



Fold superimposition in the Permian groups in the central Beishan orogenic collage (northwestern China): highlights for the late evolution of the Altaids

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The southernmost part of the Central Asian Orogenic Belt (CAOB) or Altaids (Sengör and Burtman, 1993; Xiao et al., 2009), a rare and magnificent example of mesoscopic fold superimposition, involving the Permian sandstone, slightly to mildly metamorphosed clastic rocks, is well exposed in the central Beishan Orogenic Collage (BOC). We provide a detailed description of the morphological features of this phenomenon, based on an enormous amount of structural data collected during recent twice field mapping in the study area. Two phases of folds are readily distinguishable both in satellite image (Fig.1a) and our own field map (Fig.1b). Fold is tight to close, N-S-trending in the first phase (F1), and open and E-W-trending in the second phase (F2). The first phase upright folds were refolded into a smaller number of (F2), whose axial planes and axes are vertical or subvertical. They plunge gentle to moderately in the former and moderately to steeply in the latter. Their interference is in general categorized as Ramsay's (Ramsay, 1967) type 2 or Ghosh's third/fourth mode based on the value of initial tightness. However, from east to west there exists a slight variation of a zigzag to crescent to mushroom interference pattern. This subtle variation corresponds with the westward increases of the F2 interlimb angle and of the percentage of coarse-grain clastic rocks, suggesting its dependence upon the F2 deformation and the lithology. Axial slaty cleavages (S1) and associated dip-slip slickensides are more abundant in the first phase. Cleavages and strike-slip slickensides related to the seconding refolding are also occurred in the area. Finally, according to the petrological, geochemical and geochronological data, we conclude that the deformation history of the superposed folds were associated with the late evolution in the BOC. In the late Permian, the fold superimposition occurred in sedimentary rocks deposited in a Permian back-arc basin. The basin was intensely inverted, when the Huaniushan arc collided presumably obliquely with the Tarim block in late Permian, to the west, and with the Duanhuang block in the Early to Middle Triassic. The latter collision eventually ended the evolution of the BOC. In interpretation, these collisions produced an earlier local E-W and later regional N-S compressions for the fold superimposition. Finally, the mafic dyke with the age of 219 Ma intruding the refolded Permian rocks post-dates the two stages of deformation.