High Field Strength Elements (Zr, Nb, Hf):

Distributions and Processes in the Pacific Ocean. Insights from the cruises SO289 and SO298

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Why HFSEs in the Pacific?

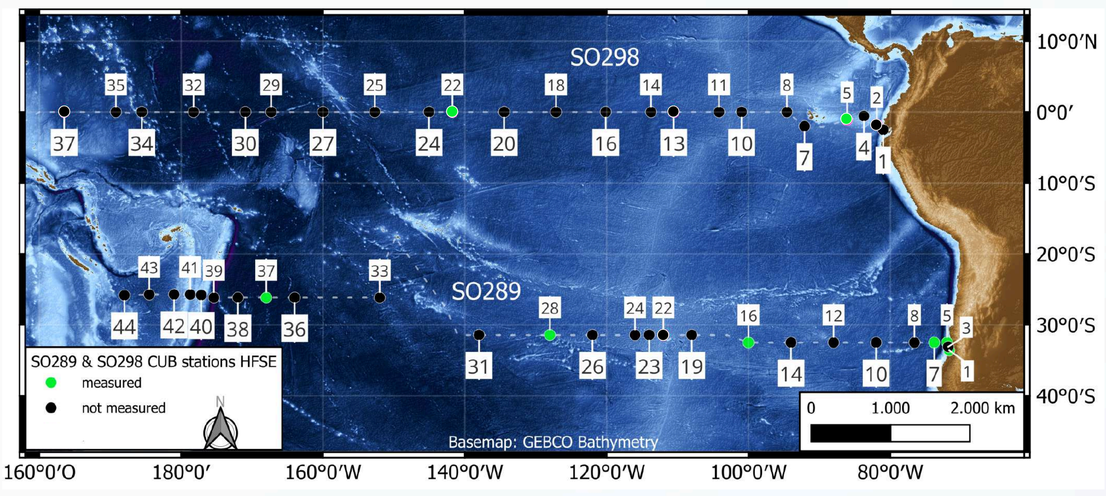
High field strength elements (HFSEs) such as zirconium (Zr), niobium (Nb), and hafnium (Hf) are emerging tracers of oceanic processes, including particle scavenging and water-mass transport [1–3]. Their dissolved concentrations in seawater are extremely low, making accurate measurement analytically challenging and resulting in sparse and partly method-dependent datasets [4–6].

Oxygen minimum zones (OMZs) are characterized by enhanced particle cycling and altered redox conditions, which may modify HFSE behavior. However, direct observations of dissolved HFSEs in OMZs, particularly in the Pacific Ocean, remain very limited [7].

Aim of the study

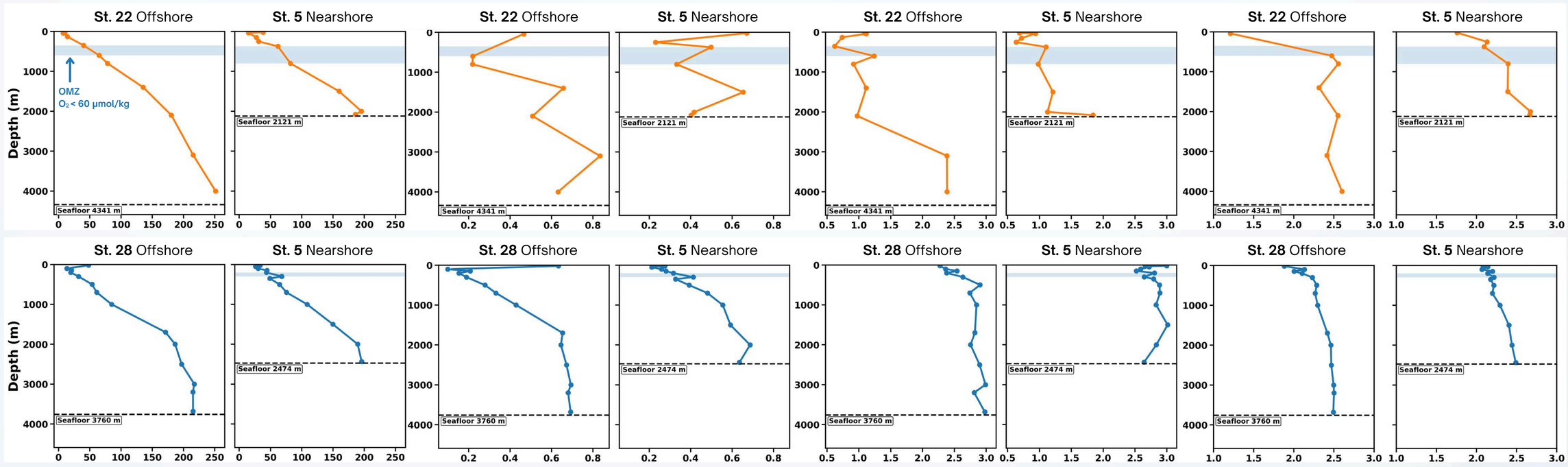
To investigate the distribution of dissolved Zr, Hf, and Nb in the Southern and Equatorial Pacific and evaluate how oxygen and nutrient gradients relate to their distributions.

Sampling



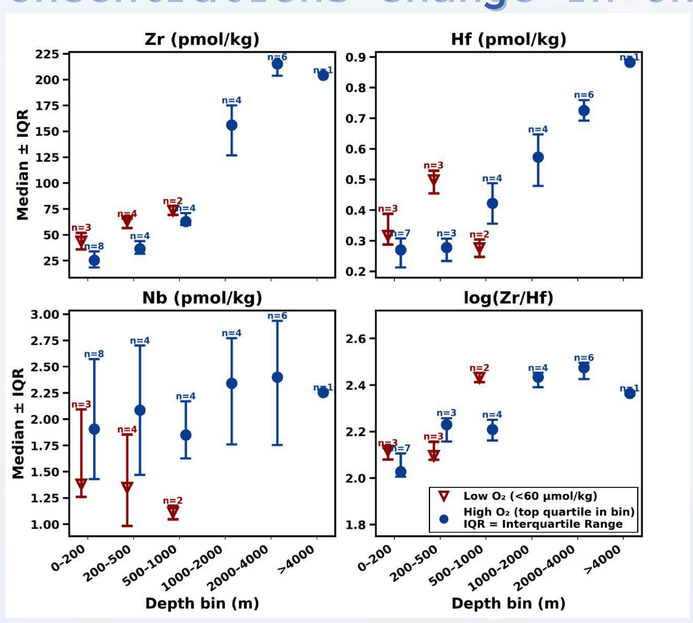
Samples were collected during the cruises SO289 (GP21) and SO298 (GP11) with a trace metal clean Ti CTD, filtered with a 0.2/0.8 µm AcroPak filter, acidified with 0.02M HCl and 0.002M HF. Preconcentrated with using offline SeaFAST method and analysed with ICP-MS.

Distribution of HFSEs

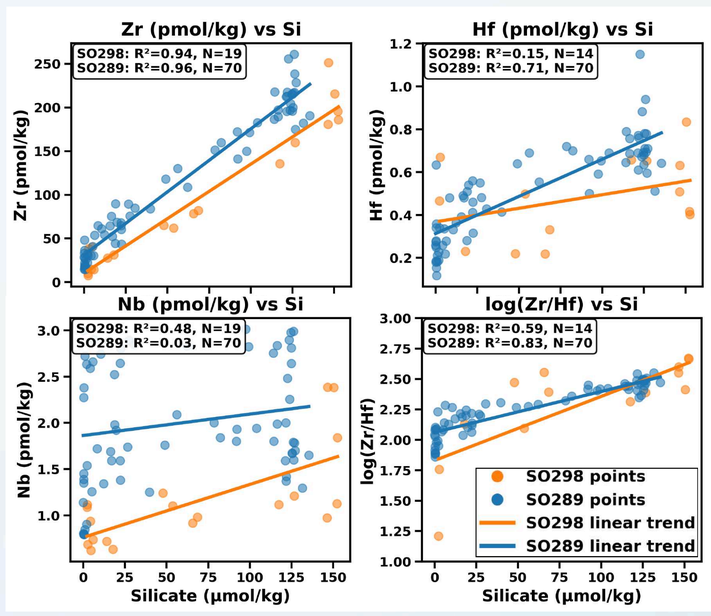


What Controls HFSE Distributions?

Concentrations change in OMZ



Consentrations vs Silicate



Main Findings

Overall, Zr, and to a lesser extent Hf show nutrient-like behavior with strong coupling to silicate and increasing concentrations at depth, while Nb is more conservative and weakly linked to nutrients. Zr/Hf varies significantly, indicating decoupling of the HFSE ‘twin’ elements. Depth-binned low-/high-O_2 comparisons show systematic differences in Zr, Nb, and Zr/Hf under low oxygen, suggesting oxygen-related modification beyond depth alone.

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References

[1] Firdaus ML et al. (2011) Nature Geoscience DOI: 10.1038/ngeo1114. [2] Schmidt K, Bau M (2014) Geochimica et Cosmochimica Acta DOI: 10.1016/j.gca.2014.05.036. [3] Frank M (2011) Nature Geoscience DOI: 10.1038/ngeo1125. [4] Firdaus ML et al. (2007) Analytica Chimica Acta DOI: 10.1016/j.aca.2006.10.033. [5] Tanaka K et al. (2019) Analytical Sciences DOI: 10.2116/analsci.19P069. [6] Ueki R et al. (2024) Marine Chemistry DOI: 10.1016/j.marchem.2024.104365. [7] Ueki R et al. (2023) Geochemical Journal DOI: 10.2343/geochemj.GJ23013

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