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Exploring the dynamics of the Dead-Sea Transform fault using data-integrated numerical models

Thomas Ulrich¹, Alice-Agnes Gabriel¹, Yann Klinger², Jean-Paul Ampuero³, Percy Galvez⁴, and Bo Li¹

¹Ludwig-Maximilians University, München, Germany (ulrich@geophysik.uni-muenchen.de)

²Institut de physique du globe de Paris, Paris, France

³Geoazur, Observatoire de la Côte d'Azur, Université de Nice–Sophia Antipolis, Nice–Sophia Antipolis, France

⁴Department of Earth Sciences, ETH Zurich, Switzerland

The Dead-Sea Transform fault system, a 1200 km-long strike-slip fault forming the tectonic boundary between the African Plate and the Arabian Plate, poses a major seismic hazard to the eastern Mediterranean region. The Gulf of Aqaba, which terminates the Dead Sea fault system to the South, results from a succession of pull-apart basins along the Dead-Sea Transform fault system. The complexity of the fault system in the Gulf has been recently evidenced by Ribot et al. (2020), who compiled a detailed map of its fault traces, based on a new multibeam bathymetric survey of the Gulf. Part of the Gulf of Aqaba was ruptured by an Mw 7.3 earthquake in 1995. Teleseismic data analysis suggests that it may have been a multi-segment rupture (Klinger et al., 1999). This event occurred offshore, in a poorly instrumented region, and therefore the exact sequence of faults that ruptured is not precisely known. The detailed fault mapping of Ribot et al. (2020) offers a fresh view of this earthquake. In particular, it identifies many oblique faults between the major strike-slip faults, which may have linked these segments.

Relying on this new dataset, on a new back-projection study, and on 3D dynamic rupture modeling with SeisSol (<https://github.com/SeisSol/SeisSol>), we revisit the 1995 Aqaba earthquake. Using back projection, we identify 2 strong radiators, which we associate with 2 step-overs. Using 3D dynamic rupture modeling, we propose scenarios of the 1995 earthquake, compatible with the various dataset available. Our modeling allows constraining the regional state of stress in the region, acknowledging transtension, offers constraints on the nucleation location and confirms the role of the oblique faults in propagating the rupture to the North. It offers new constraints on the regional seismic hazard, in particular on the expected maximum moment magnitude.

Finally, we explore the dynamics of the Gulf of Aqaba fault system using earthquake cycle modeling. For that purpose, we rely on QDYN (<https://github.com/ydluo/qdyn>), a boundary element software, which simulates earthquake cycles under the quasi-dynamic approximation on faults governed by rate-and-state friction and embedded in elastic media. We inform our parameterization of the earthquake cycle modeling using the previously described datasets and modeling results. Recently Galvez et al. (2020) demonstrated the capability of the method to

model the dynamics of complex fault system in 3D. Here new code developments are required to adapt the method to the Gulf of Aqaba fault system, e.g. to allow accounting for normal stress changes and for variations in the fault rake.

Overall, we aim to better understand how large earthquakes may nucleate, propagate, and interact across a complex transform fault network. Our findings, e.g. on fault segmentation or the conditions that promote larger earthquakes, will have important implications for other large strike-slip fault systems worldwide.