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Seismic Hazards Implications of Uplifted Pleistocene Coral Terraces in the Gulf of Aqaba

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The Gulf of Aqaba transform plate boundary is a source of destructive teleseismic earthquakes. Seismicity is concentrated in the central sub-basin and decreases to both the north and south. Although principally a strike-slip plate boundary, the faulted margins of the Gulf display largely dip-slip extensional movement and accompanying footwall uplift. We have constrained rates of this uplift by measurements of elevated Pleistocene coral terraces. In particular the terrace that formed during the last interglacial (~125 ka) is found discontinuously along the length of the Gulf at elevations of 3 to 26 m. Global sea level was ~7 m higher than today at 125 ka indicating net maximum tectonic uplift of ~19 m with an average rate of ~0.015 cm/yr. Uplift has been greatest adjacent to the central sub-basin and like the seismicity decreases to the north and south. We suggest that the present pattern of a seismically active central region linked to more aseismic areas in the north and south has therefore persisted for at least the past 125 kyr. Consequently the potential for future destructive earthquakes in the central Gulf is greater than in the sub-basins to the north and south.

Geologic Setting. The Gulf of Aqaba and Dead Sea fault system originated in the Miocene as a transform plate boundary linking the northern Red Sea to the East Anatolian fault and Zagros-Bitlas convergence zone in eastern Turkey[1–5] (Figs 1 and 2). This effectively ended continental rifting in the Gulf of Suez. A variety of different datasets indicates that transform initiation occurred at ~14–11 Ma[6,7]. With 107 km of total sinistral offset[8] this gives average slip rates of 0.76–0.97 cm/yr. The geodetically estimated present-day slip rate for the southern Dead Sea Rift[9] is only about half of this at 0.44 ± 0.03 cm/yr. Other estimates have suggested 0.5–0.7 cm/yr for the past 5 Myr[10,11]. Even considering observational uncertainties these interpretations allow for the possibility that slip rates on the Gulf of Aqaba-Dead Sea transform have varied significantly through time.

Much of the Gulf of Aqaba region is relatively unpopulated and with little infrastructure development. However large cities exist at the north end of the Gulf: Taba (Egypt), Elat (Israel), and Aqaba (Jordan) (Fig. 3). Sharm el Sheikh at the confluence with the Red Sea has grown rapidly in recent decades, and several smaller communities now exist along both margins of the Gulf. A large teleseismic earthquake in November of 1995 located offshore in the central sub-basin resulted in one fatality, numerous injuries, and the local destruction of buildings over a broad area[12]. As human development of the Gulf of Aqaba plate boundary and its environs progresses it is becoming increasingly important to better quantify future seismic risks for the region. In this paper we integrate seismological, outcrop, and geochronological data to assess the distribution of tectonic deformation through time and space in the Gulf of Aqaba. Our primary dataset is elevations of uplifted coral terraces that formed during the last interglacial sea-level high-stand. We also consider the longer-term uplift of the Arabian basement complex. This suggests a model in which seismicity will remain focused in the central Gulf of Aqaba sub-basin. Slip in the northern and southern sections of the basin will be accommodated aseismically or by smaller, non-teleseismic earthquakes.

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