The dynamics of magma recharge in persistently active basaltic andesite systems

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The triggering of eruptions by magma recharge is relatively well understood in systems where the resident magma and the recharge can be clearly differentiated. However, in persistently active basaltic andesite systems such as in the Southern Volcanic Zone of the Andes, in which both recharge and resident magmas are similar, the subtleties of the mixing and thermodynamics of the recharge have not been fully addressed. In order to formulate adequate thermodynamical models for these systems, a model for steady state recharge needs to be considered. This simple constraint implies inherent irreversibility of the recharge mechanism and permanent non-equilibrium conditions of the system. Under such conditions, the application of standard equilibrium approaches can simply not be justified. Keeping that in mind, in this work we have simulated the recharge and evolution of a steady state basaltic andesite system using alphaMELTS in small increments of evolution and recharge (quasistatic iterations), taking advantage of the fully automatic scripting capabilities of the code. Initial conditions of the calculations were based on geological constrains from both Villarrica and Llaima volcanoes, Chile. The results strongly suggest that recharge in this type of system can be modeled as a non-linear process that largely self-organizes under steady state conditions. This in turn implies that the narrow compositional range of the volcanic products in these systems (i.e. the basaltic andesite) is the direct consequence of the self-organization, while sudden changes in the behavior of the systems may be consequence of the non-linearity of dissipative structures. The calculations and model are in good agreement with the measurements of the crystal size distributions of the main mineral phases found in Villarrica and Llaima products and generated under a variety of eruptive situations. An obvious implication of these results is the inherent difficulties in using geochemistry for forecasting elevations in eruptive activity since small changes in the dynamics of the steady state system can have non-linear effects. Further work needs to be done to quantify the extent of changes that might produce a major eruptive events in these systems.