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A 25 year retrospective on "gas-driven filter pressing in magmas": a key mechanism enabling extreme fractionation of silicic melts?

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Filter pressing is an important mechanism in the fractionation of silicate magmas that has been recognized since Bowen in 1919, but gas filter-pressing was recognized in magmas by Anderson et al. (1984) [1]; then gas-driven filter pressing was elaborated on considerably by Sisson and Bacon (1999) [2] to explain a much wider range of fractionated magmatic features, including evolved rhyolites to aplitic dykes. There are several very detailed studies since then on these mechanisms, although very rarely is it recognized as a physical driver for extreme fractionation. Rather, Rayleigh fractionation associated with development of boundary layers (boundary layer differentiation) and solidification front crystal fractionation have been used to explain extensive fractionation of magmas to form granophile mineral resources, including pegmatitic deposit systems. Jahns and Burnham [3] recognized the role of exsolving volatiles in the formation of granitic pegmatites, many of which exhibit extreme fractionation. There are many rheologic issues with physically separating crystals from melt, especially within cooling felsic magmas to > 75% as noted by many experimentalists. However, gas activity increases and exsolution naturally results (magmatic volatile phase-MVP) from the crystallization process, with the ΔV of the reaction quickly increasing to change buoyancy (decreasing density) of the melt relative to crystals; this is the magmatic hydrothermal transition. This increasing internal pressure described is key to differential melt mobilization from crystal mushes as the gas-to-melt ratio increases; this can be an internal feedback mechanism for cyclic melt mobilization episodes. It is also known that fluctuating geostatic pressure can suction out melt due to over pressurizing the overall system that leads to rupture (similar to hydraulic failure) resulting in lowering the pressure on the overall melt relative to the crystal network, i.e. pressure cycling – seismic pumping, leading to selective buoyant melt migration. This is effective up to MVP-melt ratios < 70% after which melts would be pyroclastically fluidized. Pressure cycling affects degree of undercooling resulting in the formation of dike-like tuffisite-felsite, aplite to pegmatitic intrusions.