Reconstructing the Toba magmatic system: insights from stable isotope geochemistry

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The Toba caldera located in Sumatra (Indonesia) is the result of the four successive eruptions at 1.2, 0.84, 0.5 and 0.074 Ma [1]. This study presents oxygen isotope data for a suite of whole rocks and quartz crystals erupted as part of the Young Toba Tuff (YTT), an eruption event producing 2,800 km^3 of material some 74 ka ago [1, 2]. Oxygen isotope data have been obtained from whole rock (conventional fluorination), single mineral grains (laser fluorination-LF) and *in-situ* (SIMS) in combination with cathodoluminescence (CL) imaging in order to establish the relative roles of magmatic fractionation, magma-crust interaction and crystal recycling occurring in the Toba magmatic system. The CL images of quartz crystals exhibit defined patterns of zoning that often coincide with fluctuations in $\delta^{18}O$ values, allowing correlation of textural and compositional information. Measured $\delta^{18}O_{quartz}$ values from SIMS and LF range from 6.7 to 9.4 ‰, independent of their position on the crystal. Whole rock values, in turn, range from 8.2 to 9.9 ‰. The $\delta^{18}O_{magma}$ values calculated from quartz (assuming $\delta^{18}O_{quartz\text{-}magma}$ = 0.7 ‰), suggest a minimum value of 6.0 ‰, similar to that expected from a mantle derived magma [3], and a maximum value of 8.7 ‰. Several quartz crystals, however, have rims with lower $\delta^{18}O$ values, suggesting a late, low-$\delta^{18}O$ contaminant. This indicates multiple sources to the Toba system, including at least two crustal components, one with high- and one with low-$\delta^{18}O$. Helium isotope data obtained from pyroxenes from the oldest Toba eruption (R/R_A = 0.7 and 1.8) are consistent with a significant crustal contribution.

Barometry calculations from feldspar and amphibole suggest the magma chamber system resided at similar depth (~ 10 km) for all four Toba eruptions. The system probably persisted as a crystal mush, which was repeatedly re-mobilised by fresh magma injections. Crystal recycling, consistent with compositional and textural features in most of the YTT quartz crystals, seems an integral part of how super-eruptions are assembled. Therefore, large volumes of isotopically heterogeneous sources were mixed to make the final YTT cocktail, including a late low-$\delta^{18}O$ contaminant, substantial high-$\delta^{18}O$ crustal contributions, and considerable amounts of recycled antecrysts from the three previous eruptive episodes of the Toba system.

[1] Rose & Chesner (1987) *Geology* **15**, 913-917. [2] Aldiss & Ghazali (1984) *J Geol. Soc. London* **141,** 487-500. [3] Taylor & Sheppard (1986) *Rev. Min.* **16,** 227-271.

A mesocosm study of fate and effects of CuO nanoparticles on endobenthic species (*Scrobicularia plana*, *Nereis diversicolor*)

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Introduction. To investigate the transfer of CuO nanoparticles (CuONPs) from the medium to endobenthic species (*S. plana*, *N. diversicolor*), under environmentally realistic conditions, animals were exposed in field mesocosms to Cu (10 µg.L^{-1}) added either as CuONPs or as soluble Cu in comparison with controls for 21 days. The fraction of Cu under labile form was determined in water and sediment by using Diffusive Gradient in Thin film (DGT). Bioaccumulation of Cu was measured in the whole soft tissues of both species. Behavioural and biochemical biomarkers were determined in organisms.

Figure 1: Experimental intertidal mesocosms deployed in natural environment.

Results. No release of labile Cu from CuONPs was observed at days 7, 14 and 21. Cu bioaccumulation was shown in both species with CuONPs and with soluble Cu for clams. Impairments of behaviour (feeding and burrowing) were observed in both species. Antioxidant activities (CAT, GST) increased in both species for both chemical forms except for GST in worms exposed to soluble Cu. In clams exposed to both Cu forms, detoxification protein (MT) induction was observed and an apoptosis effect only under CuONP exposure. Concerning other biomarkers of defense (SOD, LDH, Laccase) and damage (TBARS, AChE, acid phosphatase) no significant effects were detected.

Conclusion. This experiment shows the suitability of mesocosms for studying the environmental effects of nanoparticles. Behavioral biomarkers and antioxidant defenses are the most sensitive tools to highlight the effect of soluble or nanoparticulate Cu forms.