The origin of evolved volcanic rocks in Methana, Greece

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The formation of evolved andesite to dacite magmas at subduction zones is an important process on Earth. The Aegean arc has one of the highest rates of sediment subduction globally that impacts on the composition of the erupted melts. Methana peninsula is located at the western margin of the Aegean arc and consists of numerous effusive andesitic to dacitic eruptions. These evolved lavas frequently contain basaltic to basaltic-andesitic enclaves. An origin of the Methana andesites as a result of melting of mantle hybridized by sediment melts can be excluded from the occurrence of basaltic enclaves. Petrological and geochemical data suggest shallow crustal processes playing a crucial role in the formation of these rocks. The major element patterns (e.g. FeO*, Al_2O_3 or TiO_2 vs. MgO) show evidence for fractional crystallization. Mineral compositions display oscillatory zonings, disequilibrium textures, secondary rim overgrowths and different mineral populations indicating complex mixing of magmas. Plagioclase generations can mainly be distinguished by their size and phenocrysts display anortithe contents from 43 to 88, while amphiboles show evidence for polybaric fractionation. Thermobarometric calculations using amphibole-plagioclase assemblages imply that magma mixing occurs in the shallow crust (9-15km) feeding the volcanic eruptions. We develop a model of a deep-reaching magma system reaching to the crust-mantle boundary. This can explain continuous magma mixing along a range of depths. Fe-Ti oxide thermometry yields partly higher temperatures than the plagioclase-amphibole thermometer and possibly resulting from rapid magma ascent. Explosive volcanism dominates the central and eastern Aegean islands, e.g., Santorini or Kos [1], while Methana displays extensive effusive volcanism with lava domes and flows. We interpret this to result from pre-eruptive re-heating [2] by recharge of more primitive and hotter magma from the crust-mantle boundary. The larger crustal thickness in the western Aegean may influence the eruptive mechanism by intensive degassing covering a higher distance during magma ascent than in other parts of the arc.

[1] Druitt et al. (2016), Journal of Petrology 57(3), 461-494; [2] Ruprecht & Bachmann (2010), Geology, 38(10), 919-922.