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Supporting Information for

The Survival of Mafic Magmatic Enclaves and the Timing of Magma Recharge

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Introduction

The supporting information includes a brief description of the underlying experiments of Fiege et al. (2017) as well as the analytical and image processing of those experimental charges. Moreover, basic observation from these experiments are summarized and connected to mafic enclave textures in natural systems.

Text S1. Summary of and motivation for experiments by Fiege et al. (2017)

We performed a time-series of diffusion couple experiments (1, 10, 79 hrs) of natural basaltic andesite (VQ22A, IGSN: PPRAI100T) and dacites (VQ37D, IGSN: PPRAI101I) from Volcán Quizapu at sub-liquidus conditions. These experiments model to first order the interaction of a highly crystalline basaltic andesite (melt fraction 20-40 vol.%) with nearly aphyric dacite (melt fraction >90 vol.%) a condition frequently found in natural systems in the form of mafic enclaves (e.g., Bacon & Metz, 1984; Clynne, 1999; Browne et al., 2006; Ruprecht et al. 2012). The time series experiments are isothermal (1000 ˚C) and at a temperature intermediate between potential storage conditions for dacite and basaltic andesite, a condition that is relevant when significant mafic recharge leads to heating and dispersal of enclaves through a dacitic magma chamber (e.g., Clynne, 1999; Browne et al., 2006; Ruprecht & Bachmann, 2010; Ruprecht et al., 2012). Furthermore, experiments were run at isobaric conditions (150 MPa) and volatile contents consistent with near volatile saturation in both the dacite and the basaltic andesite at the P-T conditions and the emerging crystallinity. A detailed description of the experimental design can be found in Fiege et al. (2017).

Text S2. Analytical procedures and observations

We investigated the textural evolution of the basaltic andesite-dacite interface via x-ray mapping at the electron microprobe facility (Cameca SX-100) of the American Museum of Natural History in New York (Figure S1). The complete data processing was described in Fiege et al. (2017). The phase assemblage (plagioclase, plg; clinopyroxene, cpx; orthopyroxene, opx; Fe-Ti oxides, ox; glass, gl) and relative fractions were quantified using WDX mapping on Ca, Mg, Fe, Al, and K. A composite phase map was produced using all five element maps for these experiments with a specifically developed MATLAB script. While the significant compositional diversity of Fe-bearing phases ensures straight forward determination of the respective phase fractions, distinguishing between plagioclase and glass is more uncertain. The latter being complicated not only by the compositional similarities, but also by the fine-grained nature (<50 microns) of the experimental products. Thus, special care was taken to analyze all time-series experiments with the same protocol. However, minor systematic errors resulting from the image processing are not affecting the outcome of this study as relative variations carry the important information to track the crystallinity evolution near the interface.

Given the nature of the experiments (short duration, no temperature cycling) the basaltic andesite is fine-grained and forms the rigid crystal framework. In naturally occurring enclaves also a fine-grained matrix (resulting from second boiling) constitutes the rigid crystal framework. However, a condition that is distinct in most natural enclaves from the experimental setup is the common presence of large phenocrysts from pre-mixing crystallization in the recharge magma.

The textural evolution of the run products is straight forward and discussed by Fiege et al. (2017). As the two magmas equilibrate the major phases in the basaltic andesite (plagioclase, orthopyroxene and clinopyroxene) all become consumed through crystal dissolution and the crystal network loosens at the interface.

Text S3. Processing of underlying data to obtain dissolution rate estimates

The underlying data in the form of phase fractions for each experimental run were published in Fiege et al. (2017) as tables S-D2 to D4. This phase fraction data represents the basis for figure 2B and parts of figure 3A in this study. The additional data processing of the phase fraction is provided in an excel sheet stored in the EarthChem library (doi.org/10.1594/IEDA/111480). The glass fractions for the 1, 10, and 79 hr experiments provided by Fiege et al. (2017) as a function of distance from the dacite-basaltic andesite interface are in columns G-L. Since this analysis exclusively focuses on the basaltic andesite part of the experiment we separate this half of the diffusion couple experiment for the three time series experiments in columns N-Q. This unfiltered dataset for the glass fraction is shown in Figure S1 as dotted lines. The noise in this dataset is substantial. Therefore, for the analysis in this contribution melt fractions from Figure S1A were smoothed using a Savitzky-Golay Filtering (second order and 33 elements; Figure S1B, column R-T). Smoothing highlights the continuous increase of melt fraction in the basaltic andesite with time. Minor deviations from a monotonous decrease in melt fraction with distance from the interface is expected in these complex experiments as phase distributions and textures are not perfectly uniform across experimental charges. The nearest intercept relative to the basaltic andesite-dacite interface was selected to determine the rate of melt fraction advancements shown in Figure 2B of the main text. The advancement of the increase of the glass fraction within the basaltic andesite follows a square-root of time dependence (Figure 2B) that we use to estimate plagioclase dissolution rates in these multi-grain composite samples. By choosing the nearest intercept the resulting diffusion-controlled dissolution rate represents a minimum, which equates to maximum mafic enclave survival times in the model.

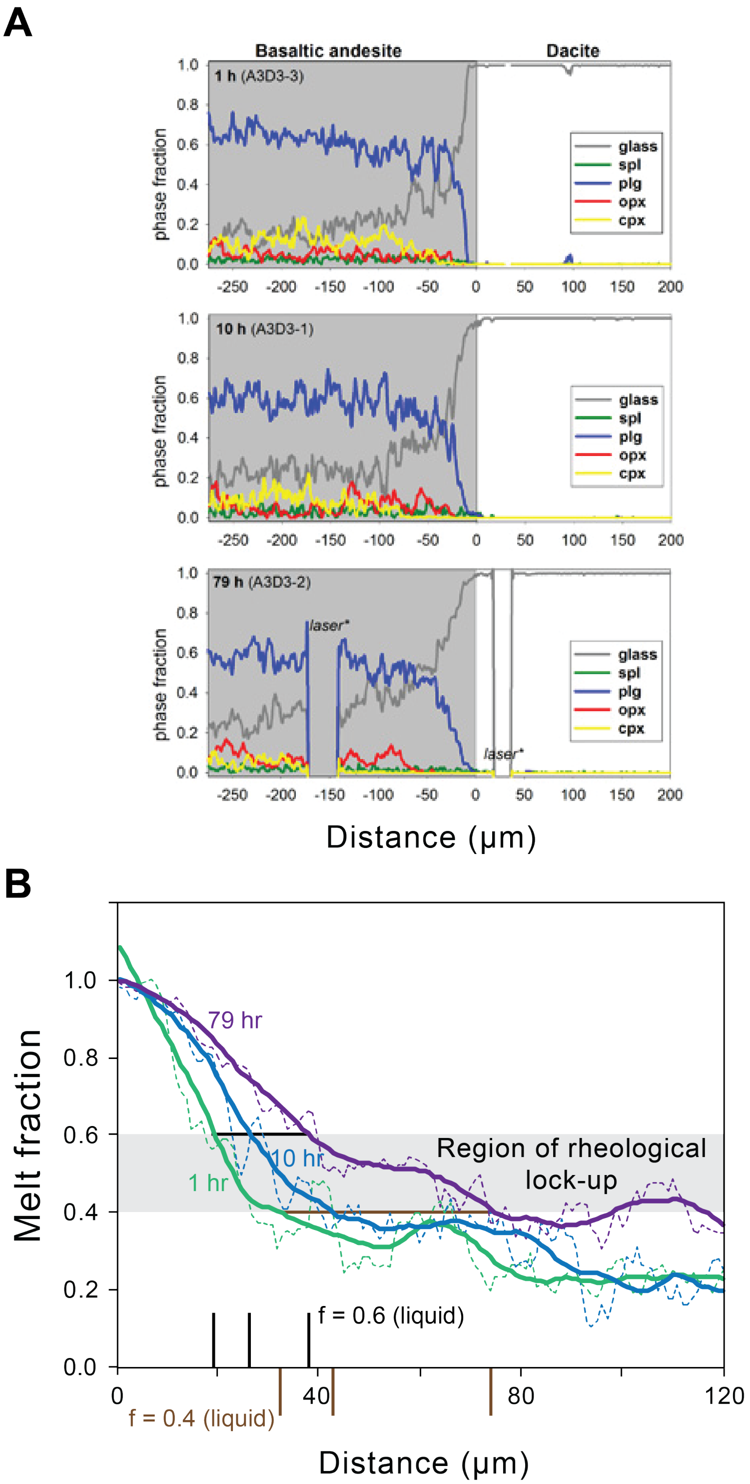

Figure S1. Analysis of advancement of melting front using the experiments of Fiege et al. (2017). A) Originally reported phase fractions for each run average the across the experimental charge modified from Fiege et al. (2017). Phase fractions were averaged perpendicular to the basaltic andesite-dacite interface. B) Smoothed melt fraction curves (solid) and original melt fractions from A (dotted). Smoothing was done using a Savitzky-Golay Filter (second order and over range of 33 datapoints). Melt front advancement is taken as the first intersection of the smoothed curve with the respective melt fraction f. Taking the first intercept represents a minimum diffusion-controlled dissolution rate and therefore, leads to maximum mafic enclave survival times in the model presented in the main text. Corrections for the zero-intercept are ignored as micron-scale localization of the basaltic andesite-dacite interface is limited by the experimental design and minor capsule deformation.