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RESEARCH ARTICLE
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The Uplift of the Troodos Massif, Cyprus

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Key Points:

- Fault-slip data constrain the uplift history of Troodos Massif by concurrent N-S shortening and E-W extension
- Geometry of high-topography region coincides with underthrusting fragment of continental crust
- Exposure of mantle rocks at top of mountain range explained by doubly-plunging antiform dissected by normal faults dipping down fold axes

Supporting Information:

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Abstract We constrain the fault pattern and the kinematics of faulting that facilitated the uplift of the Troodos Massif in Cyprus in the eastern Mediterranean. The fault pattern consists of E-W striking reverse faults, N-S striking normal faults, and NW striking dextral and NE striking sinistral strike/oblique-slip faults. Fault-slip analysis reveals that this overall pattern resulted from subhorizontal NNW directed shortening and coeval, subhorizontal ENE directed extension. Dated sediments affected by faulting reveal that the N-S striking normal faults are, at least in part, younger than 2.14 Ma. This suggests that the entire fault pattern, or at least a large part of it, resulted or was reworked during post-2.14-Ma deformation. Published work further shows that the uplift of the Troodos Massif was controlled by underthrusting of the Eratosthenes Seamount, which entered the Cyprus subduction zone by about 2 Ma. The alleged E-W extent of the underthrust segment of the seamount approximately matches the size of the high-topography area of the Troodos Mountains. We interpret this geometry to have caused spatially limited crustal thickening underneath the high-topography area by subhorizontal N-S shortening in front of and above the underthrusting seamount and coeval, subhorizontal E-W extension at its flanks, and that the uplift of the high-topography area occurred in the footwall of the N-S striking normal faults. This model is broadly in line with seismicity and may also explain why serpentinized mantle rocks and dense gabbro are now exposed on top of the Troodos Massif.

1. Introduction

Topography is a critical constraint on lithospheric tectonics and is important for regional and global climate (Molnar et al., 1993; Ruddiman et al., 1997; Kutzbach et al., 1993). If there is sufficient elevation (~1,500 m), the existence of a dominant wind direction imposes a marked asymmetry on the orogenic system leading to a rain-shadow effect (Barry, 1981) with an increase in erosion through orographic enhancement of precipitation along the windward side.

The Troodos Massif of Cyprus is a WNW trending range with the highest peak (Mount Olympos) at 1,952 m above sea level in its center. The range forms a rain shadow with a relatively wet southwestern, windward side with an average annual total precipitation increasing from 450 mm at the base to nearly 1,100 mm at the top of the Troodos Mountains, and a dry northeastern side with about 300 mm of precipitation (Department of Meteorology; www.moa.gov.cy; Figure 1). The main phase of uplift of the Troodos Massif was due to the collision and underthrusting of the Eratosthenes Seamount to the south of Cyprus (Robertson & Woodcock, 1980; Robertson, 1998; Kempler, 1998; Figure 2) since about 2 Ma (Kinnaird et al., 2011). Surface uplift of Cyprus, accompanied by concomitant subsidence of the northern underthrusting edge of the Eratosthenes Seamount, marks incipient continental collision in the eastern Mediterranean (Kempler, 1998).

While there is widespread consensus on the role the Eratosthenes Seamount played in the uplift of the Troodos Mountains, the tectonic architecture and the kinematics of the tectonic processes as well as the mechanisms that caused uplift are less well constrained. A popular model is that the uplift of the Troodos Massif was caused by serpentinization of mantle peridotite and that the massif represents a huge diapir (Schuiling, 2011; Shelton & Gass, 1979). Different views exist as to when the peridotite was serpentinized. Nuriel et al. (2009) proposed localized hydrothermal alteration by deep infiltration of seawater near the mid-ocean ridge followed by pervasive low-temperature hydration and veining during seafloor spreading in the late Cretaceous at the ocean floor. Cretaceous serpentinization cannot have aided the young uplift of the Troodos Massif. In contrast, Morag et al. (2016) proposed that apatite (U-He)/He cooling ages are related to the uplift of the Troodos Massif by serpentinite diapirism, possibly triggered by Miocene reactivation of subduction along the Cyprean Arc; that is, they call for a late Miocene age of serpentinization