Zoning and exsolution in cumulate alkali feldspars from the eruption (12.9 Ka) of Laacher see volcano (Western Germany) as an indicator of time-scales and dynamics of carbonate-silicate unmixing

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Time-scales extracted from the detailed analysis of chemically zoned minerals provide insights into crystal ages, magma storage and compositional evolution, including mixing and unmixing events. This allows having a better understanding of pre-eruptive history of large and potentially dangerous magma chambers. We present a comprehensive study of chemical diffusion across zoning and exsolution patterns of alkali feldspars in carbonatite-bearing cognate syenites from the 6.3 km3 (D.R.E) phonolitic Laacher See Tephra (LST) eruption 12.9 ka ago. The Laacher See volcano is located in the Quaternary East Eifel volcanic field of the Paleozoic Rhenish Massif in Western Germany and has produced a compositionally variable sequence in a single eruption from a magma chamber that was zoned from mafic phonolite at the base to highly evolved, actively degassing phonolite magma at the top.

Diffusion chronometry is applied to major and trace element compositions obtained on alkali feldspars from carbonate-bearing syenitic cumulates. Methods used were laser ablation inductively coupled plasma mass spectrometry (LA ICP-MS) in combination with energy-dispersive and wavelength-dispersive electron microprobe analyses (EDS & WDS-EMPA). The grey scale values extracted from multiple accumulations of back-scattered electron images represent the K/Na ratio owing to the extremely low concentrations of Ba and Sr (<30 ppm). The numerical grey scale profiles and the quantitative compositional profiles are anatomized using three different fitting models in MATLAB[®], Mathematica[®] and Origin[®] to estimate related time-scales with minimized error for a temperature range of 750 deg C to 800 deg C (on the basis of existing experimental data on phase transition and phase separation). A distinctive uphill diffusive analysis is used specifically for the phase separation in the case of exsolution features (comprising of albite- and orthoclase-rich phases) in sanidines. The error values are aggregates of propagated error through calculations and the uncertainty in temperature values. Trace element compositional data of distinct feldspar compositions that are assumed to have grown before and after silicate-carbonate unmixing are used to estimate partition coefficients between carbonate and silicate melt. The resulting values correlate well with available experimental data from the literature. We will present a genetic model based on the compositional data on feldspar zonation for the process and timing of silicate-carbonate unmixing prior to eruption of the host phonolite magma.