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Thermodynamic modeling of the origin of trachyte and pantellerite, Pantelleria, Italy.

J.C. White (1), D.F. Parker (2) and M. Ren (3)

(1) Department of Geography & Geology, Eastern Kentucky University, USA, (2) Department of Geology, Baylor University, USA, (3) Department of Geological Sciences, University of Texas at El Paso (john.white@eku.edu / Fax: +1 859-622-1450 / Phone: +1 859-622-1276)

Trachyte and peralkaline rhyolite (pantellerite) frequently comprise the felsic end-member in bimodal suites in continental rift and oceanic island settings. In these settings, the relationship between the mafic (transitional and alkali basalt to hawaiite) and felsic lavas is ambiguous; major- and trace-element models and isotopic data are often consistent with an origin for felsic lavas from both fractional crystallization of basalt and from partial melting of basalt followed by fractional crystallization. This is especially true at Pantelleria, Italy, where mafic and felsic rocks have similar Sr-Nd-Pb isotopic ratios and major- and trace-element models are consistent with an origin of trachyte by either equilibrium batch melting (EBM) or Rayleigh fractional crystallization (RFC) (Mahood et al., 1990; Civetta et al., 1998; Avanzinelli et al., 2004). Predicted values of F (proportion of liquid) for both EBM and RFC models range from 0.18-0.28 if alkali basalt (48.5 wt% SiO_2, normalized anhydrous) is selected as the model parent/source to 0.30-0.35 if hawaiite (51.1 wt% SiO_2, normalized anhydrous) is selected as the model parent/source. Previous workers have applied several other techniques to resolve this controversy (e.g., volatile content, mineral chemistry, and experimental petrology), and although there appears to be a general consensus that the pantellerite lavas and tuffs are the product of about 75% crystallization ($F \approx 0.25$) of trachyte, there is no such consensus for the origin of trachyte.

In this study, we combine the results of major- and trace-element modeling with the results of thermodynamic modeling (MELTS; Ghiorso & Sack, 1995; Asimow & Ghiorso, 1998; Smith & Asimow, 2005) of these processes and phase equilibria

calculations from mineral assemblages from a basalt-trachyte-pantellerite suite from Pantelleria, Italy. From these results we conclude that trachyte with $\sim$64% SiO_2 and $\sim$1.5 wt% H_2O formed as a result of $\sim$65% fractional crystallization (F $\approx$ 0.35) of an assemblage of plagioclase, clinopyroxene, olivine, magnetite, and apatite from hawaiite magma with 0.5 wt% H_2O at approximately 0.1 GPa of pressure and an oxygen fugacity approximately one-half of a log unit below the fayalite-magnetite-quartz buffer (FMQ-0.4 to FMQ-0.6). Pantellerite (up to $\sim$72 wt% SiO_2) then formed from $\sim$75% crystallization of an assemblage dominated by alkali feldspar from trachyte (i.e., about 91% total crystallization from hawaiite). However, compositional variation within most of the trachyte lavas and the comenditic trachyte tuffs (including the top of the Green Tuff) is the result of varying degrees of accumulation of alkali feldspar rather than either RFC or EBM.

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