FORMATION OF VAPOR CHANNELS IN CRYSTAL MUSH: IMPLICATIONS FOR DEGASSING AND MATERIAL TRANSPORT FROM SOLIDIFYING GRANITES

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Segregation of supercritical aqueous fluid (vapor, hereafter) from solidifying granitic magmas is a key process to the incipient stage of ore formation, flow and emplacement of granitic plutons and accumulation of excess pressure in magma chambers as a driving force of volcanic eruption. In the crystal-rich, highly viscous magmas (i.e. crystal mush), vapor may be transported as bubbles by buoyancy or as permeable flow via interconnected networks. To understand how vapor migrates through the vesiculated crystal mush, knowledge of its microstructure is indispensable.

To this end, we have carried out high-pressure experiments using a piston-cylinder apparatus in the mid-lower crust conditions. Crushed powders of a biotite-bearing granite and an almost biotite-free, spessartine-doped pegmatite were used as starting materials. Grain size of the powders was controlled to produce the desired size ratio among bubbles, crystals and a capsule. The powders with 8-30 wt.% H_2O were sealed in a Pt-lined Ni capsule with the ashtray method. The temperature was kept at 680-750°C and 0.7-0.8 GPa for 45-200 hours, then quenched or cooled gradually to 450°C in 10°C / hour. In some runs, capsules were placed off the hotspot of the sample assembly so that effects of buoyancy and temperature gradient were evaluated.

In both granite and pegmatite systems, vapor pools are often formed near the top of the capsules. In the granitic system, preferential distribution of bubbles on the surface of biotite crystals is conspicuous, while quartz and feldspars are not “wet” by the bubbles. Volume fraction of the bubbles increases upward and the bubbles are coalesced to show elongated and irregular shapes, which are restricted by the biotite distribution and probably by the balance between buoyancy and interfacial energy. In other words, vapor phase replaces melt as a continuous phase upward, forming vapor channels. In the slowly-cooled pegmatite systems, on the other hand, bubbles are coalesced to expel interstitial melt in the upper part of the capsules to form an almost melt-free, vapor-filled crystal aggregates. The evolution of microstructure driven by interfacial and gravitational energy reduction, therefore, results in formation of interconnected vapor networks in both systems, particularly along the easy-to-wet minerals such as biotite. Permeability of the mushy boundary layer in the upper part of the magma chambers is thus considered to be large. The euhedral crystals of alpha quartz and other vapor phase minerals such as spessartine are formed in the vapor pools and some large bubbles of the slowly-cooled, bottom-heated runs in the pegmatite system. This observation supports the existence of the interconnected vapor networks at subsolidus temperature as an effective pathway of material transport with solution-precipitation, because the amount of the crystals are larger than those expected from the volume of the host pools and solubility of the mineral components in the vapor.

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2. Behavior of Metals and Volatiles during Magmatic Processes
3. crystal mush, permeable degassing, interfacial energy, bubble coalescence
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