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Orogenesis of the Oman Mountains – a new geodynamic model based on structural geology, plate reconstructions and thermochronology

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Ophiolite obduction is an integral part of mountain building in many orogens. However, because the obduction stage is usually overprinted by later tectonic events, obduction geodynamics and its influence on orogenesis are often elusive. The best-preserved ophiolite on Earth is the Semail Ophiolite, Oman Mountains. 350 km of ophiolite and the entire overthrusted margin sequence are exposed perpendicular to the direction of obduction along the northeastern coast of the Sultanate of Oman. Despite excellent exposure, it has been debated whether early stages of obduction included formation of a micro-plate, or if the Oman Mountains result from collision of two macro-plates (e.g. Breton et al., 2004). Furthermore, different tectonic models for the Oman Mountains exist, and it is unclear how structural and tectonic phases relate to geodynamic context.

Here we present a multidisciplinary approach to constrain orogenesis of the Oman Mountains. To this end, we first restore the structural evolution of the carbonate platform in the footwall of the Semail ophiolite. Relative ages of nine structural generations can be distinguished, based on more than 1,500 vein and fault overprintings. Top-to-S overthrusting of the Semail ophiolite is witnessed by three different generations of bedding confined veins in an anticlockwise rotating stress field. Rapid burial induced the formation of overpressure cells, and generation and migration of hydrocarbons (Fink et al., 2015; Grobe et al., 2016). Subsequent tectonic thinning of the ophiolite took place above a top-to-NNE crustal scale, ductile shear zone, deforming existing veins and forming a cleavage in clay-rich layers. Ongoing extension formed normal- to oblique-slip faults and horst-graben structures. This was followed by NE-SW oriented ductile shortening, the formation of the Jebel Akhdar anticline, potentially controlled by the positions of the horst-graben structures. Exhumation in the Cenozoic was associated with low angle normal faults on the northern flank of the anticline.

We link these results with the geodynamic framework of the area, constrained by plate tectonic reconstructions. Furthermore, we constrain the exhumation history of the mountain belt using zircon (U-Th-Sm)/He dating. Geodynamic and exhumation events can be linked to structural generations. This results in a new tectonic model of the Oman Mountains. We find a remarkable along-strike consistency of mountain building phases and argue involvement of a micro-plate is not required.

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