Magmatic Volatiles: No Longer Maxwell's Demon

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To many petrologists a volatile component is exactly like a Maxwell demon; it does exactly what one may wish it to do

The sentiment expressed in this quote from Bowen [1], indicating that addition of even a small amount of a volatile component to a melt affects the physical and chemical properties of the melt to an extent that far exceeds what might be expected based on its concentration, was oft used by early 20th century petrologists to explain otherwise unexpected melt phenomena. During the past century, our knowledge of the nature, amount and role of volatiles in melts has grown considerably, and today it is understood that a small amount of a volatile component, especially water, does indeed have an effect on the physical and chemical properties of melts that is often incommensurate with its concentration.

Much of our knowledge concerning the nature of volatile components in melts, their concentrations and their effect on melting and melt properties comes from advances in experimental and analytical methods, especially during the last several decades. Application of modern analytical techniques, including SIMS, FTIR, Raman, TEM, and various synchrotron-based methods, to studies of natural melt inclusions has provided a wealth of information concerning the amounts and speciation of volatile components in melts of variable compositions, representing a wide range of geologic environments. These data have, in turn, led to improved understanding of volatile cycling in the Earth system [2] and formation of magmatic-hydrothermal ore deposits [3].

Among the more significant advances in studies of melt inclusions in recent years is the recognition that the majority of the CO_2 that was in the originally-trapped melt is now contained in the vapor bubble. For decades, the CO_2 in the vapor bubble was not included in determinations of the pre-eruptive CO_2 content of the melt, leading to significant under-estimation of the CO_2 flux from the deep crust and mantle to the atmosphere.

[1] Bowen (1928) The Evolution of the Igneous Rocks. Oxford University Press; [2] Wallace (2005) J. Volc. & Geotherm. Res., 140, 217-240; [3] Audétat et al. (2008), Econ. Geol., 103, 877-908.