The significance of two-pyroxene pseudo-decompression paths (PDPs) in mafic to intermediate arc magmas

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Two-pyroxene thermobarometry of a range of mafic to intermediate arc magmas from the Chile, Japan, New Zealand, and Taiwan yield P-T paths that are approximately isothermal and range from mantle to upper crustal pressures. Using MELTS modeling, we show that such features can be successfully reproduced by combining pyroxene crystals that formed at a range of crustal pressures but happen to be in Fe-Mg exchange equilibrium. We refer to these P-T paths as "pseudo-decompression paths" (PDPs), because they give the illusion of rapid melt ascent at constant temperature, whereas in reality they may have resulted from magma mixing or crystal uptake. We show that many "microlites" in explosively erupted arc magmas are actually small crystal fragments, arguing for crystal uptake rather than conventional magma mixing models. Further, while we cannot preclude magma mixing as a process that may result in PDPs in theory, we show that high-Mg andesite (HMA) would likely be required as one mixing component. While HMA magmas are being recognized in some volcanic arcs, they do not typically erupt at the volcanoes we studied, again arguing for crystal uptake. We conclude that many mafic to intermediate arc magmas (with the exception of remobilized porphyritic dome lavas) leave their source as aphyric melts and acquire their crystal cargo en route to the surface from previously intruded plutons. Crystallization of the host melt itself is likely prevented due to rapid ascent and superheating. Ironically, the observed PDP's may therefore actually mirror the quasi-isothermal ascent paths of these magmas. Our results have profound implications for volcano monitoring and for the compositional range of melts leaving the mantle wedge.