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Heterogeneous crystal nucleation on bubbles in silicate melt

MARK J. DAVIS* AND PHILLIP D. IHINGER

Department of Geology and Geophysics, Yale University, 210 Whitney Avenue, New Haven, Connecticut 06511, U.S.A.

ABSTRACT

Experiments reported herein document heterogeneous crystal nucleation on bubbles in supercooled lithium disilicate melt. Crystalline lithium disilicate ($Li_2Si_2O_5$) nucleated and grew on small bubbles (~1 μm) with a one-to-one correspondence between the number of bubbles and crystals (ranging from $<10^2$ to $\sim10^5$ bubbles/mm^3). Crystals grew on large bubbles (>100 μm) only in samples fused in N_2, suggesting a chemical control on nucleating efficiency. Bubbles ~1 μm in diameter served as nucleation sites for polycrystalline lithium disilicate spherulites; bubbles smaller than ~1 μm served as nucleation sites for the more common ellipsoidal crystalline form. This difference in behavior might be due to the additional surface area available for crystal nucleation on the 1 μm bubbles.

Our findings suggest that superliquidus thermal history can influence crystal nucleation via bubble formation induced by supersaturation, and has implications for both natural samples and experimental studies. Heterogeneous crystal nucleation on bubbles may serve as an efficient nucleation mechanism in natural degassing magmas and may aid in the formation of fine-grained groundmasses common to many volcanic rocks. Furthermore, we have documented a new mechanism of spherulite formation in highly supercooled silicate melt, similar to conditions thought to exist during devitrification of natural glasses. The ability of crystals to nucleate on bubbles can be exploited in the production of commercial glass-ceramic materials.