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Ultra-high resolution element mapping reveals sub-micron scale Sr disequilibria within plagioclase microlites: Implications for magma ascent chronometry

DANIEL COULTHARD JR.[1], CHARLINE LORMAND[2], RAIMUNDO BRAHM[3], **GEORG F. ZELLMER**[3], DR. NAOYA SAKAMOTO[4], JONATHAN D. BLUNDY[5], YOSHIYUKI IIZUKA[6] AND HISAYOSHI YURIMOTO[4]

[1]Volcanic Risk Solutions - Massey University
[2]Durham University
[3]Massey University
[4]Hokkaido University
[5]Oxford University
[6]Academia Sinica, Taipei, Taiwan

Presenting Author: g.f.zellmer@massey.ac.nz

A **S**tacked **C**MOS **A**ctive **P**ixel **S**ensor (SCAPS) [1] was used to image the two-dimensional distribution of ^{28}Si, ^{40}Ca, and ^{88}Sr within plagioclase microlites through ion microprobe analysis. From the isotopographic images generated, high-precision profiles detailing total Ca/Si and Sr/Si from core to rim were sampled. These profiles constitute the highest resolution sampling of intra-crystal Sr ever and present a unique opportunity to study the compositional systematics of microlite textures. We calculated the equilibrium Sr distribution for each profile using distribution coefficients calculated from observed anorthite contents (anorthite content was calculated from observed Ca/Si). Comparison of this equilibrium profile to the observed Sr profile (converted from Sr/Si using an internal calibration of Sr) constitutes the basis for determining whether intra-crystal equilibrium was attained during ascent or not. For most crystals, there is abundant intra-crystal disequilibrium as evidenced by deviation from unity along concentration ratio profiles (observed Sr/equilibrium Sr) and in the derivative of this profile (the slope of the concentration ratio profile is diagnostic of an equilibrium condition between adjacent points in each plagioclase crystal). Using a two-way finite difference method, intra-crystal diffusion was forward modelled to envision how intra-crystal Sr disequilibrium will disappear over time. Short-length scale disequilibrium disappears from the slope profile in less than 1 week (see Figures). Its preservation in the studied cystals is evidence for very short residence times at magmatic temperature, consistent with recent petrologic studies on these tephras [2]. The formation of relatively long-scale zones of disequilibrium along each profile takes several weeks, and the total time to equilibration takes several years for many of the crystals considered. Thus, SCAPS isotopography is a powerful tool in the compositional analysis of intra-crystal zonation.

[1] Yurimoto, Nagashima & Kunihiro (2003), *Applied Surface Science* 203-204, 793-797.

[2] Lormand, Zellmer, Kilgour, Németh, Palmer, Sakamoto, Yurimoto, Kuritani, Iizuka & Moebis (2020), *Journal of Petrology* 61(10), egaa077.