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Magma Degassing Process during Plinian Eruptions

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Magma degassing process is the driving force behind explosive eruptions. To assess our knowledge on this phenomena, we have measured noble gas abundance and isotopic ratio in pumice produced by fragmentation of volatile-enriched magma. In fact noble gases are chemically inert and therefore can only fractionate during physical processes such as diffusion. They provide therefore strong constraints on such degassing processes.
Gases were first extracted by crushing pumices under vacuum. Extracted gases were purified before to be analyzed with a mass spectrometer (ARESIBO, IPGP). Most of the samples belong to well-studied plinian eruptions like Mt Pelée, St Helens, Ruapehu, Taupo which occured along different subduction zones and two samples come from Azores hotspot. All of them are characterized by a systematic enrichment in neon over argon and a fractioned 38Ar/36Ar ratio. Fractionation factors do not depend of geological setting, neither pumice age, nor eruption intensity. However they are similar for pumices emitted at the same instant of the eruption. We show that a correlation appears between krypton fractionation factor and the 38Ar/36Ar ratio. This illustrates that only one physical process can be at the origin of the fractionation. Here we propose a model of magma kinetic degassing before its fragmentation to explain the elemental and isotopic fractionation. In this model, noble gases diffuse in a magma shell surrounding a preexisting bubble. This model put forward an alternative to the model of Pinti et al. (1999) [1], in which diffusion occurred after pumice quenching in plinian plume. Our model fits all measurements and shows a fast magma degassing process in the conduit, which would require a fragmentation process in the order of few minutes.

[1] Pinti, D. et al. (1999) Journal of Volcanology and Geothermal Research 88: 279-289.