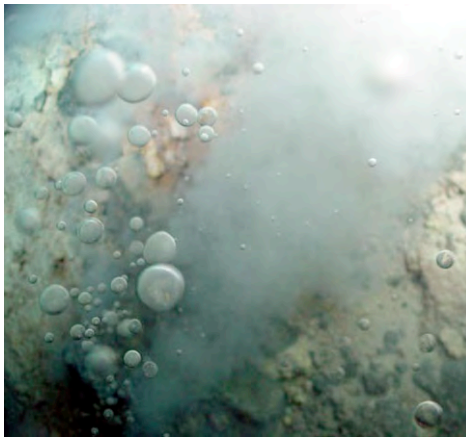


Ocean in a high CO2 world

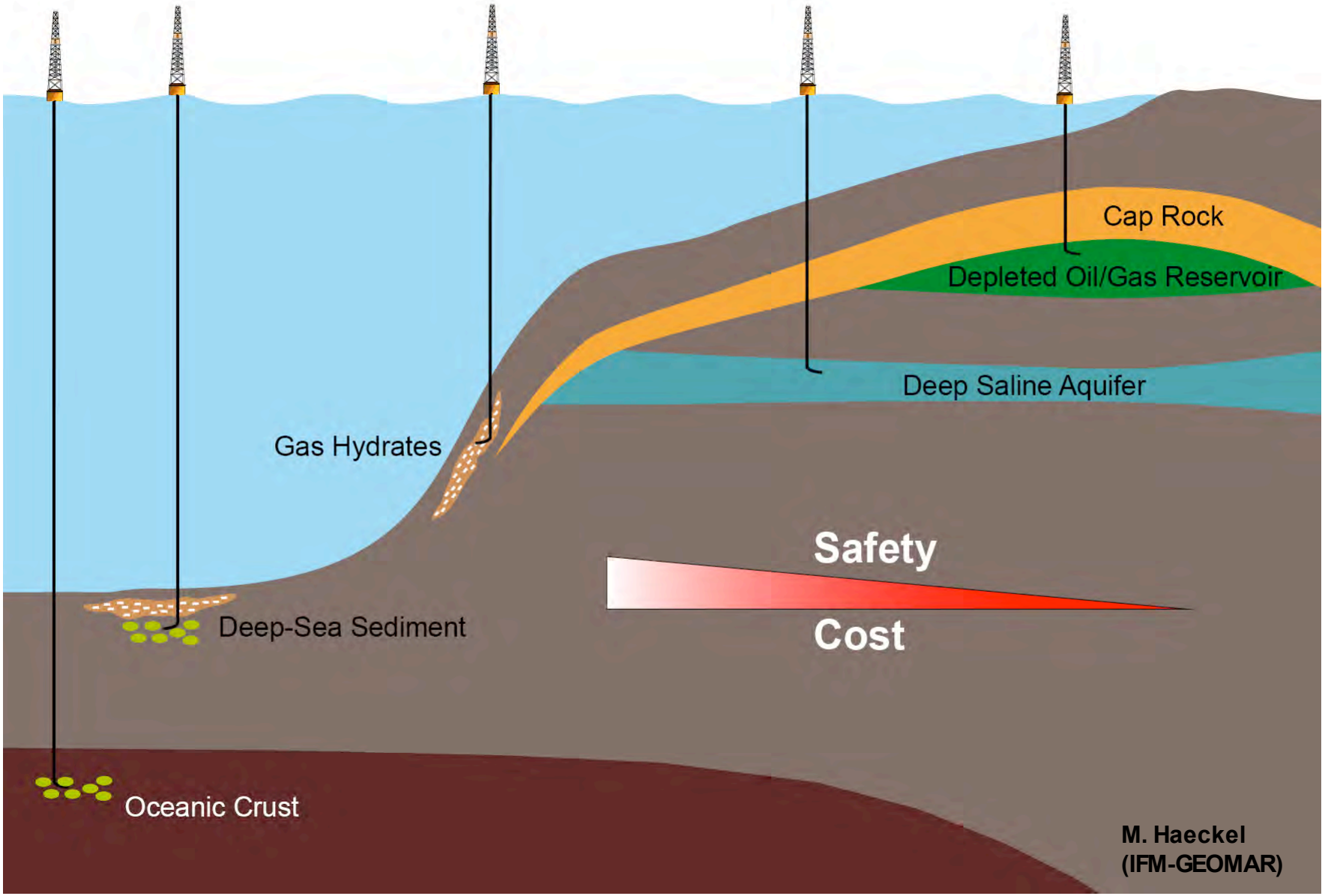
Monaco, 06.-09. October 2008

CO_2 leakage in the deep ocean and its effect on biota and biogeochemistry – lessons from natural analogues for CO_2 disposal in the ocean

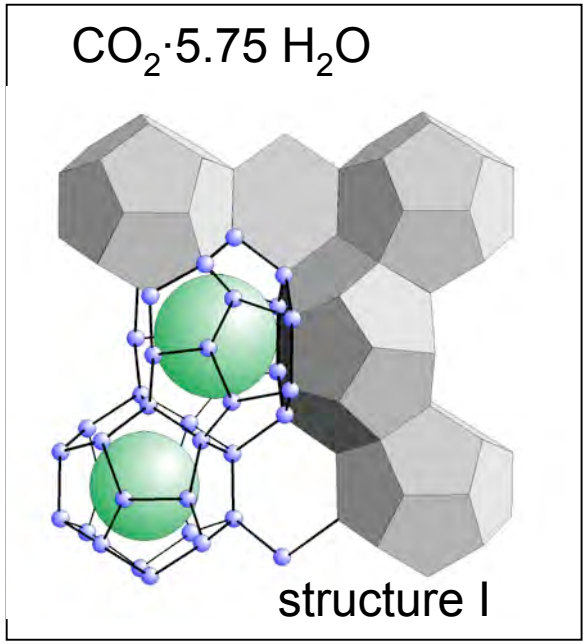
[1,2]Antje Boetius, [1]Dirk de Beer, [1]Judith Ufkes, [3]Matthias Haeckel, [4]Fumio Inagaki, [5]Koichi Nakamura, [6]Gregor Rehder

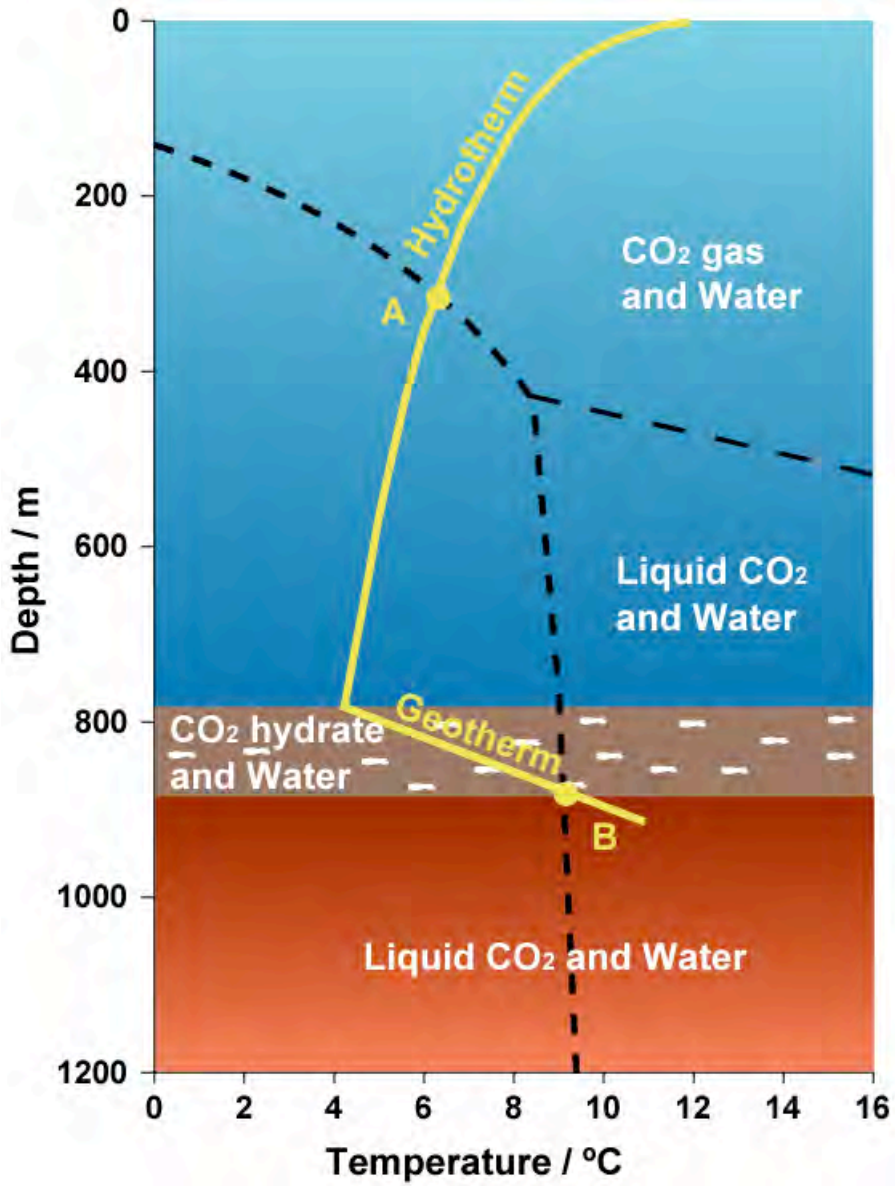
1 Max Planck Institute for Marine Microbiology
2 Jacobs University Bremen
3 Leibniz-Institute for Marine Sciences IFM-GEOMAR
4 Kochi Institute for Core Sample Research, JAMSTEC
5 National Institute of Advanced Industrial Science and Technology (AIST)
6 Baltic Research Institute

Marine CO_2 storage options



CO_2 phases

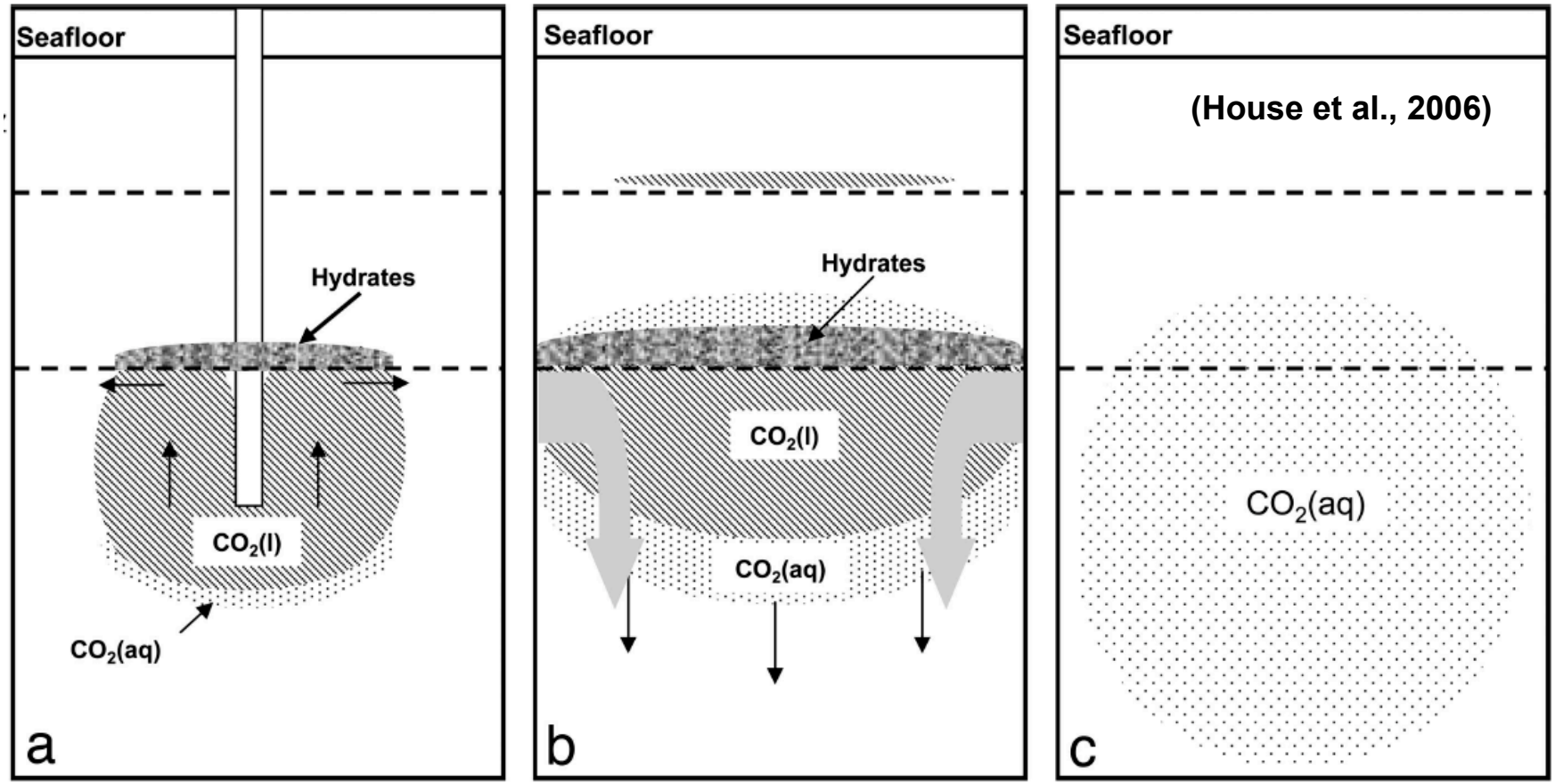




CO2 hydrates are stable at low temperatures and high pressures, liquid CO2 becomes heavier than water >3000 m

M. Haeckel (IFM-GEOMAR)

CO2 Sequestration in deep-sea sediments

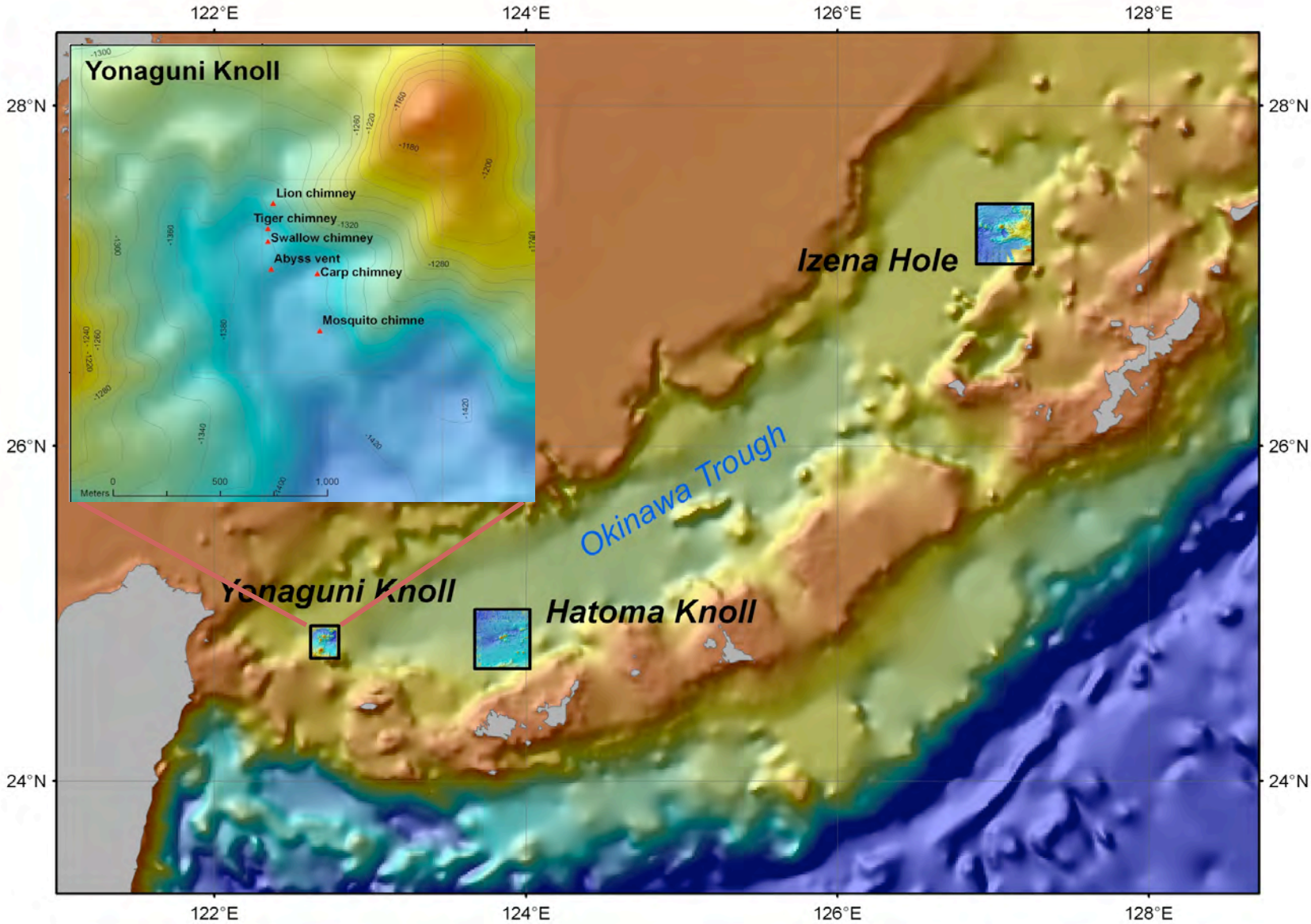


CO_2 forms a sealing hydrate cap rock and will slowly dissolve into the porewater, thereby inducing weathering of the sediments:

sediments + CO_2 => weathered clays + HCO_3^- + metal cations

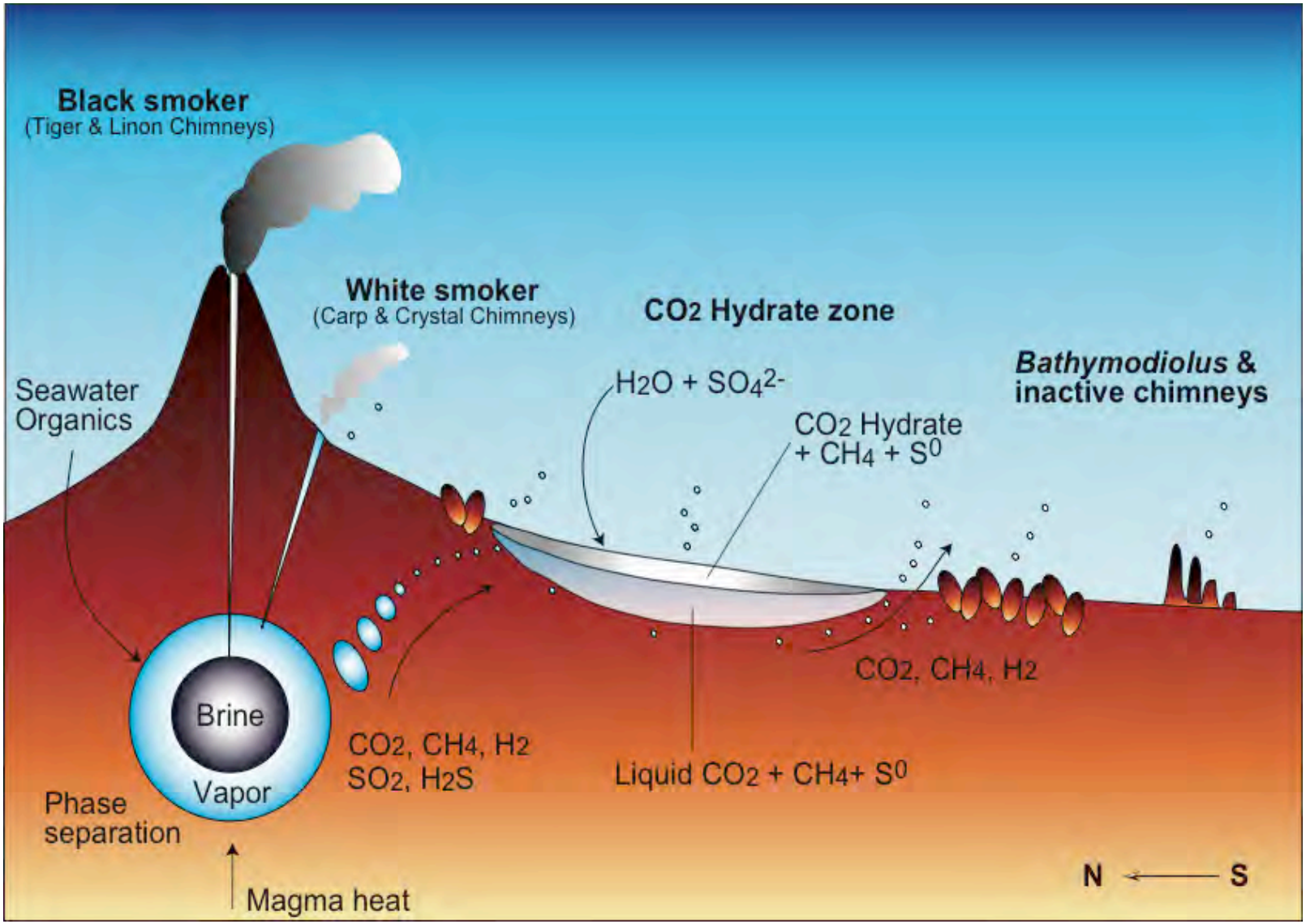
Wallmann et al. (2008)

CO2 vents as natural analogues for CO2 leakage from deep subseafloor sequestration



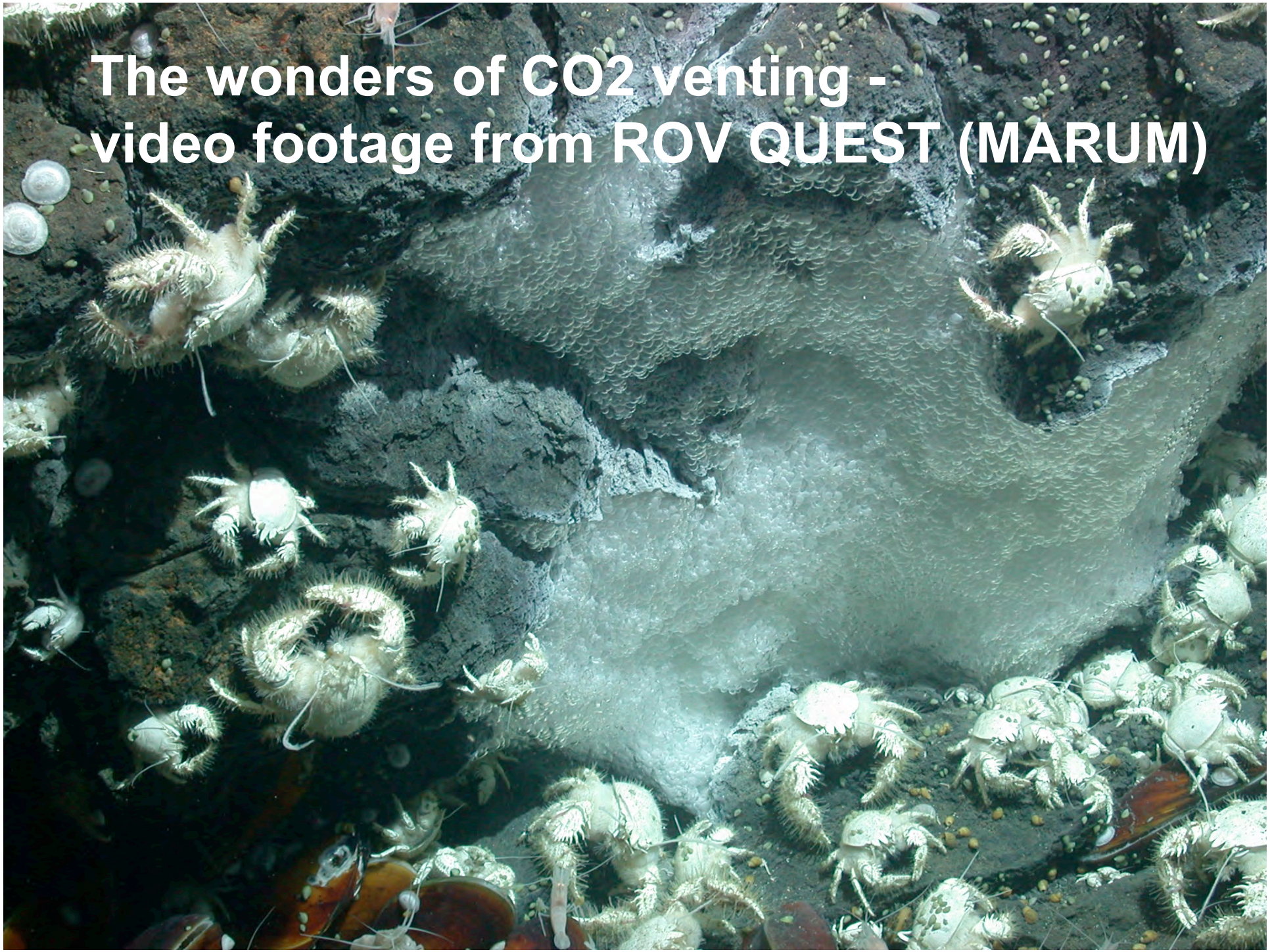
RV SONNE 169 expedition SUMSUN, March 2008; G. Rehder IOW

Liquid CO2 and hydrate system at the Yonaguni Knoll hydrothermal field, southern Okinawa Trough

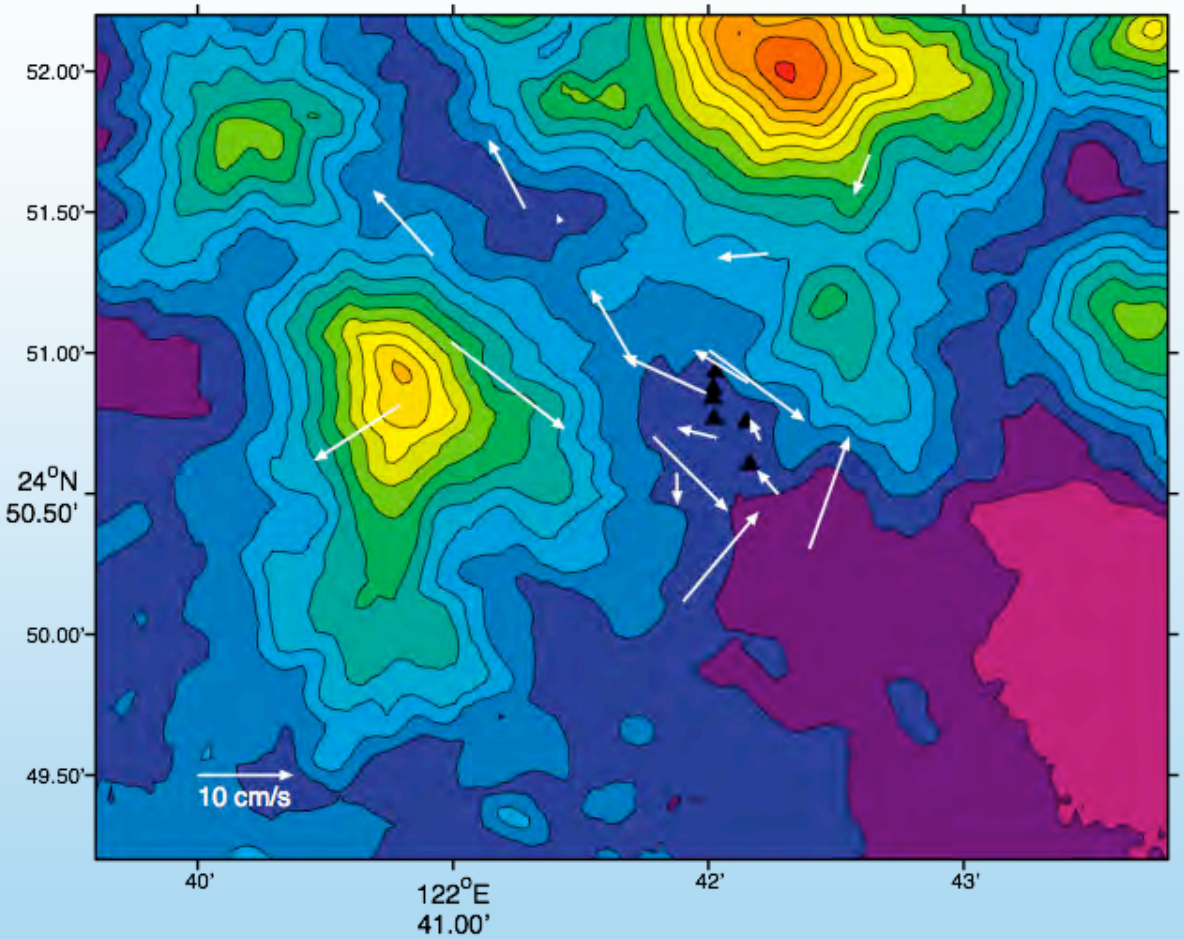


Inagaki et al. 2006 PNAS

The wonders of CO2 venting - video footage from ROV QUEST (MARUM)



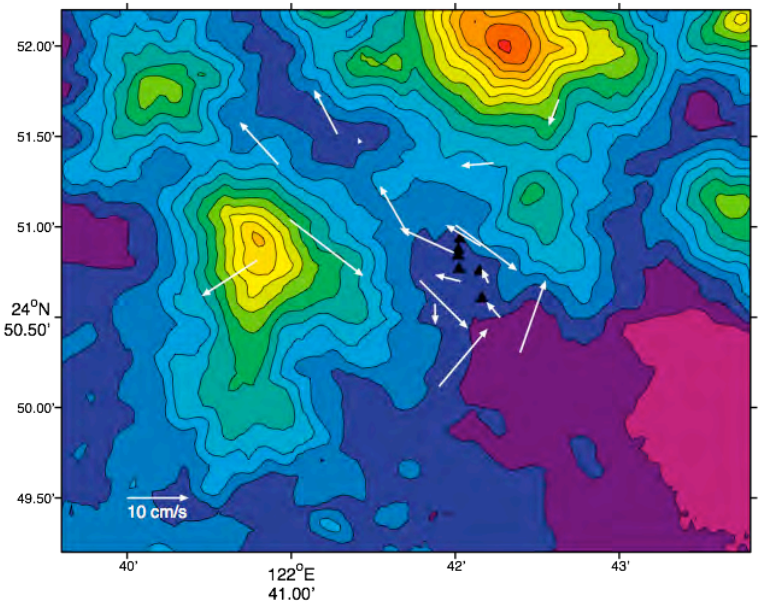
Bottom currents at Yonaguni Knoll

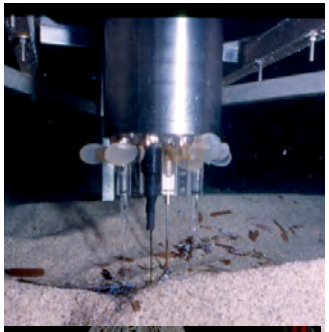


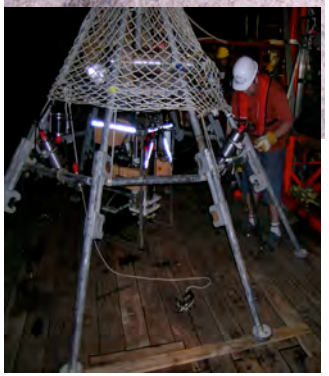
Mean currents in the lower 100 m of the water column follow the topography and reverse with the tides, washing the basin with high CO2 water

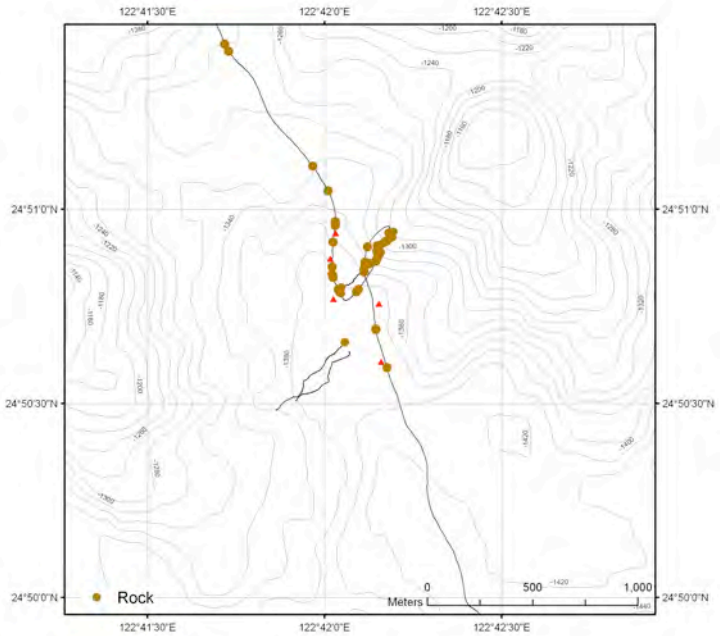
C. Mertens, M. Rhein Univ. Bremen

TV- Multicorer-Microsensor Profiler Transect





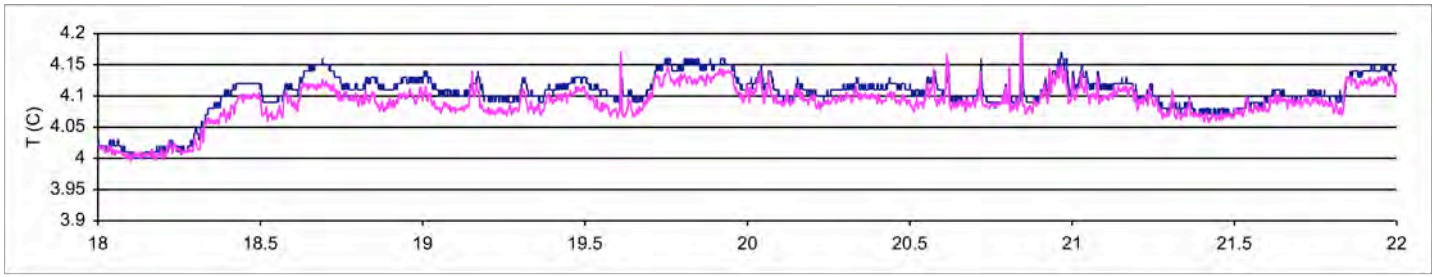




2 sensor packages — 1.5 m a.b. — 2.5 m a.b.

Temperature

4-4.2°C

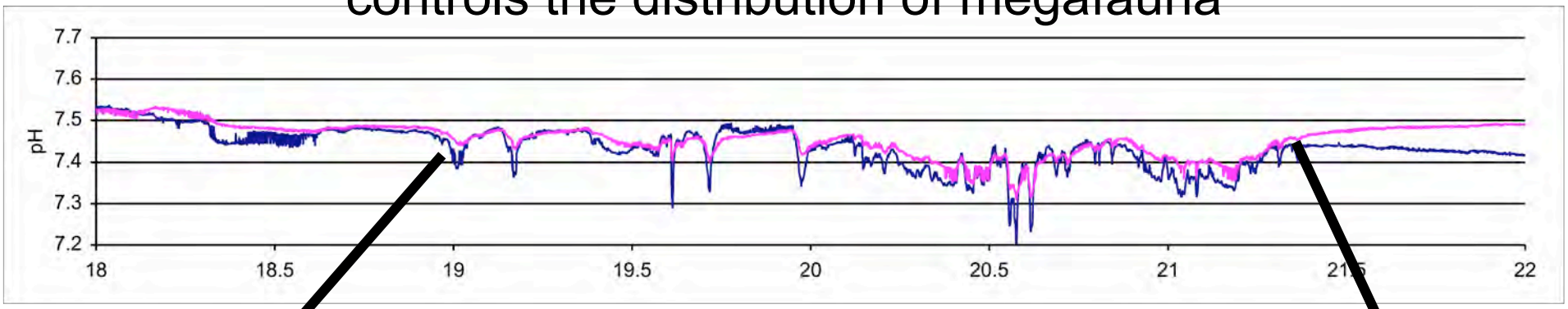


South

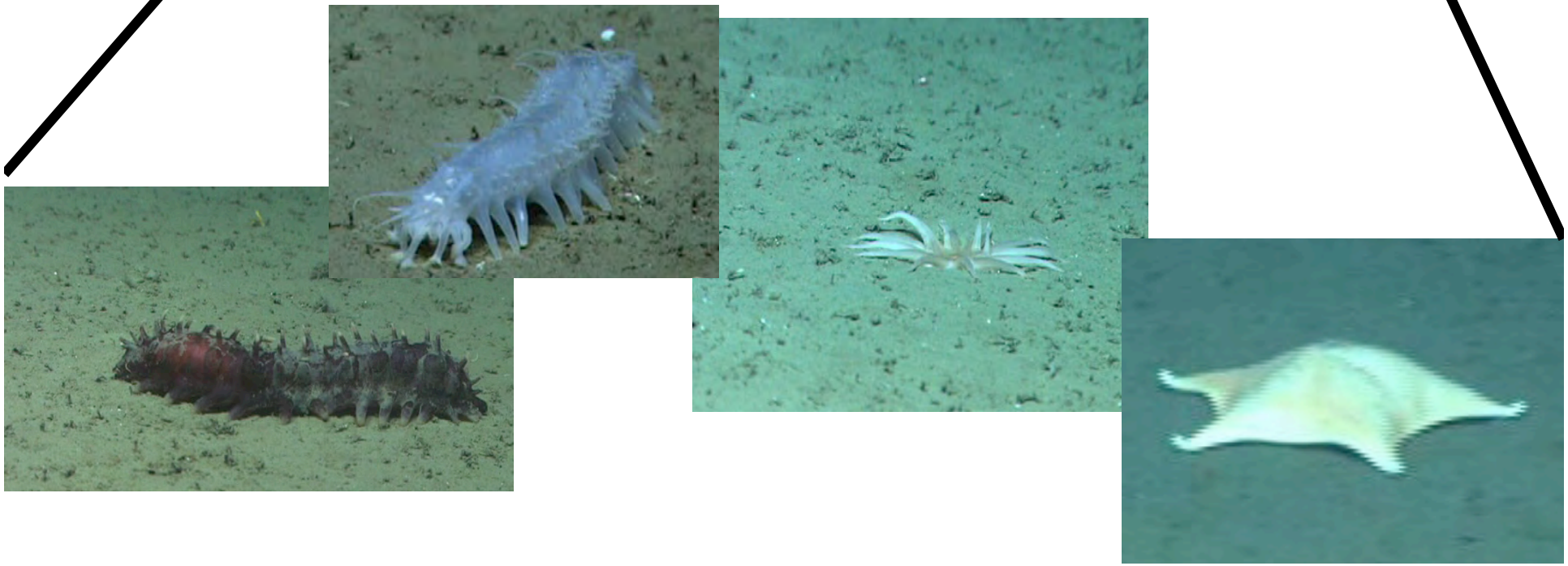
North

DeBeer, Boetius unpublished data

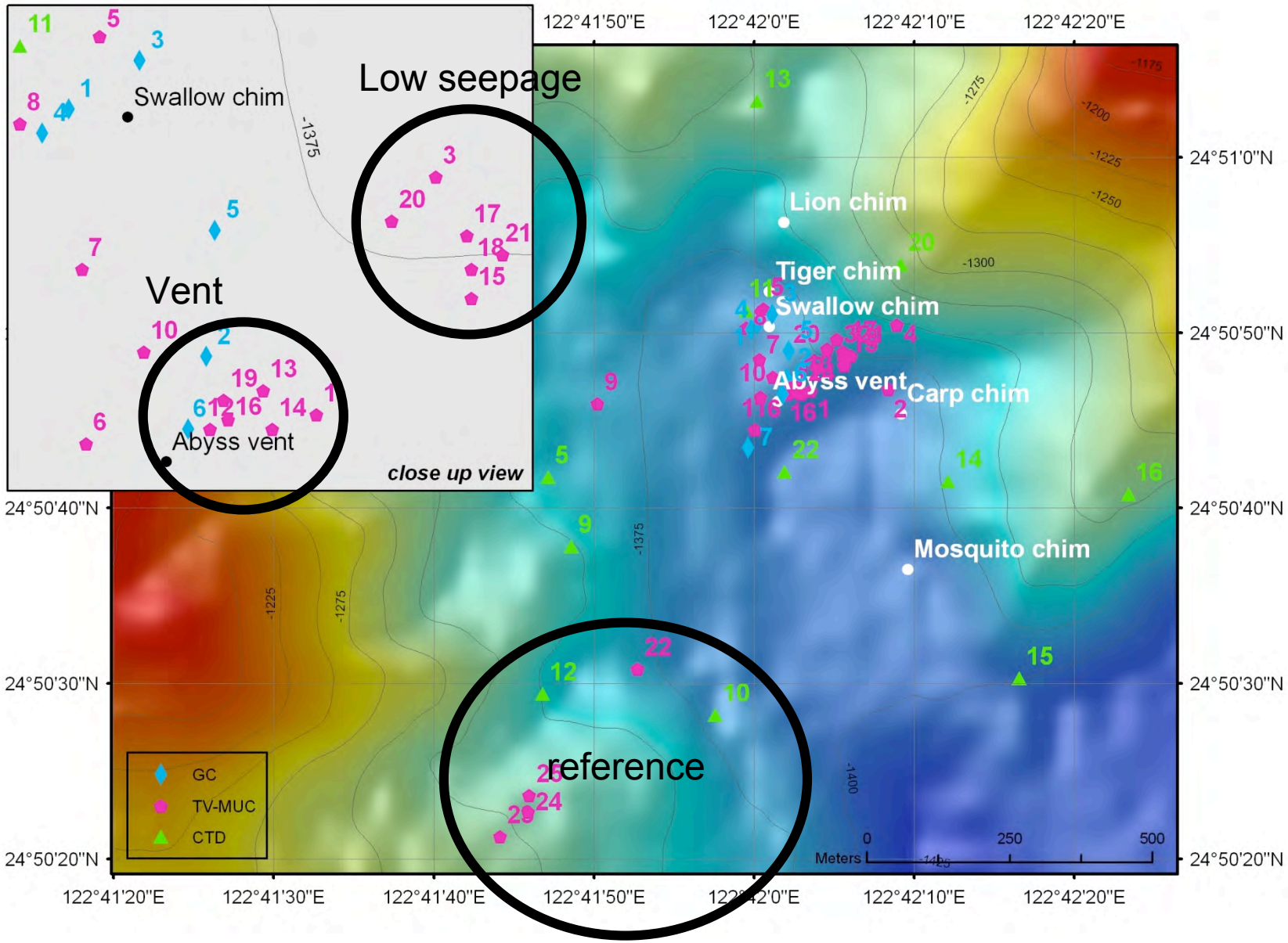
Low pH (Δ -0.1) /high CO2 (Δ +30 μM) controls the distribution of megafauna



†



Benthic sampling

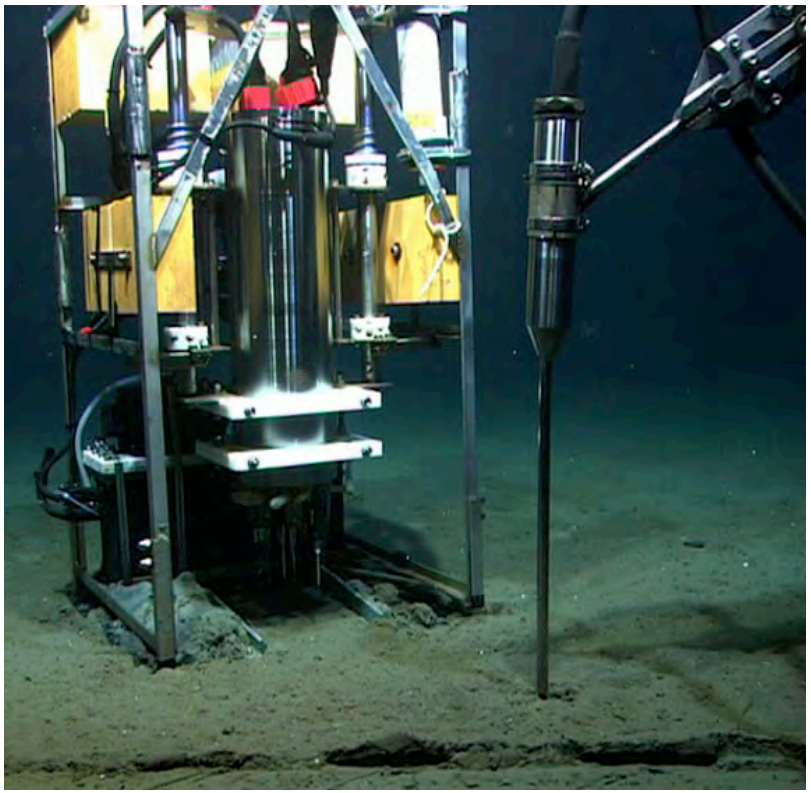


Observations from sieving macrofauna in the CO_2 vent field:

- lack of diversity, no benthic foraminifera/echinoderms

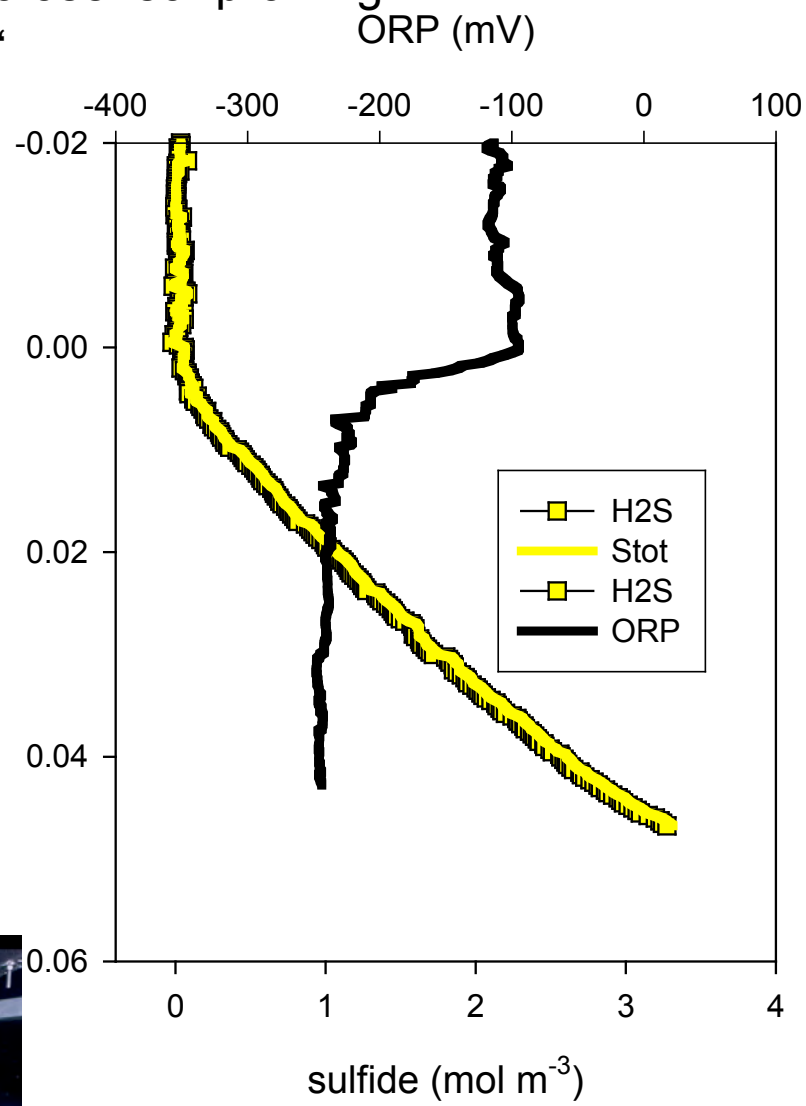
- highly patchy, low diversity „pioneer“ communities (including bivalves and some polychaetes)

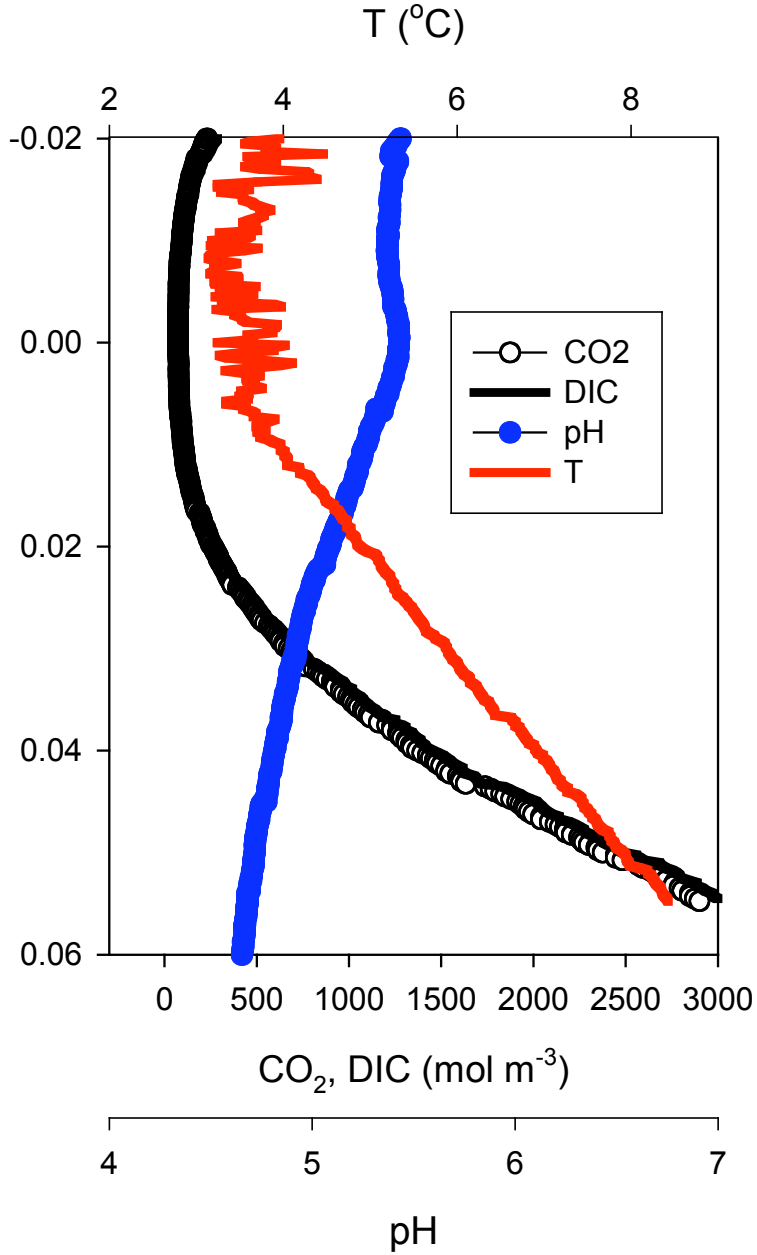
Reference



Low seepage

In situ microsensor profiling
‚Vent site‘

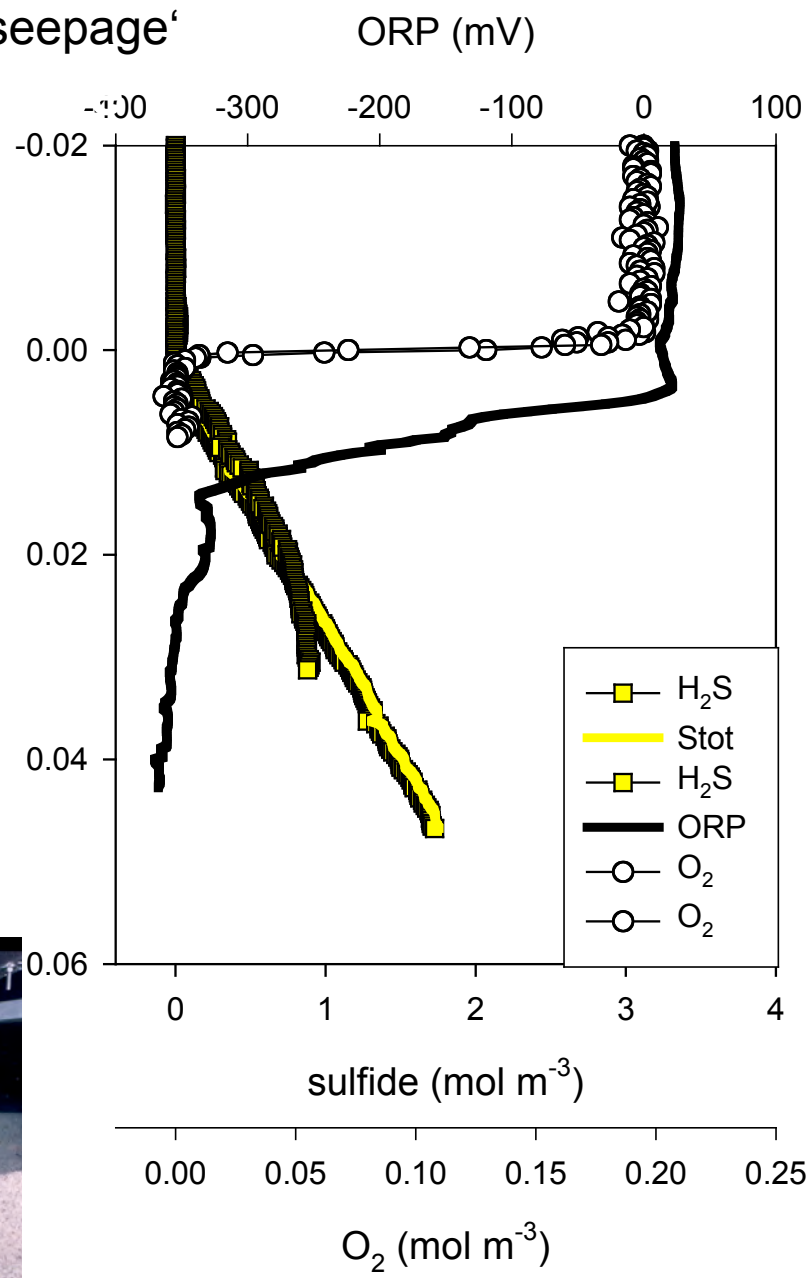


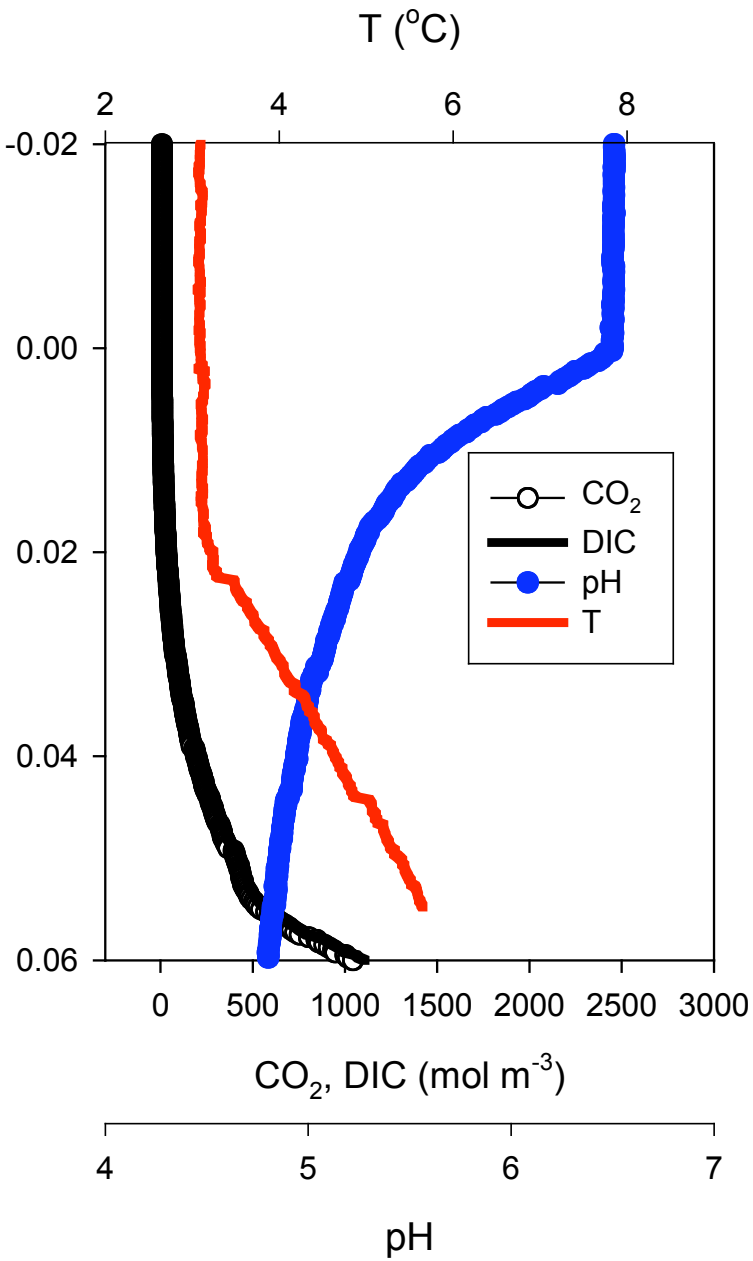


DeBeer, unpublished data

In situ microsensor profiling

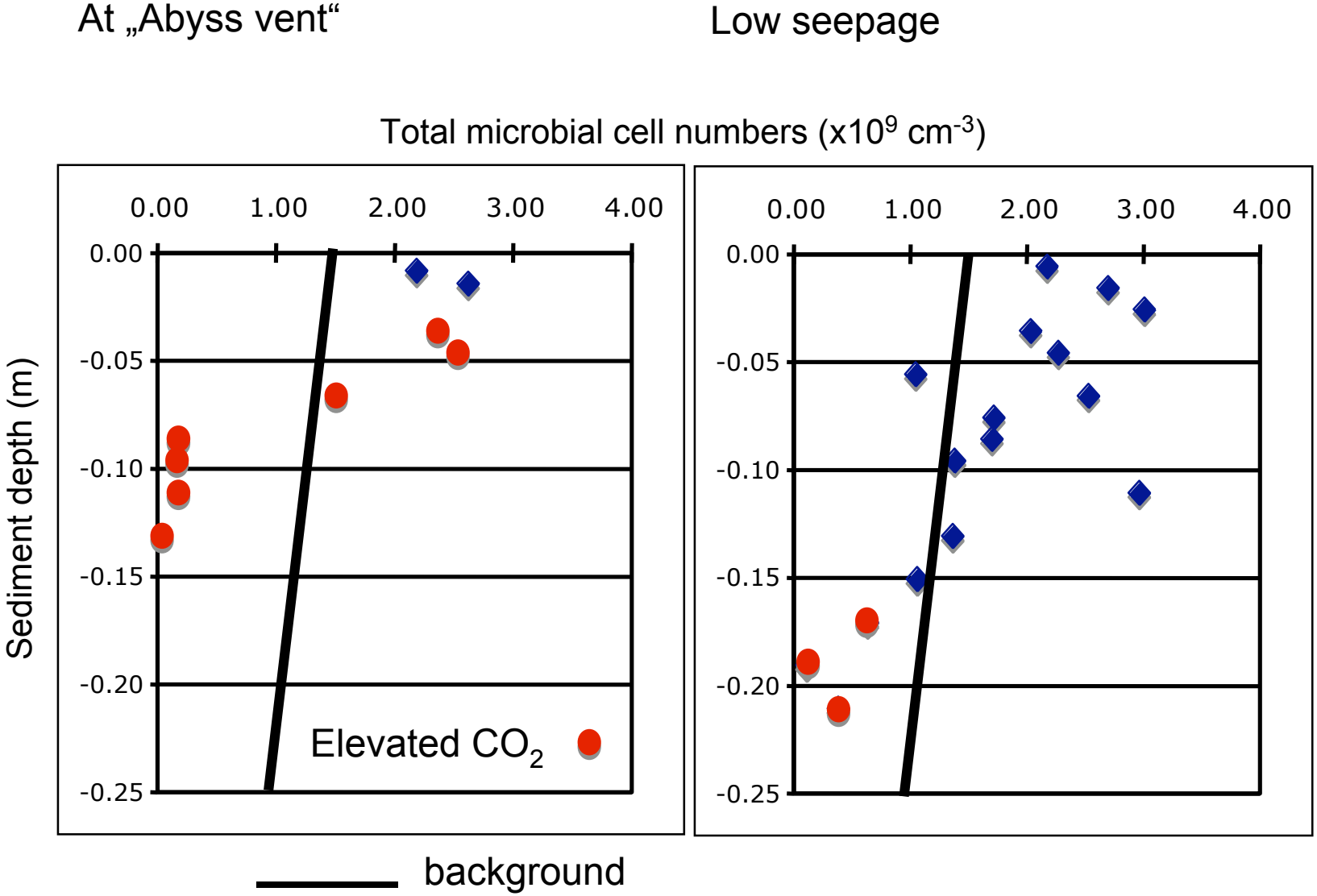
‚low seepage‘



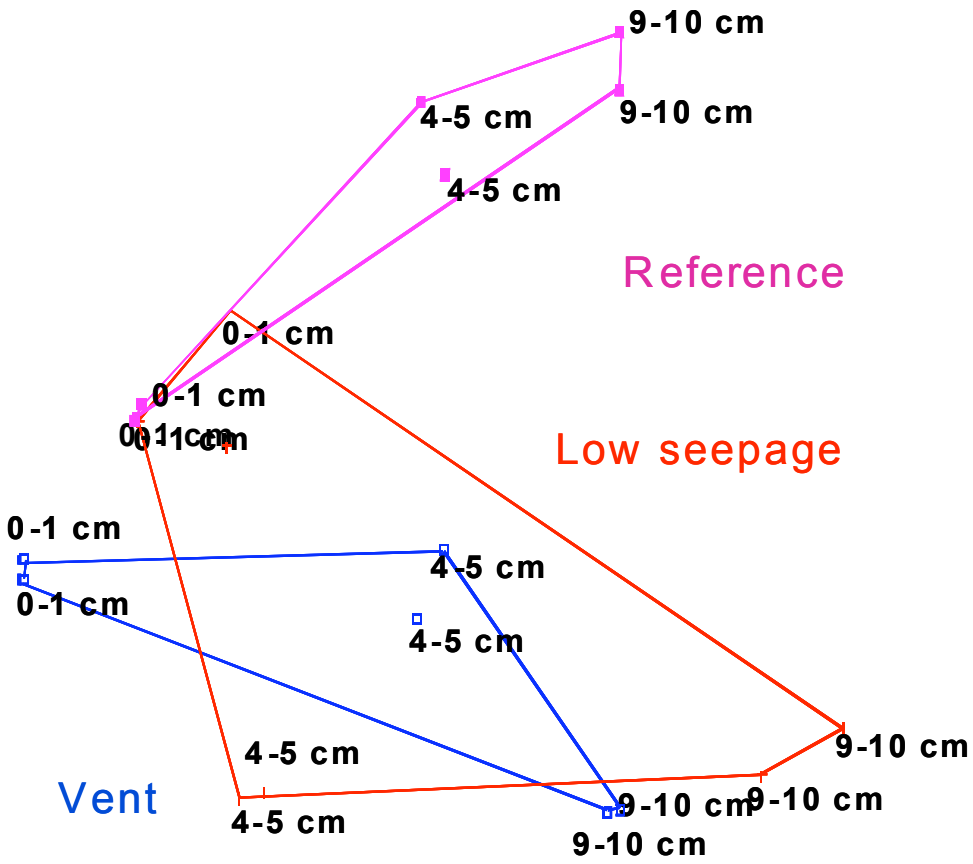


DeBeer, unpublished data

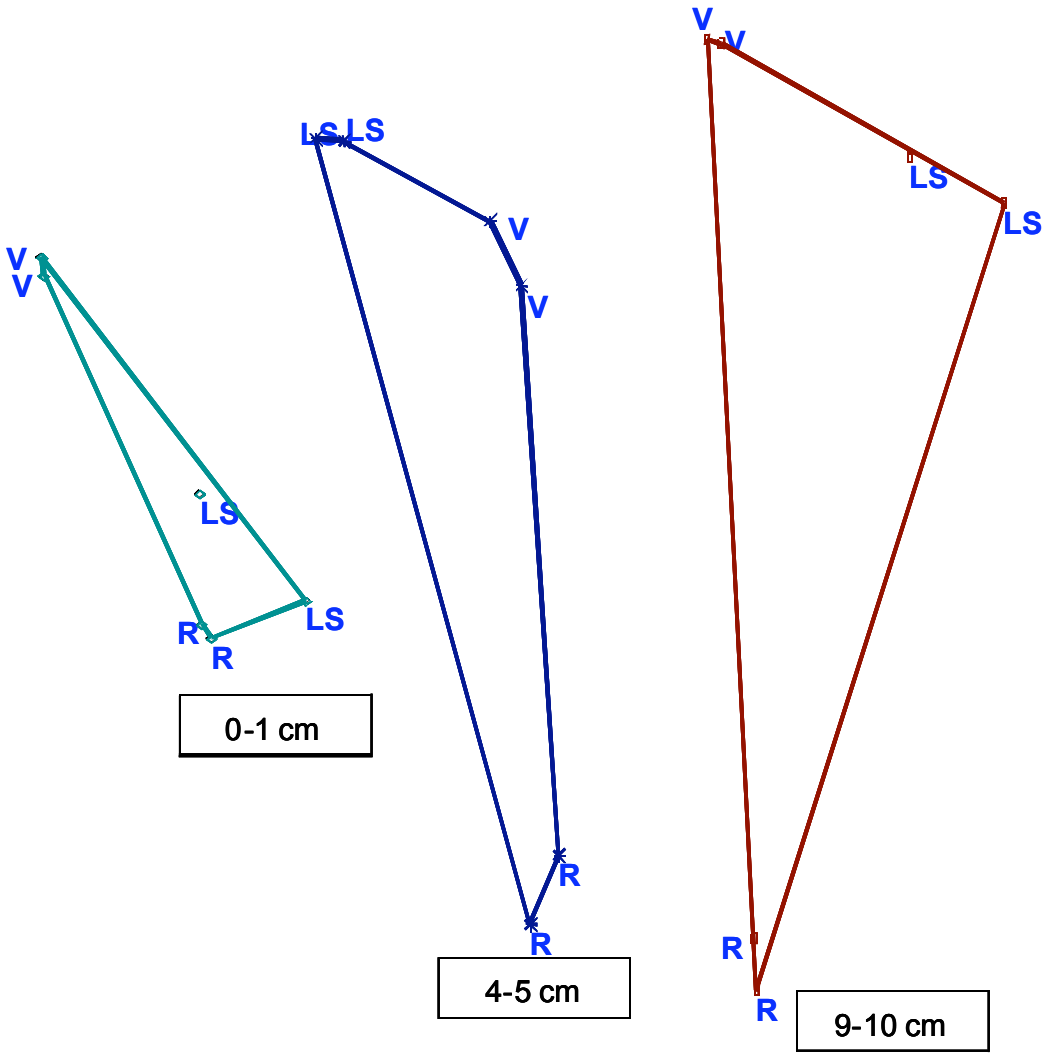
Effect of CO_2 leakage on total microbial cell numbers



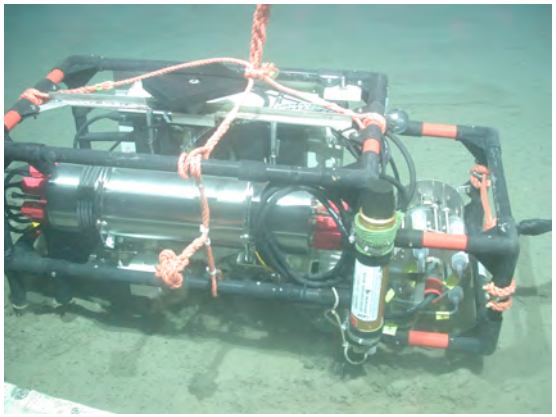
Similarity analyses of bacterial community structure at Yonaguni Knoll (T-RFLP)



Similarity analyses of bacterial communities at Yonaguni Knoll (T-RFLP)

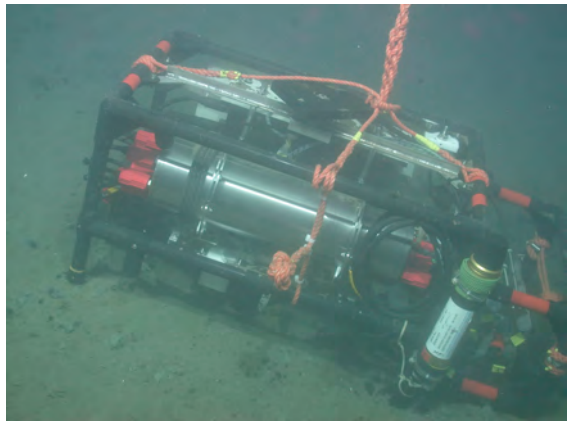


reference



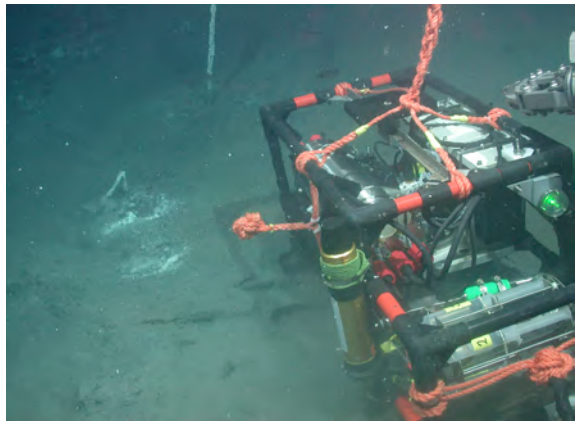
Background respiration rate: 1mM O_2 m^{-2} d^{-1}

low seepage



Low heat flux, low CO2/SiO4 flux, elevated respiration rate (8 mM O_2 m^{-2} d^{-1})

abyss vent



Heat flux, CO2+CH4 efflux, silicate efflux, low respiration rate (7 mM O_2 m^{-2} d^{-1})

But: normal respiration rates at methane seeps: 100 mM O_2 m^{-2} d^{-1} (Boetius, Wenzhöfer et al. Unpublished data)

Conclusions:

CO_2 leakage strongly controls the distribution and composition of benthic communities.

Many organisms - especially members of the Echinoderms and Polychaetes - are absent from high CO_2 environments

Some organisms, especially typical vent-associated symbiotic animals, can adapt to high CO_2 levels

Microbial communities and their functions are highly impacted

Natural CO_2 vent systems are interesting exploratories for research on the effects of CO_2 disposal and in general, for CO_2 effects

SO 196 *S U M S U N*

Thanks to scientific crew and ship‘s crew of SUMSUN (SONNE196)!