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Mechanisms of forearc uplift of the Hellenic Subduction Zone revealed by dating of paleoshorelines on Crete, Greece: Implications for geodynamics and earthquake hazards in the Eastern Mediterranean

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As part of the Hellenic Subduction forearc, the mechanisms of uplift on Crete are key constraints on assessments of the seismic hazard. Late Pleistocene coastal uplift data reported for Crete are inconsistent. Studies using OSL and U-series dating of paleoshorelines demonstrate relatively slow, steady uplift rates of ∼1 mm/a argued to be due to material underplating deep along the plate interface , and suggest earthquake hazards reside on upper plate normal faults with maximum magnitudes of approximately Mw 7.5; whereas, others using radiocarbon dating show variable and rapid uplift rates that locally exceed 6 mm/a caused by motion on hypothesized steeply dipping, surface breaking offshore thrust faults. Here, we present mapping results, 20 new optically stimulated luminescence (OSL) and 5 new radiocarbon dates from paleoshorelines observed along the coastline of Crete to constrain Pleistocene rock uplift rates in space and time to distinguish between these competing tectonic models. Pleistocene paleoshorelines were mapped at elevations from several meters to 130 m above sea level and correlated along the coast. Double dating of 9 marine terraces give radiocarbon dates ranging from 2 – 50 ka with inconsistent age –elevation patterns within terrace sequences. Contrastingly, luminescence dating of the same terraces shows consistent ages from 60 – 220 ka with consistent age-elevation patterns. This new data suggests that most late Pleistocene marine terraces on Crete are older than can be dating with radiocarbon and that secondary contamination of radiocarbon material is likely. We developed a new Monte-Carlo approach to calculate coastal uplift rates that includes consideration of various paleoshoreline formation mechanisms and sea level histories to better account for the uncertainties. Our data demonstrate relatively consistent uplift rates of ca. 0.5 - 1.1 mm/a along the western and southern coastlines of Crete. The northern and eastern coasts of Crete and the island of Gavdos (∼36 km south of Crete) remain approximately stable in elevation, as indicated by marine terraces from the last interglacial and paleosols that are found close to modern-day sea level. This new data suggests that the uplift rates on Crete range from ∼0 - 1.2 mm/yr, with the most rapid rates focused along the southern coast. The patterns of uplift deduced in this study are most consistent with slip along upper crustal normal faults that act to locally augment a strong regional signal of uplift interpreted to be the result of underplating along the plate interface. This study indicates that, while faults embedded in the Hellenic forearc represent a significant seismic hazard in the Eastern Mediterranean, the magnitude and frequency of large-to-great earthquakes is likely exaggerated by some recent studies.