Assessing the contribution of hydrothermal alteration to element fluxes from volcanic island arcs using dissolved Ge/Si ratios in rivers

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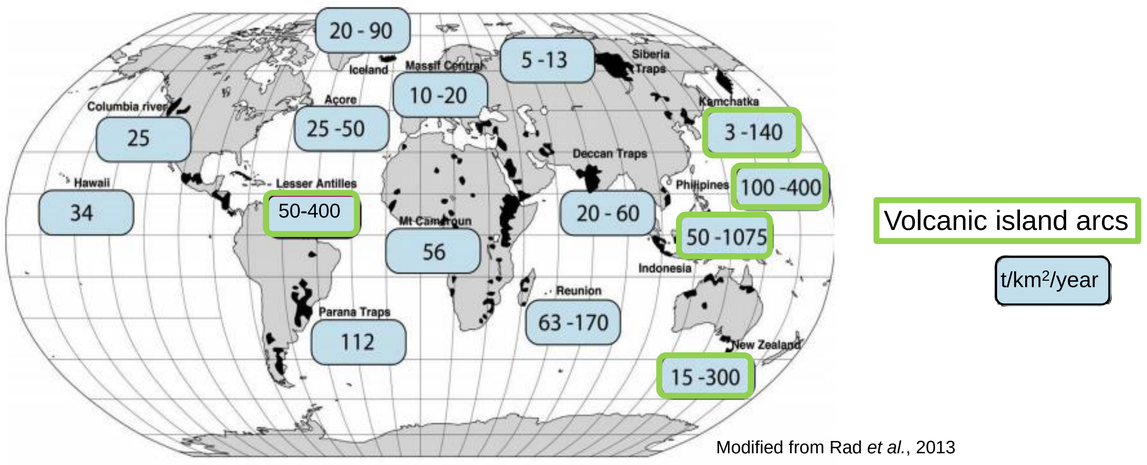
1. Introduction

- Volcanic island arcs have the highest chemical weathering rates on Earth (Fig. 1)
- What is the hydrothermal contribution to chemical weathering fluxes in volcanic island arcs ?



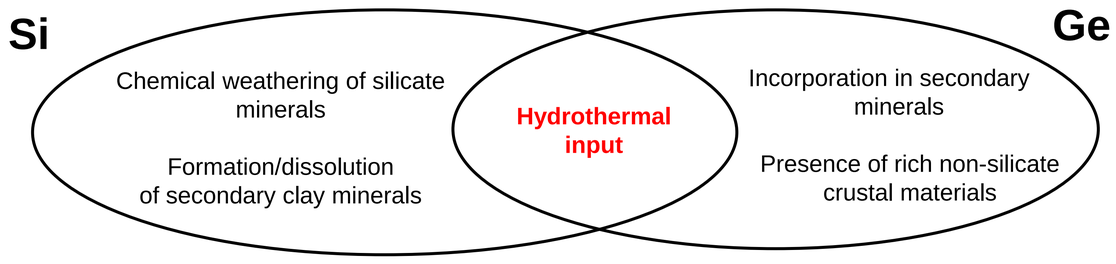
Modified from Rad *et al.*, 2013

Fig. 1

- Since Ge/Si values [µmol/mol] of terrestrial hydrothermal waters are higher than those values in river waters, the Ge/Si ratio is a useful tool to trace hydrothermal contribution

Terrestrial hydrothermal springs : 2 – 1000 µmol/mol

River waters : 0.16 – 2.72 µmol/mol



2. Study sites and methods

1. La Soufrière (Guadeloupe, FWI)
13 hydrothermal springs,
22 river waters

Sampling February 2015

2. Aso (Japan)
6 hydrothermal springs,
11 river waters

Sampling Spring 2015

3. Kawah Ijen (Indonesia)
12 hydrothermal springs,
22 river waters

Sampling January 2017

- Dissolved Ge concentration was measured by HR-ICP-MS and Si by ICP-AES

3. Ge/Si in hydrothermal springs

- There is a large range of Ge/Si values (Fig. 3) in the three hydrothermal systems characterized by different water compositions (Fig. 2)

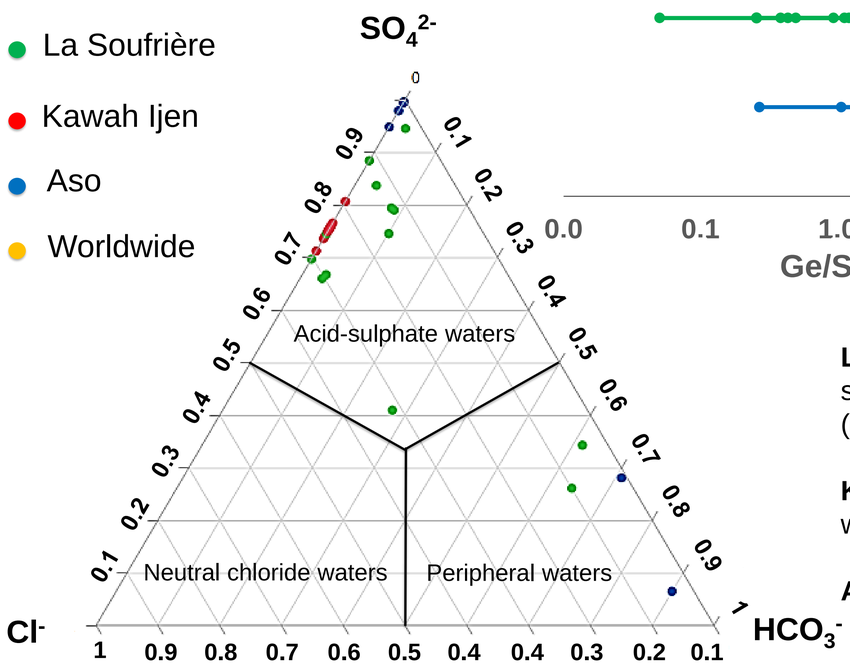


Fig. 2

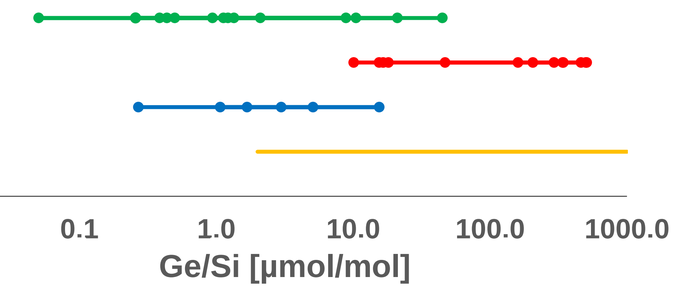


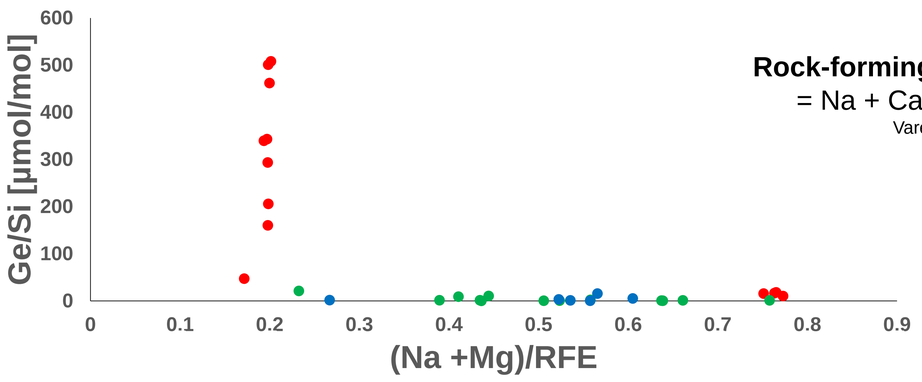
Fig. 3

La Soufrière: Chloride alkaline, acid-sulphate and acid-sulphate waters (pH 3.3 – 8.3)

Kawah Ijen: acid-sulphate-chloride waters (pH 0.1 – 6.8)

Aso: Ca-sulphate waters (pH 2.1 – 8)

- The highest Ge/Si values were obtained for Kawah Ijen acid-sulphate-chloride waters (Fig. 3). These waters are also characterised by the lowest Na+Mg/RFE (Fig. 4) which is considered to reflect longer water-rock interaction. The high Ge/Si values could reflect significant silica precipitation at Kawah Ijen.



Rock-forming element (RFE) [ppm]
= Na + Ca + Mg + K + Al + Fe
Varekamp *et al.*, 2000

Fig. 4

4. Ge/Si in river waters

- River waters are considered as hydrothermally impacted if $Cl^-/SO_4^{2-} < 7.14$, $[SO_4^{2-}] > 5$ ppm and high SO_4^{2-}/Na^+ (Fig. 5)

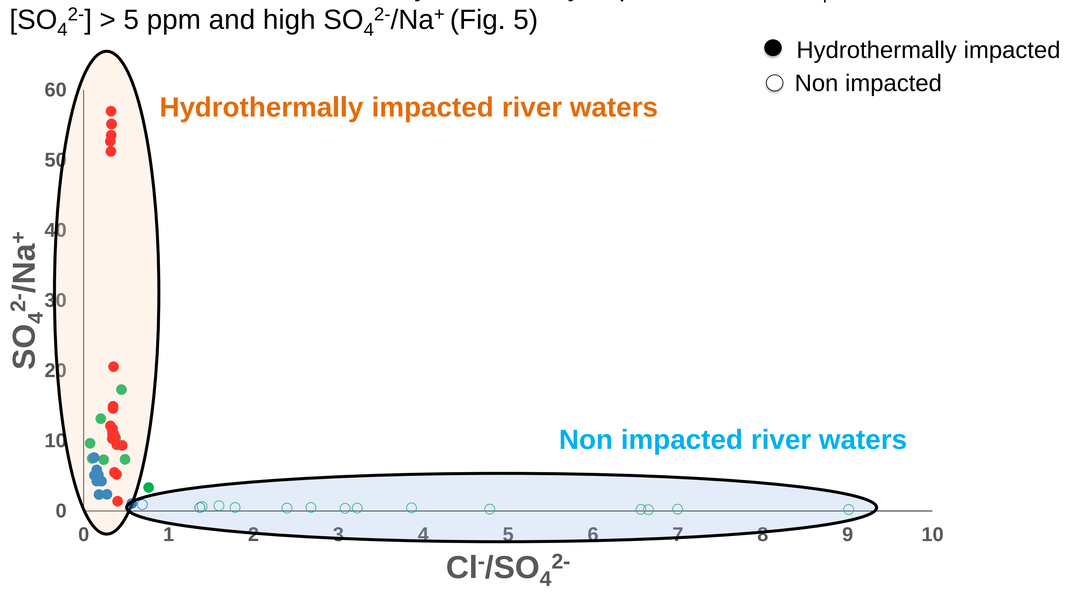


Fig. 5

- The Ge/Si ratio in hydrothermally impacted river waters increases with hydrothermal contribution and is higher than in non impacted river waters (Fig. 6)

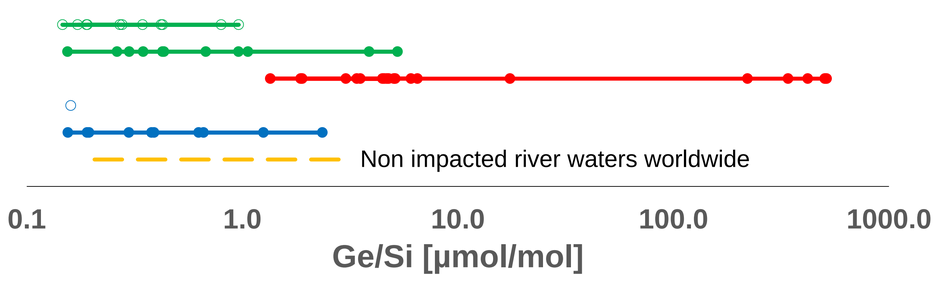


Fig. 6

- The impact of internal river processes (biological consumption or precipitation) on Ge/Si ratios in hydrothermally impacted rivers seems negligible. Dilution with non impacted waters seems to explain the evolution of Ge/Si ratio downstream as illustrated for Banyu Pahit River draining from Kawah Ijen volcano (sampled at ten different locations 40 km downstream, Fig. 7)

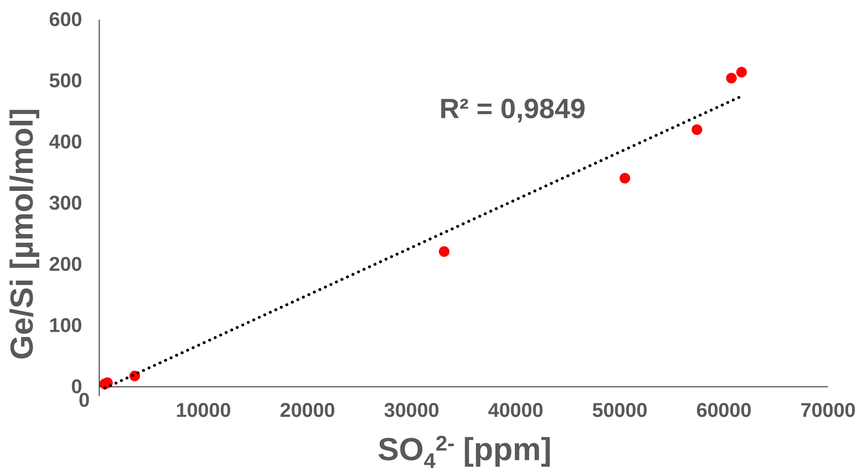


Fig. 7

5. Take home message and perspectives

- There is a large range of Ge/Si ratios in hydrothermal springs of different hydrothermal systems, propably due to the silica precipitation.
- Ge/Si ratios should be coupled with other geochemistry indicators such as $\delta^{34}S$ to better understand hydrothermal influence.

Rad *et al.*, 2013. *Journal of South American Earth Sciences* 45: 331-344.
Varekamp *et al.*, 2000. *Journal of Volcanology and Geothermal Research* 97:161-179.

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