Exploring cool hydrothermal circulation in the global ocean

BACKGROUND

- Earth's oceanic crust is composed of basalt covered by a layer of impermeable sediment. Where basalt is exposed, seawater soaks into the crust and flows along temperature and pressure gradients[1,2] (Figure 1).
- Seawater reacts chemically with basalt and microbial activity in the crust can change the concentrations of **dissolved elements that are important for life** (e.g., oxygen, NO_3^- and Fe) and are **linked to the carbon cycle** (e.g., Ca)[3-11].
- Despite their biogeochemical importance, these cool hydrothermal systems have only been identified in a few areas[4,9,10,12-17]. **No attempt has yet been made to track this phenomenon in the global ocean.**

RESARCH QUESTION

How widespread are existing observations of cool hydrothermal flow in the global ocean?

OBJECTIVES

- Mine an existing database for diagnostic geochemical profiles (e.g., sulfate) indicative of cool hydrothermal flow.
- Generate a database and map of the phenomenon that will be shared with the research community.

RESULTS

- The database of drilling reports from the International Ocean Drilling Program (IODP) was queried (Figure 4)
- Python code was developed to search all published IODP drilling reports for the keyword "basalt", and return the site and expedition number where the word was found (Figure 5).
- So far, 84 sites from 24 IODP expeditions have been identified that mention "basalt"
- Two IODP sites where cool hydrothermal flow has been previously identified were identified by the Python code (Figure 6).
- In manual review of a random subset of 10 identified reports, evidence of cool hydrothermal flow was present in 6, was not present in 2, and may be present in 2 (pending further review).

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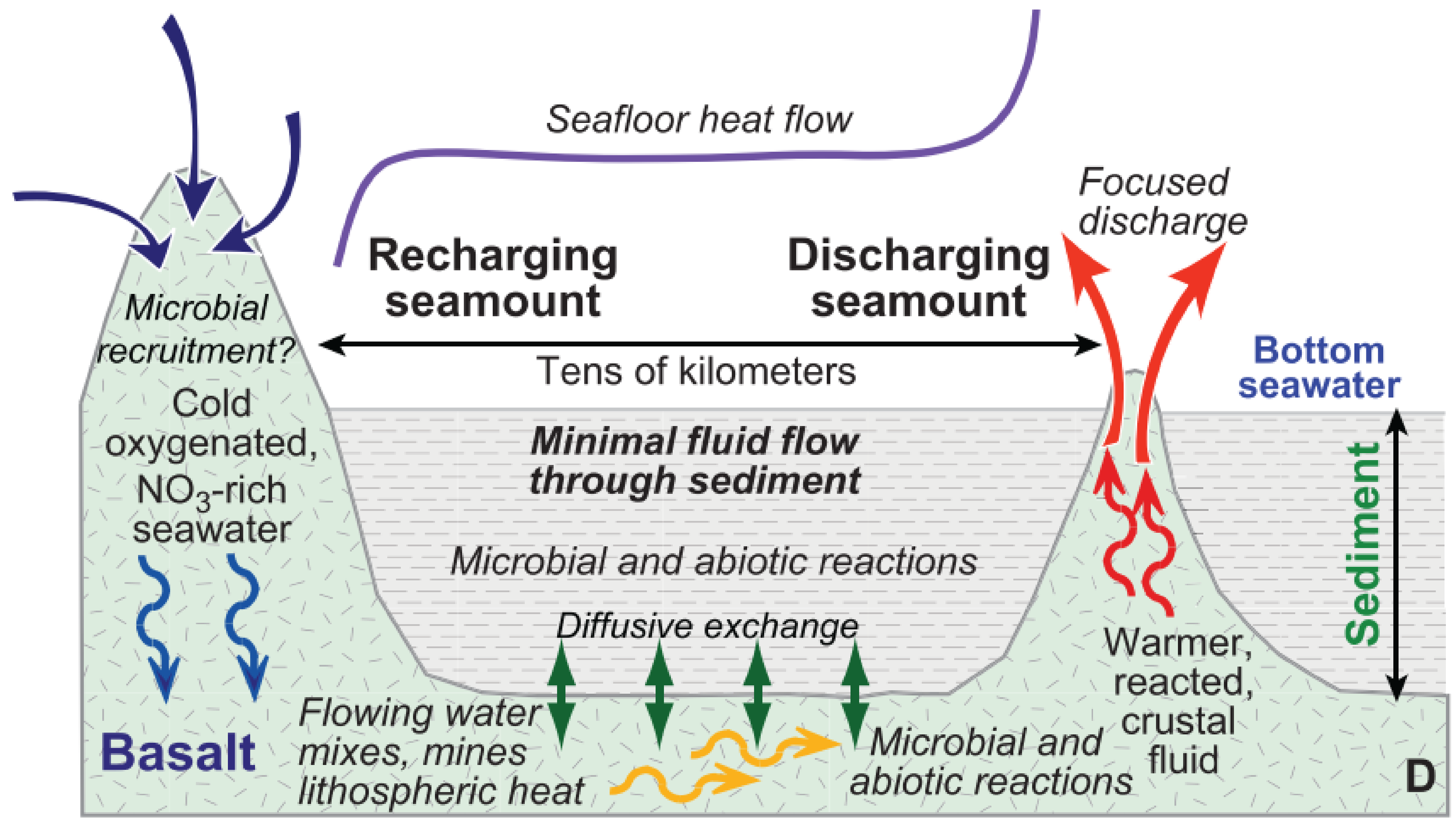

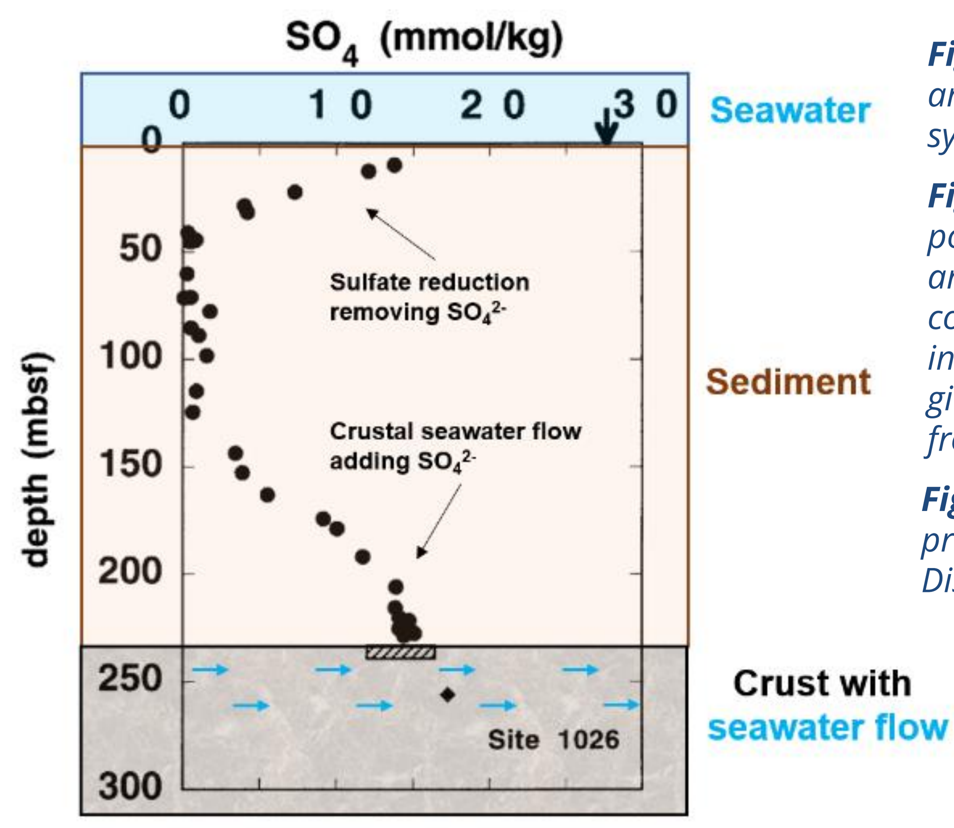

Figure 1 (above). *Schematic illustrating the recharge and discharge mechanisms of a cool hydrothermal system (Fisher and Wheat, 2010).*

Figure 2 (left). *Example of a gradient reversal in pore water sulfate from the Juan de Fuca Ridge. The arrow on the x-axis indicates seawater sulfate concentration, and the rectangle with hashing indicates the sediment-crust interface. Depth is given in meters below sea floor (mbsf). Modified from Elderfield et al., 1999.*

Figure 3 (below). *The Joides Resolution, which is the primary coring vessel for the international Ocean Discovery Program*

IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM

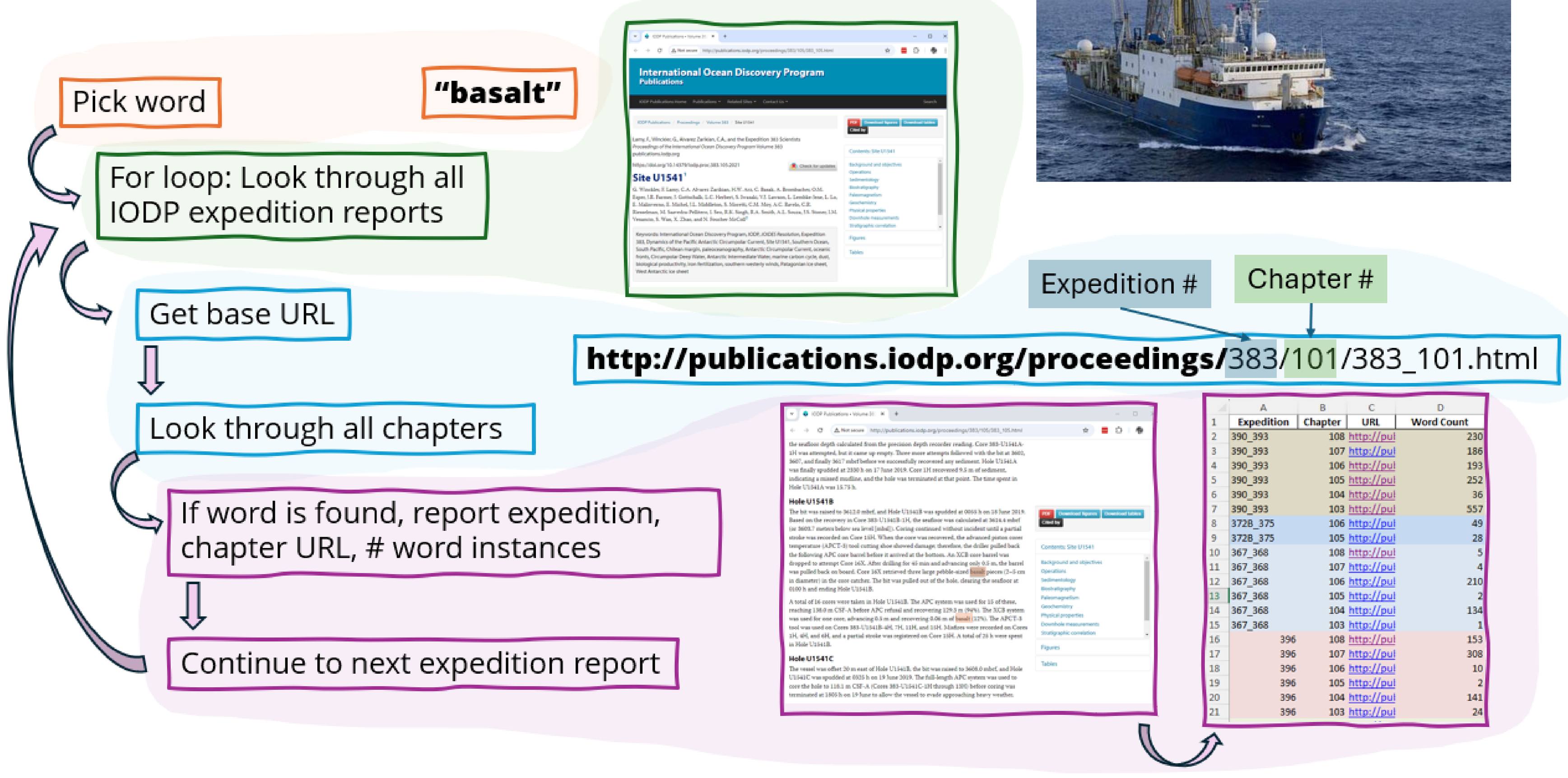

Figure 5 (above). *Schematic representing the logic used to scrape the web for reports of contact with basalt while sediment coring.*

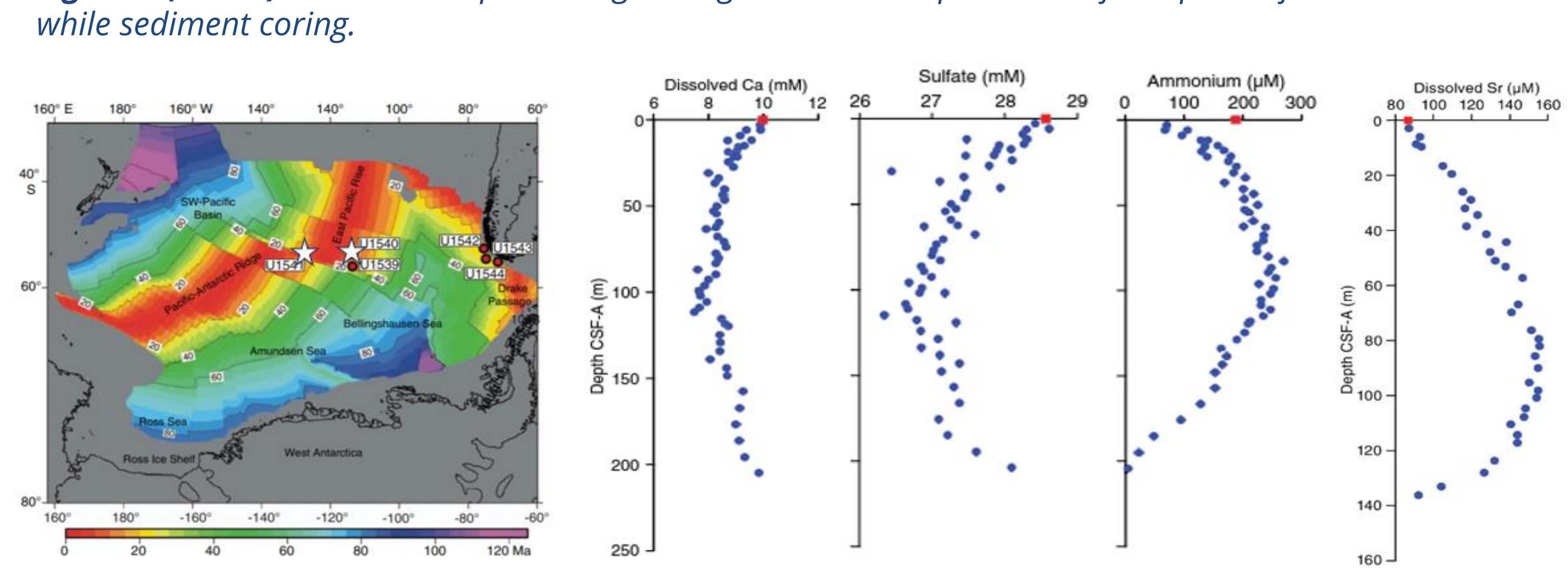

Figure 6 (above). *Locations of study sites U1540 and U1541 (marked in white stars), and gradient reversals in pore water calcium, sulfate, and ammonium at U1540, and strontium at U1541 (IODP Expedition 383 Proceedings). The red squares indicate the overlying water concentrations.*

NEXT STEPS

- Results will be compared to published literature→ were known sites of cool hydrothermal flow were identified by our method?
- Geochemical data corresponding to identified sites will be downloaded and collated
- Using Python, pore water data (e.g., sulfate) will be extracted to diagnose cool hydrothermal flow (by evaluating the slope of the depth profile)
- Finally, a map will be created in ArcGIS to illustrate all locations where the signature of cool hydrothermal flow has been observed.

REFERENCES: 1. Fisher and Wheat, 2010; 2. Kuhn et al., 2017; 3. Anderson et al., 1976; 4. Baker et al., 1991; 5. Kastner and Gieskes, 1976; 6. Santiago Ramos et al., 2020; 7. D'Hondt et al., 2004; 8. Orcutt et al., 2013; 9, Zhang et al., 2016; 10. Zhao et al., 2019; 11. Zinke et al., 2018; 12. Desens et al., 2018; 13. Elderfield et al., 1999; 14. Hulme and Wheat, 2019; 15. Versteegh et al., 2021; 16. Wheat and Fisher, 2008; 17. Wheat et al., 2020