SO263 – Geochemical investigation of hydrothermal fluids from Niuatahi rear-arc volcano, North East Lau Basin, SW Pacific

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Introduction

The North Eastern Lau Basin is an area of intense hydrothermal activity with at least 43 active sites (Baker et al. 2019); much of the hydrothermal activity occurs in the rear-arc, at the Mata volcanoes and at Niuatahi.

Here we report on the first detailed geochemical and isotopic analyses for hydrothermal fluids from Niuatahi rear-arc volcano.

Sampling site

Niuatahi has a near circular caldera with ~8 km in diameter and a prominent post-caldera cone (Motutahi) is located in the center.

At Motutahi, the occurrence of alunite and metal-rich molten sulfur displays direct evidence for the degassing of metal-bearing magmatic vapors (Kim et al. 2009).

High-temperature hydrothermal fluids were recovered at three vent sites within the Niuatahi caldera (**Figure 1**).

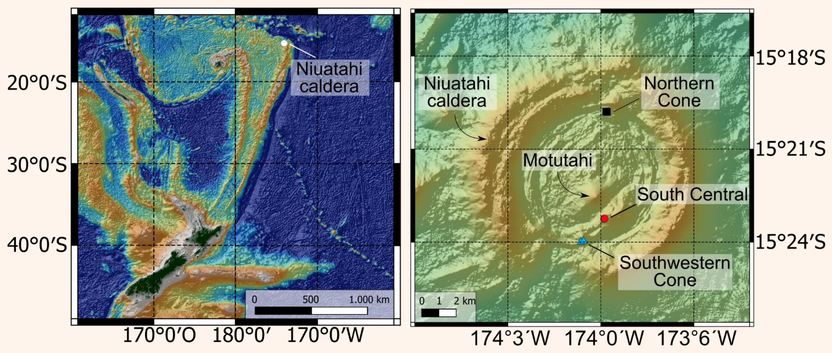

Figure 1: (A) Overview of the southwest Pacific. The white circle marks the location of Niuatahi caldera volcano. GEPCO Compilation Group (2021) (doi:10.5285/a29c5465-b138-234d-e053-6c86abc040b9)
(B) Detailed map of the study site at the off-axis caldera volcano Niuatahi and the hydrothermal sites. Bathymetry data taken from R/V Falkor expedition FK171110 (2017) Merle et al. (2018) (doi: 10.1594/IEDA/324447).

Results & Discussion

At South Central venting of black smoke with T_{max} = 334°C and pH_{min} = 2.8 was observed. At the Southwestern and Northern Cone T_{max} and pH_{min} ranged between 293 °C and 319 °C and 3.4 and 3.2, respectively.

All fluids show a depletion of Mg, SO_4, U as well as an enrichment of (trace) metals (e.g., Fe, Mn, K, Li, **Figure 2**) and dissolved gases (e.g., H_2S, CO_2, H_2) compared to seawater.

Results & Discussion

Low Cl concentrations at the South Central site is indicative for phase separation (**Figure 2**).

The chondrite-normalized rare earth elements (REE) overlap with other high-temperature black smoker fluids from island arc volcanoes as well as from sediment-starved MOR hydrothermal systems (**Figure 3**).

Overall fluid composition from the Northern and Southwestern Cone are almost congruent, despite being situated on opposite sides of the caldera.

Fluids from the Northern and Southwestern Cone show low Fe/Mn ratios, indicating subsurface cooling.

Water/Rock (W/R) ratios based on K, Li, Rb, Cs as well as δ^7Li, $^{87}Sr/^{86}Sr$ and $\delta^{11}B$ (**Figure 4**), yield values between 1-6 for the Northern and Southwestern Cone and 1-9 for the South Central site.

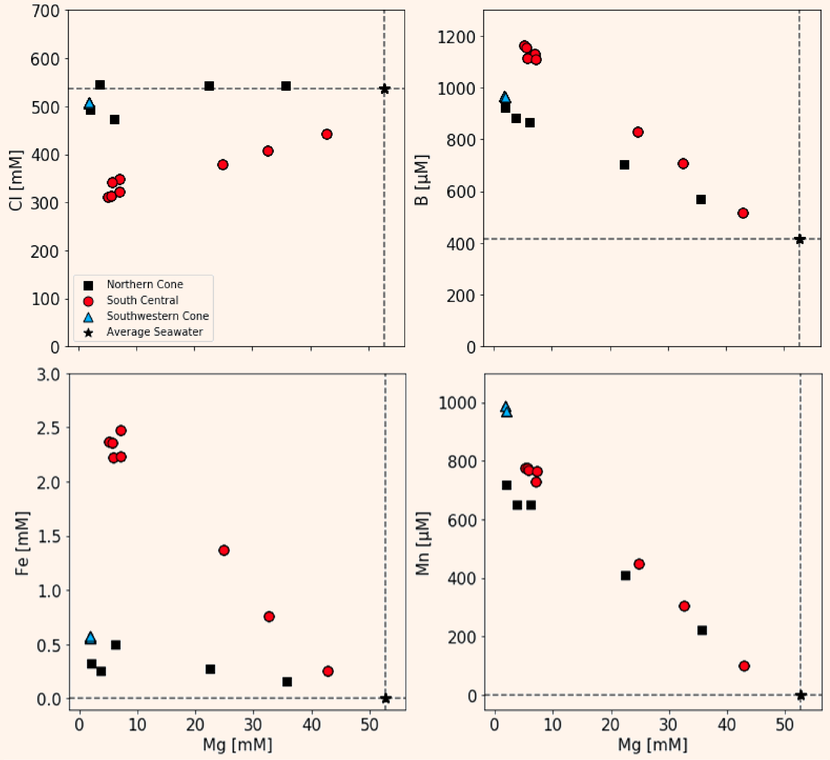

Figure 2: Selected measured element concentration versus Mg concentration of samples collected from Niuatahi during research cruise SO263. Dashed lines represent element concentration in seawater. Units [mM] and [µM] refer to mmol/kg and µmol/kg, respectively.

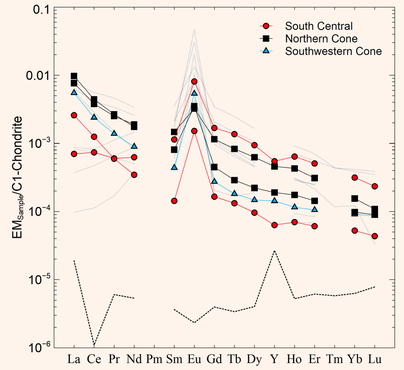

Figure 3: Chondrite-normalized REY patterns of hydrothermal end-members fluids as well as literature (grey lines) data from sediment-starved mid-ocean ridge, back-arc and oceanic island arc systems (Craddock et al. (2010), Kleint et al. (2019)). Seawater values (black dotted line) were taken from Alibo and Nozaki (1999).

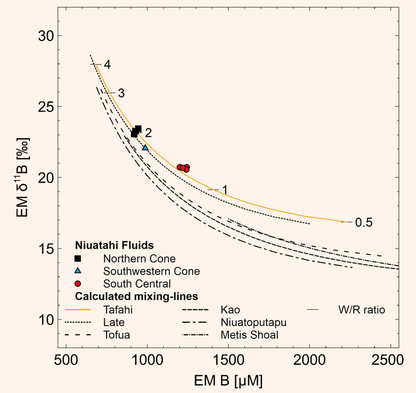

Figure 4: Boron conc. vs B isotope ratios in end-member hydrothermal fluids from Niuatahi together with calculated equilibrium mixing-lines for the northern most samples at the Tofua island arc reported by Leeman et al. (2017). Best fit is observed between hydrothermal fluids and Tafahi lavas.

Conclusion

High-temperature fluids from Niuatahi reflect typical black smoker type fluids based on chemical composition e.g. pH, REE, W/R ratios.

Results suggest that fluid-rock interactions under rock-dominated conditions are predominant at all sampling sites.

At South Central, fluids seem to be affected by phase-separation and subsequent W/R interaction.

At the Northern and Southwestern Cone, results suggest similar conditions in the hydrothermal root zones as well as subseafloor cooling prior to venting.

References

Alibo D. S. and Nozaki Y. (1999) Rare earth elements in seawater : Particle association , shale-normalization , and Ce oxidation. Geochim. Cosmochim. Acta 63, 363–372.

Baker E. T., Walker S. L., Massoth G. J. and Resing J. A. (2019) The NE Lau Basin: Widespread and Abundant Hydrothermal Venting in the Back-Arc Region Behind a Superfast Subduction Zone. Front. Mar. Sci. 6, 1–15.

Craddock P. R., Bach W., Seewald J. S., Rouxel O. J., Reeves E. and Tivey M. K. (2010) Rare earth element abundances in hydrothermal fluids from the Manus Basin, Papua New Guinea: Indicators of sub-seafloor hydrothermal processes in back-arc basins. Geochim. Cosmochim. Acta 74, 5494–5513. Available at: http://dx.doi.org/10.1016/j.gca.2010.07.003.

Kim J., Son S. K., Son J. W., Kim K. H., Shim W. J., Kim C. H. and Lee K. Y. (2009) Venting sites along the Fonualei and Northeast Lau Spreading Centers and evidence of hydrothermal activity at an off-axis caldera in the northeastern Lau Basin. Geochem. J. 43, 1–13

Kleint C., Bach W., Diehl A., Fröhberg N., Garbe-Schönberg D., Hartmann J. F., de Ronde C. E. J., Sander S. G., Strauss H., Stucker V. K., Thal J., Zitoun R. and Koschinsky A. (2019) Geochemical characterization of highly diverse hydrothermal fluids from volcanic vent systems of the Kermadec intraoceanic arc. Chem. Geol.

Leeman W. P., Tonarini S. and Turner S. (2017) Boron isotope variations in Tonga-Kernadec-New Zealand arc lavas: Implications for the origin of subduction components and mantle influences. Geochemistry, Geophys. Geosystems 18, 1126–1162.

Funding of this project (03G0263) was provided by the BMBF (German Federal Ministry of Education and Research) and is gratefully acknowledged.