

Using Petrography, CO₂ contents of Melt Inclusions, and Phase Equilibria Experiments to Understand the Petrogenesis of Plagioclase Ultraphyric Basalts (PUB) in Mid Ocean Ridges (MOR)

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The petrogenesis of the PUB component in MOR basalts has been a topic of debate for over 40 years (Flowers, 1980; Fisk, 1984). From the beginning, there was a prominent role of pressure in models of their formation. However, there were few constraints on the depth at which PUB lavas differentiated or on the potential significance of pressure in the process. In the past 5 years, evidence from CO₂ in melt inclusions documented that the plagioclase megacrysts in PUB commonly formed at pressures in the range of 1-8 kbar. Using that constraint, we conducted a series of experiments on PUB related compositions within this pressure range. Our experiments (Ustunisik et al., 2021) are consistent with the presence of a pseudoazeotrope at pressures >3.5 kbar in the anorthitic end of the compositional spectrum (>An₇₀) (Nekvasil et al., 2015). This topology among phase boundaries cause magmas to fractionate towards more anorthitic compositions at pressures consistent with the melt inclusion CO₂ values. Further, previous puzzling petrography – the absence of olivine inclusions in plagioclase megacrysts and characteristic resorption surface between olivine and plagioclase in troctolitic inclusions in PUB, can be attributed to changes in the topology of the plagioclase loop as magmas rise and pressure decreases. At pressures <3.5 kbar, the pseudoazeotrope in the plagioclase loop at higher pressures “unwinds”, resulting in an increase of ~25 °C in the plagioclase loop topology at lower pressures. While these systems are multiply saturated with olivine, plagioclase, and spinel at 3.5-8 kbar, the change in the loop causes only a rise in the plagioclase loop temperature at high An %. Since the olivine loop does not exhibit similar behavior at high Mg#, this results in olivine dissolution, consistent with the petrographic observations while the dissolution of olivine and spinel buffers the changes in Mg# or Ca/Al as plagioclase forms at lower pressure.

Flower 1980; Fisk 1984; Ustunisik et al. 2021; Nekvasil et al., 2015

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