Isotopic and mass balance constraints on the origin(s) of carbon dioxide emissions from Merapi volcano, central Java, Indonesia

Patrick ALLARD

Institut de Physique du Globe de Paris, UMR7154 CNRS, Paris, France

E-mail: pallard@ipgp.fr

Carbon dioxide produced by arc volcanism can have a complex origin, involving different sources: the upper mantle wedge, the subducting slab, and the crust in case of continental arcs. Discriminating between these sources is thus important to properly constrain the deep carbon cycle at regional and global scales. Merapi volcano, in central Java, is famous worldwide for its sustained dome forming eruptive activity but also for the presence of metamorphosed carbonate xenoliths and calcium rich xenocrysts in its basaltic andesite products, providing evidence of direct magma interaction with carbonate host rocks in its crustal basement. This has raised the idea that crustal derived CO2 could contribute significantly to its volatile budget and even play a key role in its explosive phases. Based on data for Merapi volcanic gases over the past 35 years, here I outline a prevalent slab derivation and minor bearing of crustal interactions for CO2 emitted during the prevalent dome forming activity. Carbon dioxide is released at an average rate of 300 tons per day by hot (900-600 degree C) gas venting from the extruding lava dome and summit fumarolic fields, plus 200 tons per day from summit soil degassing. Its uniform delta13C of -4.0 per mil at all degassing sites, and the remarkable constancy of this parameter over 35 years of volcanic activity (except for one single value of -2.4 measured just after a nearby tectonic earthquake in 2006), demonstrate its bulk derivation from a steady magmatic source. In the same time, its high CO2 to helium-3 ratio (6 times the average MORB ratio) implies a large fraction (0.8) of non-mantle carbon with maximum possible delta13C of -3.2 per mil. Such a component cannot be produced by metamorphism or melting of local carbonate sediments (-2.2 to 1.4 per mil) which, moreover, should lead to higher isotopic variability in emitted gases. Instead, it fits with the expected C isotopic signature for Indian Ocean sediments subducted beneath Java. Therefore, these observations, as well as typical arc isotopic signatures for water, sulfur and nitrogen in the volcanic gases, support a prevalent slab carbon contribution, in agreement with O, Sr, Nd, Pb isotopic data for bulk Merapi lavas. The CO2 to HCl ratio of the volcanic gases, combined with melt inclusion data for chlorine, imply a pre-eruptive CO2 content of between 0.5 and 1 wt per cent in Merapi feeding magma.

©IAVCEI 2013 Scientific Assembly. All rights reserved.