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From thrusting to transpressional tectonics in the Aghdarband Basin (NE Iran): evidence for Cimmerian oblique convergence

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The Aghdarband Basin, consisting of a strongly deformed arc-related Triassic marine succession, is a key-area for the study of the Cimmerian events, as it is unconformably covered by mid-Jurassic gently folded sediments entirely sealing the Cimmerian compressive structures. The basin developed during part of the Triassic in a highly mobile tectonic context suggested by abrupt facies variations and local unconformities. In addition, syn-sedimentary tectonic activity is testified by the occurrence of carbonate olistholiths in the deepest parts of the basin. The marine succession, spanning from Olenekian to lowermost Carnian, shows at the base continental conglomerates andsandstones, as well as basaltic lava flows, possibly of Early Triassic age. They are followed by the shallow water Sefid Kuh Limestone, in which an intraformational unconformity has been now identified. This unit is locally covered by deep-water limestones of the Nazarkardeh Fm. which interfinger with slope facies of the Sefid Kuh Limestone. The volcaniclastic sandstone layers of the Sina Fm follow up-section with a deep unconformity, marked in several places by deep erosion and tilting of the underlying units. The Sina Fm. is in turn unconformably covered by the coal bearing shales of the Miankhui Fm., with a Norian-Rhaetian age testified by plant megafossils, marking the end of marine sedimentation and of volcanic-arc activity.
The Triassic units are overthrusted to the south by Upper Palaeozoic siliciclastic successions showing in some cases a LG metamorphic imprint. They largely include the Qara Geithan Fm. consisting of granitic rocks, acidic to basic volcanics, and locally also large blocks of Permian bioclastic limestones derived from the erosion of the Palaeotethys accretionary wedge, exposed south of Aghdarband.
The whole succession of the Aghdarband Basin, including the unconformable Miankhui Fm., is deeply involved in a north-verging thrust stack which interacts in the northern part of the area with an important strike-slip shear zone. Several tectonic units have been recognized within the Triassic succession, causing repetitions of the whole stratigraphic succession. Two main thrust sheets are exposed in the southern part of the basin under the Upper Palaeozoic thrust stack. Thrust faults and folds consistently show a N-directed tectonic transport, suggested by dip-slip motion along S-dipping reverse faults and axial plane geometry. Deformation occurred at shallow levels taking to the formation of cataclastic shear zones and to disjunctive and pencil cleavage in the shale layers of the succession. The thrust sheets comprise the Miankhui Fm. which shows a thick basal coal layer (up to 10 m) deeply excavated at the Aghdarband Mine. Nice examples of coal-related tectonics are exposed in open pits and tunnels of the mine. Intensive deformation of the coal, forming complex shear zones with s-c bands, causes the décollement of the Miankhui beds which show intensive tectonic thickening and repetitions mainly caused by polyphase thrust imbrications and disharmonic folding.
The northernmost part of the Triassic basin shows a very complex setting, with traspressional structures given by vertical strike-slip faults and closed to tight folds with steeply plunging axes. According to our new data, up to four tectonic slices can be distinguished in this complex area. This structural zone is directly bounded to the north by severely deformed LG metamorphic rocks resulting from a volcaniclastic succession with Devonian and Carboniferous marble layers. Systematic asymmetry of major and parasitic folds, as well as rotation and torsion of axial surfaces indicate a general left-lateral transpressional regime, whereas kinematic indicators along the main fault planes show both left- and right-lateral motions. According to our relative chronology, dextral movements follow in time the sinistral ones reactivating previous Cimmerian structures and displacing also the surrounding Jurassic to Neogene succession of Kopeh Dagh in relatively recent times. Fold analyses along the area of interaction between thrust structure and the transpressional zone suggest an intricate interference pattern between thrust-related folds and strike-slip brittle shear zones, suggesting that the latter caused a strong

reorientation of previously formed folds. The extension of the traspressional zone, which can be followed for some 20 km across the study area, indicates that important left-lateral movements, roughly parallel to the orientation of the convergence zone, were active during the last stages of the Late Triassic Cimmerian event, in contrast to what indicated by previous authors in the Mashhad area.