Textural and Mineral Chemistry Constraints On Evolution of Merapi Volcano, Indonesia

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We analyze and compare the textures of Merapi lavas (basalts and basaltic andesites) ranging in age from Proto-Merapi through modern activity, with the goal of gaining insights on the temporal evolution of Merapi magmatic system. Analysis of textural parameters, such as phenocryst and microphenocryst crystallinity, coupled with crystal size distribution theory, provides information about the storage and transport of magmas. We combine textural analyses with geochemical investigations for a comprehensive comparison of erupted lavas over time. The chemical analyses identify crystal growth processes in the magma chamber and underline differences between sample groups. We analyze also the textures and mineralogy of Merapi tephra generated during explosive eruptions with VEI 3-4, and compare these data to those observed for Merapi dome and flow lavas. We find that the Merapi tephra and lava textures differ significantly with respect to small-size crystal populations, but that phenocryst textures are generally similar. A similar initial phase of crystallization is indicated for tephras and lavas in mid-crustal reservoirs. Subsequent textural differences are mainly affected by ascent rate and degassing during ascent, and, for dome lavas, with temporary storage in a shallow reservoir. These differences correspond to different eruptive styles. In general, comparison of the crystal size distributions and calculated residence times among the effusive and explosive eruptive styles indicates that the two magma types resided for a similar length of time in a mid-crustal reservoir, before ascending toward the surface and either erupting (tephra), or stagnating in a shallow magma chamber (lava). The interpretation is supported by the occurrence of amphibole in pristine condition (tephra) or altered state (lava). Dome lavas from the 20th century eruptive activity indicate steady-state, open-system behavior, while samples from the stratigraphic history of Merapi record both repeated attainment and loss of steady-state conditions. This observation suggests that the relatively benign activity of the 20th century will be interrupted from time to time by more explosive eruptions such as that of 2010.