

Discovery of high-temperature hydrothermalism and massive sulfide formation at Hatiba Mons volcano, Central Red Sea

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Background Red Sea

- Ultra-slow spreading ridge
 - Known hot brines
 - Largest modern submarine metal deposit at Atlantis II Deep
 - Inactive sulfide deposits at Kebrit & Shaban Deeps
 - Newly discovered <60°C hydrothermal vents at Hatiba¹
 - Fe-oxyhydroxide, Mn-oxide mounds & yellow microbial mats at active vents
- Further investigation of these unique systems needed!

Research Questions

- How do active hydrothermal systems in the Red Sea form?
- What are links between geochemistry, microbiology, fluid chemistry and mineralisation?
- Which processes are responsible for the variability within and between Fe-mounds?

Why?

- Understand formation processes of hydrothermal deposits
- Reveal microbial role in mineral precipitation
- Assess geochemical cycling in Red Sea hydrothermal environments

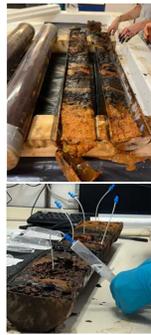


Multidisciplinary Approach:

How?

Sediment/Rock Geochemistry & Mineralogy

- Bulk chemistry
- Mineralogy (XRD, Microscopy, SEM)
- S-isotopes
- Mineral chemistry (EMP, LA-ICP-MS)



Microbiology

- Metagenomics (Illumina NovaSeq 6000, SP150)
- Functional potential analysis
- Morphology (SEM)



Fluid Chemistry

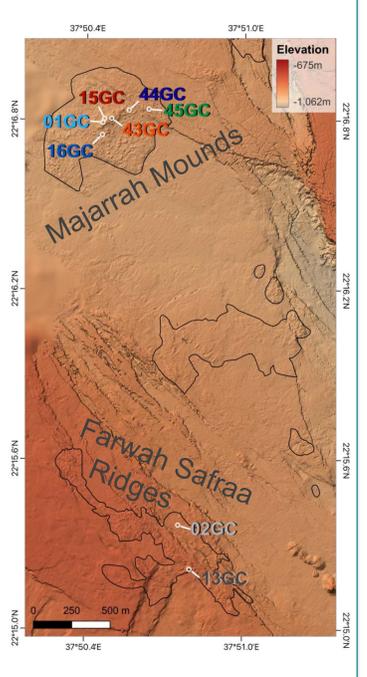
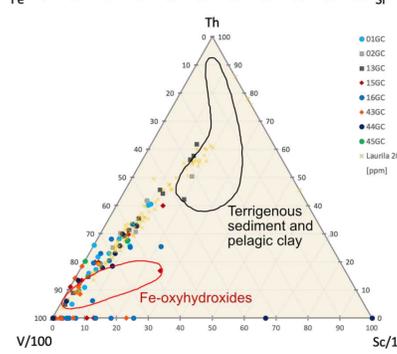
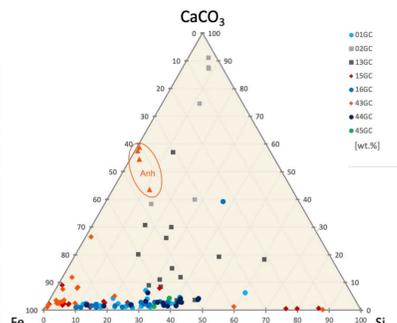
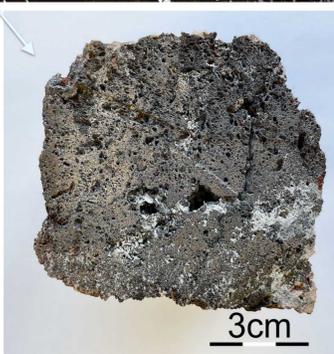
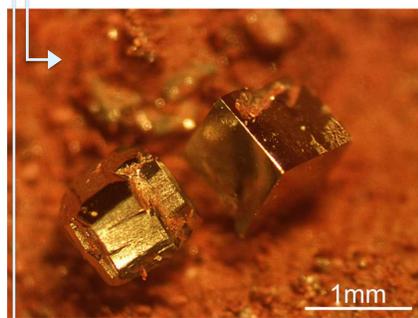
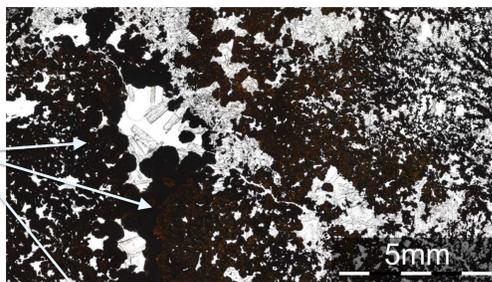
- Porewater analysis:
- Inorganic nutrients (CFA)
 - Salinity & Conductivity
 - Temp., Eh, pH
 - Major & minor elements (IC, ICP-MS)



Preliminary Results – Geochemistry and Mineralogy

Hydrothermal Precipitates

- Anhydrite (CaSO_4) [150°C]
- Fe-oxyhydroxides
- Hematite (Fe_2O_3)
- Sphalerite (ZnS) [$<350^\circ\text{C}$]
- Pyrite/Marcasite (FeS_2)
- Barite (BaSO_4) [120-300°C]²



➤ **First description** of the geochemistry & mineralogy of an active non-brine hydrothermal system in the Red Sea

➤ Massive sphalerite, idiomorphic pyrite, barite, and anhydrite = indicating **high formation temperatures** (higher than current vent temperatures)

➤ **Variability of mounds** through differences in detrital input, distance to vent sites, fluid temperatures & pH, and mixing with seawater, amongst others

Literature:

- 1 van der Zwan, F.M., Augustin, N., Petersen, S., Altalhi, S.M., Schultz, J., Peixoto, R.S., Follmann, J., Anker, A., Benzoni, F., Garcia Paredes, E.R., Al Malallah, M., Ouhassain, M., Jägerup, B., Jones, B.H., Rosado, A.S. (2023) Discovery of widespread diffuse venting and large microbial Fe-mounds in the Red Sea. *Commun. Earth Environ.*
- 2 Jamieson, J.W., Hannington, M.D., Trvej, M.K., Hansteen, T., Williamson, N.M.B., Stewart, M., Fietzke, J., Butterfield, D., Frische, M., Allen, L., Cousins, B., Langer, J. (2015) Precipitation and growth of barite within hydrothermal vent deposits from the Endeavour Segment, Juan de Fuca Ridge. *Geochim. Cosmochim. Acta*
- 3 Laurila, T.E., Hannington, M.D., Petersen, S., Garbe-Schönberg, D. (2014) Early depositional history of metalliferous sediments in the Atlantis II Deep of the Red Sea: Evidence from rare earth element geochemistry. *Geochim. Cosmochim. Acta*

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