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Effect of CO_2 content on magma supply rate at Kilauea volcano, Hawaii

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The dynamics of magma supply and transport largely govern volcanic activity. In many cases, they remain relatively poorly constrained, as they are inaccessible to direct observation. Kilauea volcano, Hawaii, is one of Earth's most active and well-studied volcanoes and has been erupting virtually continuously during the last three decades. Consequently, Kilauea provides a unique opportunity to study the interplay between magma supply, volatile content of the mantle-derived basalt magma, and its transport to the surface. Dynamics of magma ascent and degassing have the potential to be affected by temporal variations in the volatile content of the magma source because of feedbacks associated with the ascent of a low-viscosity basalt melt in conjunction with an exsolved CO_2 fluid phase. Using a numerical model of two-phase flow within Kilauea's lithospheric plumbing system, we find that realistic variations in CO_2 content of the deep magma source have the potential to result in significant variations in the magma supply rate to Kilauea's shallow crustal magma storage and transport system. This is a consequence of associated changes in magma density with depth and ensuing changes in pressure gradients throughout the magmatic plumbing system. In particular, we suggest that the observed surge in magma flux to Kilauea's summit reservoirs, as well as in CO_2 gas emissions during 2003-2007, could have been the consequence of a modest increase in CO_2 content of the deep magma supply. This raises the question whether previous periods of heightened eruptive activity at Kilauea could have also been the consequence of variations in volatile content of the deep magma supply and, hence, its mantle source. A comparison between model predictions of dissolved CO_2 and H_2O in Kilauea's magma at shallow depth and melt inclusions from several explosive eruptive episodes at Kilauea (e.g., Kilauea Iki 1959 and Halema'uma'u 2008-2010) suggests that such changes in CO_2 content may be difficult to recognize in the melt inclusion record.