active, inactive, and extinct sulfide occurrences: biodiversity and ecosystem setting, including connectivity

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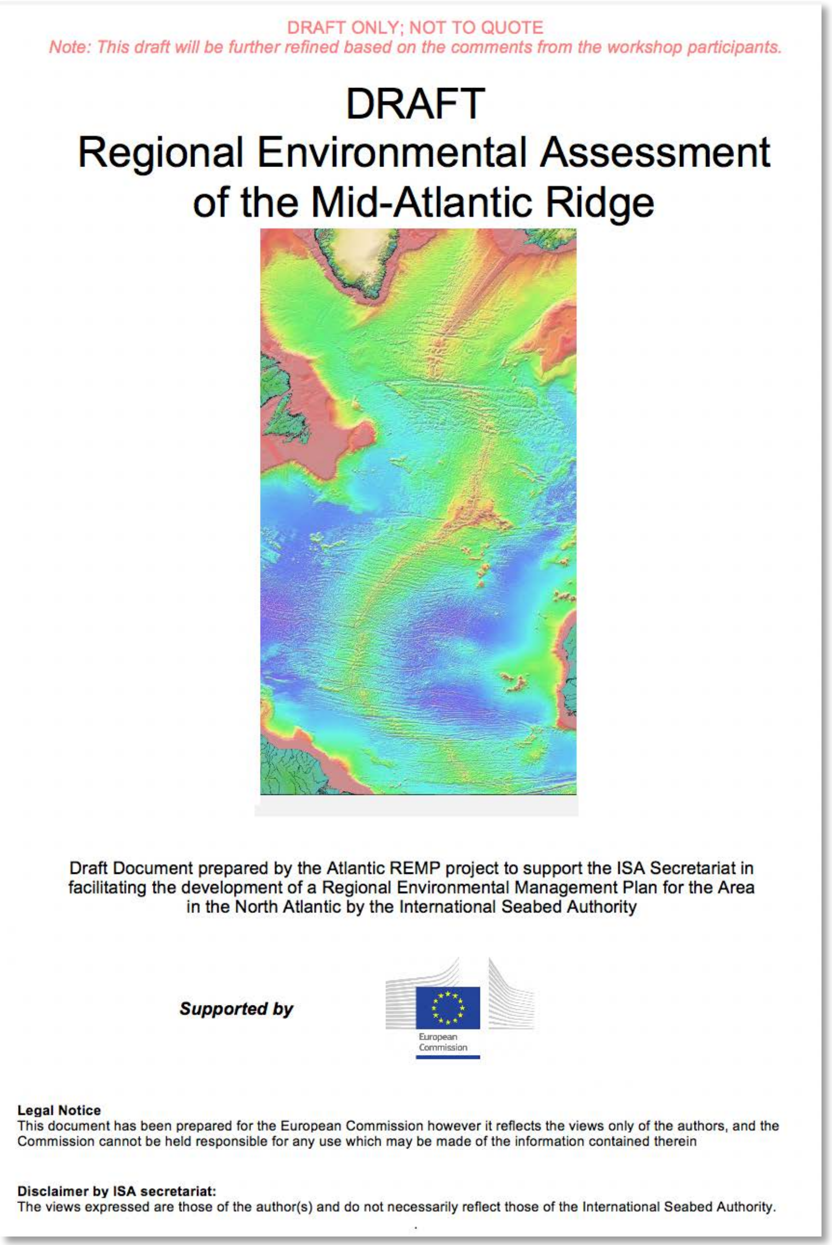
refer to REA for a very competent review



DRAFT ONLY; NOT TO QUOTE

Note: This draft will be further refined based on the comments from the workshop participants.

DRAFT
Regional Environmental Assessment of the Mid-Atlantic Ridge

Draft Document prepared by the Atlantic REMP project to support the ISA Secretariat in facilitating the development of a Regional Environmental Management Plan for the Area in the North Atlantic by the International Seabed Authority

Supported by European Commission

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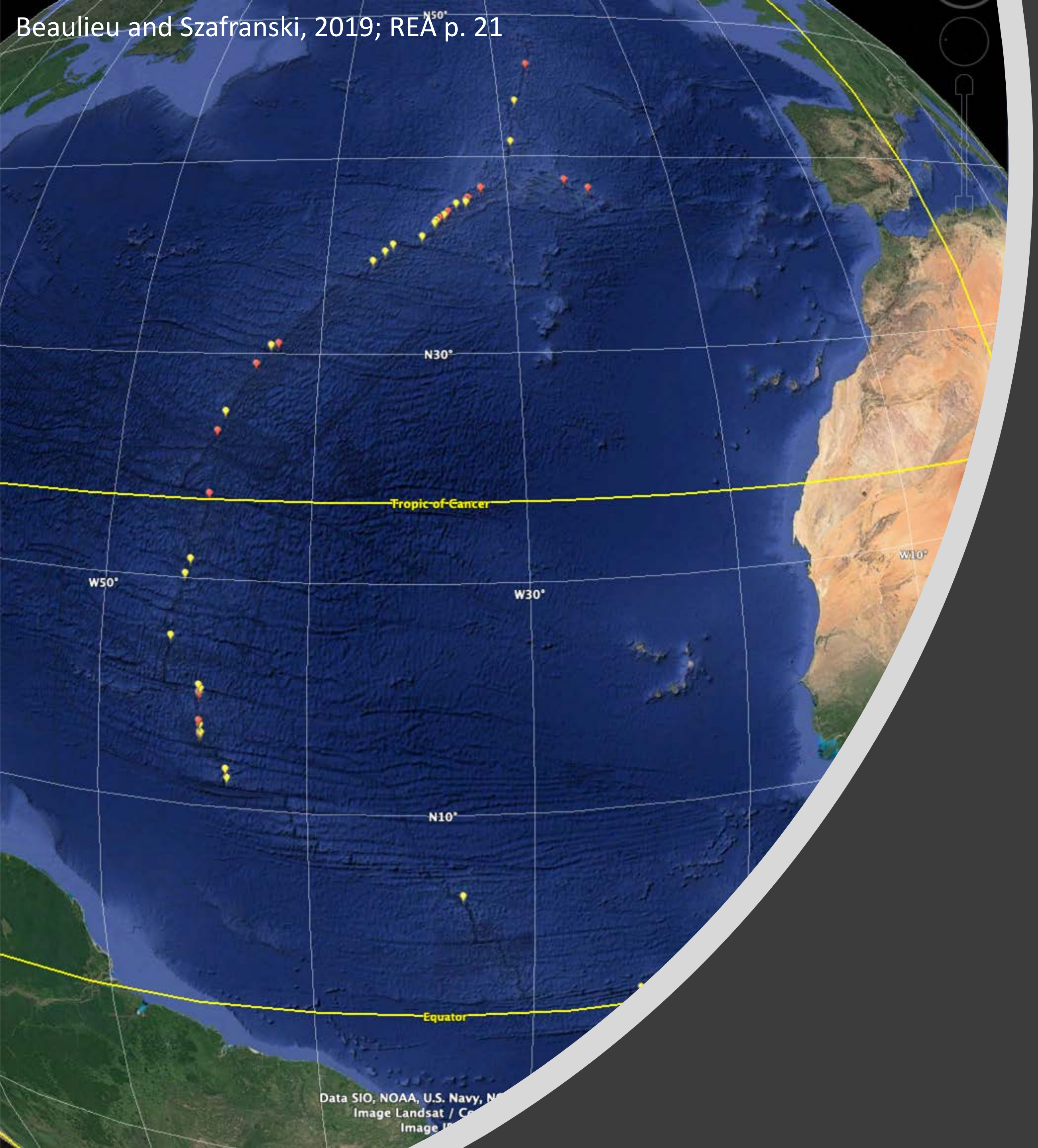
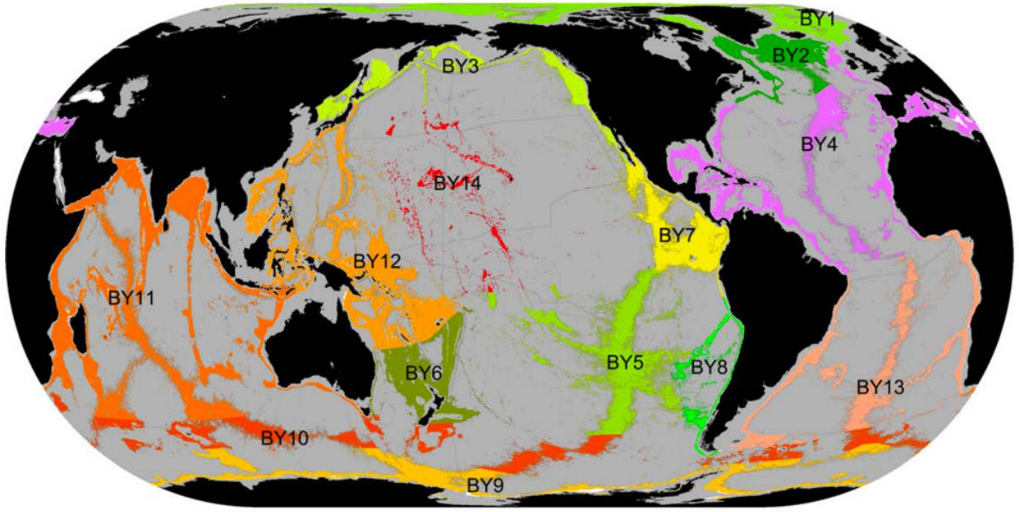
Beaulieu and Szafranski, 2019; REA p. 21



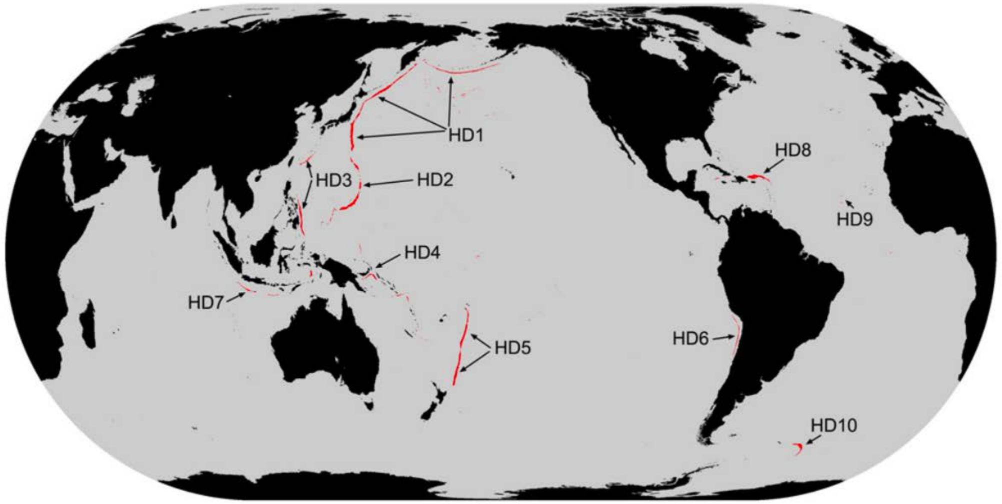
GLOBALLY RARE HABITATS

distribution of known active* and inactive sulfides

*globally an area ~50 km^2



BY1: Arctic
BY2: Northern Atlantic Boreal
BY3: Northern Pacific Boreal
BY4: North Atlantic
BY5: Southeast Pacific Ridges
BY6: New Zealand-Kermadec
BY7: Cocos Plate
BY8: Nazca Plate
BY9: Antarctic
BY10: Subantarctic
BY11: Indian
BY12: West Pacific
BY13: South Atlantic
BY14: North Pacific



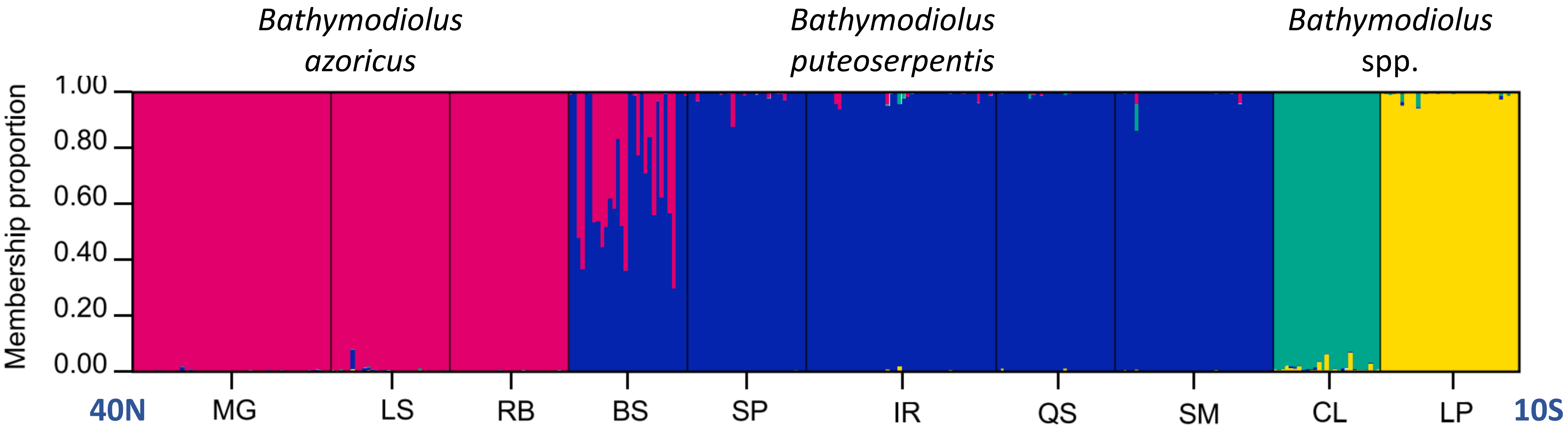
HD1: Aleutian-Japan
HD2: Philippine
HD3: Mariana
HD4: Bougainville-New Hebrides
HD5: Tonga-Kermadec
HD6: Peru-Chile
HD10: Southern Antilles
HD7: Java
HD8: Puerto Rico
HD9: Romanche

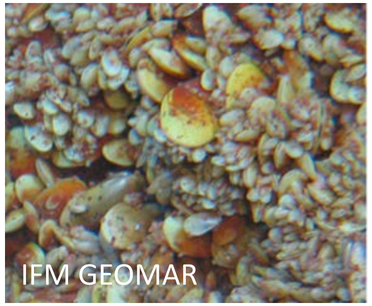
Watling et al. 2013

BIOGEOGRAPHICAL CONTEXT

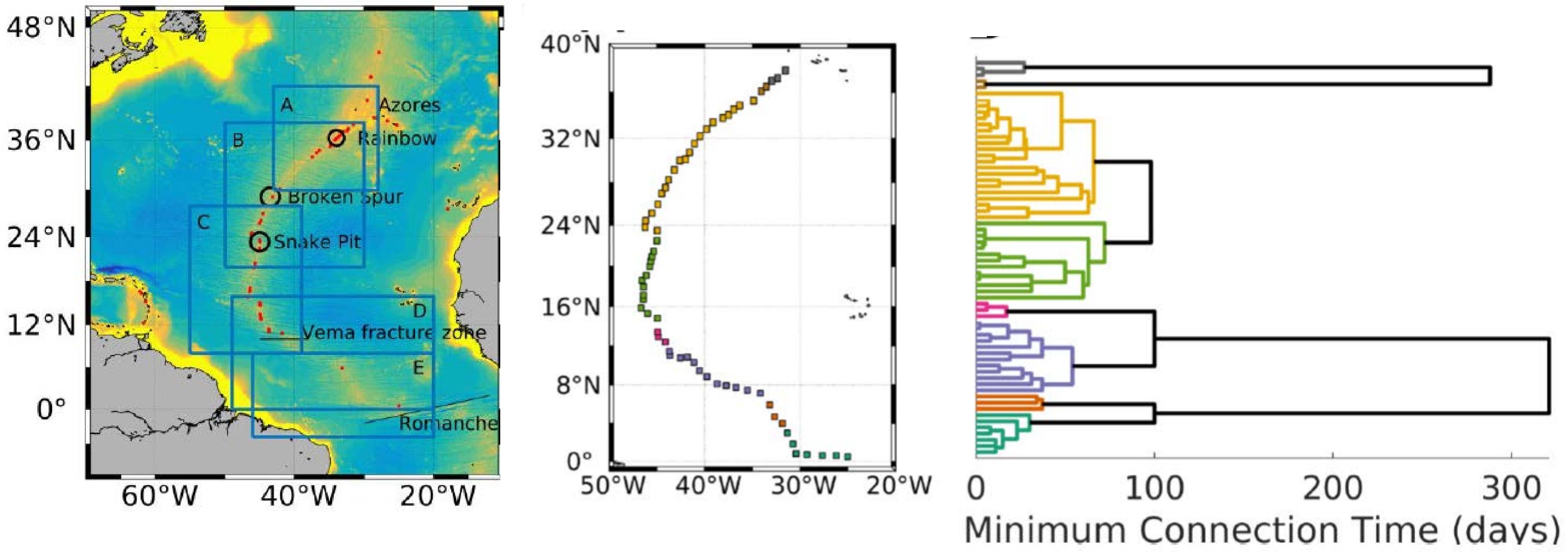
- Lower Bathyal and Hadal Provinces

finer-scale biogeography *Breusing et al. 2016* (90 SNPs, 9 msats, mND4)



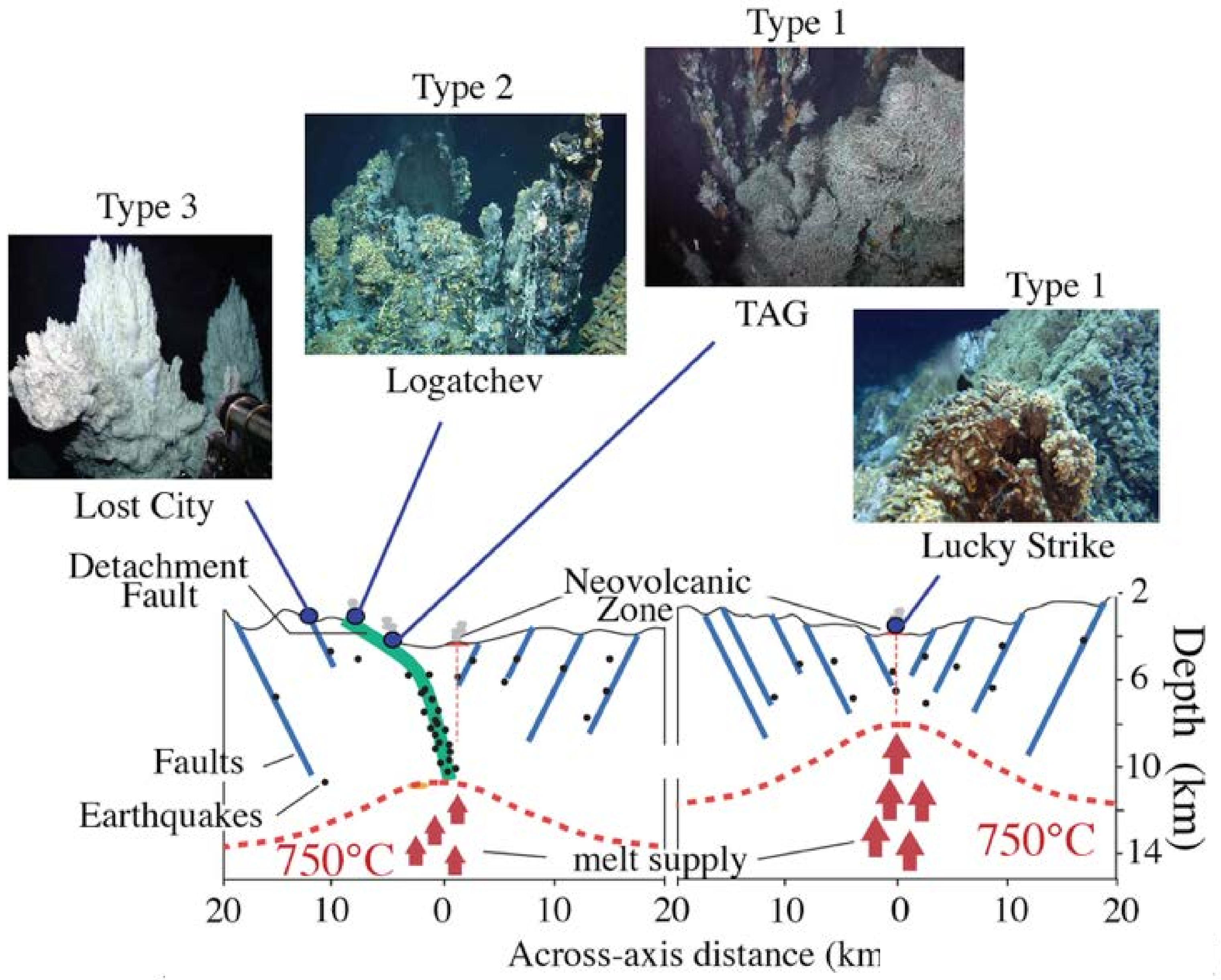


Refinement of Management Units: Mid-Water Connectivity *(ARGO floats)*



Yearsley et al. unpublished

MAR Active Vent Heterogeneity

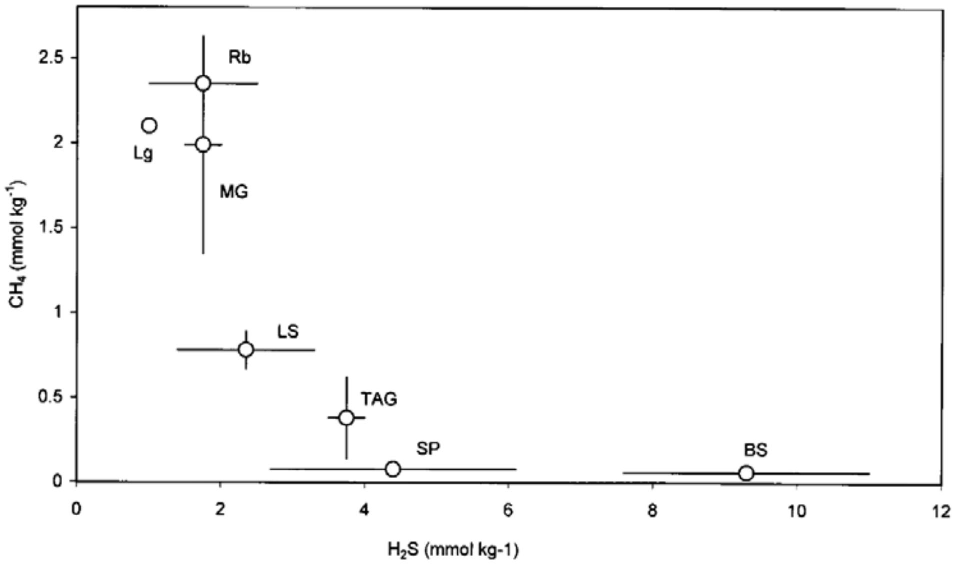


Type 1: basalt (crust); **Type 2**: mixtures of peridotite, gabbro (mantle); **Type** 3: carbonate

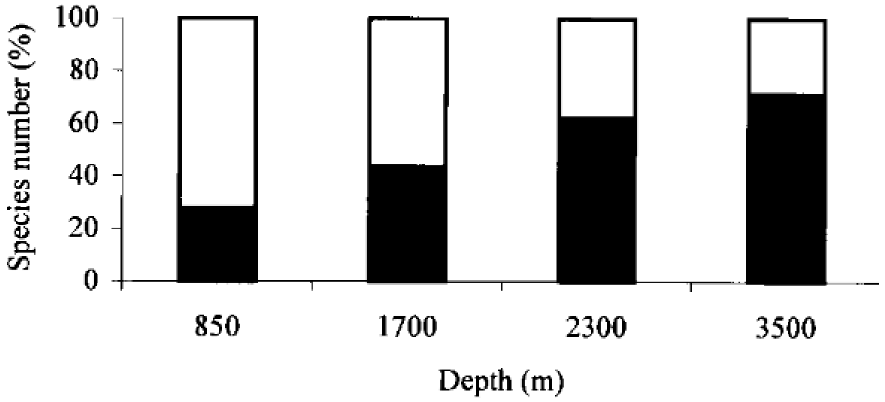
Karson et al 2013

MAR Active Vent Heterogeneity

Variation in Key Chemical Parameters



Contribution of non-vent fauna decreases with depth



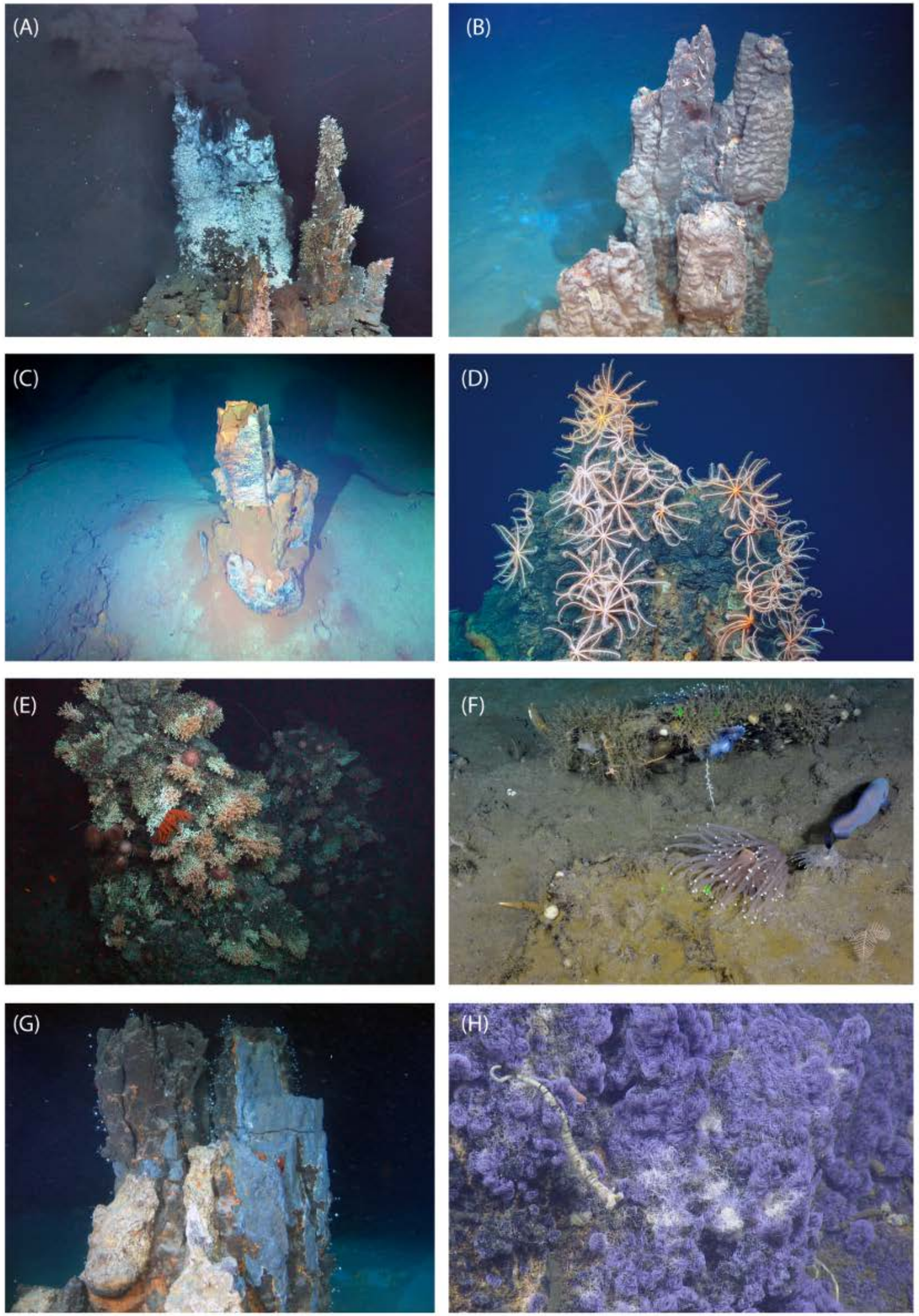
Vent fauna

Non-vent fauna

Dèsbruyeres et al. 2000

Inactive Sulfide Ecosystems

Currently, these are data-poor ecosystems on the MAR and mid-ocean ridges in general



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ISA Definitions (ISBA/25/LTC/6)

Active sulfides

Polymetallic sulfides through which warm or hot water is flowing.

Inactive (or dormant) sulfides

Polymetallic sulfides through which water is no longer flowing into the overlying seawater (i.e., they are “cold”).

Disturbance of these sulfides may result in renewal of hydrothermal fluxes into the water column, turning inactive sulfides into active sulfides, hence the concept of “dormant” sulfides.

Extinct sulfides

To be added (recommendation from Galway workshop)

A Sulfide Classification Scheme

Sulfide Classification	Location	Ecosystem Brief
Active occurrence	Especially typical of fast spreading centers	Ephemeral (decadal scale), with endemic taxa
Inactive occurrence	Especially typical of fast spreading centers	Ephemeral (decadal scale), without endemic taxa (?)
Potential active deposit includes active sulfide ecosystems and active/inactive sulfide complex ecosystems	Most likely at intermediate, slow, and ultraslow spreading centers, and some seamounts	Persistent (millennial+ scale) habitats, with endemic taxa
Potential inactive deposit may be *near- or far-field* (relative to active deposits) and/or *sediment-covered*	Most likely at intermediate, slow, and ultraslow spreading centers, off-axis of these spreading centers, and some seamounts	Persistent (millennial+ scale) habitats; may be colonized by suspension-feeding and microcarnivorous invertebrates; possibly colonized by specialist taxa but so far this remains speculation

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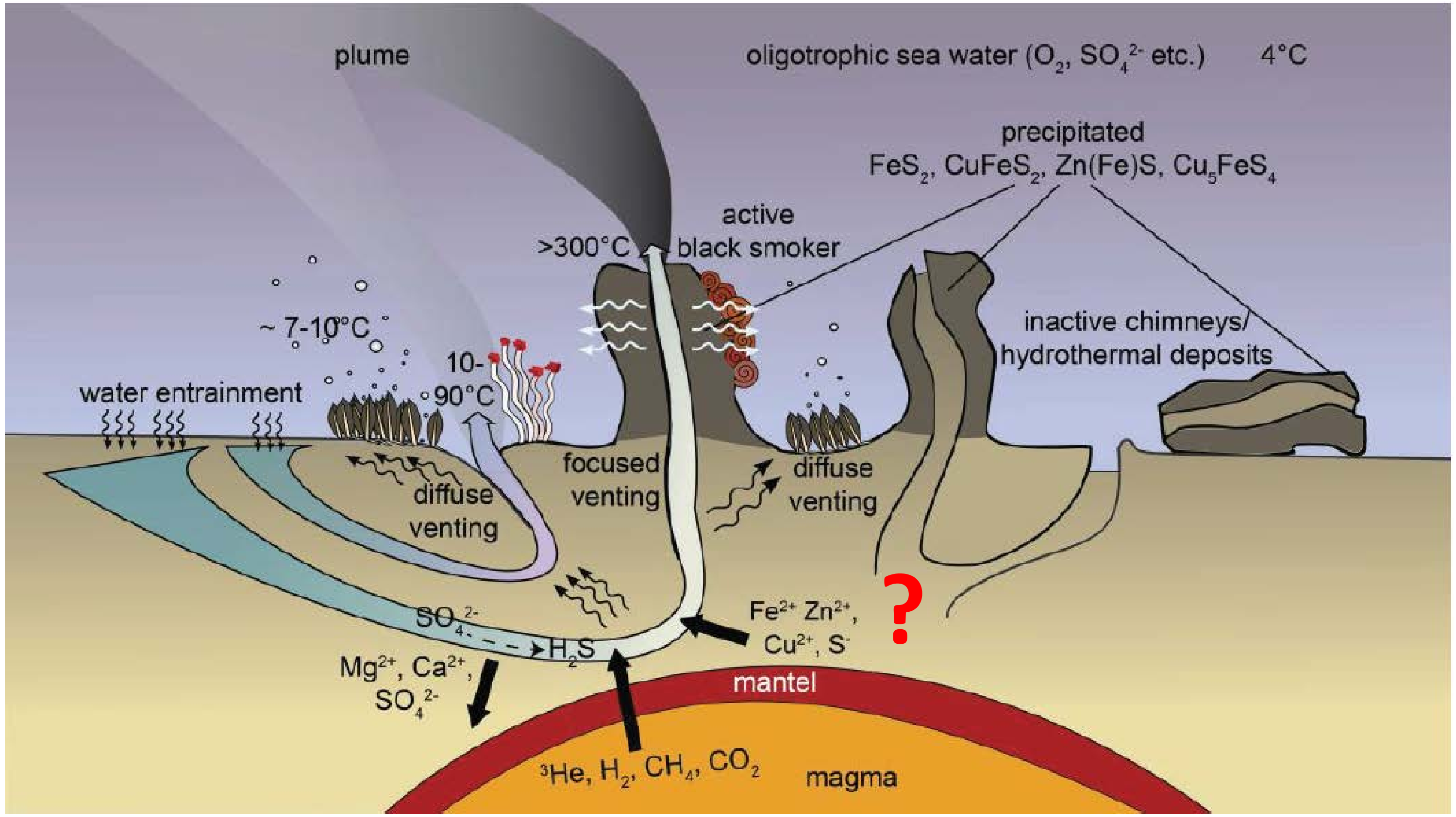
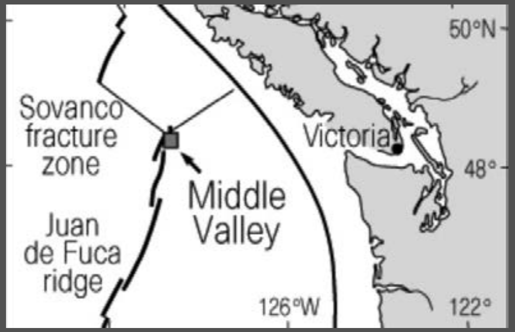
subsurface linkages?



Meier 2016

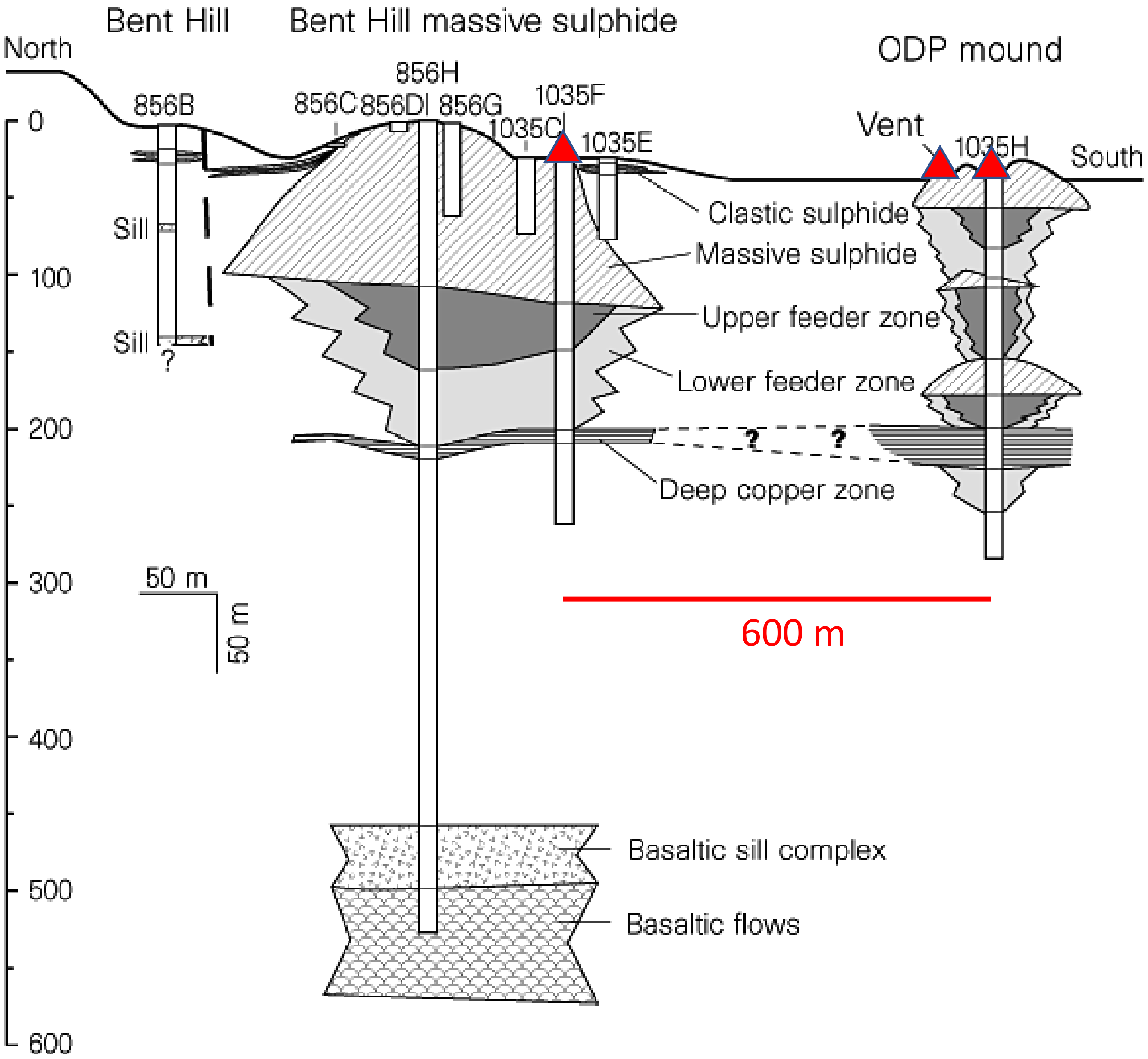


reactivation of venting

ODP Drill Holes

Zierenberg et al. 1998

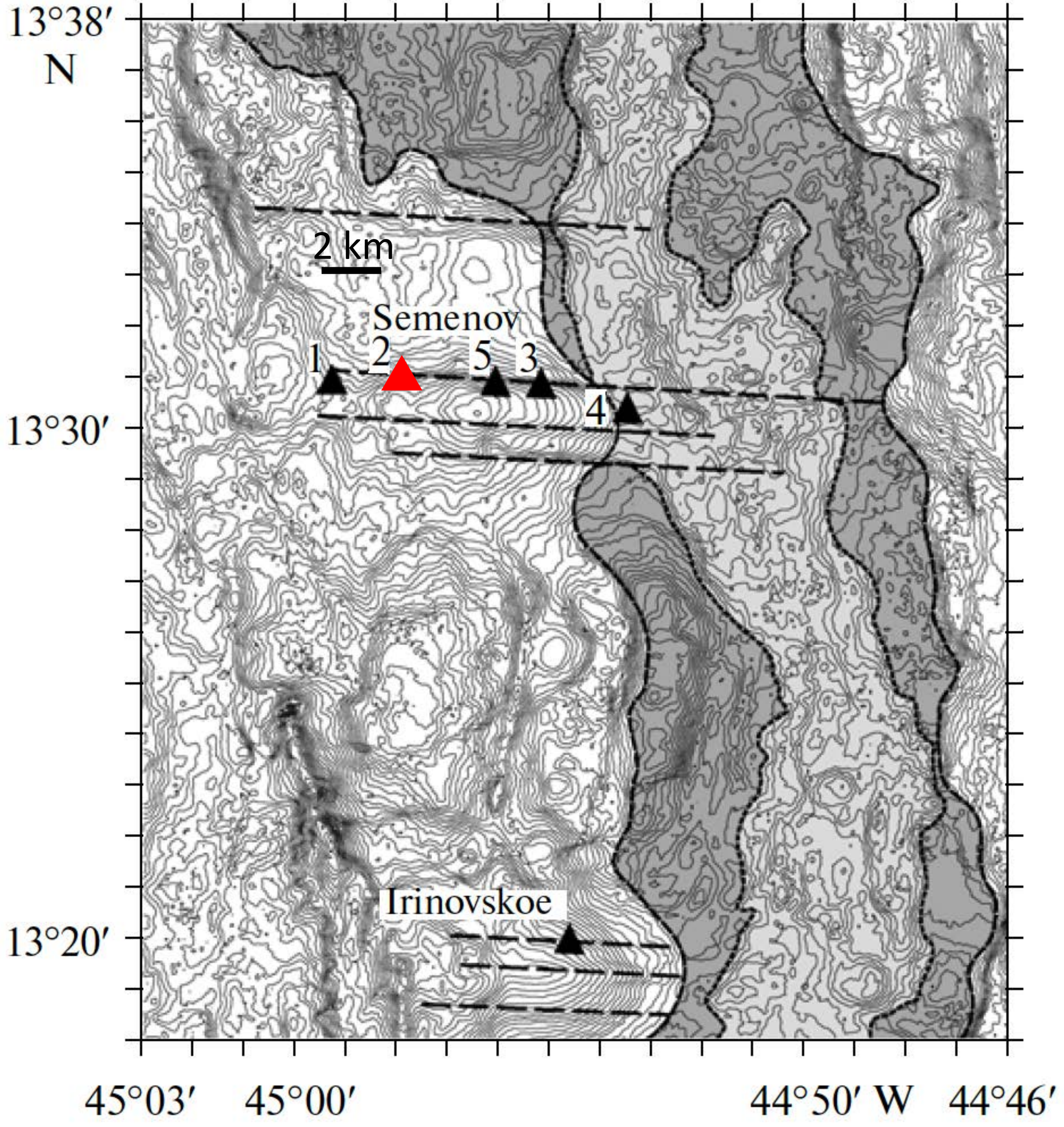
also Jamieson & Gartman, in review



inactive/dorment
or
extinct?

How does reactivation of hydrothermal flow in an adjacent sulfide deposit impact an active vent ecosystem?

Are there geophysical tools that can distinguish dormant and extinct deposits in advance of a drilling or mining disturbance?

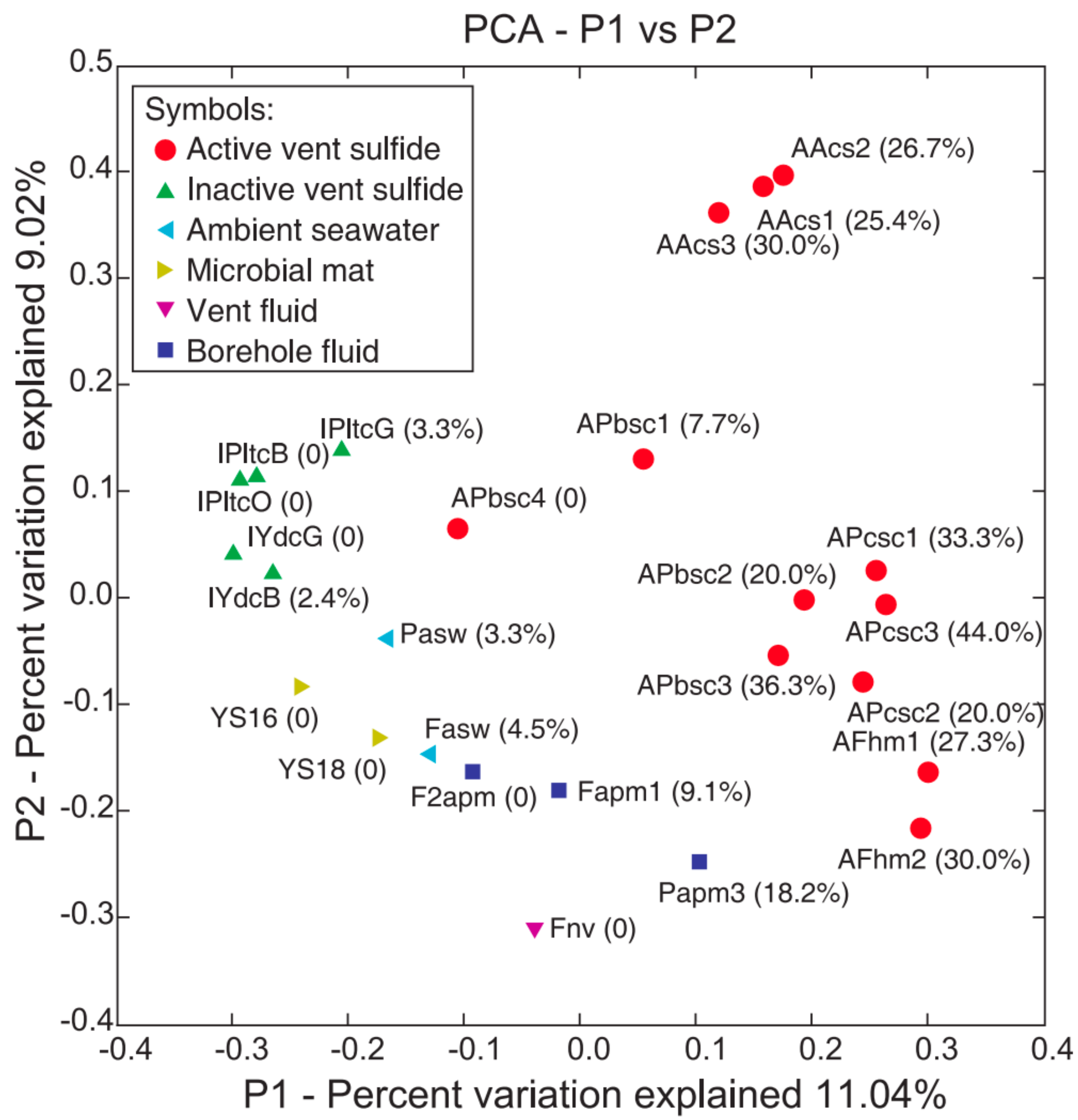


Cherkashev et al. 2013

Microbial Succession

active to inactive sulfides

Kato et al. 2010



COMPARISON OF MICROBIAL SERVICES

SERVICES	active sulfides	inactive/extinct sulfides
primary production	critical value, well understood, high vulnerability	major value, poorly understood, low vulnerability
endosymbiosis	critical value, well understood, high vulnerability	major value, poorly understood, low vulnerability
nutrient regeneration	minor value, poorly understood, low vulnerability	minor value, poorly understood, low vulnerability
regulation of toxic gases (CH_4, H_2S)	critical value, well understood, high vulnerability	major value, well understood, low vulnerability
carbon sequestration	minor value, well understood, low vulnerability	minor value, well understood, low vulnerability
genetic resources	critical value, well understood, high vulnerability	major value, well understood, low vulnerability
cultural & educational value	major value, well understood, low vulnerability	minor value, well understood, low vulnerability
scientific research	critical value, well understood, high vulnerability	major value, well understood, low vulnerability

- critical value, well understood, high vulnerability
- major value, well understood, low vulnerability
- minor value, well understood, low vulnerability
- major value, poorly understood, low vulnerability
- minor value, poorly understood, low vulnerability

modified from Orcutt et al. 2018

inactive sulfides: environmental risks/concerns to evaluate

- Modification of nearby hydrothermal activity
- Indirect effects at active vents (e.g., from plumes, light)
- Vulnerability of background fauna and pelagic systems to metal toxicity, particle deposition
- Loss of inactive sulfide habitat, including local topographic highs
- Loss of connectivity of putative endemic taxa
- Effects of removal of overburden
- Cumulative impacts of mining multiple sites
- Effective monitoring and assessment of impacts

partial excerpt from Galway workshop reports

environmental management needs specific to inactive sulfides

- Ecological characterization of inactive sulfide ecosystems, including connectivity
- Characterization of any overburden and its biota
- Distribution and size of occurrences/deposits
- Hydrothermal linkages among occurrences/deposits
- Monitoring of overburden deposition sites

partial excerpt from Galway workshop reports

Some Key Points

- There are genetic and hydrographic indications that finer-scale biogeographic patterns than those of, for example, Watling et al. (2013) may be important to consider as management subunits.
- Active vent ecosystems are diverse, with heterogeneity along the ridge axis driven by geological settings and fluid chemistries, among other factors.
- There is scientific consensus that active vent ecosystems are vulnerable to serious harm from mining activities and should not be mined.
- Inactive sulfide ecosystems are poorly described and represent a huge knowledge gap.
- One of the greatest environmental concerns about mining inactive sulfides is the potential for serious impacts to active sulfide ecosystems.