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# Stable isotopes in interstitial fluids evidencing microbial activity, mineral authigenesis, and fluid mixing in deep interstitial fluids off SW Australia (IODP Leg 369)



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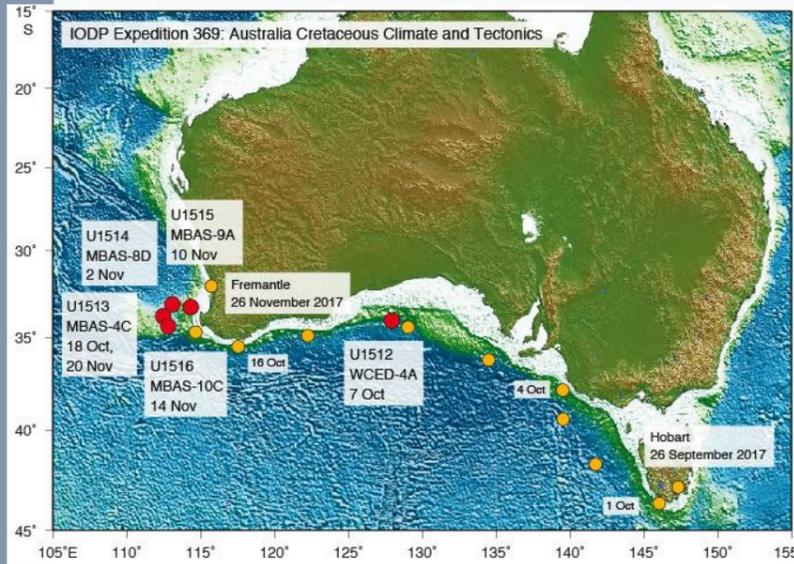
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## Introduction

Interstitial waters extracted from long sediment cores retrieved during IODP expedition 369 (Sites U1512-U1516) of the International Ocean Drilling Program (IODP) were analysed for the stable water isotopic (O and H isotopes) composition to constrain hydrographic changes in this region prior to modern time and possible changes due to water-rock interaction and fluid mixing. Dissolved sulfate (S and O isotopes), sulfide (S isotopes), and inorganic carbon (C) were analyzed to characterize, in concert with concentration measurements, the impact of diagenetic microbial, water-rock interaction and fluid mixing.

Fig.1 Investigated drill sites of IODP Leg 369, off South-Western Australia.

Fig.2: Joides Resolution



## Results and Discussion I

The measurements demonstrate substantial downcore variations in the water oxygen isotope composition. Net microbial sulfate reduction with depth was observed at all sites, but sulfate was only found to be consumed completely, within the investigated core lengths at Site U1512, that is located off southern Australia. Whereas associated sulfur isotope fractionation is characteristic for medium range fractionation factors, the oxygen isotope composition provides evidence for a much more complex story of sulfur diagenesis at the investigated sites: At Site U1516, for instance, the oxygen isotope composition of dissolved sulfate is equilibrated with pore water, although sulfate concentrations remain above 20 mM. This indicates an intense re-oxidative sulfur cycle. At Site U1513, on the other hand, the oxygen isotope composition remains out of isotope exchange equilibrium although sulfate concentrations fall below 20 mM, indicating that the net decrease in dissolved sulfate is dominantly caused by authigenic gypsum precipitation at depth, which is further confirmed by the dissolved Ca concentrations.

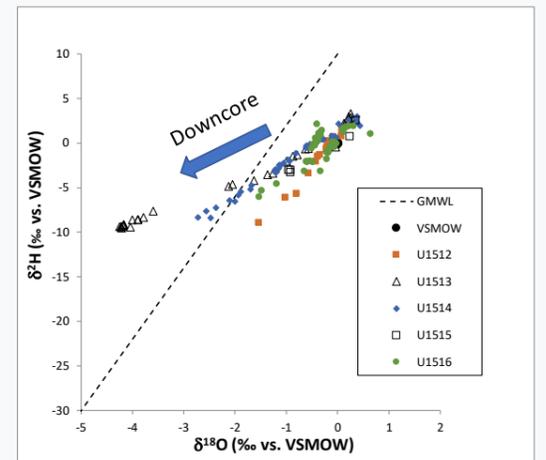


Fig.4 Covariation of H and O water isotopes. GMWL: Global Meteoric Water Line.

Fig.3: Lithology of drilled IODP Leg 369 sites

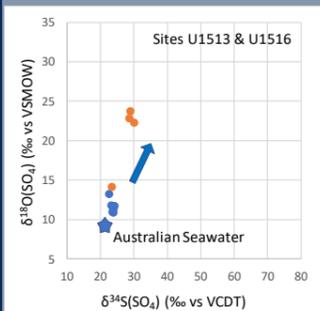
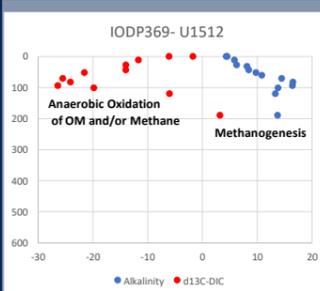
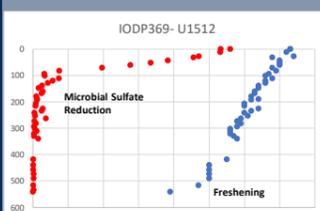
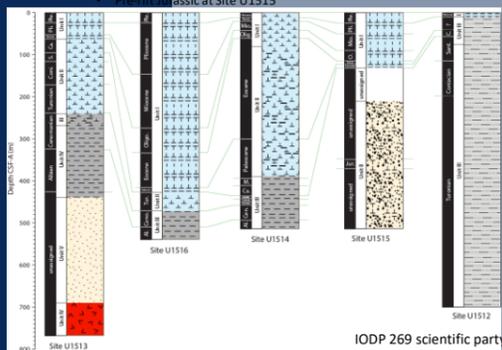
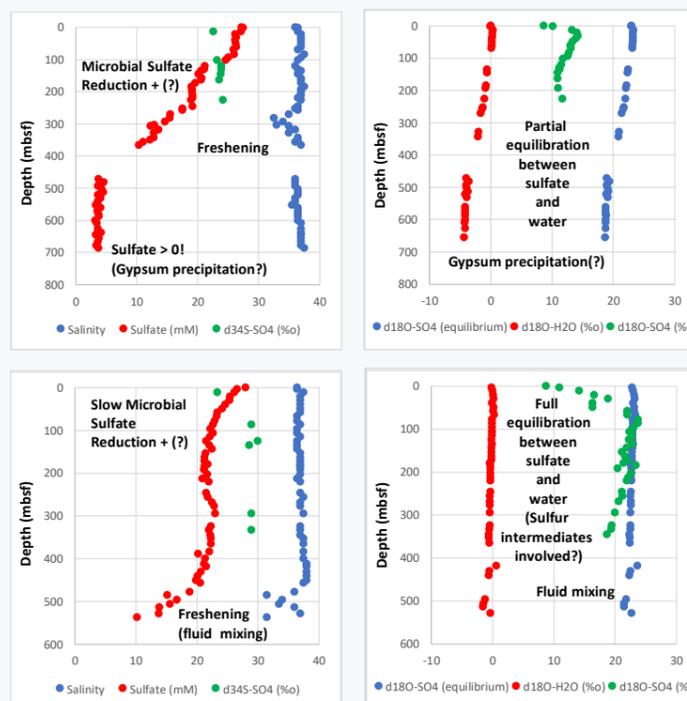


Fig.5: Sulfate reduction and methanogenesis at Site U1512

Fig.6: The 'Böttcher-Hypothesis' (Brunner et al. (2005): Covariation of the O and S isotope composition indicates slow cellular microbial sulfate reduction rates at sites U1513 and U1516

## Results and Discussion II



Chlorinity	Oxygen isotopes	Hydrogen isotopes	Process
↑	↑	↑	Dissolution of hydrated salts
↑	↑	↑	Input residual brine
↓	↓	↓	Mixing with meteoric water
≈	↓/↑	≈	Recrystallization of carbonate
↓	↓/↑	≈	Recrystallization of biogenic opal
≈	↓/↑	↑	Alteration of ash particles
↓	↑	↑	Dissociation of gas hydrate
↓	↓	↓	Anaerobic methane oxidation
≈	↓	↓	Clay membrane ion filtration
↓	↑	↓	Kaolinite-fluid interaction
≈	↑	↓	Clay mineral dehydration
↓	↓	↓	Gypsum precipitation

Table: Compilation of potential processes that may alter the water isotope composition and chloride contents in interstitial waters (modified from Dählmann & de Lange, 2003). ≈: unchanged; ↓: shift to lower values; ↑: shift to higher values.

Fig.7: Vertical profiles for concentrations and isotope composition of dissolved constituents (Leg U1513 (top) and U1516 (bottom)). Blue dots indicate predicted isotope exchange equilibrium conditions.

## Summary

We measured the hydrogeochemical and stable isotope composition of interstitial waters of IODP Leg 369 to elucidate microbial activity, fluid mixing and water-rock interaction

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Acknowledgements