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Structural evolution of the Laibid pop-up structure, Sanandaj-Sirjan Zone, West Iran

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Abstract: The Laibid pop-up structure is located in the highly deformed sub-zone of the Sanandaj-Sirjan Zone, western Iran. In this zone, structural trends are parallel to the Zagros fold-thrust belt (NW-SE), but the pop-up structure has a different trend of E-W and is surrounded by several fault sets, which are the youngest deformational event. Comparison between the fold axes and axial plains of the inner and outer part of the pop-up structure and also coaxial interference patterns of polyfolding show a continuous deformation in the study area. It seems that during Late Jurassic, due to right lateral transpression movement resulting from the collision of the Iranian and the Afro-Arabian continents, three folding stages formed and passively rotated in a continuous deformation condition.

Keywords: pop-up structure, Sanandaj-Sirjan zone, polyfolding, brittle deformation.

Laibid, Muteh and Mahallat pop-up structures are located in the Sanandaj-Sirjan Zone (Fig. 1), which is a metamorphic belt in the northeastern part of the Zagros fold and thrust belt caused by the convergence of the Afro-Arabian continent and the Iranian micro continent during the Late Cretaceous-Miocene (Mohajjel *et al.*, 2003). In this area, trends are parallel to the Zagros fold-thrust belt, but these pop-up structures have different trends of NE-SW to E-W (Thiele *et al.*, 1968). They are surrounded by several sets of bounding faults which are the youngest deformational event (Soltani, 2002). In this paper we have focused on the deformational history of the Laibid pop-up structure (Fig. 2).

In this pop-up structure Permian metamorphosed rocks are exposed, which are mostly limestone to dolomitic limestone, with abundant chert bands and nodules, but in the lower parts include meta quartzarenite, grey pellitic shale, meta-limestone and meta-calcareous sandstone with metamorphosed acidic sills and flows (Moosavi *et al.*, 2005). The Hassan Robat Intrusive body, which is a white brown to pink alkali-porphyritic-granit with an abundance of aplitic veins, is exhumed in the eastern part of this pop-up structure where it caused a circular morphology. Dark grey shales and phillites of Triassic and Jurassic age surround the Permian units. Cretaceous units, which are exposed in the southern parts of the Laibid pop-up structure, started with basal calcareous sandstone with intercalations of basic lava and sandy dolomite (Moosavi *et al.*, 2005).

Methods

During the field work, data of foliations, lineations, fold axes, axial plains, s-c fabrics of shear zones and fault striations were collected. Also, Aster satellite images were used to obtain more information, especially recognition of fault trends. GEOrient 9.3 software (Rode Holcombe) is used for data processing.

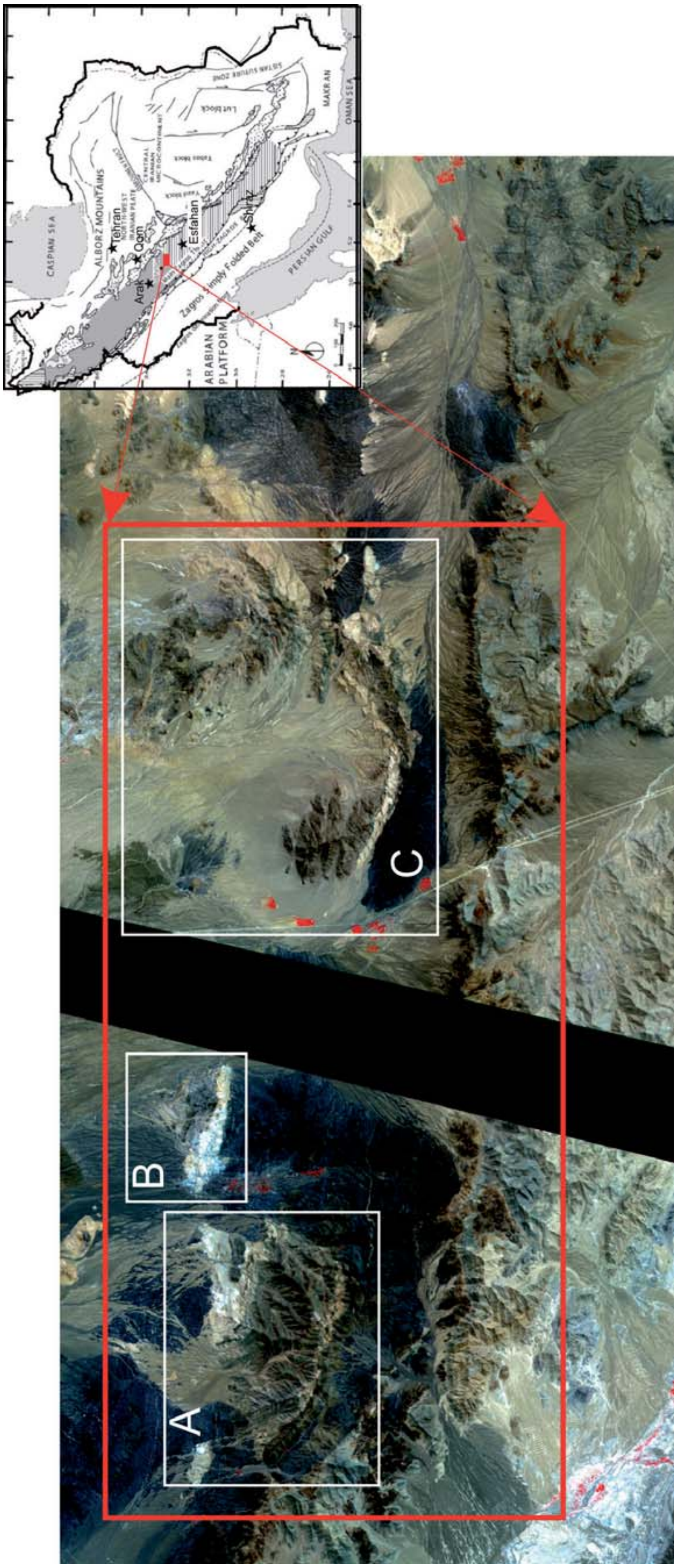

Figure 1. Location of the study area in the Sanandaj-Sirjan Zone and the Aster image showing eastern, central and western parts of the Laibid pop-up structure.

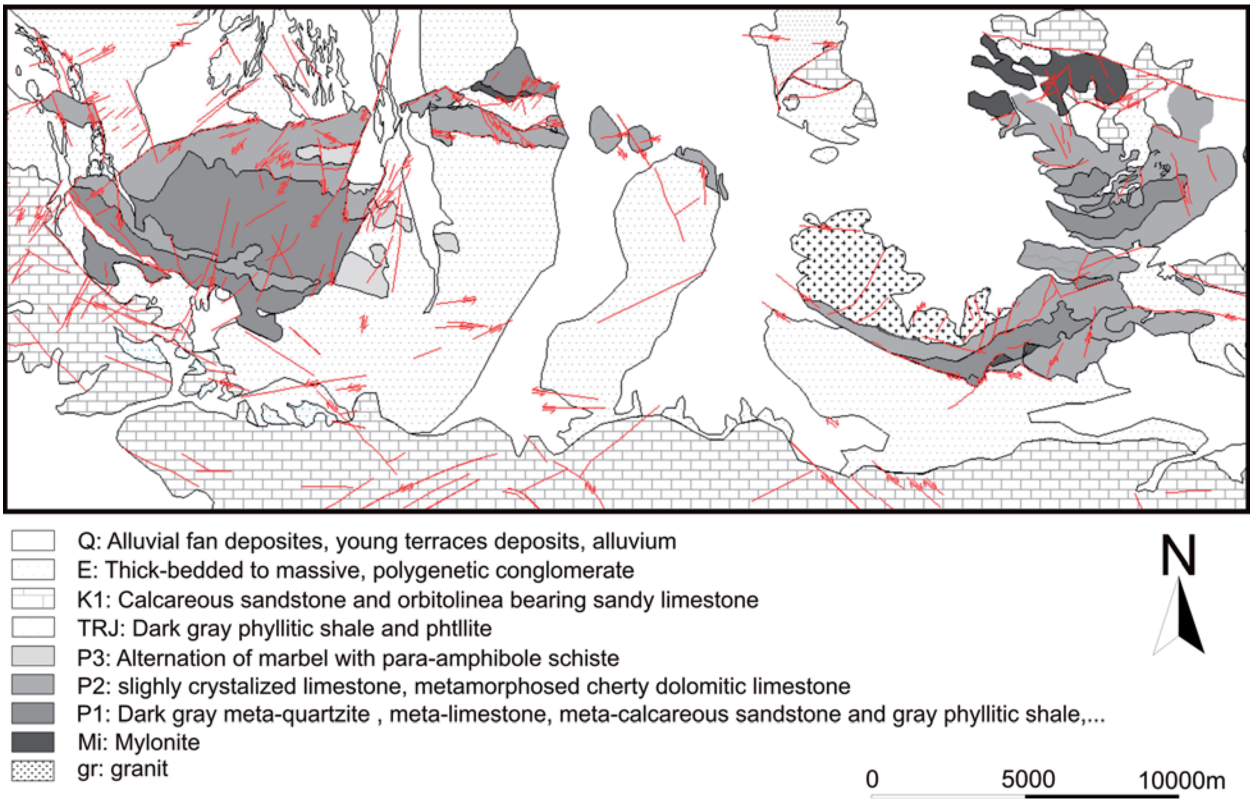

Figure 2. Geological map of Laibid pop-up structure.

Analysis and results

Folds

According to field studies, three geometrically distinguishable fold stages were recognized in the study area. The first stage includes tight to isoclinal folds with fold axis plunging moderately toward NW or SE (Figs. 3A and 3B). The second includes open to close folds that plunge gently toward NW or SE and axial plains that dip toward NE (Figs. 3C and 3D). The third stage includes gentle to open upright folds and E-W fold axis trend (Figs. 3E and 3F). From the first to the third stage, the wavelength of the folds gradually becomes longer, so that their aspect ratio changes respectively from tall and short for the first stage to broad for the second and to wide for the third. Superposition of these fold stages caused the formation of coaxial interference patterns (Figs. 3C, 3D, 3E and 3F).

Data reveal that there is no special contrast between the folding geometry of the inner parts (Permian units) and outer parts (Triassic-Jurassic units) of the pop-up structure. We therefore conclude that they might have the same folding history.

Faults

As the pop-up structure is limited by several sets of faults and the faults cut the ductile structures, they must be a later deformational event. Evidence of thrust (Fig. 4B), normal (Figs. 4C and 4D) and strike-slip (Fig. 4A) faulting is revealed in the study area.

Evidence of normal faulting is rarely seen at the northern boundary of western Laibid (Figs. 4C and 4D), and strike-slip faults (Fig. 4A) are extended in the western Laibid. Also, several fault trends are recognizable in aerial photos and satellite images (Fig. 1), the most characteristic of which are as follows (Fig. 5):

NNE-SSW trend: are mostly concentrated between the central and western Laibid, with large dextral strike-slip components which are recognizable in satellite images (Figs. 1 and 2), especially those at the western boundary of the western Laibid.

NW-SE trend: NE-dipping thrust faults with NW-SE trends (Fig. 4B) are very unusual in western Laibid (Fig. 2).

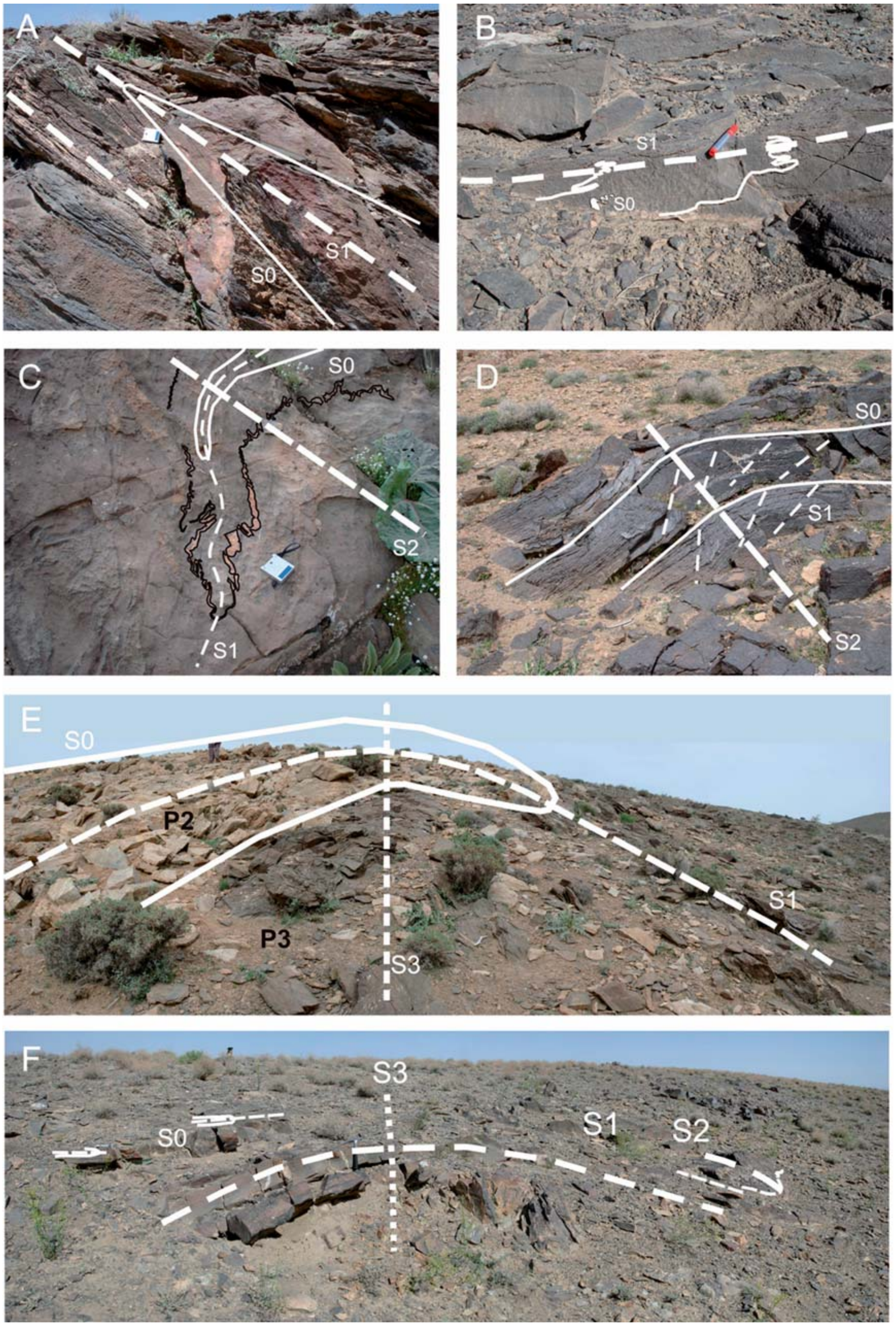

Figure 3. Samples reveal the folding style in the first (A and B), second (C and D) and third (E and F) stage and coaxial interference patterns resulting from folding stage superposition.

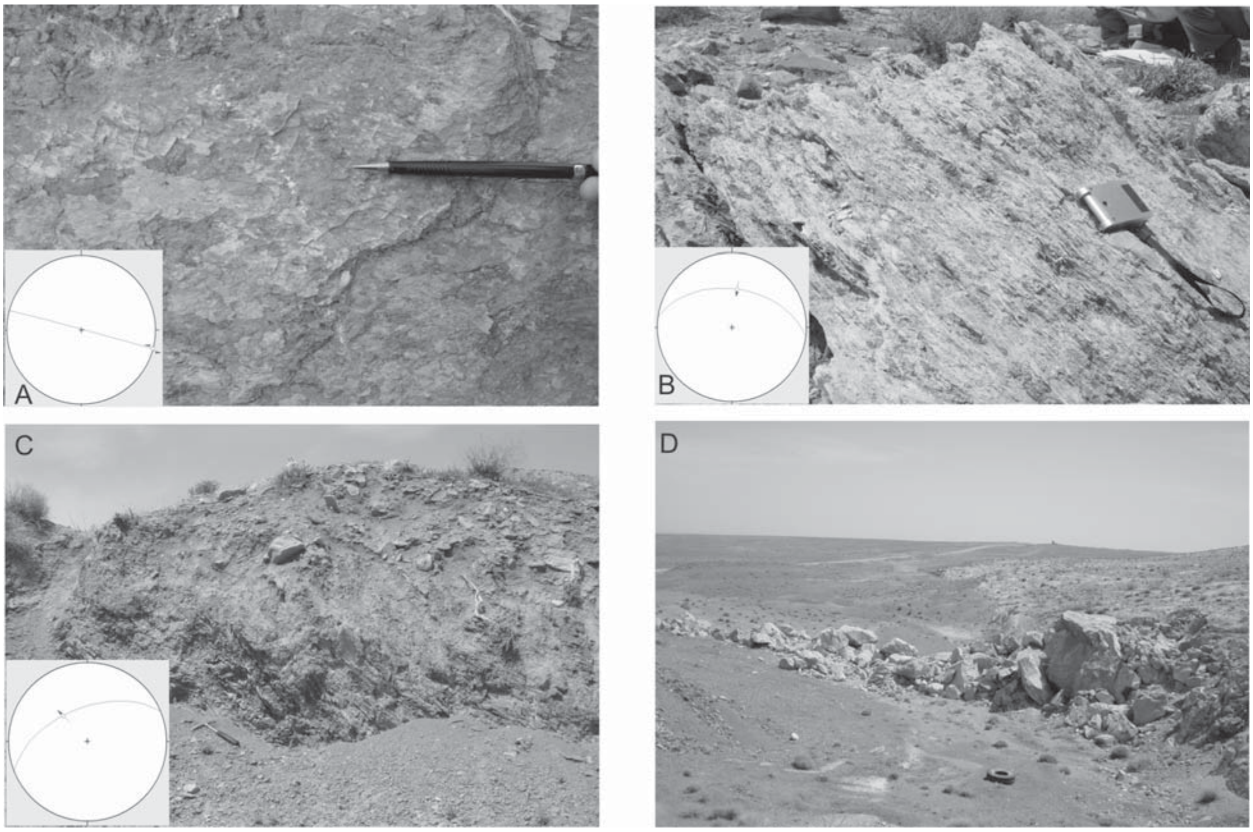

Figure 4. Samples of fault types in the study area. A) A left lateral strike-slip fault in central Laibid, B) North dipping thrust zone in western Laibid, C and D) North dipping normal fault zone in northern boundary of western Laibid.

NE-SW or N60E trend: extended in all parts with the main concentration in the eastern part of the Laibid pop-up structure. A sinistral strike-slip component is identified for some of them (Fig. 2).

NNW-SSE or N30W trend: these trends, with dextral strike-slip component, exist in the central and western Laibid.

Discussion and conclusions

Permian units of the inner parts and Triassic-Jurassic phyllitic rocks of the outer parts of the pop-up structure must fold simultaneously in the same deformational event. By referring to the coaxial interference patterns, resulting from the superposition of the folding stages, polyfolding should form in a continuous deformation. Faulting is the youngest deformational event in the study area which cuts the older ductile structures and also divides the pop-up structure into three parts. According to morphotectonic evidence, structural activities must become younger from the west toward the east. The Late Cretaceous continental collision between the Afro-Arabian continent and the Iranian microcontinent resulted in a dextral

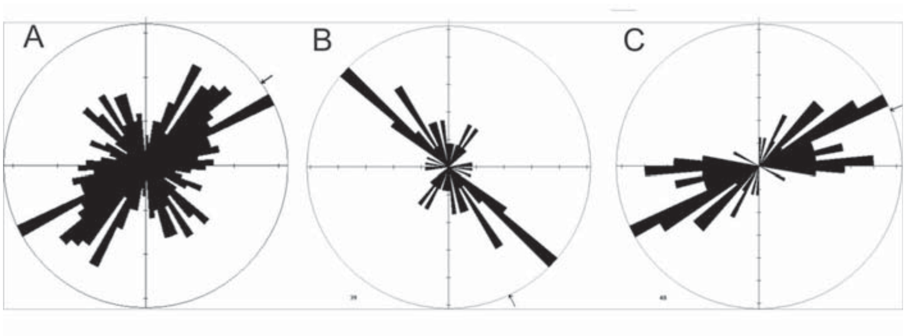

Figure 5. Rose diagrams of the total (A), right-lateral (B) and left-lateral (C) fault trends in Laibid area.

transpression movement (Mohajjel *et al.*, 2003). The data show the strong affect of this dextral movement on the formation and evolution of the Laibid pop-up structure during a continous deformation from ductile to brittle in which further movements resulted in the separation to form the pop-up structure.

References

MOHAJJEL, M., FERGUSSON C. L. and SAHANDI, M. R. (2003): Cretaceous-Tertiary convergence and continental collision, Sanandaj-Sirjan Zone, western Iran. *J. Asian Earth Sci.*, 21: 397-412.

MOOSAVI, E., SAHANDI, M. R., NAVAJARI, SH. and BAHREMANI, M., (2005): *Geological map of "Kuhe-Dehagh", series 1:100 000,* No. 6156.

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SOLTANI, Y. (2002): *Geometrical and kinematical analysis of faults bounding the Muteh-Golpaygan pop-up structure*. MSc Thesis, Tarbiat Modares University, Tehran, Iran, 92 pp.

THIELE, O., ALAVI, M., ASSEFI, R., HUSHMAND-ZADEH, A., SEYED-EMAMI, K. and ZAHEDI, M. (1968): Explanatory text of the Golpayegan Quadrangle Map. *Geol. Surv. Iran*, Rept. No. E7: 24 pp.