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Linking surface deformation and lake level changes in the Dead Sea

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Climate-controlled lake level changes may exert a fundamental influence on the patterns of surface deformation, seismogenesis and fault activity. However, the relative contribution of climatic and tectonic factors on surface deformation at millennial time scales still remains poorly understood. The Dead Sea is the deepest continental basin on Earth; it is characterized by a complex history of abrupt lake level changes, active faulting, and variable seismic recurrence during the late Pleistocene and Holocene. Elucidating the interaction between climate and tectonics in this area is an extremely relevant topic in light of potential seismic scenarios associated with global climate change and anthropogenic impacts that may alter current lake levels and hence influence the crustal stress field. Here we study the outstanding exposure of fossil lacustrine shorelines along the coast of the Dead Sea, these geomorphic markers resemble past lake level positions and can be used to determine surface deformation rates and to test climate induced changes in deformation. We studied nine sites distributed along the eastern and western coasts of the Dead Sea, performing field topographic surveys, field observations and sampling for dating in each site. This study for first time provides chronological constraints for the sequence of lacustrine shorelines including 30 radiocarbon ages from fossil stromatolites. To map the morphology and distribution of the fossil shorelines we used high-resolution drone and LiDAR topography analyzed using surface classification models. Our results suggest a sequence of up to 20 levels of fossil lacustrine shorelines between -150 and -380 m and with ages ranging between ∼10 and ∼40 ka, which resembles the progressive drop of the Lake Lisan (paleo Dead Sea). The shoreline elevations display a long wavelength deformation pattern decreasing in elevation northwards and southwards. The shorelines are locally offset by faults at Ein Gedi, Ye'elim Creek, Ein Boquek, Metzoque Dragot, along the western coast and by the Sehati, and Movenpick faults along the eastern coast; preliminary fault slip rates estimates range between 0.05 and 0.2 m/ka. By comparing the elevation among shorelines of different sites we estimate a continuous deceleration of vertical deformation rates towards the present. Based on the comparison with previously published lake level curves, we suggest that isostatic rebound associated with lake-level drop may locally counteract tectonic subsidence. Our study emphasizes the link between climate and surface deformation processes in the Dead Sea. This work is supported by the German Science Foundation (DFG) grant JA 2860/1-1 "LIFE" and the German-Israeli Foundation for Scientific Research and Development (GIF), grant I-1280-301.8/2014.