

Resolving the effects of degassing vs. magma mingling in andesites and dacites from Medicine Lake Volcano.

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Abstract

A detailed petrologic study is presented for seven phenocryst-poor andesites and dacites erupted from Medicine Lake Volcano, CA. This volcanic edifice has erupted phenocryst-poor liquids ranging over the complete compositional spectrum from basalt to rhyolite, often coevally (Donnelly-Nolan *et al.*, 2008), which makes it the ideal place to evaluate and resolve the effects of degassing vs. magma mingling in producing complex textures and zonation patterns in the phenocrysts of intermediate magmas. Despite having only 2 to 10% phenocrysts (+ microphenocrysts), the andesites and dacites featured in this study are each multiply saturated with six to seven mineral phases (plagioclase + orthopyroxene + clinopyroxene + ilmenite + titanomagnetite + apatite ± hornblende). Plagioclase, orthopyroxene and clinopyroxene phenocrysts often display diffusion-limited growth textures (e.g., swallow tail and hopper textures, large melt hollows, etc.). Temperatures ($\pm 1\sigma$) were calculated with the two Fe-Ti oxide geothermometer of Ghiorso & Evans (2008) and range from 960 (± 25) to 1021 (± 16)°C for the andesites and from 876 (± 18) to 966 (± 19)°C for the dacites. Oxygen fugacities, relative to the Ni-NiO buffer ($\Delta\text{NNO} \pm 1\sigma$), range from -0.2 (± 0.02) to 1.1 (± 0.1). With temperature known, the plagioclase-liquid hygrometer of Lange *et al.* (2009) was employed to determine pre-eruptive melt water concentrations. Maximum melt water concentrations, based on the most calcic plagioclase phenocryst in each sample, range from 3.4 to 4.2 wt% H₂O for the andesites and from 4.2 to 5.8 wt% H₂O for the dacites. These results require that the magmas were fluid saturated at pressures >0.9-1.7 kbars (~3-6 km), and underwent degassing upon ascent to the surface. Plagioclase phenocrysts span a wide range in composition (20-40 mol% An). Some of this variability can be attributed to degassing, owing to the fact that dissolved water strongly affects plagioclase composition. The basis of the plagioclase-liquid hygrometer is that dissolved hydroxyl groups preferentially speciate with Na vs. Ca, thus reducing the albite component in the melt, leading to more calcic plagioclase at higher melt water concentrations. Orthopyroxene, like plagioclase, also spans a wide range in composition (≤ 27 mol% En) in the andesites and dacites, and again some of this compositional variability can be attributed to changing melt water concentration during degassing. Because hydroxyl groups preferentially speciate with Mg vs. Fe²⁺, higher melt water contents lead to more Fe-rich orthopyroxenes. Thus, the effect of degassing is to produce more sodic plagioclases and more Mg-rich orthopyroxenes. According to calculations based on the JANAF tables, plagioclase is expected to be more sensitive than orthopyroxene to changing melt water concentrations during degassing, and the Fe-Ti oxides are expected to change little. Therefore, another diagnostic tool to resolve the effects of degassing vs. magma mingling in andesites and dacites, in addition to phase equilibrium experiments to verify phenocrystic compositions, is the observed variability of calculated temperatures from all possible pairs of ilmenite and titanomagnetite crystals.

Fire as a Gaian mechanism to regulate atmospheric oxygen: an experimental investigation

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In his first book on Gaia, Lovelock suggested the idea that fire might be an important regulator of atmospheric oxygen. Here we describe experimental investigations undertaken in the 1970s, but not widely published then, designed to test this idea. Rate of spread and the energy required for ignition were measured in paper, as an analogue for natural fuels, and the results were mapped as functions both of the moisture content of the fuel and the atmospheric oxygen tension. These can be translated approximately into probabilities of ignition and rates of spread of wildfires under different oxygen mixing ratios, by comparison with fire danger rating indices. The results suggest that wildfire destructiveness has a rapidly increasing dependence on atmospheric oxygen at the present concentration of about 21%. Consideration of the importance of fire in limiting productivity on land today, then suggests that fire is an important factor setting the current and past atmospheric oxygen concentrations, and that this sensitivity can provide an explanation for why atmospheric oxygen is stable on geological time scales, at present levels.