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The tectonic evolution of Jebel Hafit and Al-Jaww Plain: structural style and fracture analysis

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Jebel Hafit, an elongated structure with elevation up to $\sim$ 1134 m above sea level, is situated at the divide between the Northern and Central Oman Mountains. It is an asymmetric, east verging double plunging whaleback anticline. It extends ca 26 km in the direction NNW - SSE with average width of 4 to 5 km. Together with Al-Ain anticline that has almost entirely been eroded, they form en-echelon structures, which are separated by a saddle. Structurally the saddle region consists of tight SW verging syn- and antiforms. Furthermore, the position of these structures coincides with the region where the general NNW-SSE strike of the Hafit-Al Ain structure changes to a NNE-SSW strike direction resembling the geometry of a large kink-band. Field evidences together with the fracture and paleostress analyses emphasize the following key elements of Jebel Hafit structure:

- Along the eastern flank of the Hafit anticline bedding planes change their dips from ca 20(s)º to 60(s)º to vertical to overturned dipping beds within a scale of tens of meters contrasting with the long-wavelength gentle folding of the same stratigraphic horizons within the easterly adjacent Al Jaaw plain. In cross-sectional view the dip of the bedding plane is fanning around a vertical axis thereby resembling the geometry of a positive flower structure, what is consisted with slip along steeply dipping fault planes with dominantly reverse sense of shear.
- Outcrop-scale fault planes containing differently oriented striations emphasize the poly-phase deformation in the Hafit area. In particular dextral and sinistral

strike-slip faults have been found cutting the Hafit structure. Offsets are in the range of a few meters to tens and hundreds of meters.

- Paleostress analysis of all minor and major faults based on their geometries and kinematics clearly indicates two main directions of compressional maximum principal stress σ_1 which are WSW-ENE (the Oman SW verging thrusting regime) and N – S to NNE – SSW (the Alpine (Zagros) Orogeny with wrench dominating regime).
- Several generations of mineralized fault planes and veins (mainly iron oxides, calcite and clay) are found indicating multiple reactivations to accommodate different stress regimes with time.

Based on the above described observations, we introduce a structural model, which involves a transpressional deformation (positive flower structure) along (deep?) seated faults. These faults possibly represent reactivated late Cretaceous and Tertiary structures. Transpressional deformation is concentrated along the eastern flank of the Hafit anticline and also forms viable kinematic boundary conditions to explain small-scale folding as observed within the saddle region which separates the Hafit from the Al-Ain antiform. Wrenching is associated with N-S shortening which to our opinion is related to the Alpine (Zagros) Orogeny since the Pliocene time. This deformation phase postdates formation of the Hafit antiform proper, which occurred within an ENE-WSW contractional regime during the Eocene-Miocene. This phase of deformation is genetically linked to Tertiary deformation within the Oman mountain belt.

Keywords: Jebel Hafit, Fractures, Faults, Paleo-stresses, Tectonic Evolution