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Mantle Response to Collision, Slab Breakoff & Lithospheric Tearing in Anatolian Orogenic Belts, and Cenozoic Geodynamics of the Aegean-Eastern Mediterranean Region

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The geochemical and temporal evolution of the Cenozoic magmatism in the Aegean, Western Anatolian and peri-Arabian regions shows that plate tectonic events, mantle dynamics, and magmatism were closely linked in space and time. The mantle responded to collision-driven crustal thickening, slab breakoff, delamination, and lithospheric tearing swiftly, within geologically short time scales (few million years). This geodynamic continuum resulted in lateral mantle flow, whole-sale extension and accompanying magmatism that in turn caused the collapse of tectonically and magmatically weakened orogenic crust. Initial stages of post-collisional magmatism (∼45 Ma) thermally weakened the orogenic crust in Tethyan continental collision zones, giving way into large-scale extension and lower crustal exhumation via core complex formation starting around 25-23 Ma.

Slab breakoff was the most common driving force for the early stages of post-collisional magmatism in the Tethyan mountain belts in the eastern Mediterranean region. Magmatic rocks produced at this stage are represented by calc-alkaline–shoshonitic to transitional (in composition) igneous suites. Subsequent lithospheric delamination or partial convective removal of the sub-continental lithospheric mantle in collision-induced, overthickened orogenic lithosphere caused decompressional melting of the upwelling asthenosphere that in turn resulted in alkaline basaltic magmatism (<12 Ma). Attendant crustal extension and widespread thinning of the lithosphere facilitated rapid ascent of basaltic (OIB) magmas without much residence time in the crust and hence the eruption of relatively uncontaminated, asthenosphere-derived magmas at the surface (i.e. Kula lavas in SW Anatolia).

Subduction of the Tethyan mantle lithosphere northward beneath Eurasia was nearly continuous since the latest Cretaceous, only temporarily punctuated by the collisional accretion of several ribbon continents (i.e. Pelagonia, Sakarya, Tauride–South Armenian) to the southern margin of Eurasia, and by related slab breakoff events. Exhumation of middle to lower crustal rocks and the formation of extensional metamorphic domes occurred in the backarc region of this progressively southward-migrated trench and the Tethyan (Afro-Arabian) slab throughout the Cenozoic. Thus, slab retreat played a major role in the Cenozoic geodynamic evolution of the Aegean and Western Anatolian regions. However, the subducting African lithospheric slab beneath the Aegean-Western Anatolian region is delimited to the east by a subduction-transform edge propagator (STEP) fault, which corresponds to the sharp cusp between the Hellenic and Cyprus trenches whose surface expression is marked by the Isparta Angle in the Western Taurides. This lithospheric tear in the downgoing African plate allowed the mantle to rise beneath SW Anatolia, inducing decompressional melting of shallow asthenosphere and producing linearly distributed alkaline magmatism younging in the direction of tear propagation (southward). The N-S-trending potassic and ultra-potassic volcanic fields stretching from the Kirka and Afyon-Suhut region (∼17 Ma) in the north to the Isparta-Gölcük area (4.6 Ma–Recent) in the south are the result of this melting of the sub-slab (asthenospheric) mantle, which was metasomatized by recent subduction events in the region. Asthenospheric low velocities detected through Pn tomographic imaging in this region support the existence of shallow asthenosphere beneath the Isparta Angle at present. These observations suggest that currently there is no active subduction underneath much of Western Anatolia.