ABSTRACT

An abstract of the thesis of Meghan Lunney for the Master of Science in Geology presented June 3, 2002.

Title: Andesite Magma Evolution Based On Textural and Compositional Analysis of Plagioclase Phenocrysts of Arenal Volcano, Costa Rica

Arenal Volcano in Costa Rica has undergone steady eruption since 1968 and maintained a basaltic andesite composition ranging from 54-55 wt. % SiO₂. Phenocryst-rich lavas (40%) are primarily composed of plagioclase, with smaller amounts of clinopyroxene, orthopyroxene and titanomagnetite.

Nomarski Differential Interference Contrast microscopy and core-rim microprobe traverses were used to collect compositional data in 120 plagioclase from 15 rock samples representing the eruption dates of 1968-1996. Most traverses analyzed every 3-4 µm, while a smaller amount collected every 20-40 µm. Analyzed plagioclase range between 90-3500 µm across and indicate normal or reverse An zoning. Contrary to the bulk composition, plagioclase within lava samples record a wide compositional range (An₉₄-An₅₅) and a variety of textures, implying a more complex magma history than would be inferred from the bulk composition alone.

Most plagioclase contain either mottled cores with average An (89-81), or flat cores with a slightly higher An (90-85). Zoning styles of overgrowth on cores include 1) oscillatory zoning: straight, convolute, or hieroglyphic (An₇₇-₆₈), 2) pitted zones:
boxy cellular (An_{81-72}), spongy cellular (An_{86-75}) or pitted texture (An_{82-72}) or 3) texturally homogeneous growth zone (An_{70-62}). Continuous and variable growth environments produce homogenous zones and oscillatory zoning, respectively, whereas resorption conditions create boxy, spongy and pitted textures.

The majority of phenocrysts (69%) share the last crystallization episode resulting in a homogenous growth zone (5-20 µm) at the rim that is compositionally zoned from An_{69-62}. Evidently, phenocryst rim crystallization occurred concurrently to growth of compositionally similar micro-phenocrysts (≥70µm and ≤200µm) and microlites (<70µm). Conversely, vastly different and complicated growth histories of phenocrysts in individual lava samples suggest recurring and multiple growth environments juxtaposing phenocrysts during mixing shortly before rim crystallization in final ascent during eruption. Chief controls on plagioclase compositional variation appear to be a combination of Ca/Na of the melt and decompression during ascent. Strong variation in H₂O saturation levels is unlikely as it is inconsistent with overall strong decline from An_{90} in core to An_{55} in rim, and preliminary data on matrix glass and inclusions suggest H₂O saturated conditions for much of the compositional range.