MANTLE MELTING AT MOUNT ETNA: A THERMODYNAMIC MODELING APPROACH TO UNDERSTANDING THE POST-1971 ALKALI ENRICHMENT

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Several times in the past 60 ka, Mount Etna has erupted lavas with variable alkaline character. The most recent chemical excursion began in 1971, accompanied by an increase in explosivity and eruption frequency. The origin of the alkaline signature remains enigmatic, with endmember hypotheses involving dominant contributions from mantle vs. crust. For lavas that erupted between 1329 and 2016, we used thermodynamic modeling to test if post-1971 anomalous alkalinity is dominated by mantle processes. First, we assessed mantle melting conditions required to reproduce the chemistry of potential parental magmas. Second, we examined the differentiation of partial melts as they underwent closed-system crustal storage and ascent. The mantle melting conditions explored via ~300 models include source compositions (peridotite + pyroxenite ± metasomatic phases), pressure, extent of melting, and f_{O_2}. Best-fit models that reproduce the major element chemistry of volcanics interpreted as parental magmas involve 20 to 30% melting of a peridotite-pyroxenite mantle source that contained phlogopite, pargasite, and CO_2 (~1 wt.%) between ~1-1.5 GPa (~30-45 km) along the QFM+1 buffer. Subsequent isentropic decompression (adiabatic and reversible) of mantle partial melts + crystallization at shallower pressures (0.8-0.2 GPa) were modeled to test the effects of closed system ascent and storage. Isentropic decompression models yield no crystallization although temperature decreases ~3°C/0.1 GPa. Decompression + closed system crystallization *fail* to replicate post-1971 glass samples and do not explain observed post-1971 alkali enrichments. We conclude that partial melting of a metasomatized source produced Etna parental magmas, but closed system crustal ascent and storage cannot fully account for alkali enrichment highlighted in post-1971 products at Etna. Open system modeling suggests that assimilation and crystallization (e.g., Takach et al. 2024) play a critical role, and ongoing modeling is testing the contributions of recharge (magma replenishment) and entrainment of previously formed mushes to the high alkalinity excursions.

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