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Crustal CO_2 liberation at Merapi volcano, Indonesia: an earthquake trigger?

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High-temperature volcanic gas is widely considered to originate from ascending, mantle-derived magma. In the case of CO_2 at arc-related volcanoes, its provenance is thought to be predominantly from the mantle wedge and subducted sediments from the down-going slab [1, 2]. Our investigation focuses on the carbon isotope composition (δ13C) of CO_2 emitted via high-T summit fumaroles (>230°C) from Merapi volcano, Central Java.
On May 26th, 2006, the magnitude 6.4 Yogyakarta earthquake occurred along a splay of the Opak River Fault system, with hypocentres at 10-15km depth [3, 4]. Prior to 2006, variation of fumarole carbon isotope ratios was limited (rδ13C2001-2004 = 0.5‰ ± 0.3l) with an average baseline value of -4.1‰ ±0.2 (vs, PDB). This value is typical of subduction zones [2]. Carbon dioxide collected after the earthquake showed a dramatic increase from the baseline to δ13C = –2.4‰İn 2007 and 2008, δ13C values returned to background levels. This rise coincided with an increase in eruptive intensity and volcano seismicity by a factor of 3-5 for several weeks after the earthquake [3, 4].
High carbon isotope gas values, such as those observed in 2006, are not produced by decompression- or fractionation induced degassing in either open or closed system mode [5], suggesting an addition of CO_2 from a non-magmatic, high-δ13C source [2]. The increase in δ13C in 2006, its transient duration, the crustal depth of the earthquake hypocentres, and the link with eruptive and seismic intensity are all consistent with addition of CO_2 from mid- to upper-crustal depths. Such additions of crustal CO_2 to subduction zone baseline fluxes may modify volatile budgets of ascending magmas at Merapi considerably [6, 7]. Therefore, CO_2 liberation from long-term crustal storage reservoirs, such as the thick limestone basement underneath Merapi, may be a process that is triggered and/or amplified by external mechanisms such as seismic events. We thus envisage a chain of events whereby earthquake and volcano interact in a positive feedback loop. We conclude that crustal volatiles intensify ongoing eruptions and that late-stage volatile addition may potentially trigger explosive eruptions independently of magmatic recharge and fractionation processes and may even be a key factor in promoting regional seismic activity.

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