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The geochemistry of gas emissions as a tool to unravel the magma dynamics at Mt Etna (Italy)

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Since 1996 we have been performing a discrete geochemical monitoring of five peripheral gas emissions located at the base of Mt Etna, with a frequency of roughly 2 samplings campaigns per month. This has been integrated since 2007 with the periodic sampling of few fumaroles located at the top of Etna. Chemical composition of gases displayed that shallow processes such as interaction with aquifers modify the pristine gas mixture. Such effects were quantitatively modeled and removed. The obtained systematics of He-Ar-CO_2 lead us to assess the absolute pressure at which the gas are released from the magma. Peripheral gases reflect the degassing of magma bodies residing at depths of 200-400 MPa, while crater fumaroles are fed by magmas residing at shallower levels (i.e., up to $\sim$130 MPa). These estimations are in good agreement with the depth of the two main magma ponding zones (i.e., 5-12 km and 2-3 km b.s.l.) inferred by petrological and geophysical studies. Besides the pure magma degassing process, gases also reflect a mixing of volatiles exsolved from batches of melts located at variable pressures. The long-term monitoring of gases from the base and the top of the volcano displayed increasing phases of ^{3}He/^{4}He occurring some months before an eruptive activity. Such increases are interpreted as the intrusion of primitive batches of ^{3}He-rich magma into the deepest portion of the plumbing system. This behaviour has also been observed before 2011-2012 and 2013, when a terminal eruptive activity has episodically occurred and is still ongoing (January 2014). This phase is characterized by frequent fire fountains coupled to small lava flows. Finally, we underline that the maximum ^{3}He/^{4}He value of free gas emissions ($\sim$7.6 Ra, where Ra = atmospheric ^{3}He/^{4}He) is in perfect agreement with the maximum value we measured in the fluid inclusions of mafic phenocrysts of Etna.