Active Outer Forearc Basin Formation by Syn-Convergent Extension above the Hellenic Subduction Zone, Crete, Greece

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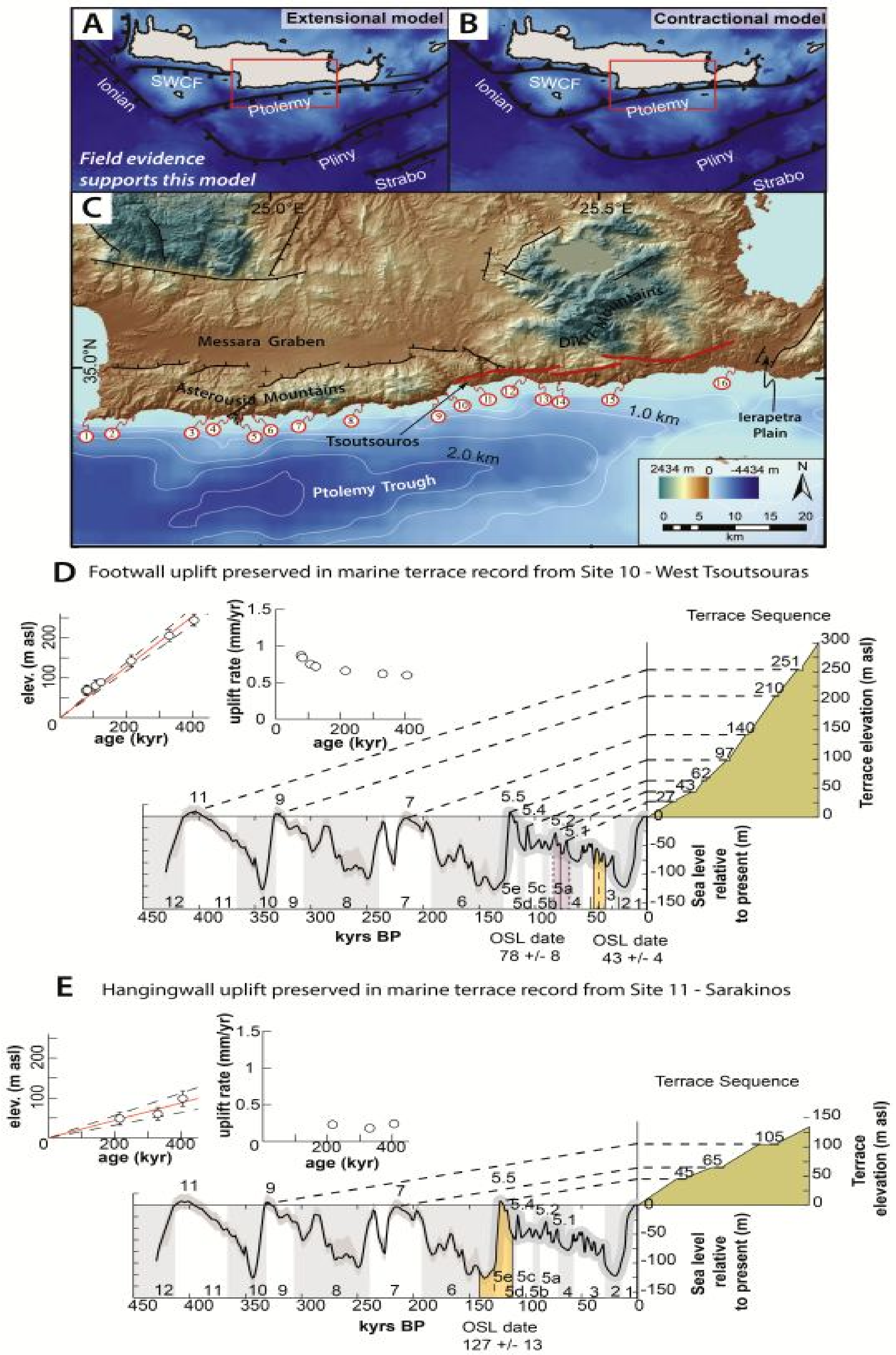

The Hellenic margin is the largest, fastest and most seismically active subduction zone in the Mediterranean. Long-lived Cenozoic convergence and subduction the Nubian (Africa) plate beneath Eurasian lithosphere has resulted in the construction of a large south-facing orogenic wedge. Rollback of oceanic African lithosphere and southward retreat of the subduction zone with respect to a fixed Eurasia likely initiated sometime in the Eocene and continues today. This geodynamic setting has given rise to a forearc characterized by a series of dramatic 2 to 4 km high topographic escarpments south of the Island of Crete; one of the few subaerial forearc highs along the Hellenic margin. It is generally agreed that these escarpments represent the surface expression of large intra-crust faults, yet the kinematics of faulting remains contentious. Different geologic and geophysical datasets have been used to argue that these structures accommodate either shortening due to continued plate convergence or extension driven by processes related to slab rollback (Fig A & B). Resolving the debate over the kinematics of the large-scale structures embedded in the Hellenic forearc is paramount to our understanding of seismic hazards, the development of forearc basins, and geodynamic processes operating in this region.

We use results from field and laboratory experiments of the tectonic geomorphology and structural geology of the south-central coastline of Crete to constrain the kinematics and evolution of the structure responsible for the Ptolemy trough, a large forearc basin south of Crete (Fig. C). Field surveys and geochronology of marine terraces reveal the pattern of late Quaternary uplift along the south-central coastline. Two large south-dipping extensional faults, which extend offshore into the Ptolemy trough, are found to offset Pleistocene marine terraces and are inferred to be active with average slip rates of ca. 0.5 mm/yr. The footwalls and hanging walls of these faults are found to be uplifting at rates of 0.5-1 mm/yr and 0.2-0.3 mm/yr, respectively (Fig. D & E). Fault-scaling relationships illustrate that it is geometrically impossible for the more easterly of these two faults to be simultaneously active with a north dipping thrust fault coincident with the axis of the Ptolemy trench. Rather, this large-scale offshore intra-crustal fault is interpreted as extensional, mimicking the active on-shore fault systems. This finding implies that the seismic threat posed by this fault is not as great as some previous research suggests. These findings, coupled with results from analyses of digital topography of south-central Crete, are consistent with a model where the Ptolemy trough, and presumably other basins in the Hellenic forearc, developed through the growth and linkage of extensional faults (Fig. A). We interpret our results as supporting a geodynamic model where extension is largely driven by processes related to slab rollback and regional uplift is the result of either inflation of the subduction wedge due to the deep underplating of material off the subduction interface and/or asthenospheric wedging related to the southerly retreat of the African slab.