MAFIC INCLUSIONS IN THE TSCHICOMA FORMATION, JEMEZ VOLCANIC FIELD, NEW MEXICO

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The Tschicoma dacites of the Polvadera Group, Jemez Volcanic Field, contain abundant inclusions of basaltic andesite. These inclusions commonly range in diameter from 1 to 12 cm and consist of acicular plagioclase, acicular oxyhornblende, vesicles (20%, enough to make the inclusions buoyant in their dacite host) and glass. Mafic inclusions such as these are now widely attributed to magma mixing. Two mechanisms have been proposed: a decrease in density as crystallization and volatile exsolution take place in a mafic magma cooling beneath a felsic magma reservoir; and forceful injection of a mafic magma into a felsic reservoir. In the latter mechanism, both magmas are fully liquid on mixing, whereas in the former, the mafic magma must be partially crystallized before mixing.

For the inclusion in the Tschicoma dacite, we can demonstrate not only that they were produced by magma mixing between the host Tschicoma dacite and an associated basaltic magma, but that the mechanism had to be forceful injection. Our evidence: 1) Major- and trace-element, as well as isotopic, data allow a least squares mixing calculation between the Tschicoma dacite and the associated Lobato basalt, which reproduces the chemistry of the inclusions. 2) Glomeroporphyritic clots of the host Tschicoma dacite, consisting of glass-charged (sieve texture) plagioclase (An3-48), hornblende and biotite, are found within the inclusions. The plagioclase in these clots, both in the inclusions and in the host Tschicoma has reversely-zoned rims (An50-52), which reflect the higher An content of the inclusions (An49-56). This rim post-dates the resorption indicated by sieve texture. Thus, these plagioclases seem to record a thermal and chemical reequilibration in response to the injection of a higher-temperature, more-mafic magma into the dacite. 3) Statistical analysis of grain size (length x width), grain acicularity (length/width) and coefficient of variance of grain size (size variability) shows a systematic variation both with the inclusion size and with position within an inclusion. Grain size and the coefficient of variance of grain size increase with inclusion size, indicating a longer period of crystal nucleation and slower cooling. Acicularity decreases in larger inclusions, indicating smaller degrees of undercooling. Within one inclusion grain size decreases, and acicularity increases, towards the boundary of the inclusion, reflecting more rapid cooling at the boundary. These observed variations in texture indicate that the inclusions were incorporated while in a liquid state. This supports forceful injection. 4) Modeling of heat flow for a spherical molten inclusion solidifying within a viscous liquid host suggests that outer boundaries cool roughly ten times more rapidly than the inclusion interiors and that smaller inclusions cool more quickly than

the larger ones, roughly in inverse proportion to the square of the inclusion radius. This model qualitatively agrees with our observation of cooling rate based on statistical analysis of grain size and acicularity. Again, this supports forceful injection, since there would be no such systematic variation in texture if the mafic magma were partially crystallized before mixing.