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Quaternary uplift, elevated marine shorelines and neotectonic activities in north-eastern Oman

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The striking coastal geomorphology of north-eastern Oman with its uplifted marine terraces indicates a dynamic landscape evolution during the Quaternary, associated with differential crustal movements. We quantified the vertical crustal movement and surveyed the associated fault block movements in order to reconstruct the spatial and temporal uplift history of the north-eastern Hajar Mountains. We aim for a better understanding of the tectonic geomorphology, neotectonics and related earthquake activity in north-eastern Oman.

The geology of the study area is dominated by Upper Cretaceous to Eocene limestone formations. These are underlain by serpentinised peridotites of the Semail Ophiolite. The rocks form a mountain range with elevations of up to 2100 m above the sea. The limestone formations are heavily karstified and wave-cut marine abrasion platforms form a terraces landscape along the coast.

We surveyed the uplifted marine terraces over a distance of 60 km with the aid of ground-based differential GPS measurements and high-resolution digital elevation models. We identified at least twelve terrace levels, reaching elevations of over 450 m above present sea level. The terraces are confined by two major faults towards the north and the south. The entire staircase formation is dissected by predominately NW-SE trending faults. The precise survey of the paleo-shoreline angles revealed a general northward dipping of the terraces.

We dated alluvial fan deposits covering the abrasion platform using OSL, and surface exposure based on cosmogenic nuclides (10Be and 36Cl). Our dating results indicate that the terraces formed and uplifted at least for one million years (MIS 25). Since then, each sea-level highstand during an interglacial period resulted in the formation of a terrace level within the coastal morphology. The oldest recorded terrace is attributed to MIS 25, while the lowest is assigned to MIS 5a. We calculated current uplift rates ranging between 0.2 mm/y in the northern and 0.5 mm/y in the southern study area.

The crustal uplift expressed in uplifted marine terraces is restricted to a fault block between Quriyat and Qalhat. While the neighboring northward block is subsiding, the block to the south is tectonically stable. The uplifting block is tectonically segmented in smaller horst and graben structures. Historical and archeological records reveal earthquake activities in the 14th century AD, related to the Qalhat fault. We conclude ongoing neotectonic activities since MIS 25.

Various models have been put forward trying to explain the neotectonic deformation pattern. These include forebulge development in association with subduction processes. Compressional tectonics dominate with continent-continent collision and along-strike transition to ocean-continent conversion forming the Makran Subduction Zone along the Arabian-Eurasian Plate boundary. We conclude that migrating flexural forebulge components in combination with the serpentinization of underlying Cretaceous peridotites triggers an ongoing isostatic response accompanied by neotectonic earthquake activity. This is of special interest to local stakeholders, as major infrastructure projects are located within the vicinity of the critical fault zone.