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Mixing Silicate Melts with High Viscosity Contrast by Chaotic Dynamics: Results from a New Experimental Device

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A new experimental device has been developed to perform chaotic mixing between high viscosity melts under controlled fluid-dynamic conditions. The apparatus is based on the Journal Bearing System (JBS). It consists of an outer cylinder hosting the melts of interest and an inner cylinder, which is eccentrically located. Both cylinders can be independently moved to generate chaotic streamlines in the mixing system. Two experiments were performed using as end-members different proportions of a peralkaline haplogranite and a mafic melt, corresponding to the 1 atm eutectic composition in the An-Di binary system. The two melts were stirred together in the JBS for ca. two hours, at 1,400˚C and under laminar fluid dynamic condition (*Re* of the order of 10^{-7}). The viscosity ratio between the two melts, at the beginning of the experiment, was of the order of 10^3. Optical analyses of experimental samples revealed, at short length scale (of the order of μm), a complex pattern of mixed structures. These consisted of an intimate distribution of filaments; a complex inter-fingering of the two melts. Such features are typically observed in rocks thought to be produced by magma mixing processes. Stretching and folding dynamics between the melts induced chaotic flow fields and generated wide compositional interfaces. In this way, chemical diffusion processes become more efficient, producing melts with highly heterogeneous compositions. A remarkable modulation of compositional fields has been obtained by performing short time-scale experiments and using melts with a high viscosity ratio. This indicates that chaotic mixing of magmas can be a very efficient process in modulating compositional variability in igneous systems, especially under high viscosity ratios and laminar fluid-dynamic regimes. Our experimental device may replicate magma mixing features, observed in natural rocks, and therefore open new frontiers in the study of this important petrologic and volcanological process.