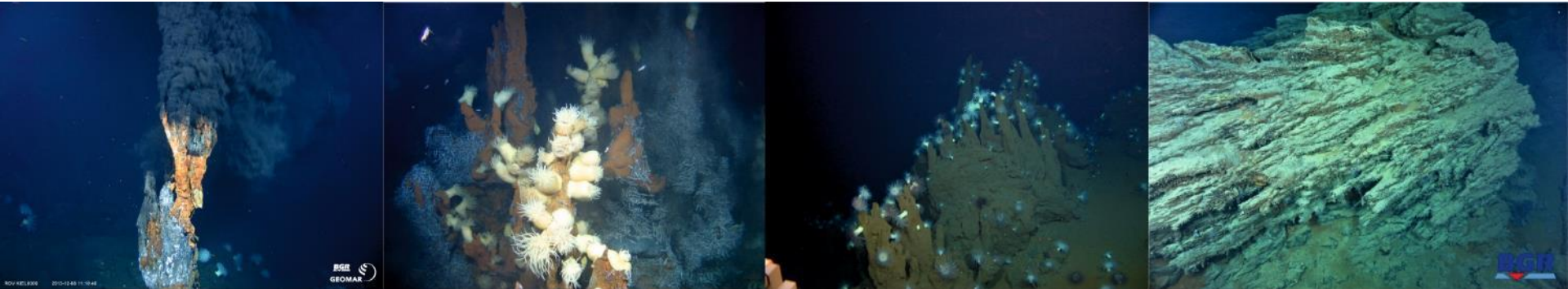




# Current Status of the Polymetallic Sulfide Exploration and Environmental Investigations in the Western Indian Ocean

U. Schwarz-Schampera, R. Freitag, C. Kriete & INDEX-Team

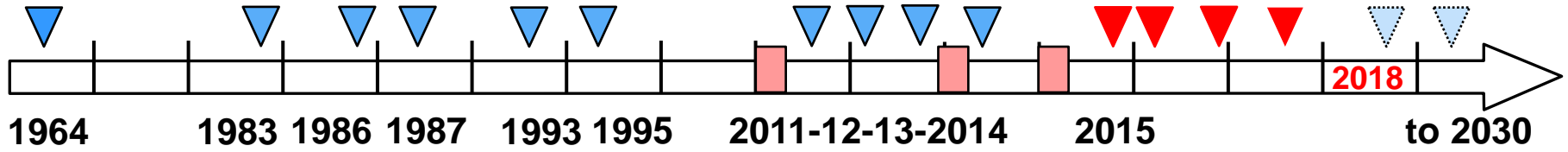


Bundesanstalt für  
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und Rohstoffe

GEOZENTRUM HANNOVER

# Exploration of Polymetallic Seafloor Massive Sulfides (SMS)

Exploration License in the Regulatory Framework of the International Seabed Authority



1st German research cruise to western Indian Ocean (IIOE)

GEMINO, HYDROTRUNC, HYDROCK research cruises to the CIR SO28, SO43, SO52, SO92, M33/2

Prospecting INDEX cruises CIR, SEIR

2015 Start of Exploration

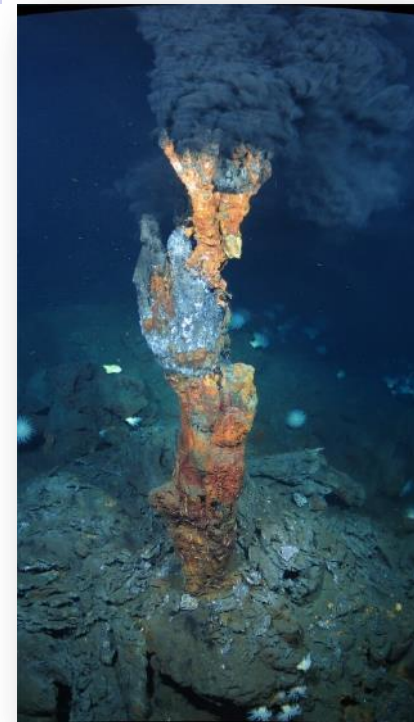
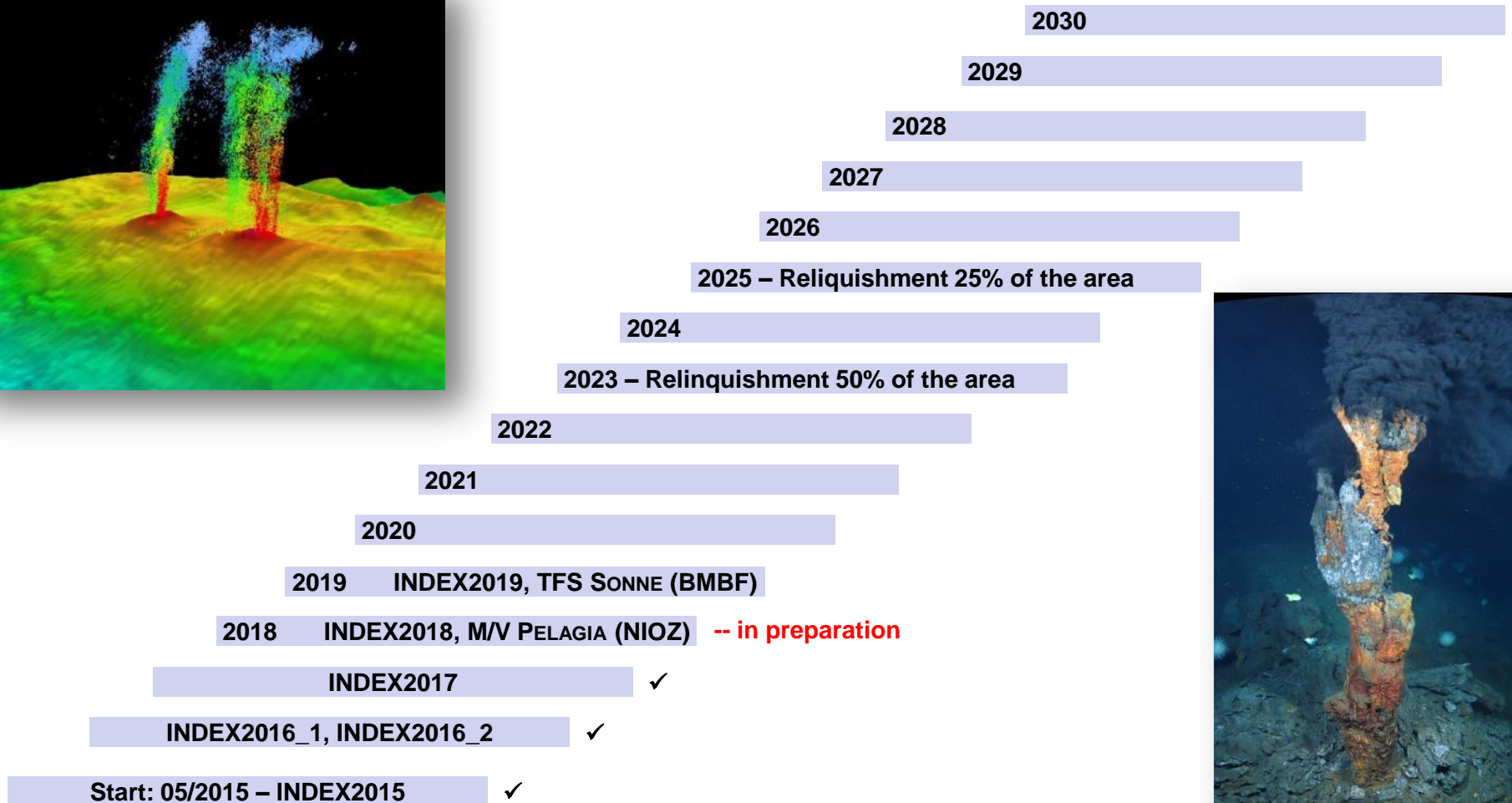
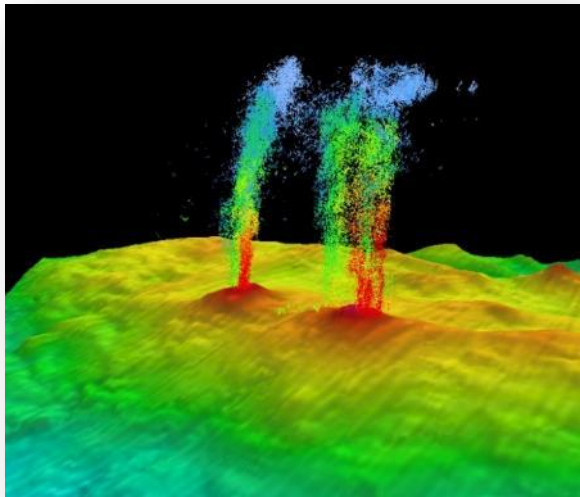


## INDEX Indian Ocean Exploration



# Exploration of Polymetallic Seafloor Massive Sulfides (SMS)

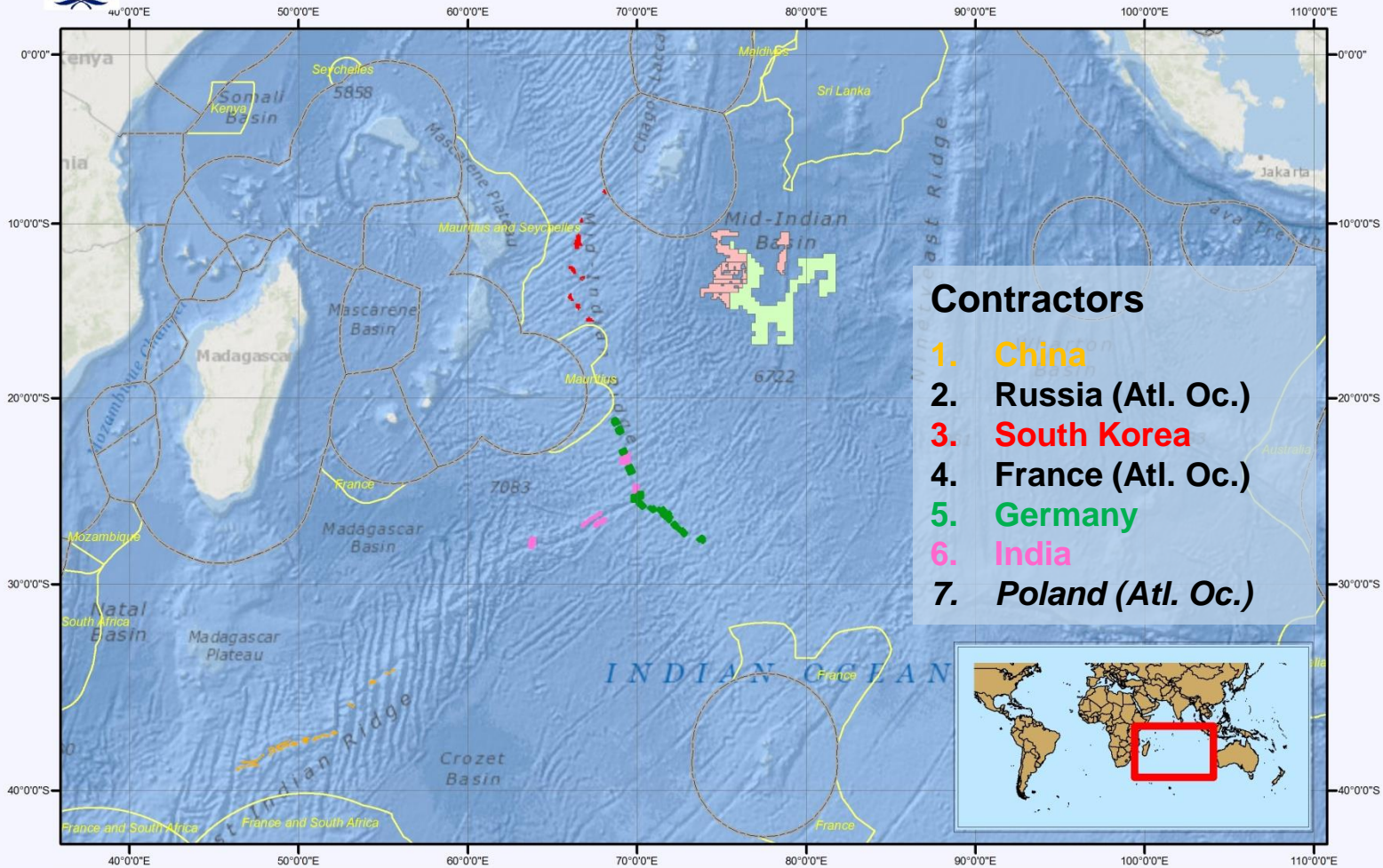
## Time Line and Activities





# Polymetallic Nodules and Polymetallic Sulphides Exploration Areas in the Indian Ocean

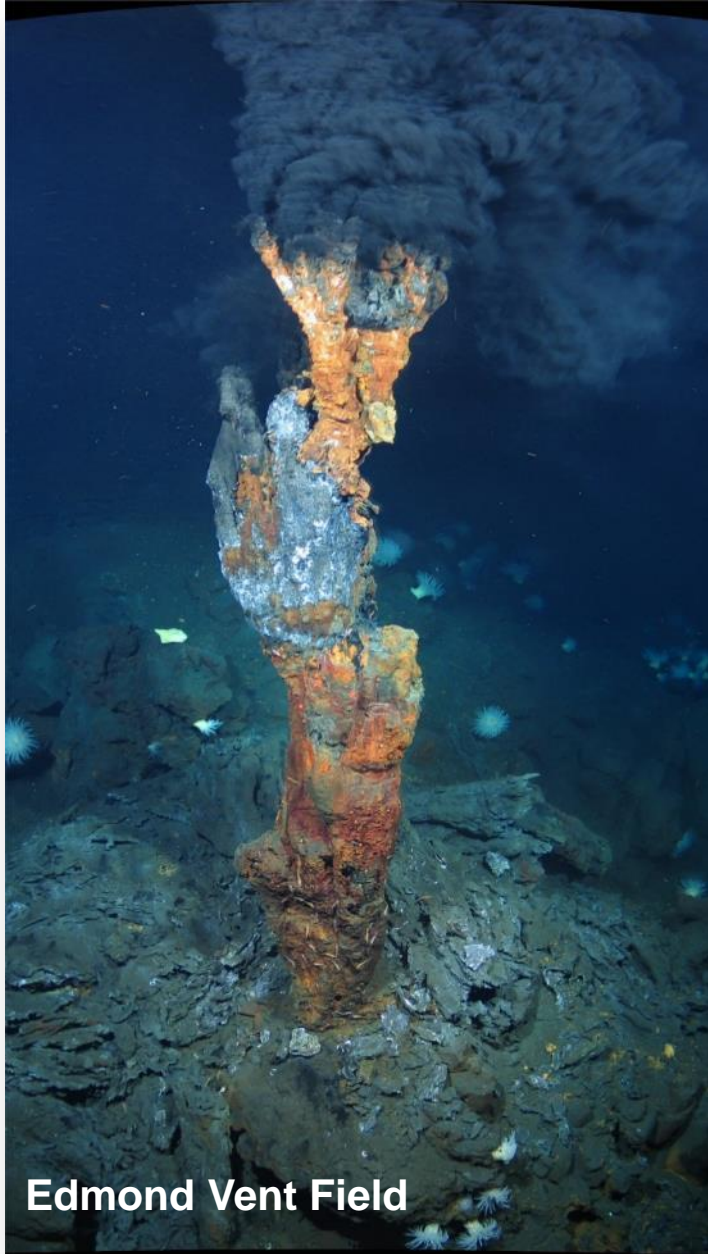
Approved plans of work and areas reserved for the International Seabed Authority



- ### Contractors
1. **China**
  2. **Russia (Atl. Oc.)**
  3. **South Korea**
  4. **France (Atl. Oc.)**
  5. **Germany**
  6. **India**
  7. **Poland (Atl. Oc.)**

India - polymetallic sulphides exploration area	India - polymetallic nodules exploration area	Exclusive Economic Zones
BGR (Germany) - polymetallic sulphides exploration area	Area reserved for the Authority	ECS Submissions
COMRA (China) - polymetallic sulphides exploration area		
Republic of Korea - polymetallic sulphides exploration area		

©International Seabed Authority, 25 July 2014. Background map: ESRI

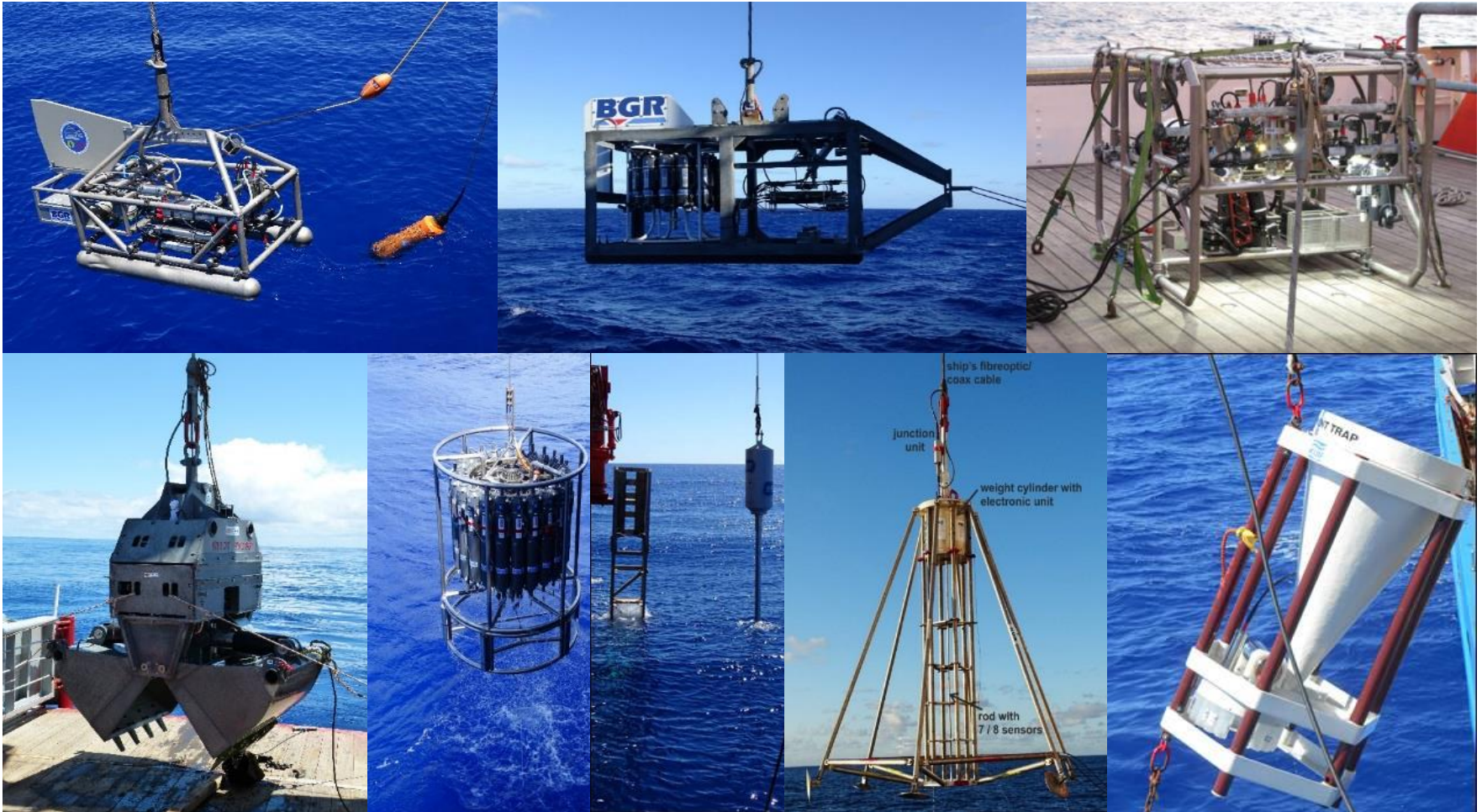


Edmond Vent Field

## INDEX - Project Objectives

- Exploration target: Inactive SMS
- Locations, Dimensions and Metal Concentrations
- Identification of Economically Feasible Deposits ( $\geq 2,5$  Mio. t)
- Environment: Biodiversity, Habitat Analysis, Mass Transfer, Water Column, Bottom Currents
- Conceptual Development of Mining Techniques
- Optimized Metallurgical Process

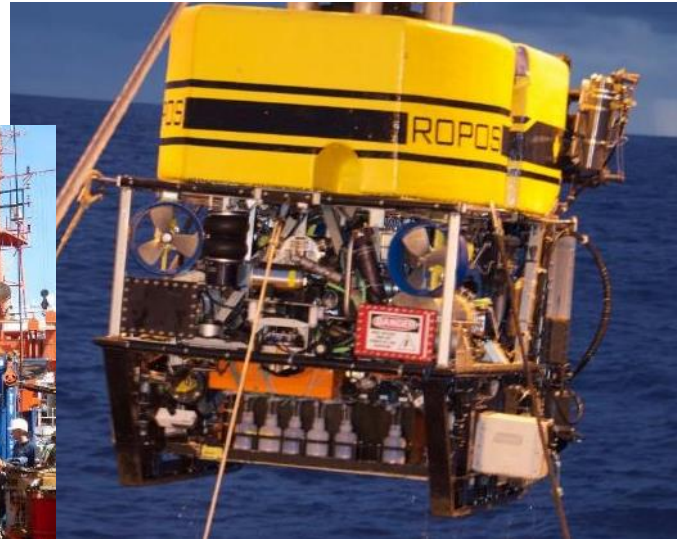
# INDEX – Tools and Methods 1



## INDEX – Tools and Methods 2



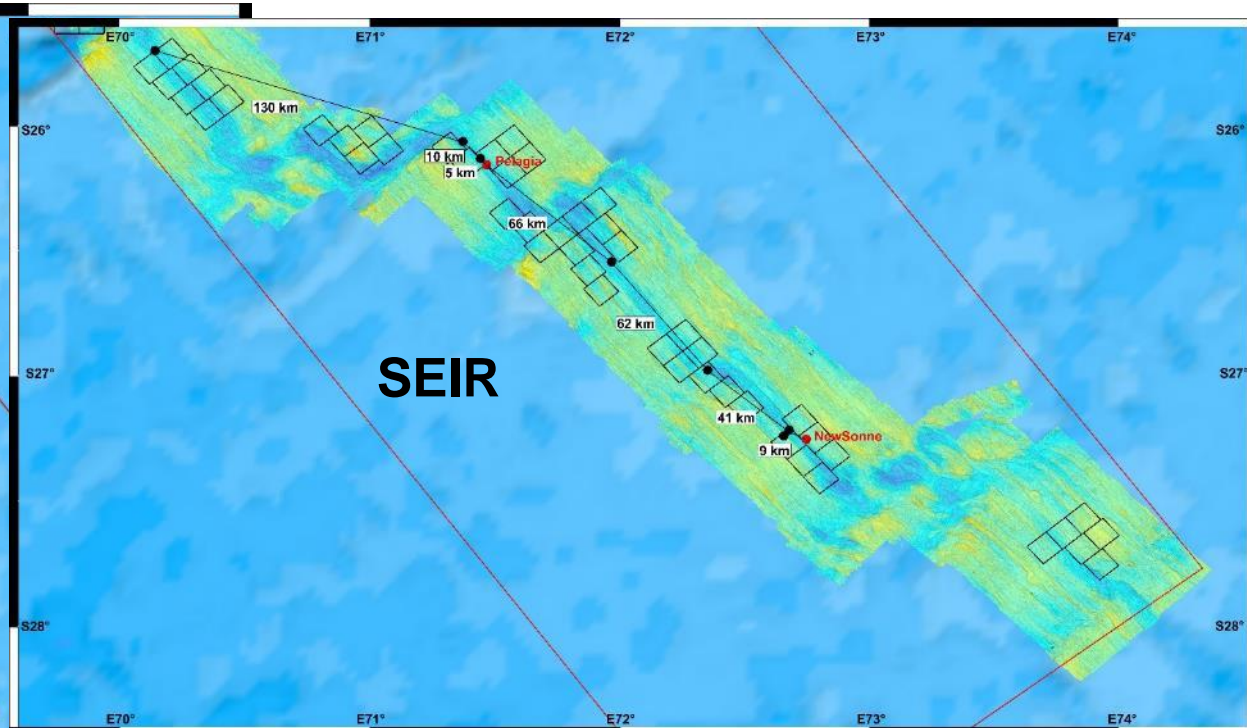
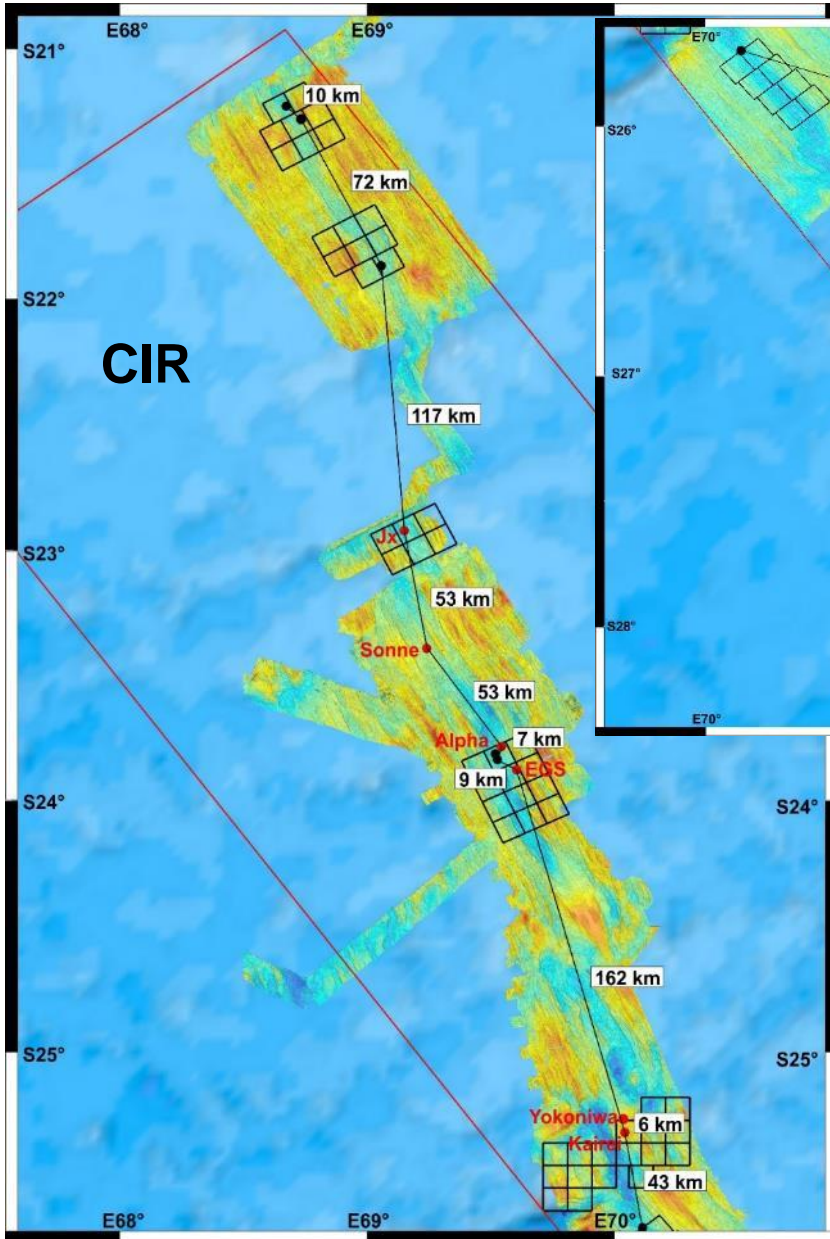
2013 - KIEL 6000 (Germany)



2015 – ROPOS (Canada)



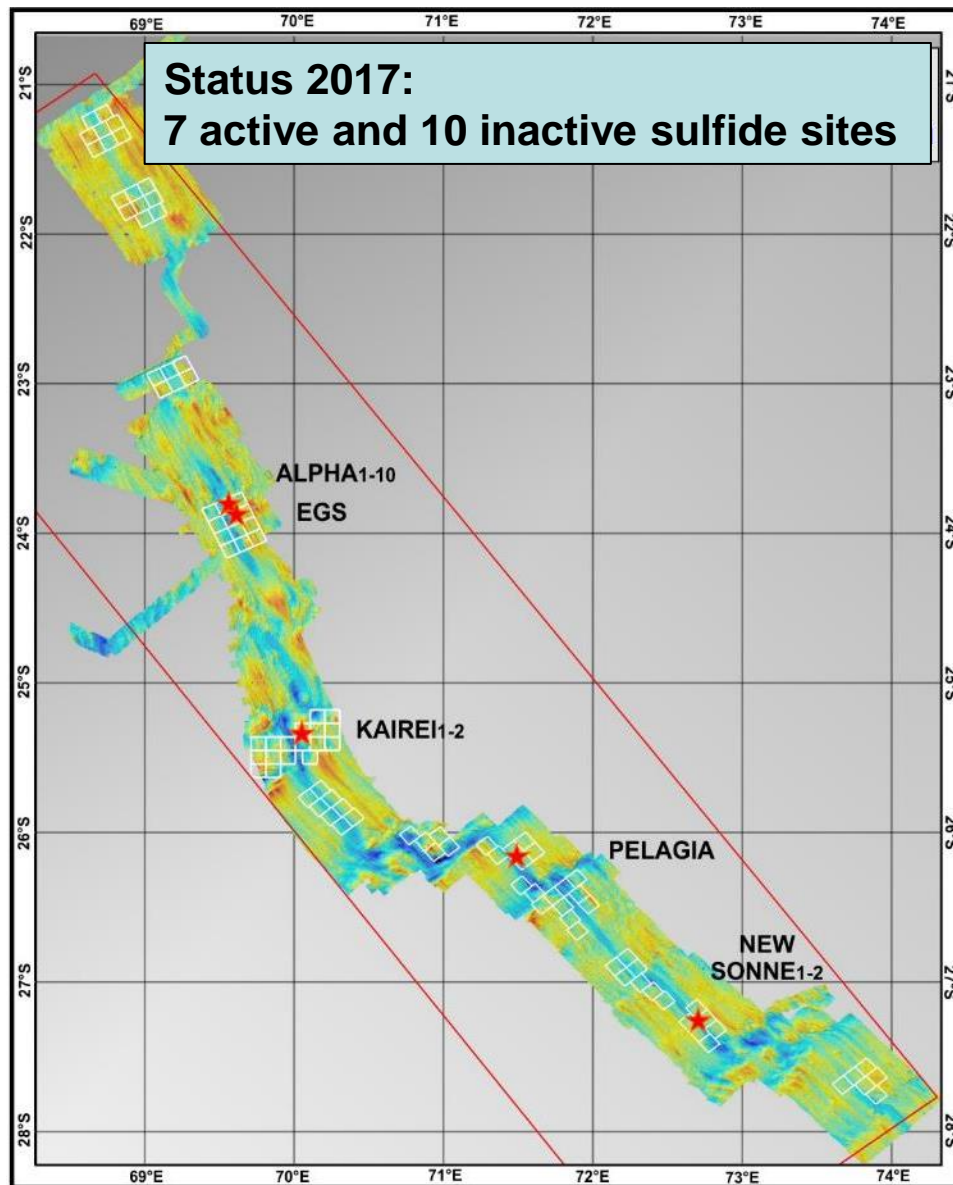
2016 – VICTOR 6000 (France)



- CIR: 6 sulphide sites, active vents and inactive fields, 5 plumes
  - overall average spacing (sites and plumes): 54 km
  - sulphide site spacing: 57 km
  
- SEIR: 2 active vent fields
  - overall average spacing (sites and plumes): 46 km
  - distance sulphide sites: 176 km
  
- CIR & SEIR: Spacing of all sulphide sites: 90 km
  - Including the identified plumes: 50 km

## Vents and Sulphide Spacing





## 1D-estimation of vent number

Total length of MOR segment: ~1000 km

Covered by License Area: ~360 km

Explored in License Area: ~200 km

Active sites discovered: 7

Estimated number of active sites in  
License Area: 12

**Estimated number of active sites  
outside License Area: 22**

Review

## Exploring the ocean for hydrothermal venting: New techniques, new discoveries, new insights



Edward T. Baker

*Joint Institution for the Study of the Atmosphere and Ocean, University of Washington, and NOAA/PMEL, Seattle, WA 98115, USA*

### ARTICLE INFO

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Diffuse flow  
Ocean ridges  
Faunal distribution  
Geochemical budgets  
Crustal circulation

### ABSTRACT

Enumerating active hydrothermal fields on the seafloor has been a challenge since their discovery almost 40 years ago. High-temperature hydrothermal fields are readily discoverable, primarily by detecting mineral-laden plumes, but low-temperature, particle-poor vent fields resist discovery. Decades of exploration for vent fields have covered, though often cursorily, about one-third of the global lengths of both oceanic spreading ridges (OSRs) and volcanic arcs, identifying some 630 active vent fields. About 80% of these fields are on OSRs, and the spatial frequency of those fields is currently estimated as  $\sim 0.5\text{--}5/100$  km, generally increasing with spreading rate. Over the last decade, however, a few detailed surveys have added sensors capable of detecting ephemeral chemical tracers (oxidation-reduction potential) in addition to standard sensors that detect quasi-conservative optical tracers (such as light backscattering). This approach has revealed a new view of the distribution of venting fields along fast-spreading ( $>55$  mm/yr) OSRs. Studies of four such ridge sections totaling 1470 km length suggest that the present inventory of vent fields may underestimate the true global population of vent fields on fast-spreading OSRs by a factor of 3–6. This increase implies that ridge axes are unexpectedly “leaky” reservoirs, from which hydrothermal fluids escape at far more sites than presently assumed; that the supply of dissolved hydrothermal iron, which may be fertilizing the primary production of the Southern Ocean, is higher than now calculated; and that present estimates of recoverable sulfide tonnage from ridge axes may be too low. Along slow-spreading ridges, which account for 60% of the global OSR length and 86% of known sulfide tonnage, expansive axial valleys present special exploration challenges that will not be easily overcome.

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## Global frequency of Active Vent Fields at MOR:

### 0.5 – 5 per 100 km

## In German License Area:

### ~ 2 per 100 km

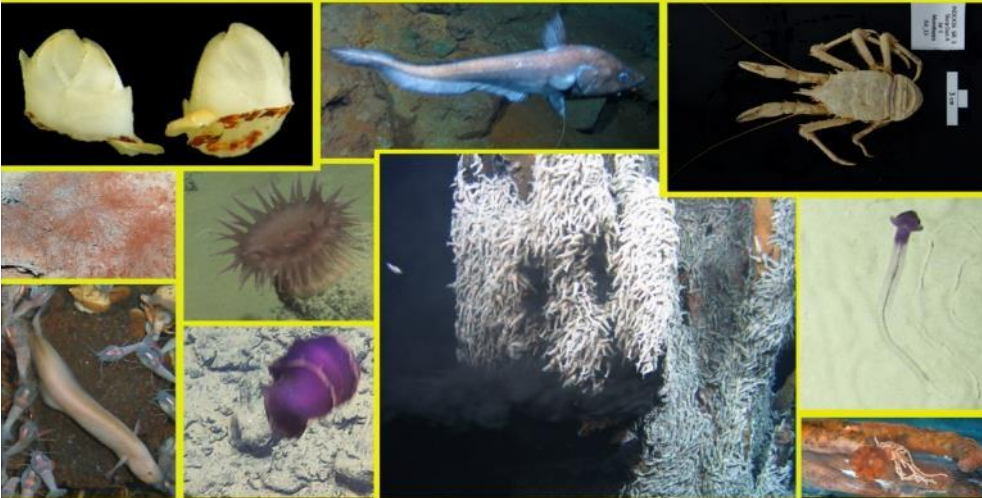
Baker 2017, Ore Geology Reviews

**BGR**



## Catalogue of INDEX Benthic Fauna

--  
DNA confirmed taxa from the Edmond and Kairei vent fields  
2015/ 2016



**SENCKENBERG**  
world of biodiversity

St Denis - St Denis -- 03. Jan - 03. Feb 2016  
St Denis - St Denis -- 12. Oct - 12. Jan 2015

Christodoulou, M.; Gerdes, K.; Kihara T.C.; Kniesz, K.

# INDEX – Tree of Life

- Started in 2015
- Continuing to 2030
- 25.000 Individuals so far
- Published in GenBank  
(<https://www.ncbi.nlm.nih.gov/genbank>)

→ Fauna genetically related  
to Dodo (CIR) & Solitär (CIR)

**BGR**

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# Decapod connectivity in the Indian Ocean deep-sea hydrothermal vents (2018)



## Preliminary results

- High connectivity
- High haplotype diversity
- Population expansion

# Reporting, Academia, Research, Media and ISA Affairs

- Annual Reports to ISA
- Symposia, Talks and Lectures for the Public and Universities
- Contracts to Universities and Research Centers
- PhD students 1 + 3
- Master / Bachelor Theses 3 / 10
- ISA Training Program – 10 Trainees in Five Years

Expedition, Six Weeks of Lab Work and Marine Research Experience

Ghana (2), Egypt (2), Nigeria, Argentina (2), Singapore, Cook Islands, Thailand

