Geophysical Research Abstracts
Vol. 17, EGU2015-3773, 2015
EGU General Assembly 2015

Along-arc and inter-arc variations in volcanic gas CO_2/S signature

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Improving the current estimates of the global volcanic arc CO_2 output requires a more accurate knowledge of the volcanic gas CO_2/S ratio signature of each individual arc segment. This, when multiplied by sulphur (S) productivity of each arc segment (derived by either studies on melt inclusions or UV-based gas measurements), could in principle yield the individual arc CO_2 output and, by summation, the global arc CO_2 output. Unfortunately, the process is complicated, among others, by the limited volcanic gas dataset we have available, particularly for poorly explored, but potentially highly productive arc segments (Indonesia, Papua New Guinea, etc). We here review the currently available dataset of CO_2/S ratios in the volcanic gas literature, and combine this with novel gas observations (partially obtained using the currently expanding DCO-DECADE Multi-GAS network) to provide experimental evidence for the existence of substantial variations in volcanic gas chemistry along individual arc segments, and from one arc segment to another. In Central America [1], for instance, we identify distinct volcanic gas CO_2/S (molar) ratio signatures for magmatic volatiles in Nicaragua (∼3), Costa Rica (∼0.5–1.0) and El Salvador (∼1.0), which we ascribe to variable extents of sedimentary carbon addition to a MORB-type (Costa Rica-like) mantle wedge. Globally, volcanic gas CO_2/S ratios are typically found to be low (∼1.0) in arc segments (e.g., Japan, Kuril-Kamchatka, Chile) where small amount of limestones enter the slab; whilst larger slab/crustal carbon contributions typically correspond to higher CO_2/S ratio signatures for gases of other arcs, such as Indonesia (∼4.0) or Italy (6 to 9). We find that CO_2/S ratios of arc gases positively correlate with Ba/La and U/Th ratios in the corresponding magmas, these trace-element ratios being thought as petrological proxies for the addition slab-fluids to the magma generation zone. This relation implies a dominant slab-derivation of carbon in CO_2-rich arc magmas, and can serve for estimating, on the base of petrological data, the gas CO_2/S ratio signature of unexplored arc segments.

[1] A. Aiuppa et al. (2014), Earth Planet Sci Lett 407, 134-147.