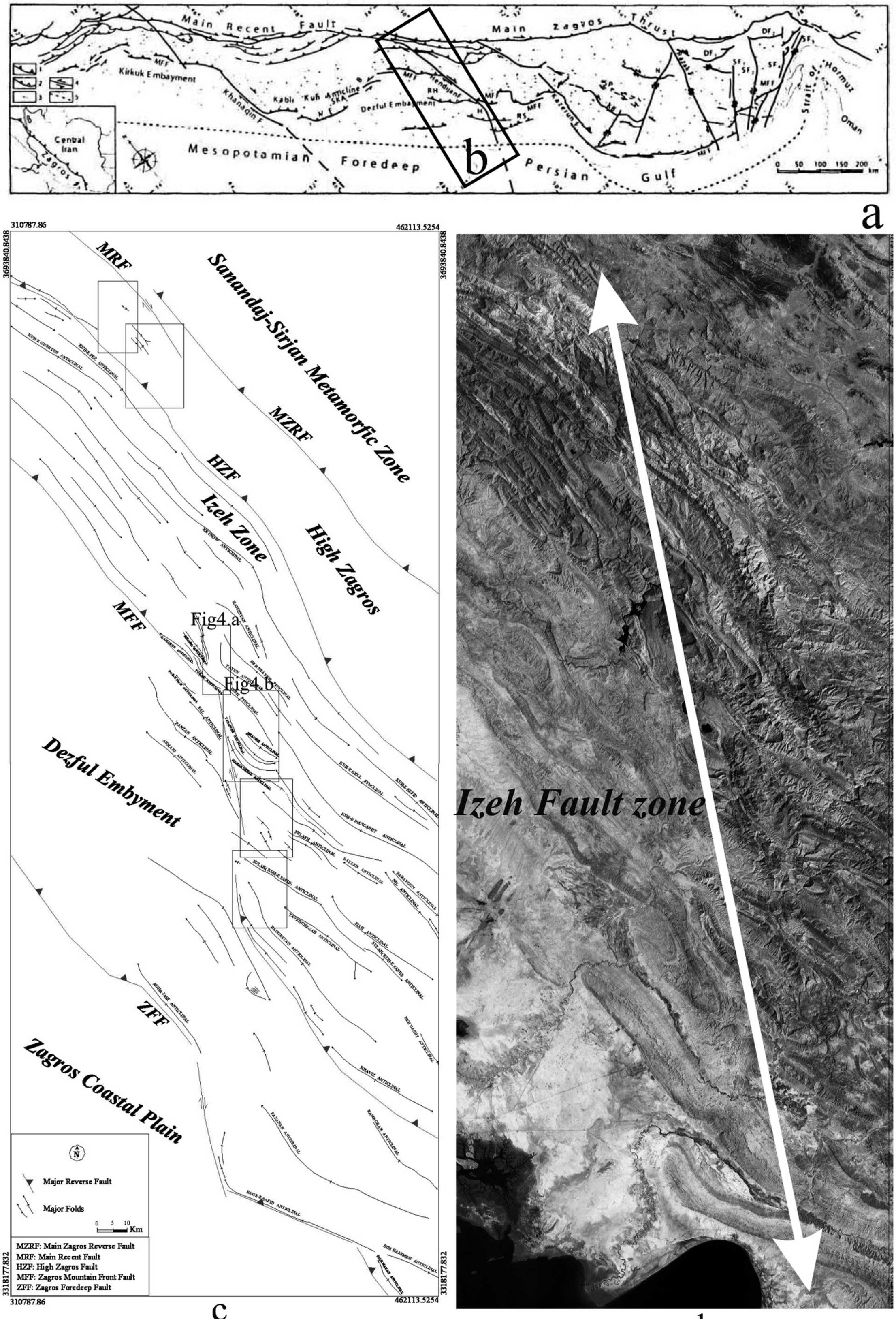

Figure 1. (a) Index map of the studied area within the Zagros Fold-Thrust Belt showing major strike-slip faults of the belt (after Hessami *et al.*, 2001), (b) satellite image of the studied area, (c) major structures along the Izeh fault zone.

Methods

Remote sensing study of Landsat images was utilized for initial recognition of the exposed structures along the Izeh subsurface fault zone. Surface patterns such as; topography, drainage pattern, spectral reflection of rocks, bending of fold axes, geometry of young folds with en echelon pattern were used for recognition of the fault zone.

Upon the results obtained from the remote sensing study, a few areas along the Izeh fault zone were selected for detailed field studies (Fig. 1c). Structural maps of 1:50 000 scales were performed for the selected areas. For data analysis we used Tectonics FP software.

Seismological approaches such as earthquake hypocentral locations and focal mechanism studies play an important role in the understanding of present activities of the fault. Therefore, a seismic map of the region has also been used. The sources of seismic data are on-line moment tensor catalogs, such as CMT (Centroid Moment Tensor), USGS (United States Geology Survey) and IIEES (International Institute of Earthquake Engineering and Seismology).

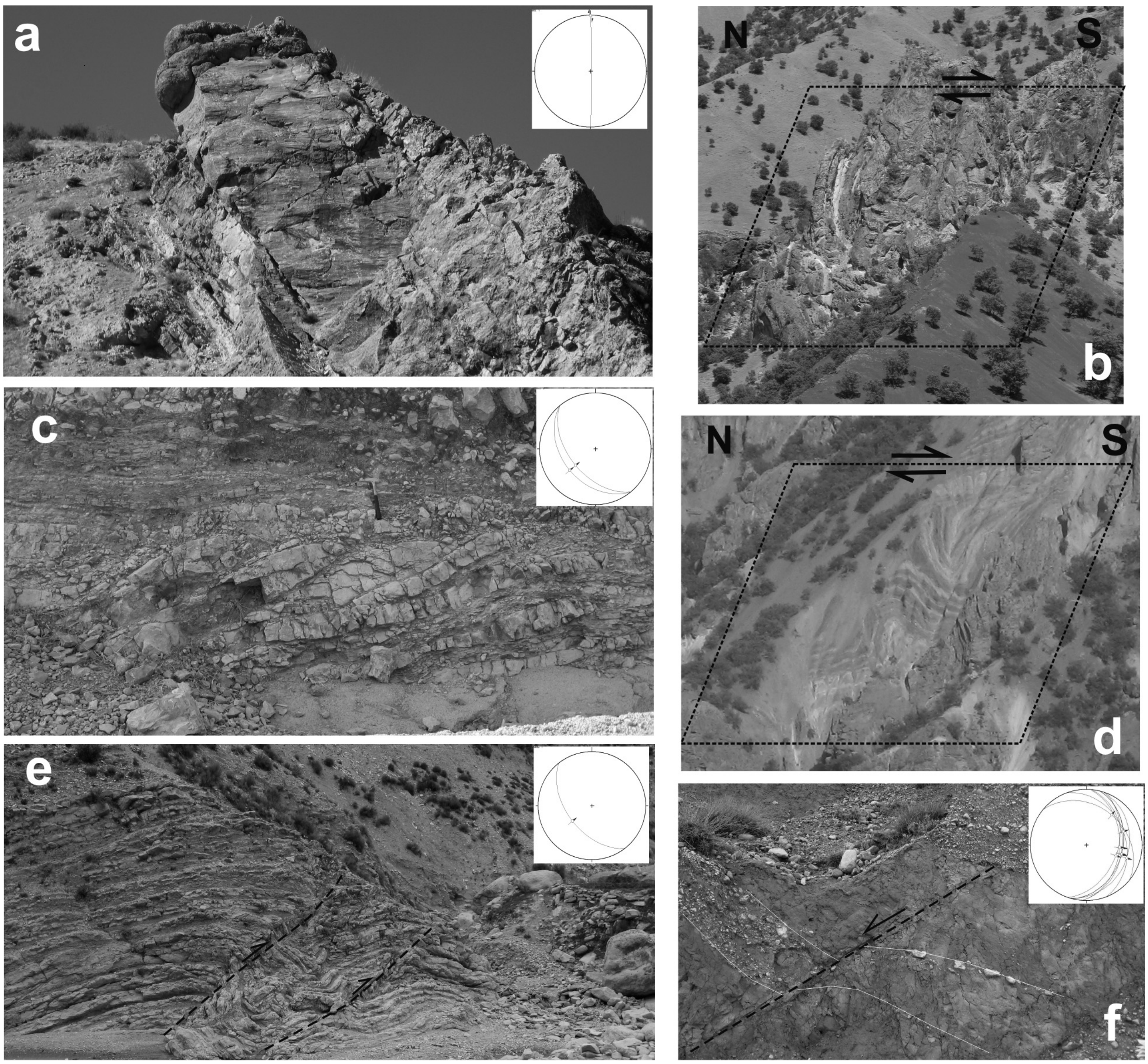

Figure 2. Minor faults along Izeh fault zone; (a) strike-slip fault plain, (b and d) strike-slip fault scarps, (c) strike-slip fault duplex, (e) reverse faults, (f) normal faults. Dots in stereograms are the fold axis and planes are the faults planes (height of outcrop is approximately 2-3 m for a, c, e and f, and 100-150 m for b and d).

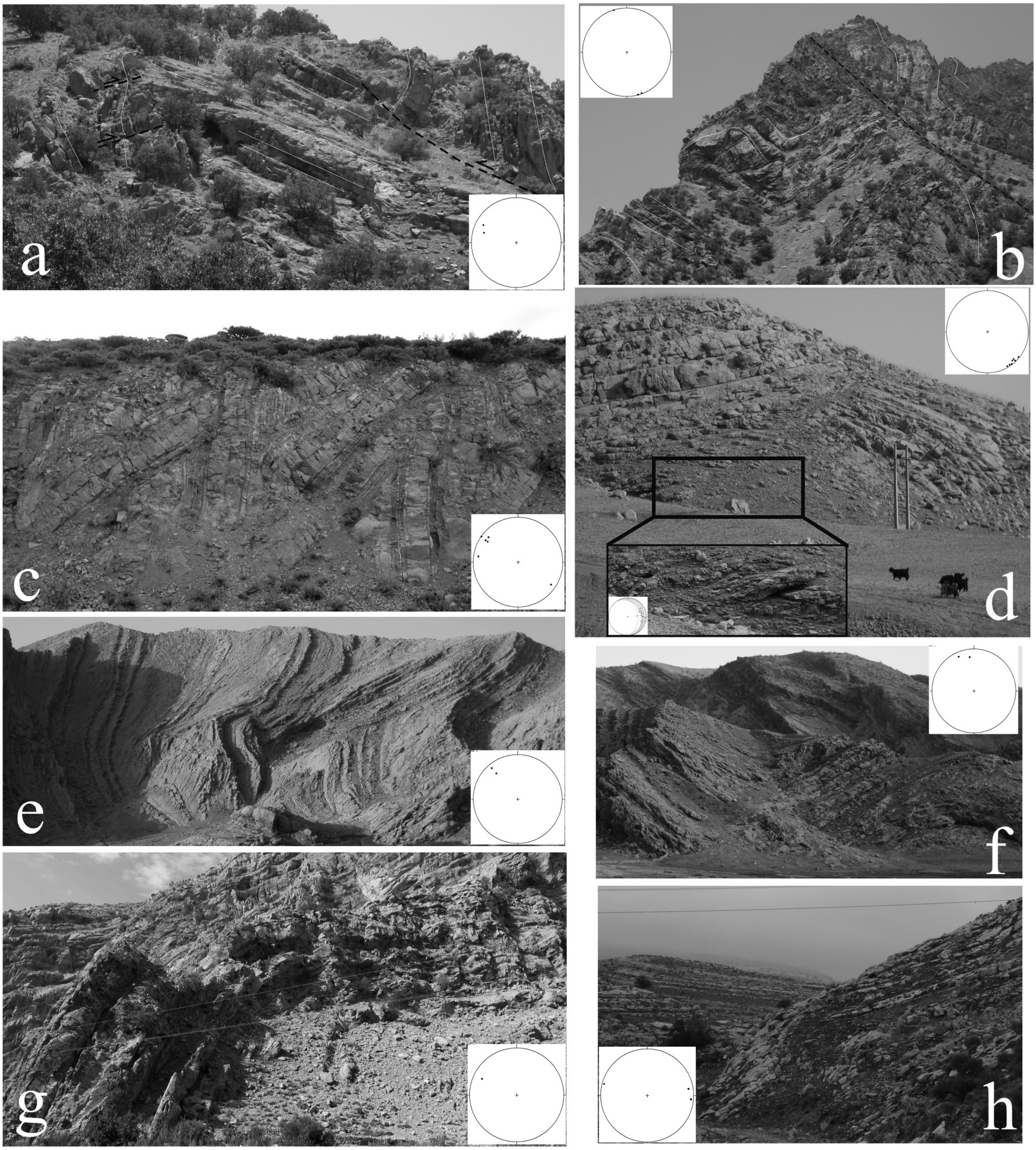

Figure 3. Minor folds along the Izeh fault zone; (a) to (h) show the folds geometries from High Zagros Zone toward the southern simply folded zones in the Zagros Fold-Thrust Belt. All formations are limestones with different age. Dots in stereograms are the fold axis and planes are the faults planes.

Structures along the Izeh fault zone

Structural evidences of the subsurface deep-seated Izeh fault zone can be recognized on the cover sediments. These structures are divided into major image scale and minor outcrop scale.

Major (image scale) structures

Remote sensing studies of Landsat images, along Izeh fault zone, show the presence of structures such as curvilinear geometry of the major fold axial traces (Keynow, Sulak, Bangestan and Ragesefid axial traces, for instance),

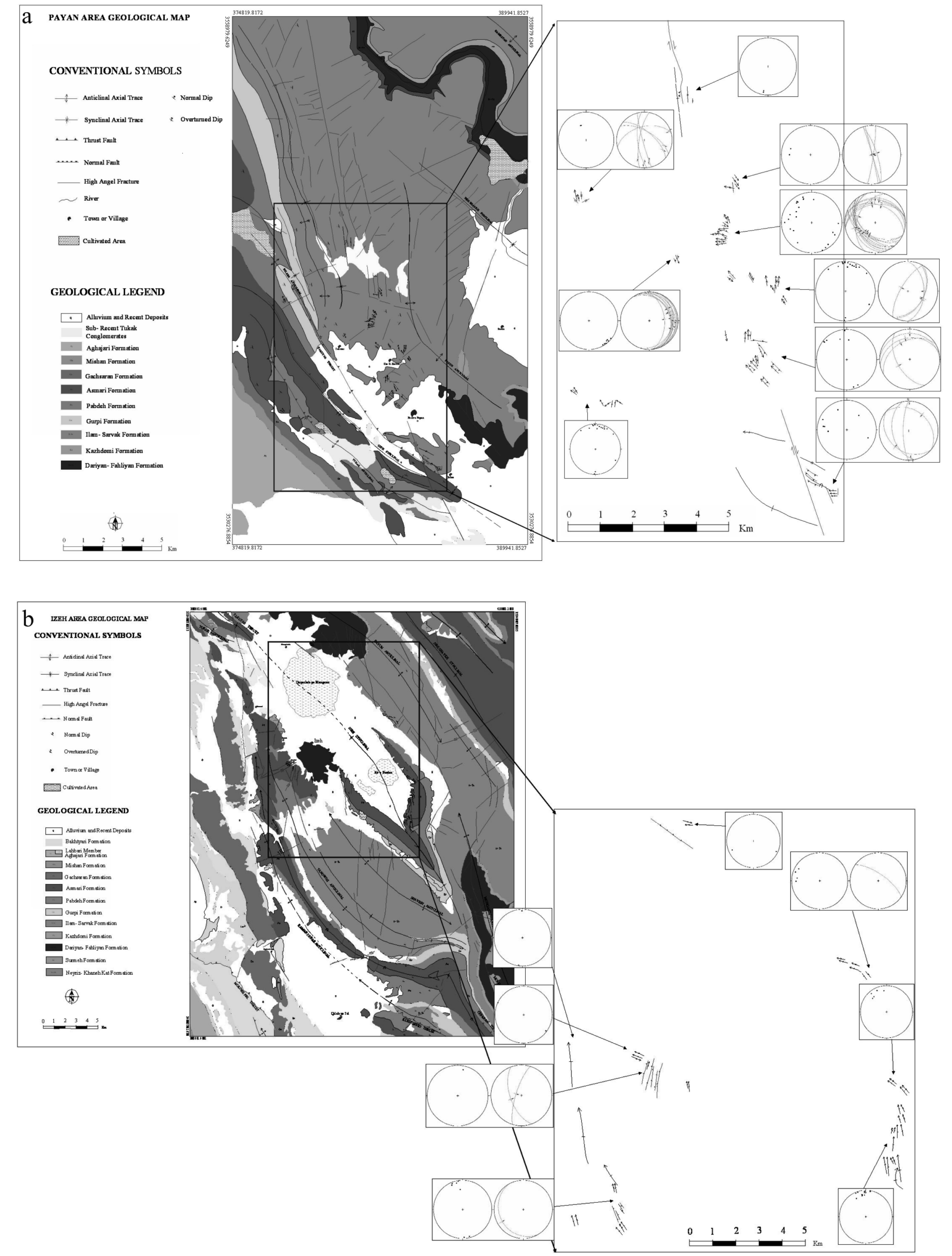

Figure 4. Structural maps of the selected areas within the Izeh fault zone. See figures 1c and 5 for location. Dots in stereograms are the fold axis and planes are the faults planes.

bending of major reverse fault traces (HZF, High Zagros Fault; MFF, Zagros Mountain Front Fault and ZFF, Zagros Foredeep Fault) and formation of a few younger folds with en echelon pattern (Figs. 1b and 1c).

Minor (outcrop scale) structures

Minor structures with different orientation than the behavior of the belt major structures, which can only be recognized in the field, were studied in detail along the Izeh fault zone. These structures, which are referred as younger structures in this study were overprinted on the belt major structures (Figs. 2 and 3). Structural maps of the two selected areas together with their stereographic plots are also presented (Fig. 4).

Discussion

The major structures mapped on the satellite images (such as curvature on the major anticline axial trace in figure 1c) demonstrate right-lateral strike-slip kinematics for the Izeh fault zone. The minor structures which are generally overprinted on the major struc-

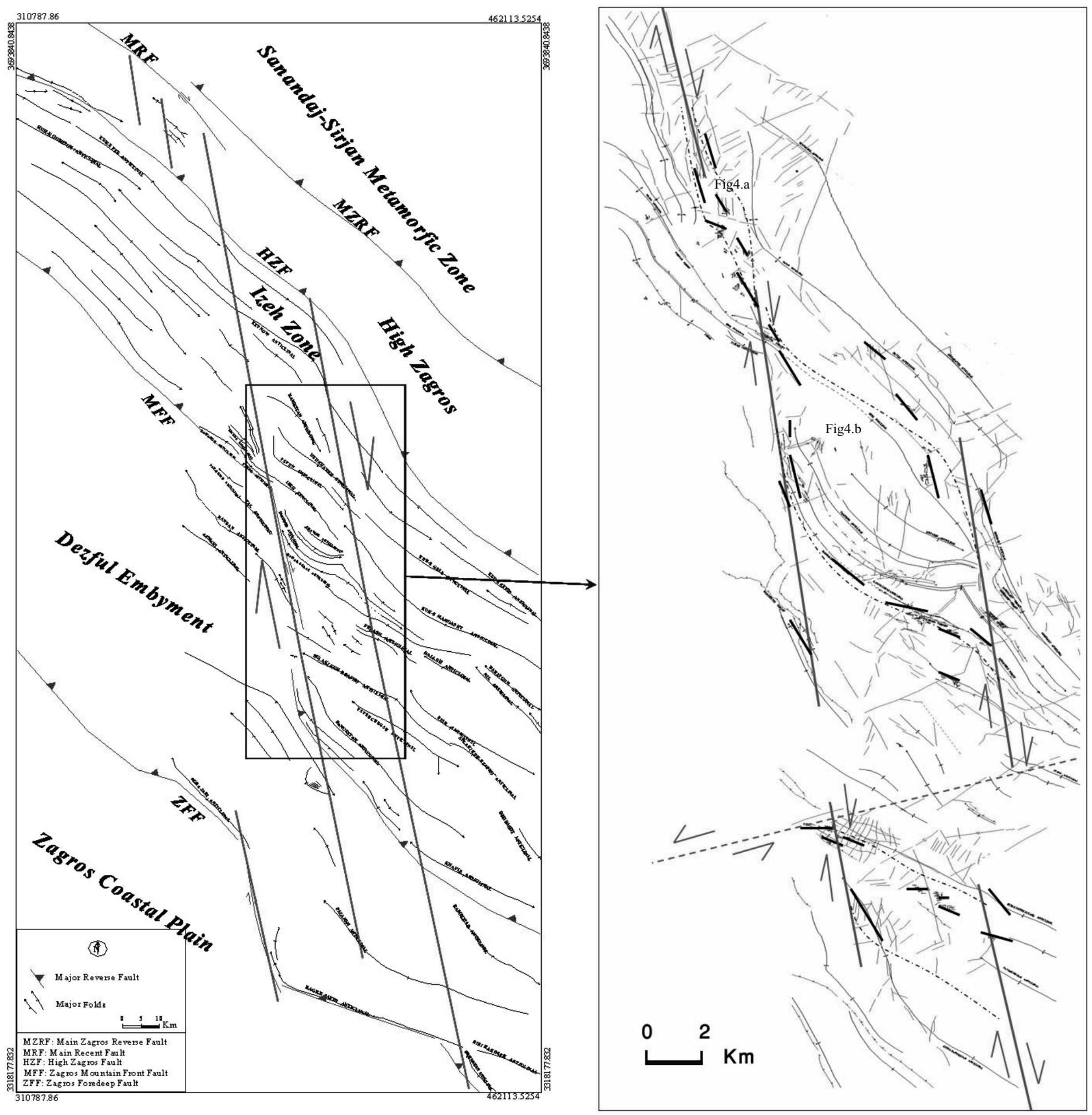

Figure 5. Map of restraining zones along the Izeh fault zone. The short solid lines are the trend of the structures within the restraining zones.

tures were developed in all rock formations from the Cambrian Mila and Lalun formations to the Pliocene Bakhtyari formation. They are mainly developed in offset zones between the en echelon arrays of the Izeh fault segments. The trends of minor folds and thrusts within these offset zones varies from SE-trending parallel to the fault segments in the fault zone margins to E-trending in the fault zones center (Fig. 4). According to Sylvester (1988), the right step pattern of the Izeh fault zone causes development of restraing zones in their step over zones (Fig. 5).

Geometry and kinematic analysis of the minor folds within the Izeh fault zone show that they have tight to close geometry in the northern parts whereas open to gentle in the southern parts (Figs. 3a to 3h).

We suggest that reactivation of Izeh fault zone is coeval to collision between the Arabian Plate and Central Iran in late Cretaceous from the north and it continued towards the south till present time. Therefore, most of the earthquakes are concentrated in the southern parts (Davoodi and Yassaghi, 2007) of the Izeh fault zone. Thus, reactivation of the Izeh fault zone have been propagated from inner (High Zagros) to outer (Dezful embayment) portions of the Zagros orogen since at least Late Cretaceous.

Conclusion

The NW-SE-trending Izeh transverse fault zone, one of the main strike-slip faults, consists of several en echelon segments in which restraining zones were developed in their step over patterns. Based on surface deformations and earthquake data, reactivation of the fault zone have propagated from inner to outer parts of Zagros orogen since Late Cretaceous. Present activity at the fault southern parts are greater than its northern portion. The northeastward movement of the Arabian Plate towards Central Iran is in favour for the reactivation of Izeh fault zone. Therefore, it is proposed that such convergence can account for the reactivation of similar fault zones in the Zagros Fold-Thrust Belt.

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