

# SPHERULES OF SULPHUR IN ACID CRATER LAKES: MAGMATIC AND HYDROTHERMAL CONTROLS ON TRACE ELEMENTS OUTPUT

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Paul R.D. Mason<sup>1</sup>, Manfred van Bergen<sup>1</sup>, María Martínez<sup>1,2,4</sup>, Sri Sumarti<sup>1,3</sup>,  
Erick Fernández<sup>2</sup>, Eliécer Duarte<sup>2</sup>, Juan Valdés<sup>4</sup>,  
Eduardo Malavassi<sup>2</sup>, Terry Sriwana<sup>3</sup>

<sup>1</sup> Faculty of Earth Sciences, Utrecht University, Budapestlaan 4, Utrecht 3584 CD, the Netherlands.

<sup>2</sup> Volcanological and Seismological Observatory of Costa Rica, OVSICORI, Universidad Nacional,  
PO Box 86-3000, Heredia, Costa Rica.

<sup>3</sup> Volcanological Survey of Indonesia, Jl. Diponegoro, 57, Bandung, Indonesia.

<sup>4</sup> Laboratory of Atmospheric Chemistry, School of Chemistry, Universidad Nacional,  
PO Box 86-3000, Heredia, Costa Rica.

Volcanic crater lakes are a major site of condensation for volatile elements and associated trace elements produced by magmatic activity. Spherules of solid native sulphur up to 4-5 mm in diameter with sulfide inclusions (mainly corroded FeS<sub>2</sub>) are common in the dense acidic waters of magmatically active lakes. They were most likely produced as hot gases (e.g. H<sub>2</sub>S or SO<sub>2</sub>) was released at the bottom of the lake creating turbulence in pools of liquid sulphur. Analyses of the spherules present a new opportunity to estimate the magmatic output of a poorly studied group of trace elements including Se, Te, As, Sb and Hg that often represent a major environmental hazard in volcanic areas.

Sulphur spherules and acid lake waters were sampled from three active subduction-related volcanoes with different stages of activity and degassing rates. Poás in Costa Rica hosts a highly dynamic acid crater lake with respect to volume and chemical composition. In contrast, the crater lakes at Kawah Ijen East Java and Kawah Patih, West Java were more stable during the last 10 years but show some seasonal variations. Major and trace elements were determined *in situ* using electron microprobe and laser ablation ICP-MS techniques.

Spherules are highly enriched in trace elements including Se (400-4000 µg/g), Te (500-800 µg/g), Sb (1-18 µg/g), and As (30-510 µg/g). The internal chemical homogeneity of the spherules supports rapid formation. Changes in lake chemistry may account in part for large differences in trace element content between samples from each volcanic center. Lower As/S and Sb/S ratios at Poás correspond to higher temperatures that promote and enhanced release of HCl vapor from the lake surface. Recycling of the hydrothermal acid brines into the lake may also have affected these trace elements ratios. High Se/S and Te/S ratios can not be explained by mixing between mantle and shallow sources and probably reflect additional sulphur loss due to degassing of the magmatic source.

Reference: Mason, P.R.D., van Bergen, M.J., Martínez, M., Sumarti, S., Fernández, E., Duarte, E., Valdés, J., Malavassi, E. & Sriwana, T. 2001. Magmatic and hydrothermal controls on trace element output at active volcanoes as recorded by spherules of sulfur in acid crater lakes. *Eos Trans. AGU*, 82(47), Fall Meet. Suppl., Abstract V42B-1019.