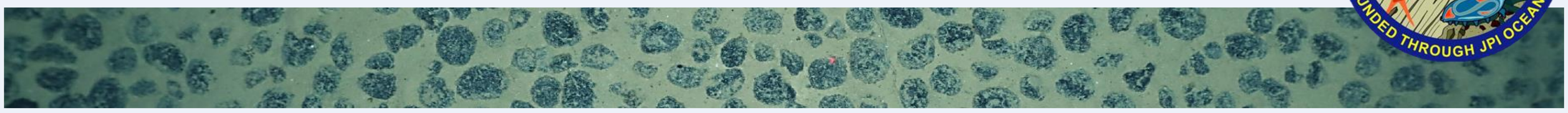
Microbial and viral communities of the deep seafloor sediment and manganese nodules from the CCZ, Pacific

J. M. OTTE[1,2,3], M. MOLARI[1,3], B. C. YAPAN[1,3], J. B. VOLZ[2], Y. BODUR[1,3], F. JANSSEN[1,2,3], F. WENZHÖFER[1,2,3]

[1]HGF MPG Group on Deep Sea Ecology and Technology; [2] Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research, Germany; [3] Max-Planck-Institute for Marine Microbiology, Germany



Background & Summary

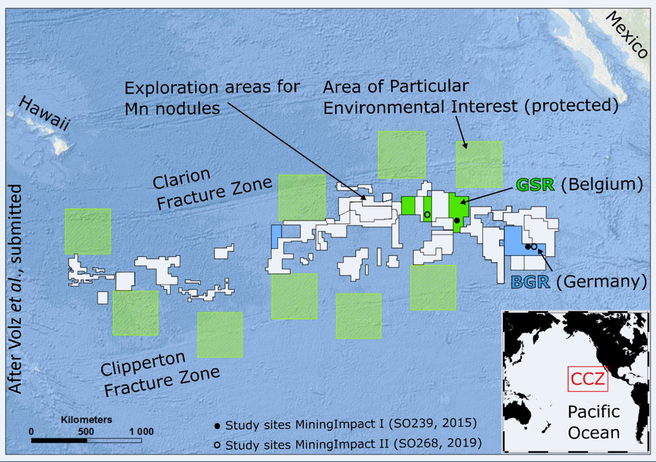
- Manganese (Mn) nodules contain Ni, Co, Cu, Mn, Fe, and **rare earth elements**.
- The environmental **impacts of large-scale deep-sea nodule mining** are currently unknown.
- In Feb.-May 2019 (RV SONNE cruise SO268, *Mining Impact II*) the Belgian & German licence area in the Clarion-Clipperton Zone (CCZ; **Eastern Pacific**) were studied to obtain **baseline characteristics of the > 4000 m deep habitat**.
- Research aspects: i) characterization of the distinct **present & active microbial and viral communities** of bottom water (> 4000 m deep), (< 5 m deep) seafloor sediment, and Mn nodules, ii) diversity and distribution of **potential deep-sea cable bacteria** and metal-cycling microorganisms, iii) **enrichment** of Mn-/Fe-cycling bacteria, iv) investigation of deep-sea **microbial metabolisms** by metagenomic/-transcriptomic, v) quantification of microbial **extracellular enzyme activity & cell number**, and vi) analysis of **(bio-/)geochemistry**
- In summary, the potential consequences associated with removal of Mn nodules and resuspension of sediments during mining could help to **evaluate the environmental risks**.

Main Goals

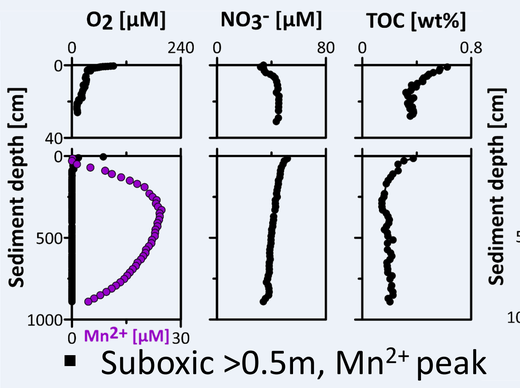
- To quantify **microbial & viral community composition** by Illumina 16S rRNA sequencing (RNA & DNA based) from ≤ 100 Mn nodules and eight 5 m long gravity cores from the CCZ.
- To follow the **distribution**, quantify the **abundance**, detect the **diversity** and **activity** of relevant metal-cycling microorganisms, and as well of potential deep seafloor cable bacteria.
- To enrich **potential Mn- and Fe-cycling** microorganisms from "live" sediment & "live" Mn nodules under (an)oxic conditions.
- To evaluate **microbial activity** by extracellular enzyme activity.
- To investigate **microbial metabolism** of potential Mn- and Fe-cycling microbes by metagenomics /metatranscriptomics.
- To compare metal-cycler of different locations (a) Mn nodule areas (CCZ/DISCOL), (b) massive sulfide deposit (Indian Ocean).

Field Sites – Clarion-Clipperton Fracture Zone (Eastern Pacific Ocean)

Sampling locations of cruises SO239 & SO268

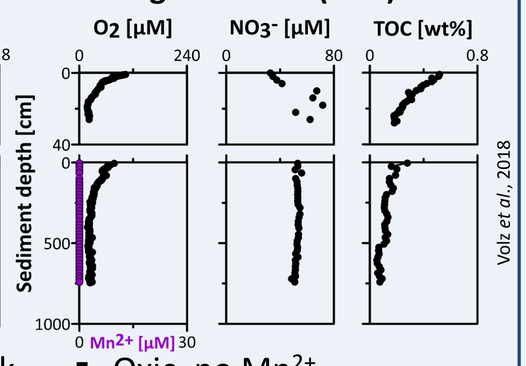


German Claim (BGR) 🟦



- Suboxic >0.5m, Mn^{2+} peak
- POC flux: 2 mg m^{-2} d^{-1}
- NO_3^- reduction

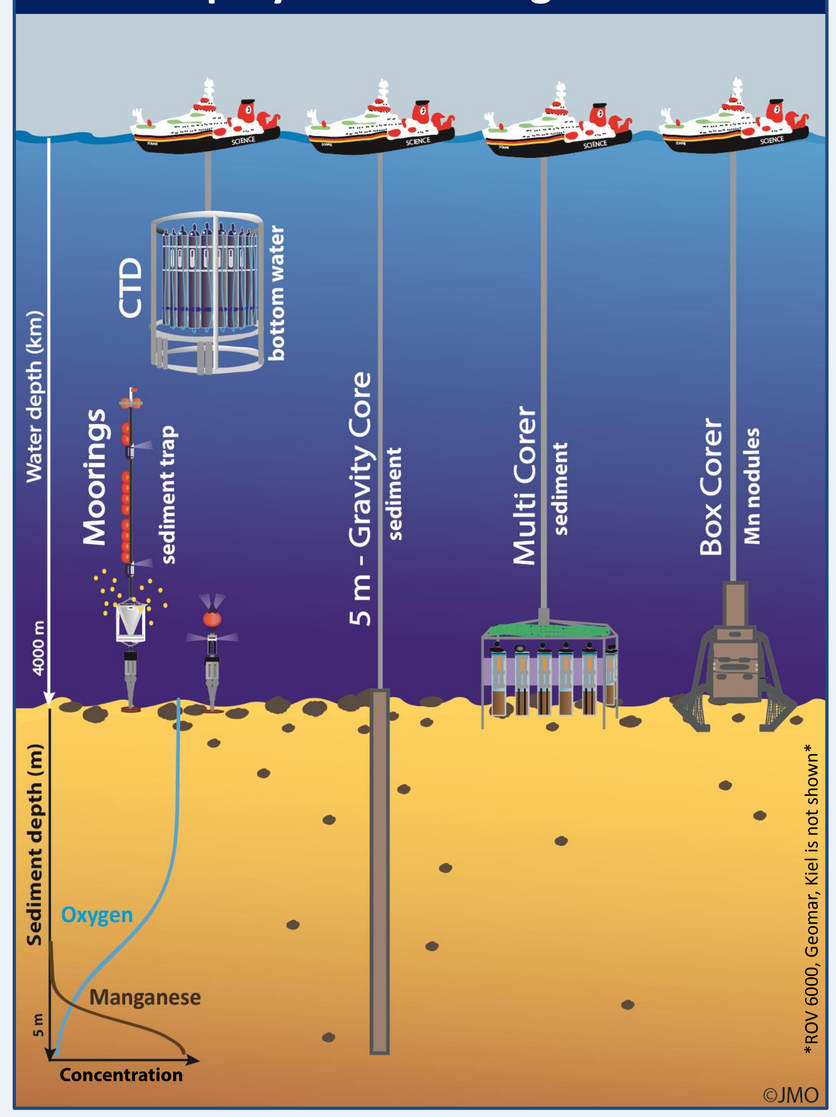
Belgium Claim (GSR) 🟩



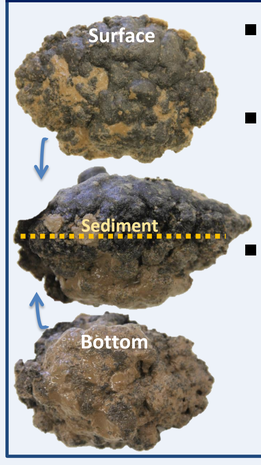
- Oxic, no Mn^{2+}
- POC flux: 1.5 mg m^{-2} d^{-1}
- Constant NO_3^-

Volz *et al.*, 2018

Deployments during SO268

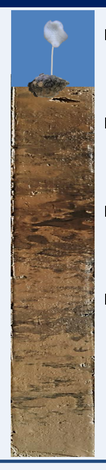


Manganese (Mn) Nodules



- ≤ 100 Mn nodules from BGR & GSR and different depth (~0.5 cm)
- Differences in volume (17 - 640 cm^3), weight (30 - 960 g), shape (round or elliptical), porosity, attached fauna
- Subsamples from on top of the nodule surface (a), bottom side (b), inside of the nodule core (c), 3 samples per nodule for DNA & RNA extraction; enzyme activity tests; cell counts

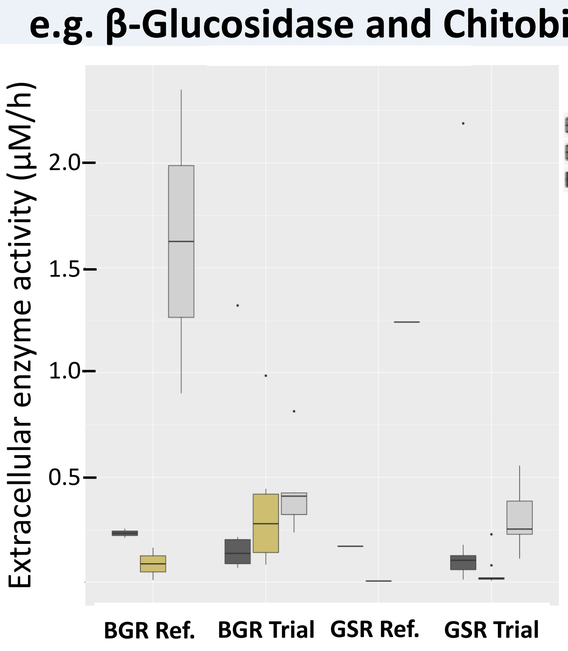
Gravity Core Sediment



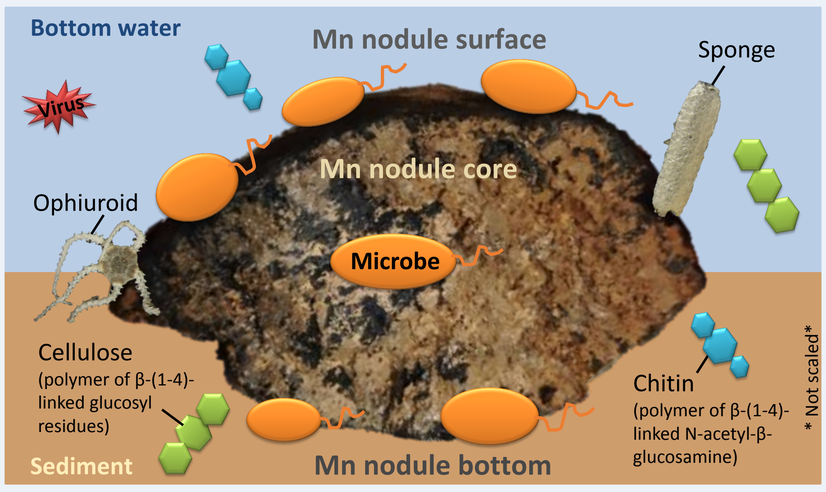
- 5 m long gravity cores (GC) from eight different locations of the CCZ
- Differences in O_2 penetration depth (around 2-3.5 m; oxic and suboxic layers)
- 8 to 27 samples per GC core, taken at 0-5 m depth; stored at -20°C and -80°C
- Preliminary enzyme activity results of an oxic GC (GSR) from a carst region: Aminopeptidase activity until 40 ± 5 cm depth⟶ detectable active C_{org} degradation

Preliminary Results – Microbial Activity of Manganese Nodules

e.g. β-Glucosidase and Chitobiase



- **Activity: surface layer > bottom layer**
- Highest activity on nodule surface of BGR Ref.: > 1.6 µM/h; nodule core: 0.3 µM/h
- **Activity: deep-sea sediment > Mn nodule**



- ➢ High **unexpected activity in & on Mn nodules**!
  - β-Glucosidase: degradation of oligosaccharides
  - Chitobiase: degradation of chitin
- ➢ Micro-habitat of Mn nodules may be a potential **major location of microbial C_{org} degradation**
- ➢ Implication: what happens after mining operations when Mn nodules are removed?
- ➢ Open question: who are the active players which are responsible for C_{org} degradation in &on nodules?

Working on board during SO268

Thanks to HGF Group Bremen and Bremerhaven; Crew and Scientists of SO268; Special thanks to Jakob Barz (help in the lab) and Dr. Katja Laufer, Geomar (ideas & discussions)