A literature review and new data of trace metals fluxes from worldwide active volcanoes

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Volcanic emissions are considered one of the major natural sources of several trace metals (e.g. As, Cd, Cu, Pb, and Zn) to the atmosphere [Nriagu, 1989], and the geochemical cycles of these elements have to be considered strongly influenced by volcanic input. However, the accurate estimation of the global volcanic emissions of volatile trace metals into the atmosphere is still affected by a high level of uncertainty. The latter depends on the large variability in the emission of the different volcanoes, and on their changing stage of activity. Moreover, only few of the potential sources in the world have been directly measured [Hinkley et al. 1999]. Atmospheric deposition processes (wet and dry) are the pathways through which volcanic emissions return to the ground (soils, plants, aquifers), resulting in both harmful and beneficial effects [Baxter et al. 1982; Aiuppa et al. 2000; Brusca et al. 2001; Delmelle, 2003; Bellomo et al. 2007; Martin et al. 2009; Floor et al. 2011; Calabrese et al. 2011].

In the first part of this study we present the results of a literature review on trace metals emissions from active volcanoes around the world. In the second part, we present new data on the fluxes of the trace metals from Etna (Italy) and four active volcanoes in the world: Turrialba (Costarica), Nyiragongo (DRC), Mutnovsky and Gorely (Kamchatka).

We found 27 publications (the first dating back to the 70's), 13 of which relate to the Etna and the other include some of the world's most active volcanoes: Mt. St. Helens, Erebus, Merapi, White Island, Kilauea, Popocatepetl, Galeras, Indonesian arc, Satasuma and Masaya. The review shows that currently there are very few data available, and that the most studied volcano is Mt. Etna. Using these data, we defined a range of fluxes for As, Ba, Bi, Cd, Cu, Fe, Mn, Pb, Se, V and Zn (Figure 1).

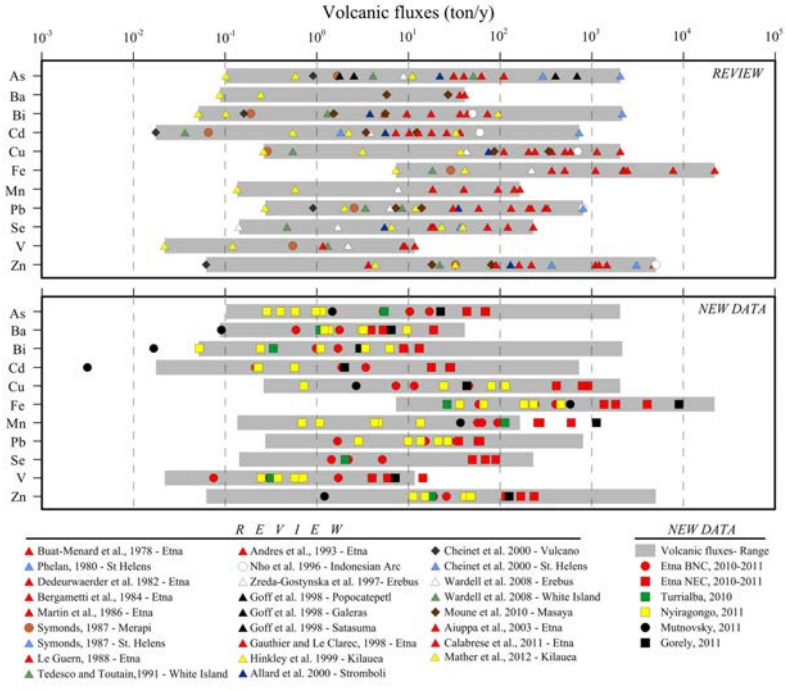

Figure 1. Volcanic fluxes of selected trace elements from active volcanoes. In the upper part data from the literature review; in the lower part new data from our study (Etna, Turrialba, Nyiragongo, Mutnovsky and Gorely).

To obtain new data we sampled particulate filters at the five above mentioned volcanoes. Filters were mineralized (acid digestion) and analyzed by ICP-MS. Sulphur to trace element ratios were related to sulphur fluxes to indirectly estimate trace elements fluxes. Etna confirms to be one of the greatest point sources in the world. The Nyiragongo results to be also a significant source of metals to the atmosphere, especially considering its persistent state of degassing from the lava lake. Also Turrialba and Gorely have high emission rates of trace metals considering the global range. Only Mutnovsky Volcano show values which are sometimes lower than the range obtained from the review, consistent with the fact that it is mainly a fumarolic field.

This work highlights the need to expand the current dataset including many other active volcanoes for a better constraint of global trace metal fluxes from active volcanoes.

References

Nriagu, J.O. (1989). *A global assessment of natural sources of atmospheric trace metals*. Nature, 338, pp 47–49.

Aiuppa, A., Allard, P., D'Alessandro, W., Michel, A., Parello, F., Treuil, M. and Valenza, M. (2000). *Mobility and fluxes major, minor and trace metals during basalt weathering and groundwater transport at Mt. Etna volcano (Sicily)*. Geochimica et Cosmochimica Acta 64, pp 1827–1841.

Baxter, P.J. Stoiber, R.E. and Williams, S.N., (1982). *Volcanic gases and health: Masaya volcano, Nicaragua*. Lancet, 2, pp 150-151.

Bellomo, S., Aiuppa, A., D'Alessandro, W. and Parello, F. (2007). *Environmental impact of magmatic fluorine emission in the Mt. Etna area*. Journal of Volcanology and Geothermal Research 165, pp 87-101.

Brusca, L., Aiuppa, A., D'Alessandro, W., Parello, F., Allard, P. and Michel, A., (2001). *Geochemical mapping of magmatic gas-water-rock interactions in the acquifer of Mt. Etna volcano*. Journal of Volcanology and Geothermal Research 108, 1-4, pp 199-218.

Calabrese, S., Aiuppa, A., Allard, P., Bagnato, E., Bellomo, S., Brusca, L., D'Alessandro, W. and Parello, F. (2011). *Atmospheric sources and sinks of volcanogenic elements in a basaltic volcano (Etna, Italy)*. Geochimica et Cosmochimica Acta 75, pp 7401-7425.

Delmelle, P. (2003). *Environmental impacts of tropospheric volcanic gas plumes*. In: Volcanic Degassing, Geol. Soc. London Spec. Publ. 213, pp 381–399.

Floor, G.H., Calabrese, S., Román-Ross, G., D´Alessandro, W. and Aiuppa, A. (2011). *Selenium mobilization in soils due to volcanic derived acid rain: An example from Mt Etna volcano, Sicily.* Chemical Geology 289, pp 235–244.

Hinkley, T. K., Lamothe, P. J., Wilson, S. A., Finnegan, D. L. and Gerlach, T. M. (1999). *Metal emissions from Kilauea, and a suggested revision of the estimated worldwide metal output by quiescent degassing of volcanoes*. Earth and Planetary Science Letters 170, pp 315–325.

Martin, R.S., Mather, T.A., Pyle, D.M., Watt, S.F.L., Day, J., Collins, S.J., Wright, T.E., Aiuppa, A. and Calabrese S. (2009). *Sweet chestnut (Castanea sativa) leaves as a bio-indicator of volcanic gas, aerosol and ash deposition onto the flanks of Mt Etna in 2005-2007*. Journal of Volcanology and Geothermal Research 179, pp 107–119.

Nriagu, J.O. (1989). *A global assessment of natural sources of atmospheric trace metals*. Nature, 338, pp 47–49.