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Mixing between deep and shallow magmatic fluids below Mount Etna and its key role during the recent eruptive periods

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Several-years long geochemical survey of fumaroles at Voragine crater rim of Mt Etna, coupled to the synchronous monitoring of some well-known peripheral gas emissions, has joined together the isotopic compositions of Ar, He and CO_2 besides to chemical compositions. Once the effects of post-magmatic shallow processes have been recognized, quantified and removed, the geochemistry of gas emissions at Mt. Etna volcano has displayed that the summit crater fumaroles are aligned along the identical degassing path of the peripheral sites in terms of He/Ar versus Ar/CO_2 ratios. Interestingly, the carbon isotope composition of the fumaroles, coupled to noble gases, put into evidence that a part of the exsolved magmatic gases at high depth interacts with gases from magma batches stored at shallow levels and modifies the compositional ratios of the main geochemical indicators of magmatic degassing. The crater fumaroles therefore result from a two-endmember mixture of magmatic gases, composed by a deep member coming from variable pressures of 400 to 200 MPa depending on time, and a shallower one exsolved at about 130 MPa. The same as the crater fumaroles, the He isotopic compositions of the peripheral sites, coupled to the He/Ar* ratios, highlight similar processes of mixing between a deep gaseous endmember and a shallow one whose exsolution pressure seems to be very variable in time. More importantly, coupled peripheral and crater emissions show that the He isotopic marker of magmas stored at shallow levels and/or in the most external portions of the plumbing system is sensibly lower, in terms of R/Ra, than that of the parental magmas from the deep source. Resident magmas can also be modified as a consequence of massive recharges of the primitive, high-R/Ra melts. This probably occurs when, besides the fluids, batches of the recharging magmas reach the shallow reservoirs. The time variation of He isotopic compositions, as well as their spatial distribution, are coherent with the idea of a multipart plumbing system made of dykes, sills and reservoirs barely interconnected, in agreement with the most recent views of Mt. Etna structure arising from geophysical studies. The geochemical resolution of the deep and shallow gaseous endmembers allows to distinguish the periods during which the deep magmatic fluids become more important and/or new magmas coming from depth invade the shallow levels of the Etnean plumbing system. This result provides key information on volcanic activity in the medium- and long-term. Episodes of magma recharge below Mt Etna have in fact accompanied periods of rising volcanic activity, such as those preceding the 2006, 2008 and 2011 Etnean unrests.