Magmatic Carbon: resolving crustal, mantle and slab contributions using a global volcanic gas dataset

ALESSANDRO AIUPPA[12]

[1]Dipartimento DiSTeM, Università di Palermo, via archirafi 36, 90123, Palermo, Italy, alessandro.aiuppa@unipa.it
[2]Istituto Nazionale di Geofisica e Vulcanologa, Sezione di Palermo, via la Malfa 153, 90146; Palermo, Italy

There has been growing interest in the past decades in quantifying the potential role of crustal assimilation in controlling the global volcanic carbon budget. Althought it is commonly accepted that recycling of slab-derived carbon (from subducted sediments and altered oceanic crust) plays a key control on the volcanic arc CO_2 budget, recent experimental work and related modelling has demonstrated the potential additional contribution from carbon reservoirs in the crust. The carbon isotope signatures of volcanic gases, combined with He isotope systematics, have widely been used to constrain carbon origin, but results have remained somewhat elusive and controvertial, owing to potentially overlapping isotope compositions of crustal and slab carbon.

Here, I show that key insights into crustal vs. slab vs. mantle carbon origins can be derived from a global dataset that compares the CO_2/S composition of high-temperature (> 450 °C) magmatic gases with the trace element composition of the corresponding source magmas (as derived from whole-rock compositions of erupted volcanics). This global volcanic gas vs. whole-rock association suggests that, while the majority of arc gases exhibit compositions (CO_2/S < 4) that are consistent with a carbon derivation from a variably carbon-enriched slab, some key arc volcanoes exibit CO_2-S-Sr-Ba-LREE compositions that are inconsistent with a slab origin, and point instead to the involvement of crustal carbon. The C-rich compositions (CO_2/S > 4) of these volcanoes (Etna, Stromboli, Vulcano Island, Popocatépetl, Soufriere of St Vincent, Bromo and Merapi) are thus (at least partially) interpreted as the product of magma-limestone interactions in the upper crust, additional evidences for which come from carbonate xenoliths and/or carbonate basement that characterize these volcanic systems. It is finally concluded that, although the mean global CO_2/S ratio of arc gas (~2.5) reflects a predominant source from subducted sediments, limestone-assimilation-derived C may account for ~20-33% of the present-day global arc budget. The same global dataset also shows that the CO_2-enriched volcanic gases observed in continental rift and hot-spot context imply carbon trasport from the deep mantle via carbonated silicate melts.