# NIDIS: The non-isothermal diffusion incremental step model - a new approach to elemental diffusion in volcanic rocks

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Volcanic systems are normally considered as isothermal diffusing systems in which the diffusion temperature is treated as "constant" for the duration of the pre-eruptive processes. Diffusion coefficient depends exponentially on temperature and on other intensive thermodynamic variables. However, temperature is the main critical parameter. In cases were the chemical zoning pattern of minerals indicates a substantial difference (~ 50 °C) in the equilibrium temperature of the different zoned portions, we found that this produces a bias in the estimated timescales of a factor of 3 to 5. This is a significant difference and cannot be ignored.

We propose a new approach to take into account a diffusion coefficient for each compositional band in order to match the specific equilibrium temperature of the band. A mineral showing multiple bands of different composition, testifying the arrival of hotter and more mafic magma, will show multiple diffusion profiles which are the results of diffusion at different temperatures for different timescales. It is thus possible to deconstruct the main core-rim diffusion profile into different isothermal steps with its own diffusion coefficient. Each step takes into account the diffusion timescale of the previous step. The final diffusion profile is thus the result of different isothermal steps at different temperatures. We propose to call this approach the Non-Isothermal Diffusion Incremental Step (NIDIS) model. This novel approach considers the so-far-ignored importance of changes in temperature, and consequently in the diffusion coefficient, also in volcanic systems. This model can also have important implications in reconsidering the meaning of crystal residence time in fast cooling systems.