CENOZOIC MAGMATISM AND EXTENSIONAL TECTONICS IN THE AEGEAN PROVINCE OF WESTERN ANATOLIA: MAKING CONTINENTAL CRUST IN A HIGHLY EXTENDED TERRANE IN A ZONE OF REGIONAL CONVERGENCE

Yıldırım Dilek[a], Şafak Altunkaynak[b]

[a]Miami University, Department of Geol. & Env. Earth Science, Shideler Hall; 250 South Patterson Avenue, Oxford, OH 45056, USA

[b]Istanbul Technical University, Department of Geological Engineering, Maslak 34469, Istanbul, Turkey

(dileky@miamioh.edu)

ABSTRACT

The continental crust constitutes the primary archive of earth history, and crustal growth takes place mainly through magmatism at active continental margins (subduction–related) and intra-plate settings (plume–related), and by accretion of volcanic arcs, oceanic plateaus and continental blocks along the edges of continents. Most of these crustal growth processes are spatially and temporally associated with subduction geodynamics and collision tectonics. The role of extensional tectonics and accompanying magmatism in crustal growth has been lees emphasized in the literature, with the exception of the development of volcanic rifted margins. We discuss here a case study of significant crustal growth via subduction–driven extensional magmatism in Western Anatolia throughout the Cenozoic, and show that: (1) the major component (by volume) of continental crust in this region is made of Eocene and younger magmatic rocks and their derivatives that formed in a broad ~N-S–oriented extensional stress regime, and (2) both lithospheric and asthenospheric mantle melting have contributed to the magma budget and have provided the necessary heat and melt flux for thermally weakening the young orogenic crust.

Western Anatolia is situated in an active plate convergence zone between Africa and Eurasia, and its tectonics has been controlled mainly by the northward subduction of the Africa lithosphere since the Eocene and the W-SW escape of the Anatolian microplate from the Arabian collision zone to the east and its counter-clockwise rotation since the late Miocene. Southward retreat of the subducting Africa lithosphere and the slab suction force induced upper plate extension in Western Anatolia starting ~30 Ma, causing large–scale lithospheric thinning and decompression melting, reminiscent of the Indonesia–Melanesia region after the India–Asia collision in the eastern end of the Tethyan realm. The collision of the Eratosthenes Seamount with the Cyprean Trench in the latest Cenozoic resulted in segmentation of the downgoing Africa slab along a Subduction–Transform Edge Propagator (STEP) fault zone (Isparta Cusp and its transtensional fault system) and in focused asthenospheric upwelling beneath SW Anatolia.

We demonstrate that magmatic crustal growth in Western Anatolia has occurred in four temporally, geochemically and geodynamically distinct phases during the Cenozoic. The first phase is represented by Eocene plutonic–volcanic rock suites that are linearly distributed along / across the suture zone between the Sakarya and Tauride continental blocks. These Eocene rocks display medium- to high-K calc-alkaline geochemistry, moderately evolved melt com-

positions, and LILE enrichment (over MREE) – HFSE depletion, characteristic of subduction–influenced sub-alkaline magmas. The second phase is represented by Oligocene – early Miocene plutonic and volcanic rocks, which have shoshonitic to high-K calc-alkaline compositions, show enrichment in the most incompatible elements and depletion in Nb, Ta and Ti, and exhibit LREE enrichment and flat HREE patterns. Increased crustal contamination was an important process in the melt evolution of these Oligo–Miocene magmatic suites, and their magmas were derived largely from partial melting of subduction–metasomatized sub-continental mantle lithosphere. Spatial association of ash-flow tuff deposits with lacustrine rocks, widespread ignimbrite flows and coal layers suggests development of accommodation space and terrestrial depocenters via tectonic extension during this phase. Mildly alkaline and bimodal, Middle Miocene volcanic rocks represent the third phase of the Cenozoic magmatism in Western Anatolia. Their less pronounced enrichment trends in Ba, Th and K, weaker Nb and P anomalies, and lower LREE enrichment patterns in comparison to the Eocene and Oligo–Miocene rock suites indicate reduced crustal contamination and subduction influence effects in their melt evolution. Asthenospheric mantle–derived melt contribution was important for this phase, which also coincided with widespread extensional deformation, structural graben formation and crustal exhumation. Upper Miocene–Quaternary alkaline and super–alkaline volcanic rocks with ocean island basalt (OIB)–like geochemical features belong to the fourth phase of magmatism. Commonly associated with major extensional and transtensional fault systems (particularly within the Isparta Cusp) in SW Anatolia, these potassic and ultrapotassic volcanic rock suites have very low SiO_2*–high MgO contents and lamproitic affinities, show high LILE and LREE distributions compared to HFSE, and display low Sr–high Nd isotopic compositions. Magmas of these highly alkaline volcanic rocks carried little subduction influence and no crustal contamination effects, and were produced by decompression melting of upwelling asthenospheric mantle beneath the highly attenuated continental lithosphere. Doming of the Central Menderes Core Complex and the eruption of the Na-alkaline Kula lavas occurred during this phase, attesting to the existence of convecting mantle beneath the region by the Holocene. The spatio–temporal distribution of the Cenozoic igneous rock assemblages in Western Anatolia shows a conspicuous southward migration of magmatism and magmatically–driven crustal growth through time with increased asthenospheric input.*

We posit that this time–progressive, Cenozoic magmatic evolution of Western Anatolia presents a common template for the mode and chemical geodynamics of magmatism in collisional orogenic belts. Initial slab breakoff–generated asthenospheric flow is commonly followed by lithospheric delamination–related asthenospheric flow and then by tectonic extension–driven upward asthenospheric flow in such orogenic belts. We compare and contrast the Cenozoic magmatic evolution and crustal growth of Western Anatolia with that of the Tibetan–Himalayan orogenic belt in order to derive tangible conclusions for the mode, tempo and geochemical–isotopic fingerprint(s) of magmatic phases in continental collision zones.

Keywords*: Cenozoic magmatism in Western Anatolia; extensional tectonics; crustal growth; asthenospheric flow; slab breakoff; lithospheric delamination; potassic–ultrapotassic volcanism; collisional orogenic belts*