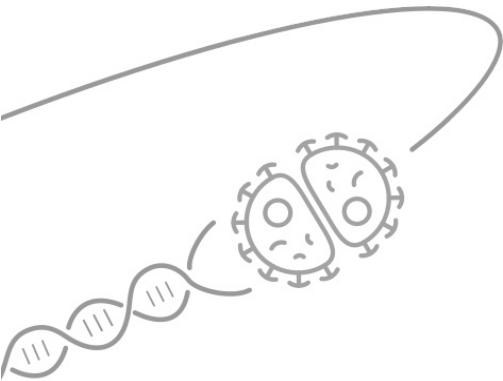
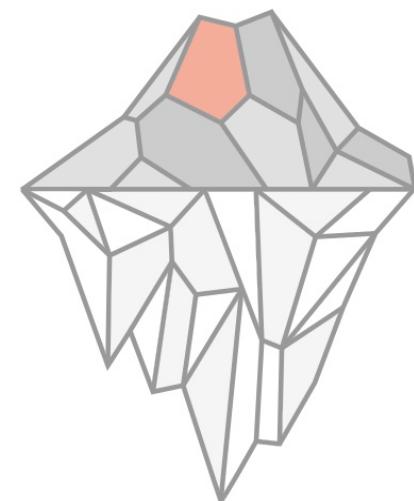


MICROBIOLOGY OF EXTREME ENVIRONMENTS



SHALLOW WATER HYDROTHERMAL VENTS



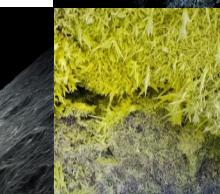
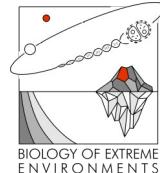
Donato Giovannelli

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 [@d_giovannelli](https://twitter.com/d_giovannelli)

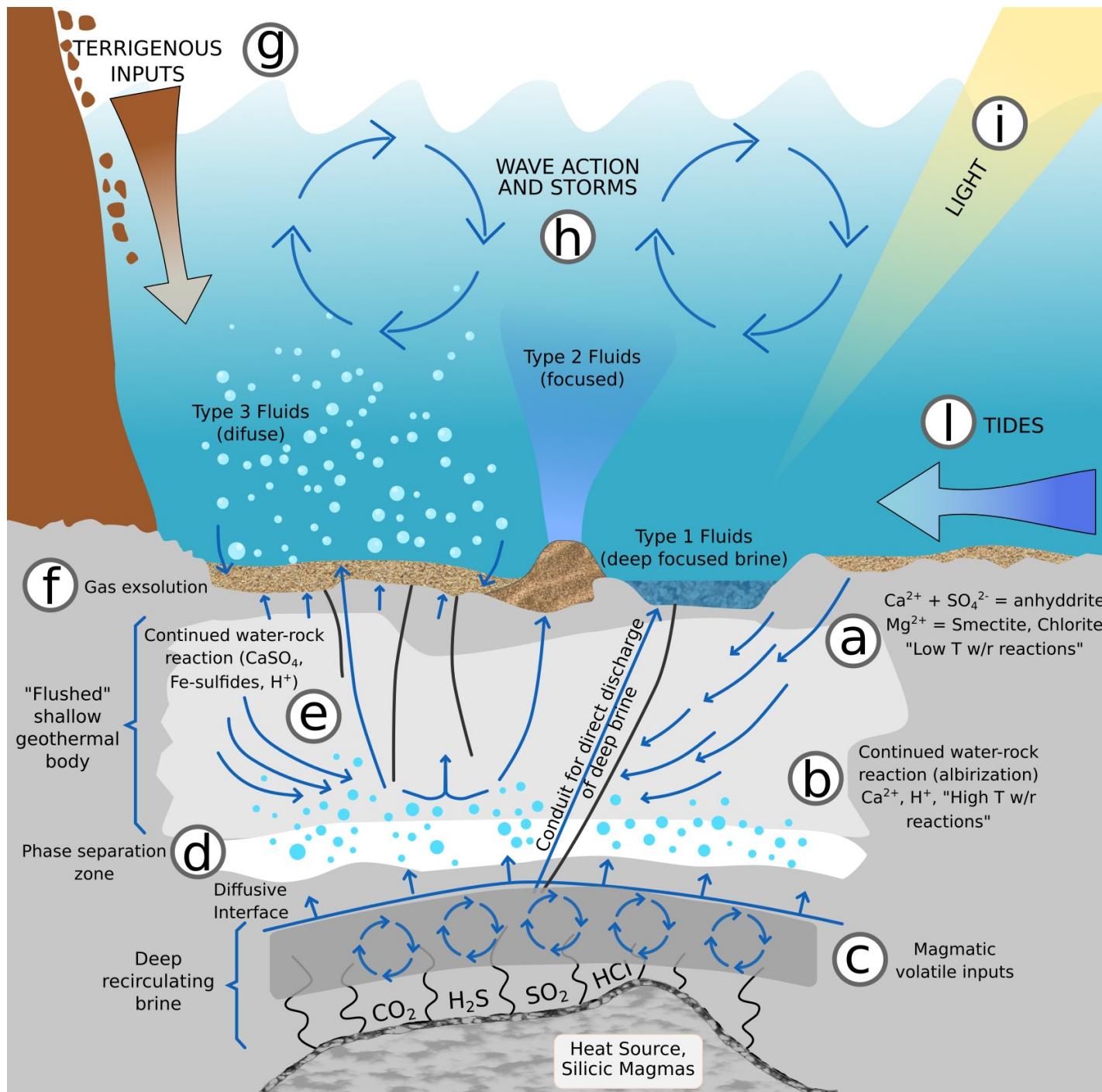
 [@donatogiovannelli](https://www.instagram.com/donatogiovannelli)



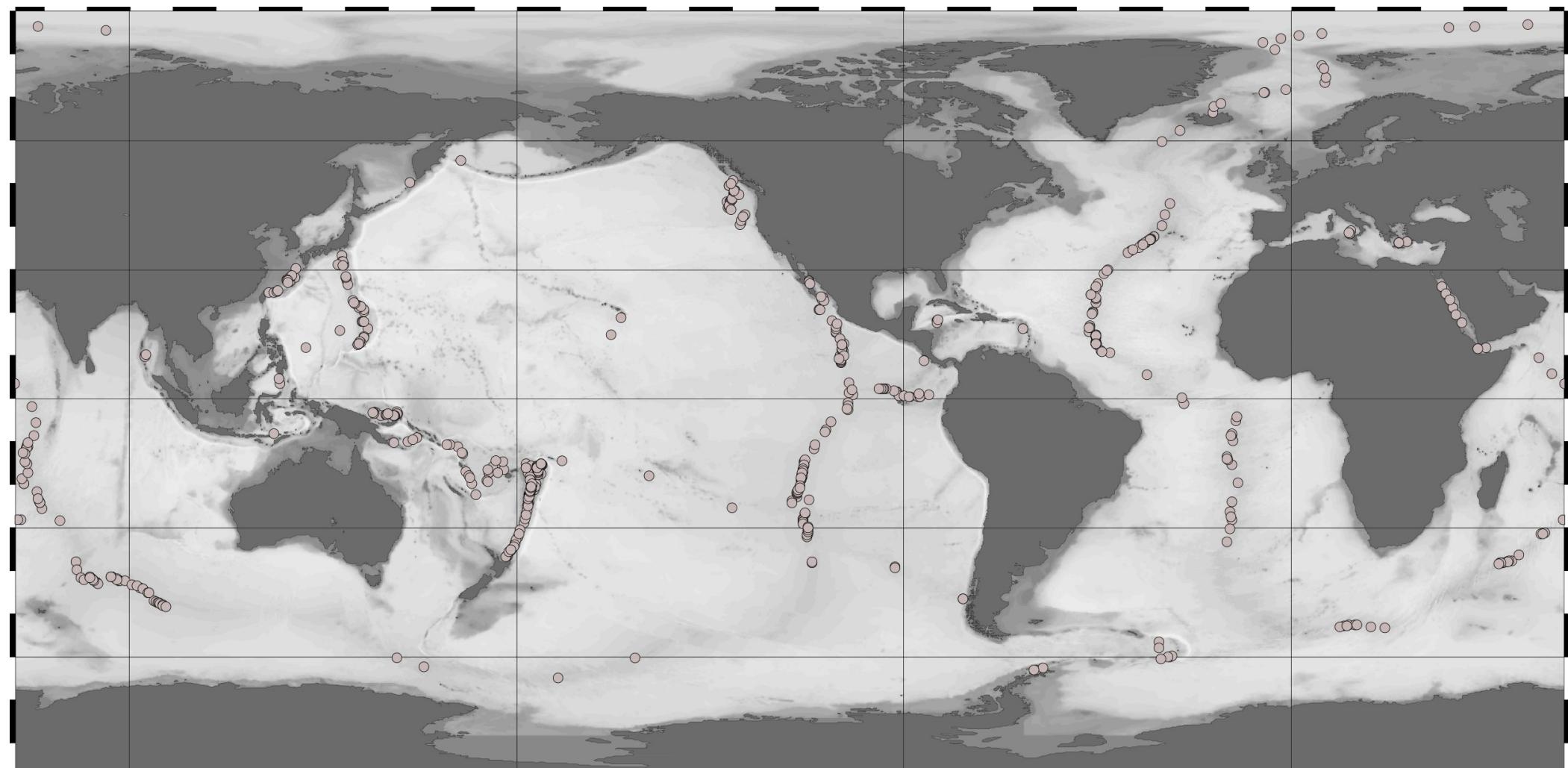


Kueishan island, Taiwan – vent plume

credit: <http://www.earth-of-fire.com> / Chen Minming

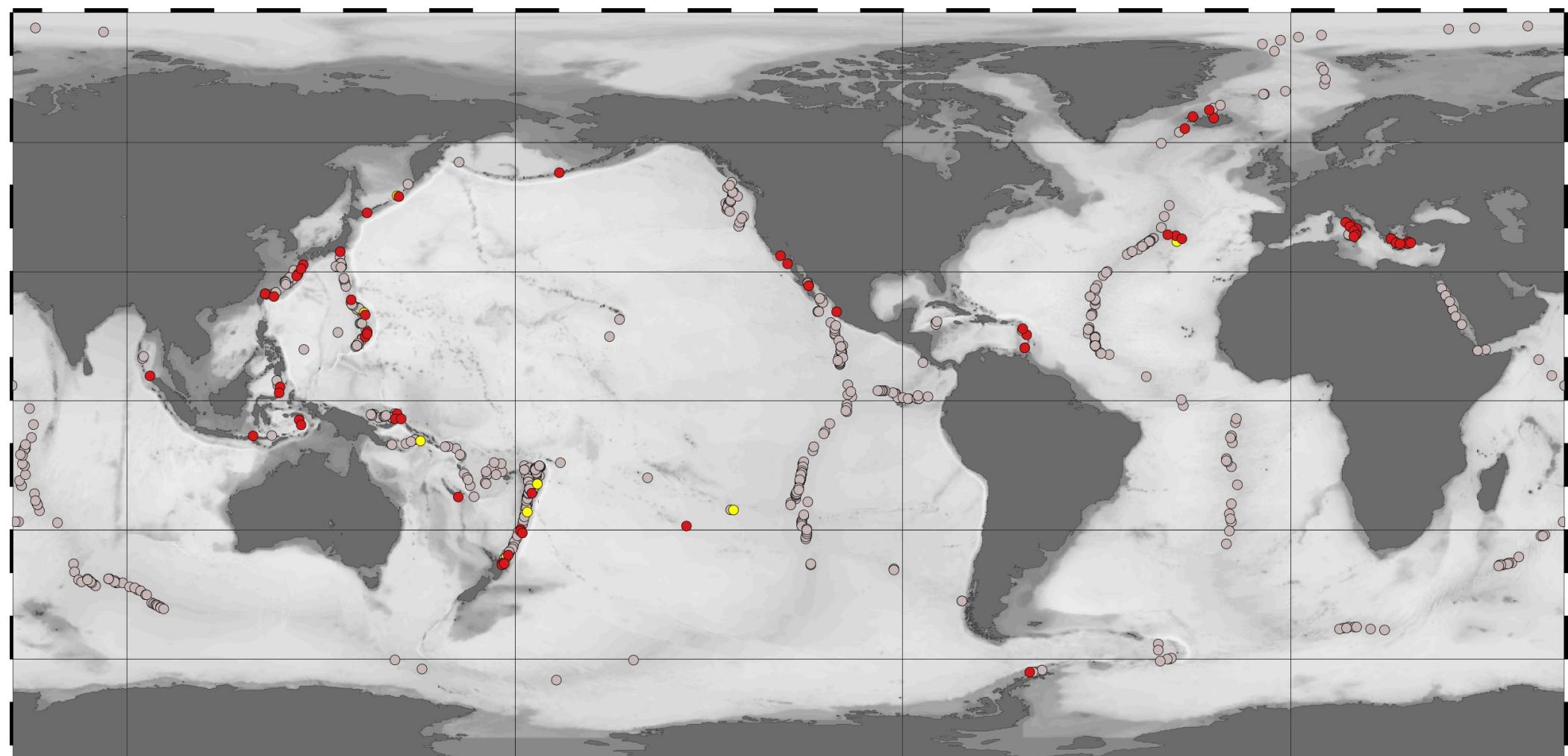


606 deep-sea hydrothermal vent sites (InterRidge database)



Deep-Sea Vents

77 shallow-water hydrothermal vent sites (InterRidge database)



Deep-Sea Vents

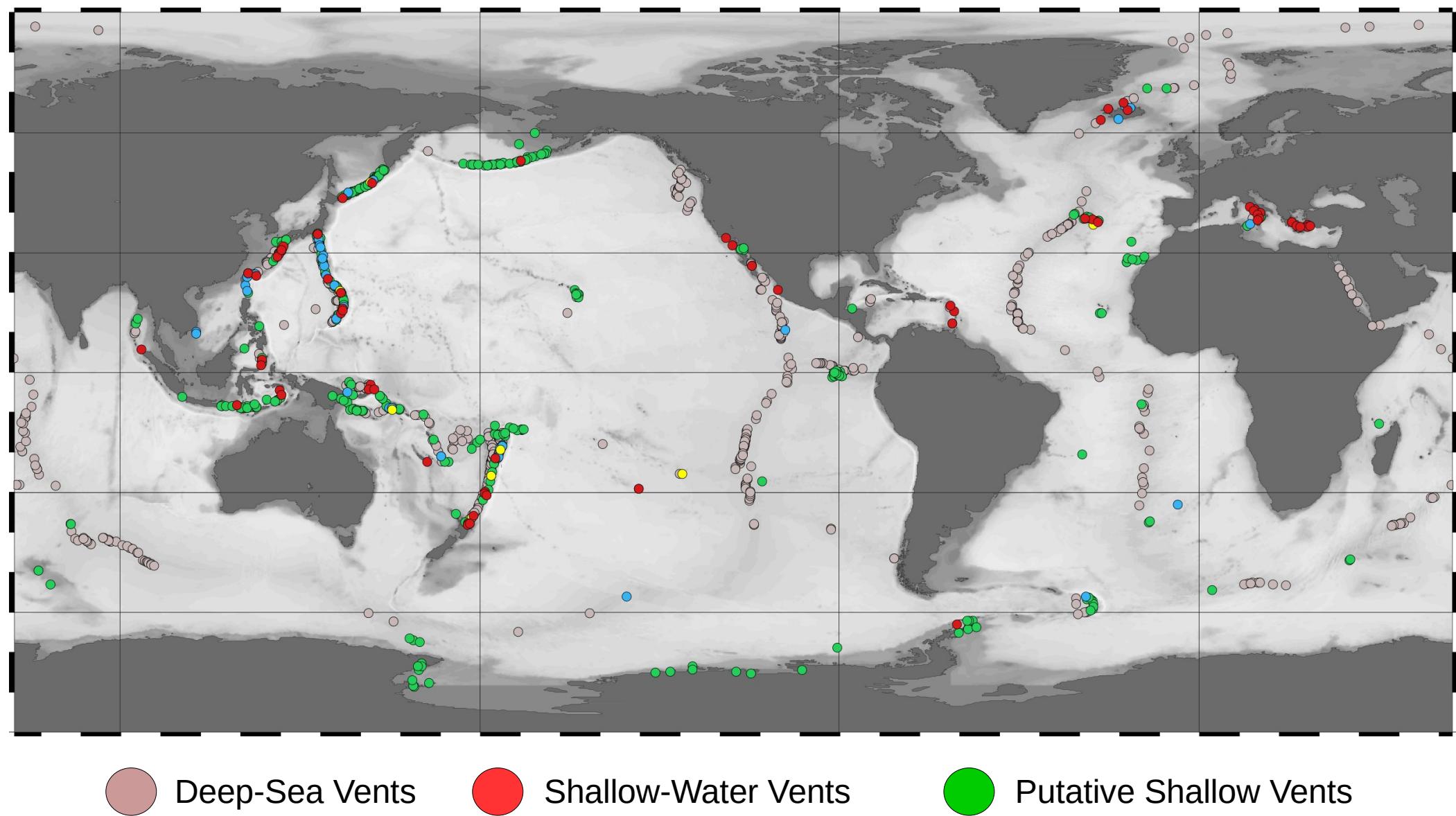


Shallow-Water Vents



Price and Giovannelli, 2017

487 Putative shallow vent sites (estimated)



487 Putative shallow vent sites (estimated)

~43% of all vent could be above 200 m depth



Deep-Sea Vents



Shallow-Water Vents



Putative Shallow Vents

Can we better constrain the total number of shallow-water hydrothermal vents?





credits: CNR-ISMAR

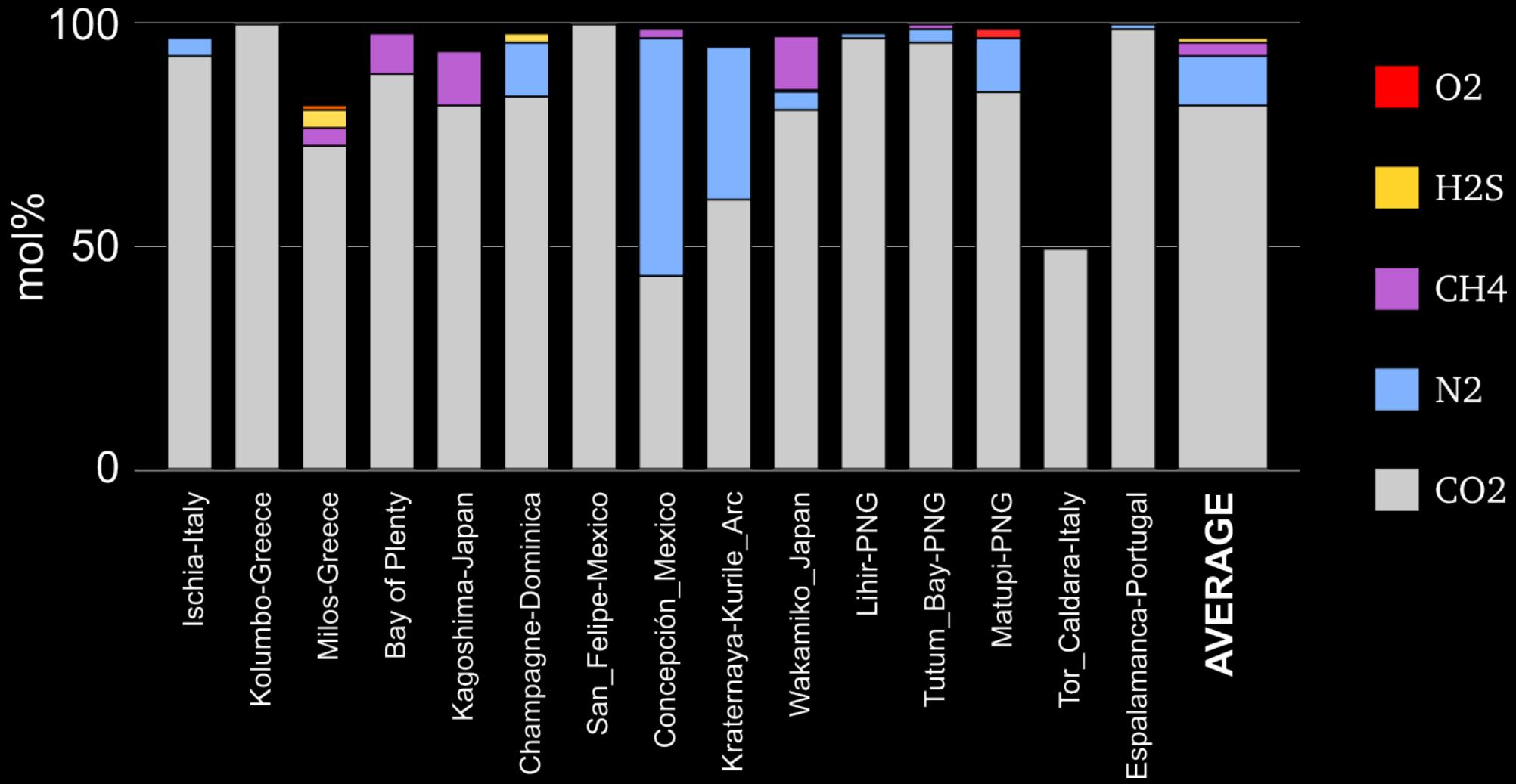


credits: Jorge Fontes

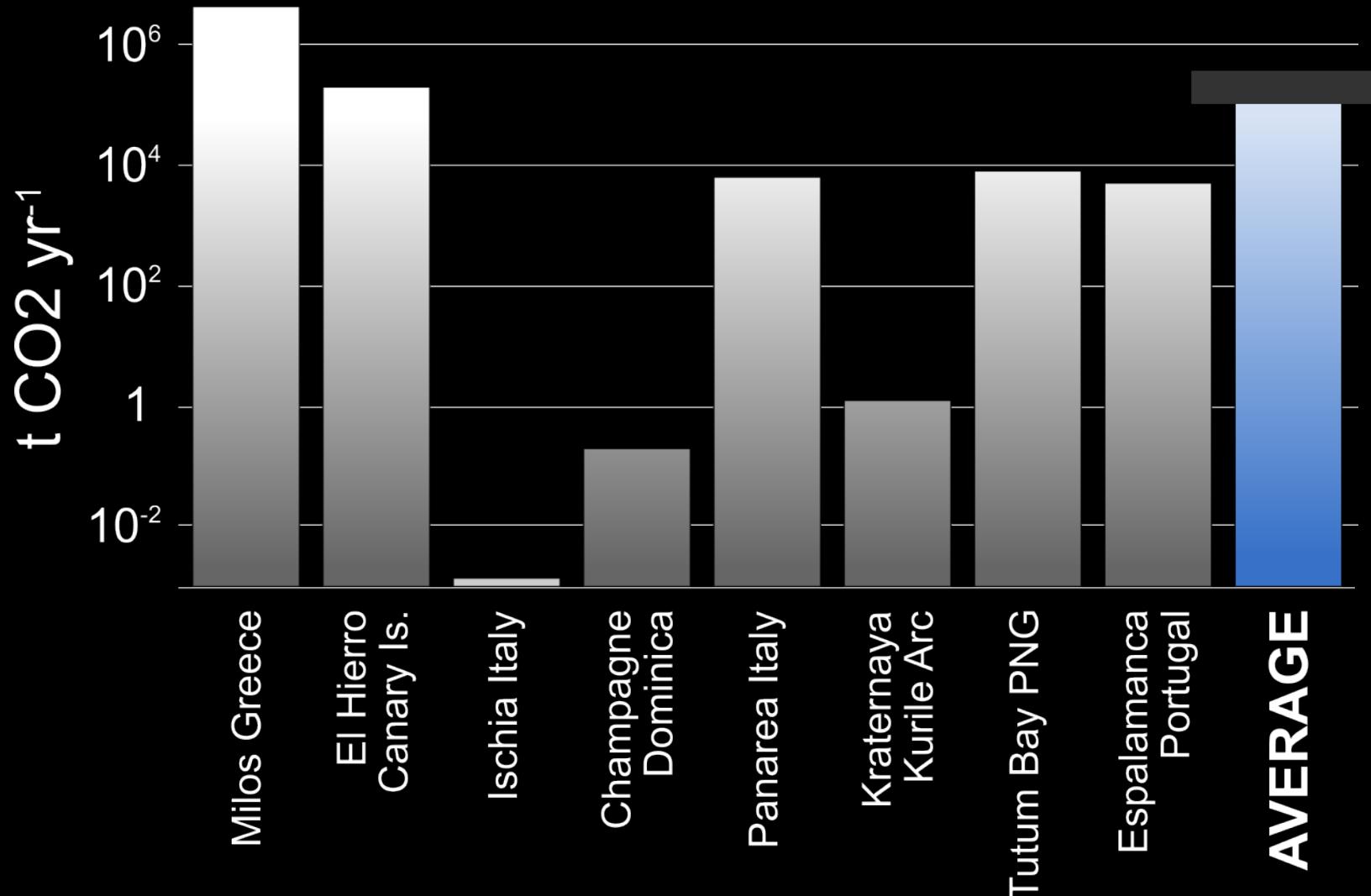


credits: Vetriani (Rutgers U)

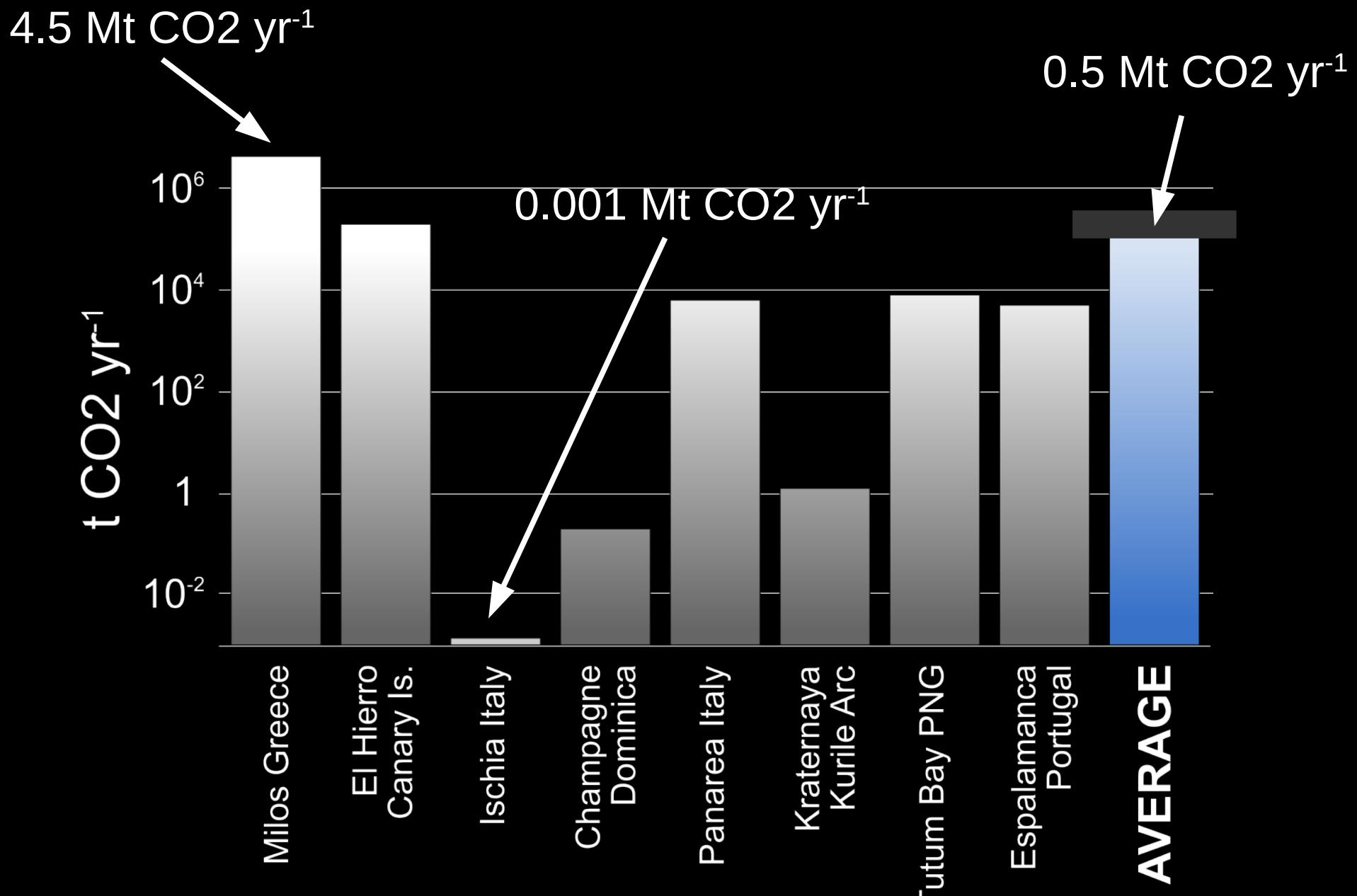
Gas composition



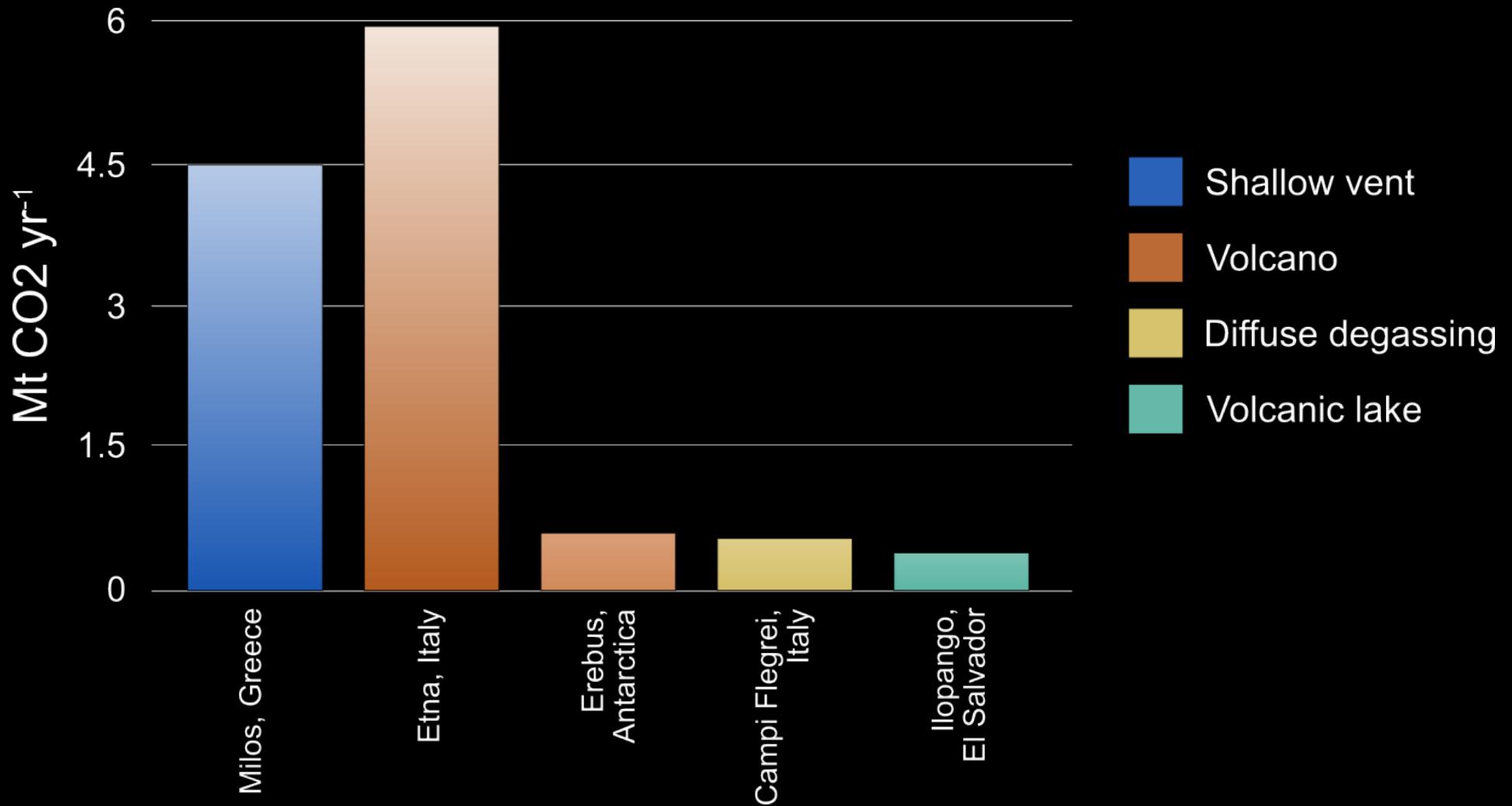
CO₂ flux



CO₂ flux



CO₂ Flux comparison



Global Shallow Vent CO₂ Flux Estimates

- Sum of the CO₂ flux present in the literature is ~5 Mt CO₂ yr⁻¹
- The average flux is ~0.5 Mt CO₂ yr⁻¹

Global Shallow Vent CO₂ Flux Estimates

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| Estimate | x | Average CO ₂ Flux | Flux |
|--|---|------------------------------|--|
| Number of shallow vent in the literature | x | Average CO ₂ Flux | 46 Mt CO ₂ yr ⁻¹ |
| 50% of number of estimated shallow vents | x | Average CO ₂ Flux | 144 Mt CO ₂ yr ⁻¹ |

Global Shallow Vent CO₂ Flux Estimates

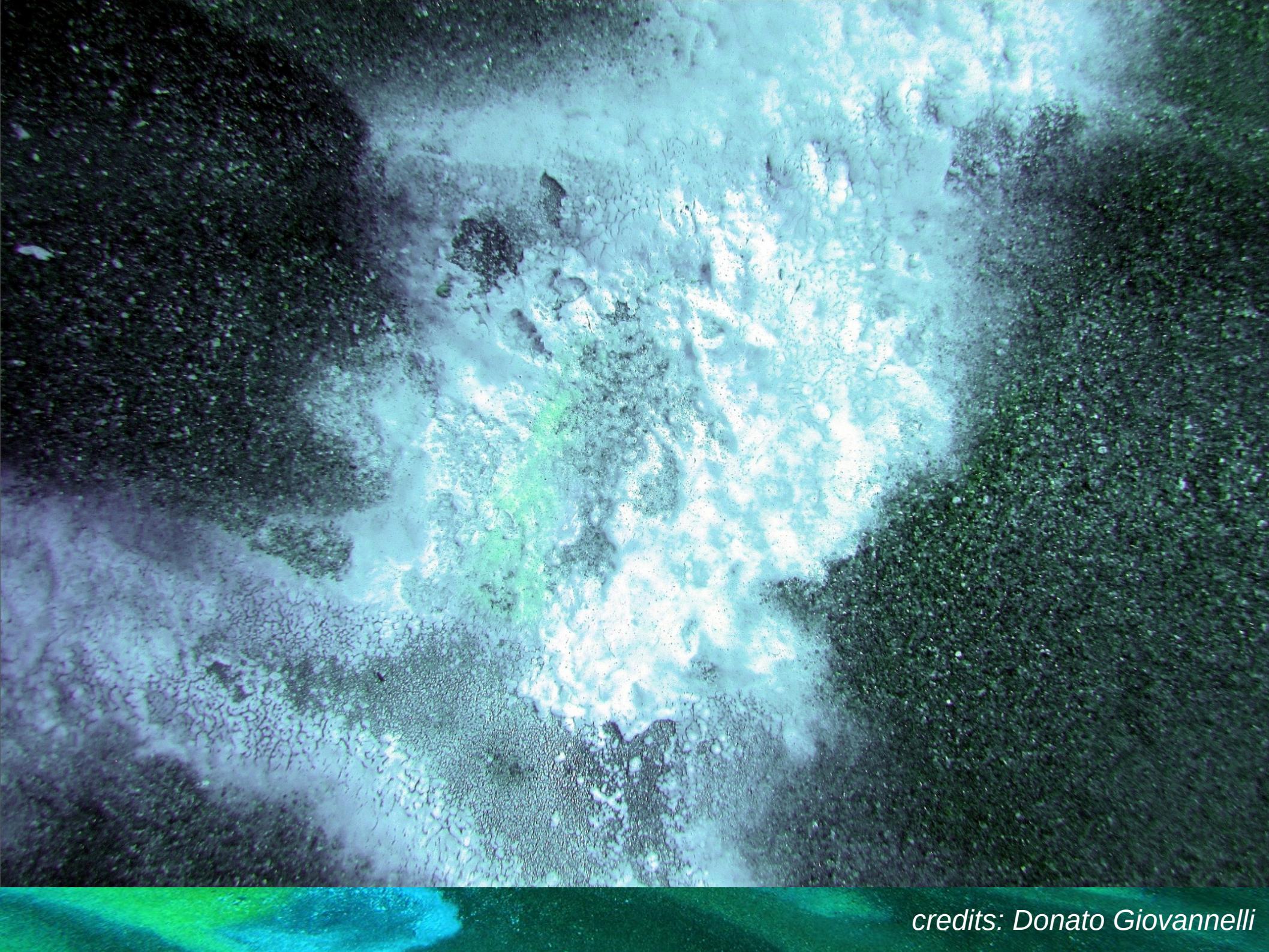
- Sum of the CO₂ flux present in the literature is ~5 Mt CO₂ yr⁻¹
- The average flux is ~0.5 Mt CO₂ yr⁻¹

| Estimate | x | Flux |
|--|---|---|
| Number of shallow vent in the literature | x | Average CO ₂ Flux |
| 50% of number of estimated shallow vents | x | 46 Mt CO ₂ yr ⁻¹ |
| | | 144 Mt CO ₂ yr ⁻¹ |

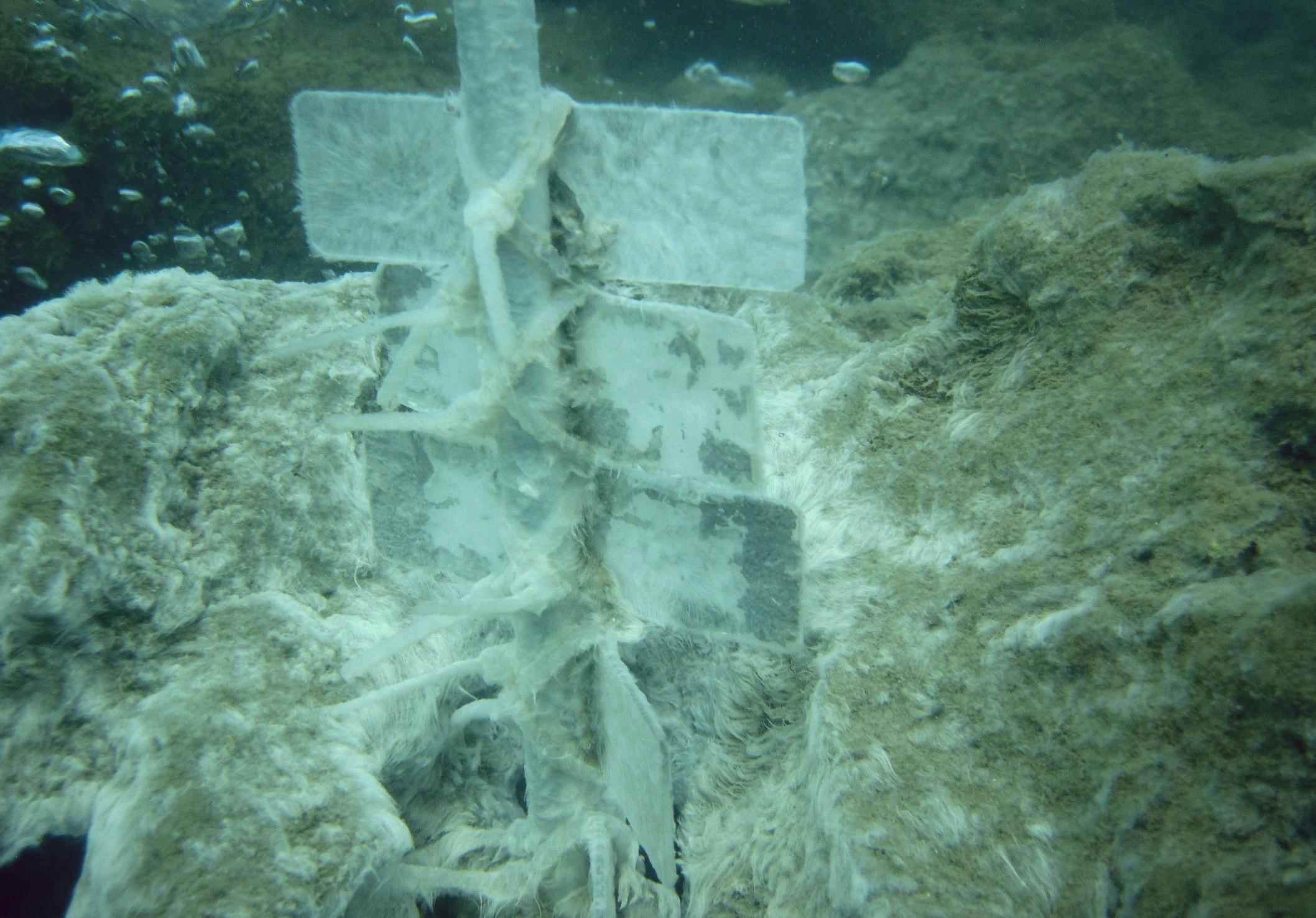
Even excluding Milos, global estimate are between 3 and 17 Mt CO₂ yr⁻¹

*Can we constrain the global contribution of
shallow-water venting to global CO₂
degassing?*





credits: Donato Giovannelli

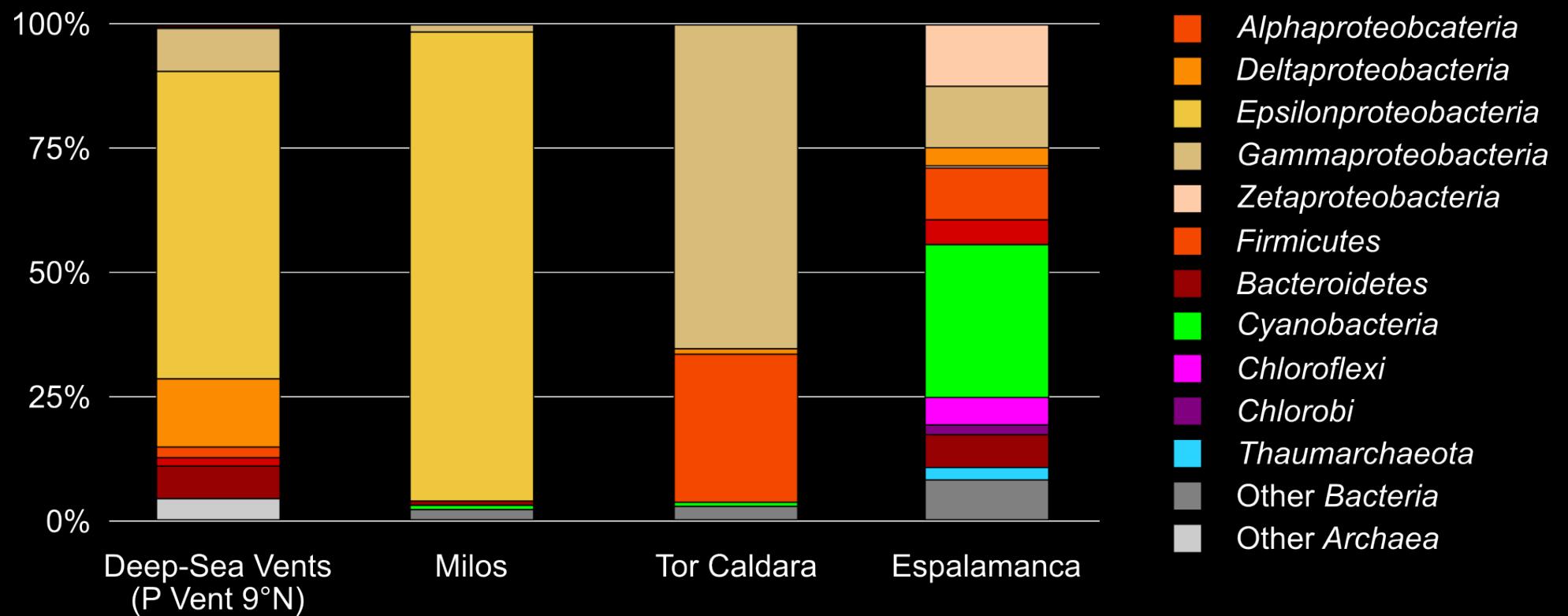


credit: Vetriani (Rutgers U)

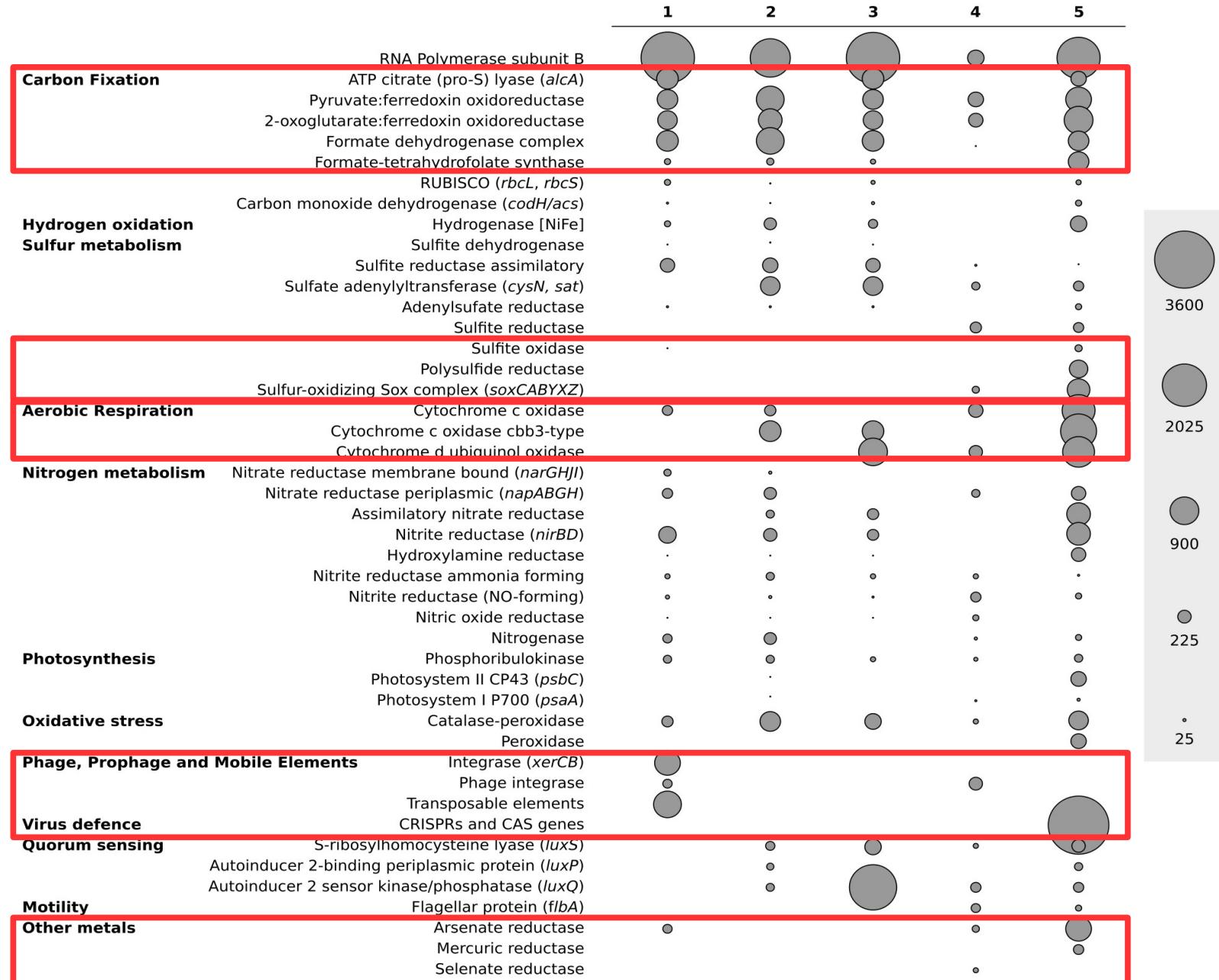


credits: Jorge Fontes

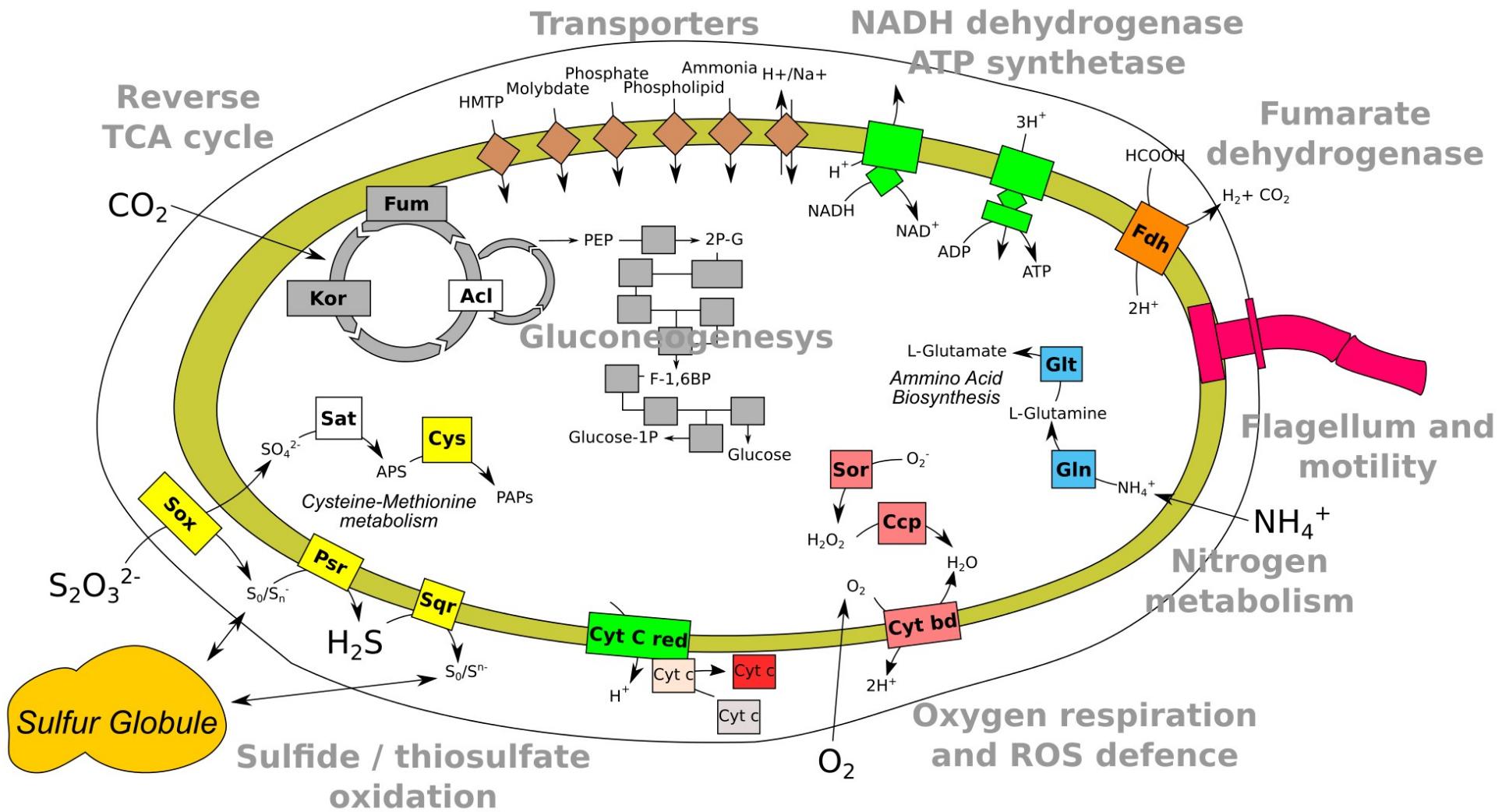
Community composition



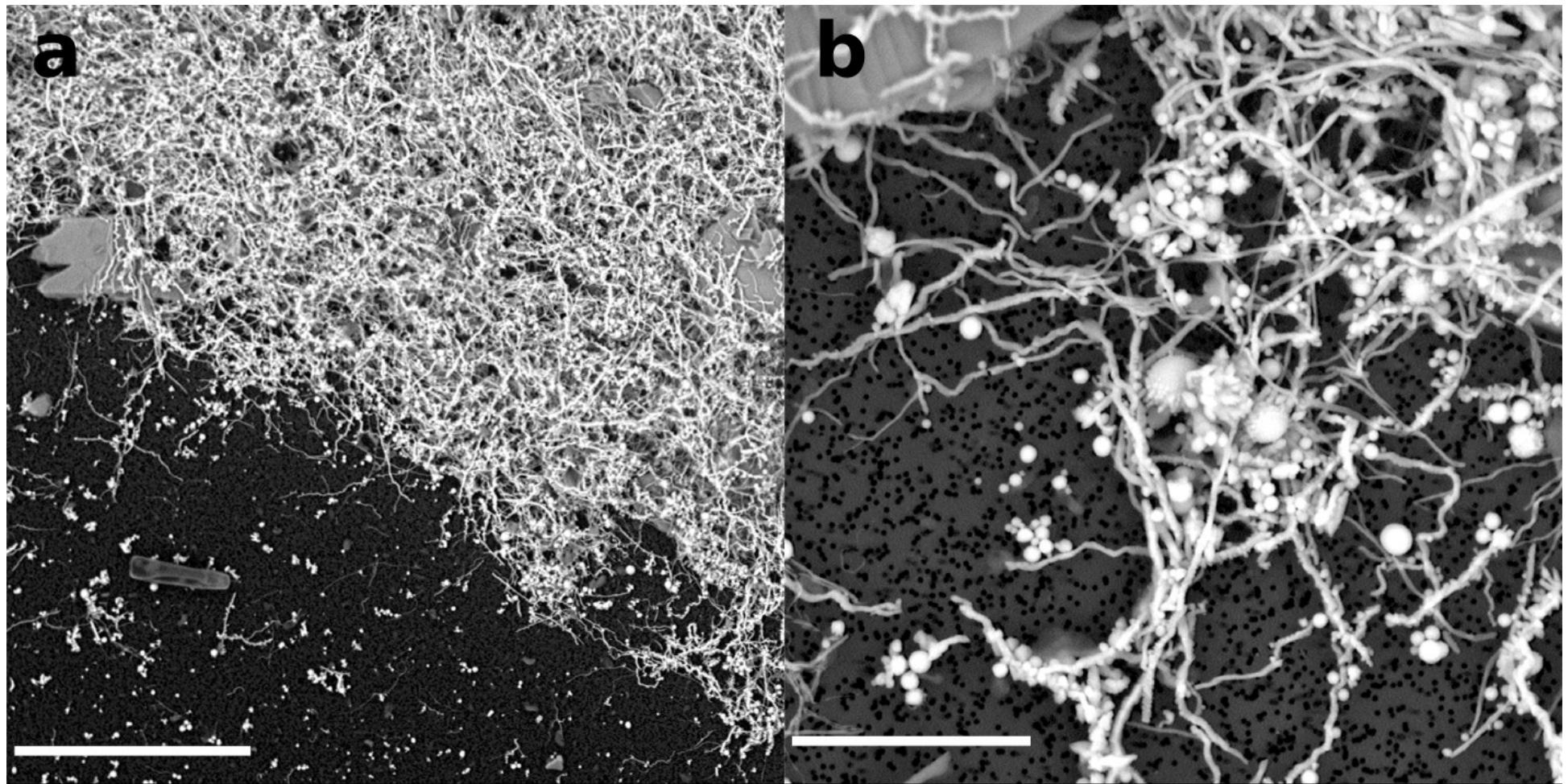
Metabolic potential



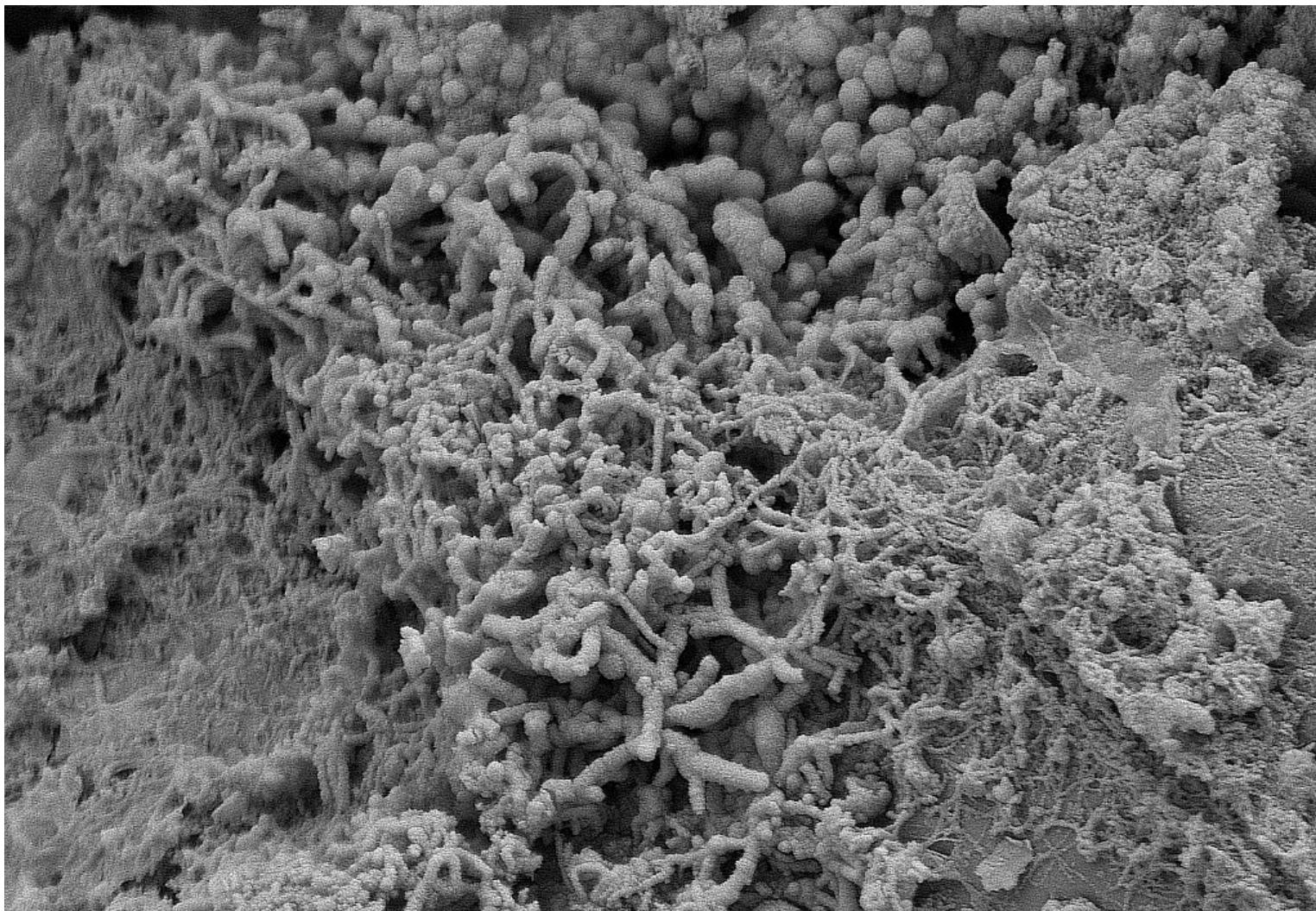
“Candidatus Thioarachnea milensis”



SEM micrographs Milos white mats



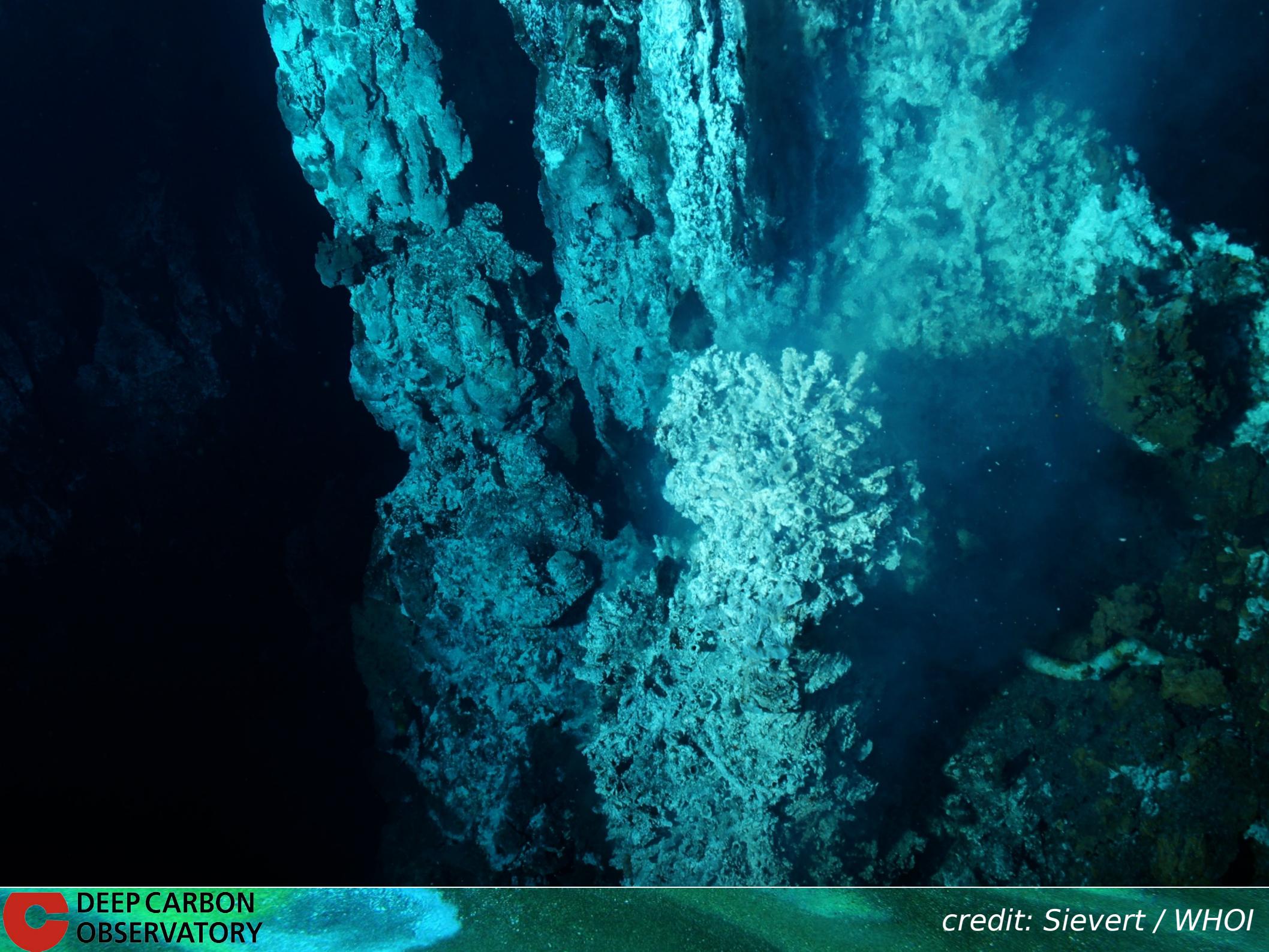
SEM micrographs Espalamanca mats



200 nm
H

Mag = 30.00 K X Width = 10.02 µm WD = 5.9 mm Signal A = SE2 EHT = 5.00 kV Date : 4 May 2016

*How diverse are microbial community
across the wide range of different shallow
vent environments?*





DEEP CARBON
OBSERVATORY



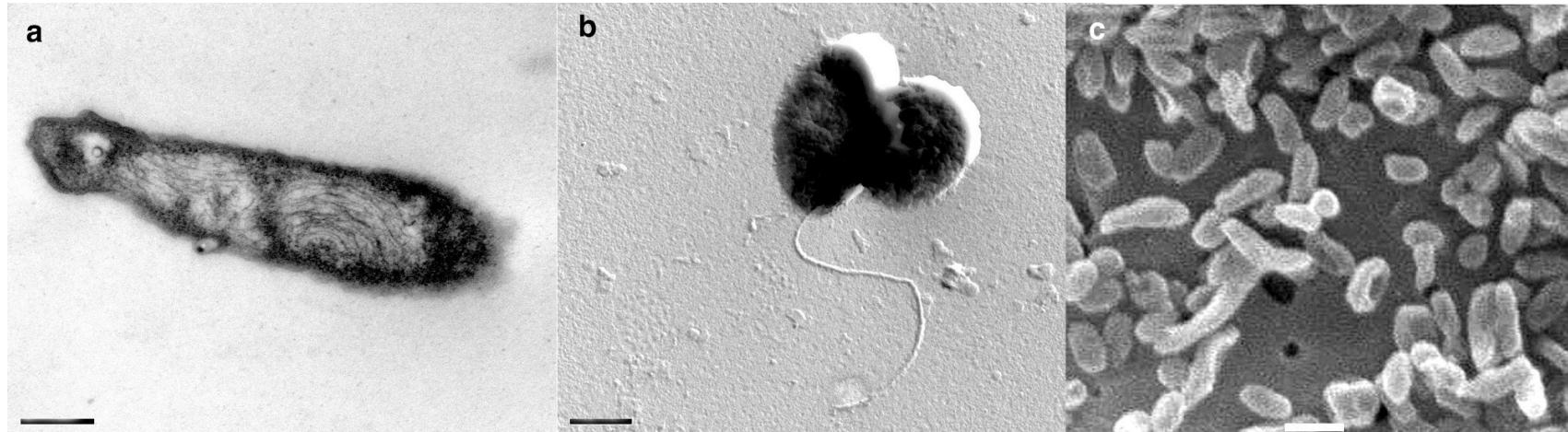
credit: Giovannelli and Vetriani

Isolate Diversity

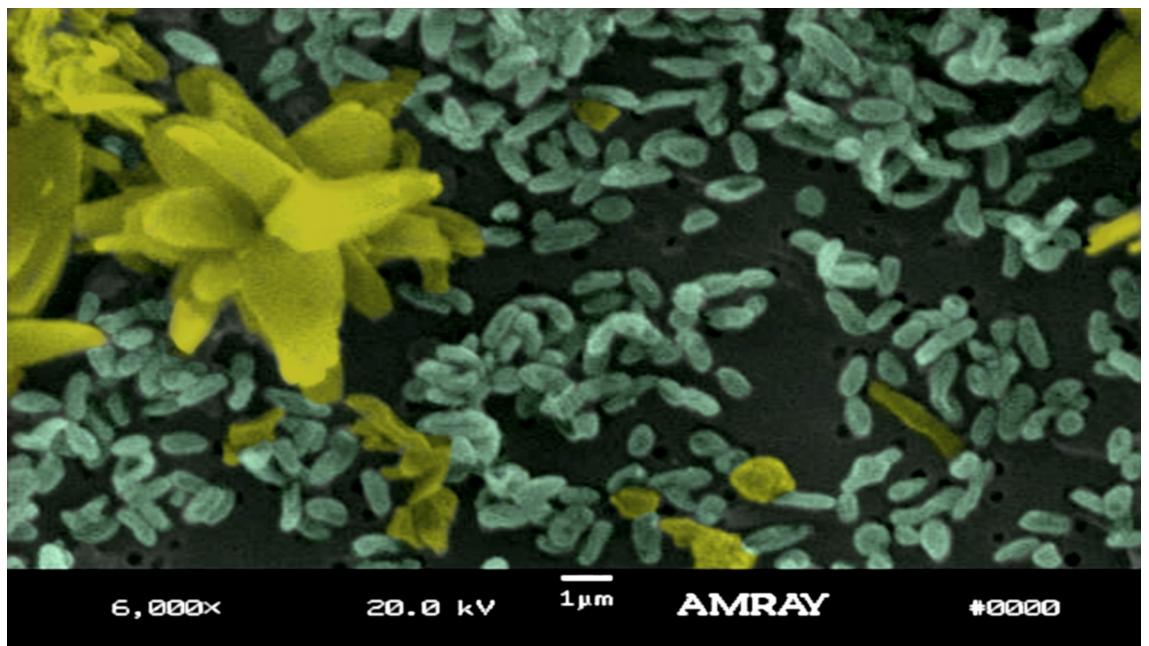
Table 2. Characteristics of chemolithoautotrophic prokaryotes isolated as pure cultures from shallow-water hydrothermal vents.

| Species | Phylum | Isolation Site | Optimum Temp (°C) | Electron Donor(s) | Electron Acceptor(s) | Carbon Source | Reference |
|---|----------------------|---|-------------------|--------------------------|---|----------------------------------|-------------------------------------|
| Archaea | | | | | | | |
| <i>Acidianus infernus</i> | <i>Crenarchaeota</i> | Campi Flegrei and Vulcano Island, Italy | 90 | S ⁰ | S ⁰ , O ₂ | CO ₂ , organic carbon | Segerer et al., 1986 |
| <i>Ignicoccus hospitalis</i> | <i>Crenarchaeota</i> | Kolbeinsey Ridge, Iceland | 90 | H ₂ | S ⁰ | CO ₂ | Jahn et al., 2007 |
| <i>Ignicoccus islandicus</i> | <i>Crenarchaeota</i> | Kolbeinsey Ridge, Iceland | 90 | H ₂ | S ⁰ | CO ₂ | Huber et al., 2000 |
| <i>Archaeoglobus fulgidus</i> | <i>Euryarchaeota</i> | Vulcano island and Stufe di Nerone, Italy | 83 | H ₂ | SO ₄ ²⁻ , SO ₃ ²⁻ , S ₂ O ₃ ²⁻ | CO ₂ , organic carbon | Stetter et al., 1987; Stetter, 1988 |
| <i>Ferroglobus placidus</i> | <i>Euryarchaeota</i> | Vulcano Island, Italy | 80 | Fe ²⁺ | NO ₃ ⁻ | CO ₂ | Hafenbradl et al., 1996 |
| <i>Methanococcus aeolicus</i> | <i>Euryarchaeota</i> | Lipari Islands, Italy | 37 | H ₂ , formate | methanogen | CO ₂ | Kendall et al., 2006 |
| <i>Methanococcus thermolithotrophicus</i> | <i>Euryarchaeota</i> | Naples, Italy | 65 | H ₂ | methanogen | CO ₂ | Huber et al., 1982 |
| <i>Methanopyrus kandleri</i> | <i>Euryarchaeota</i> | Kolbeinsey ridge, Iceland | 98 | H ₂ | methanogen | CO ₂ | Kurr et al., 1991 |
| <i>Methanotorris</i> <i>(Methanococcus) igneus</i> | <i>Euryarchaeota</i> | Kolbeinsey ridge, Iceland | 88 | H ₂ | methanogen | CO ₂ | Burggraf et al., 1990 |
| Bacteria | | | | | | | |
| <i>Aquifex aeolicus</i> § | <i>Aquificae</i> | Vulcano Island, Italy | 95 | H ₂ | O ₂ | CO ₂ | Huber and Stetter, 1992 |
| <i>Aquifex pyrophilus</i> | <i>Aquificae</i> | Kolbeinsey ridge, Iceland | 95 | H ₂ | O ₂ | CO ₂ | Huber et al., 1992 |
| <i>Hydrogenivirga calditoris</i> | <i>Aquificae</i> | Ibusuki, Japan | 75 | S ⁰ | O ₂ | CO ₂ | Nakagawa et al., 2004 |
| <i>Hydrogenobacter</i> | | | | | | | |

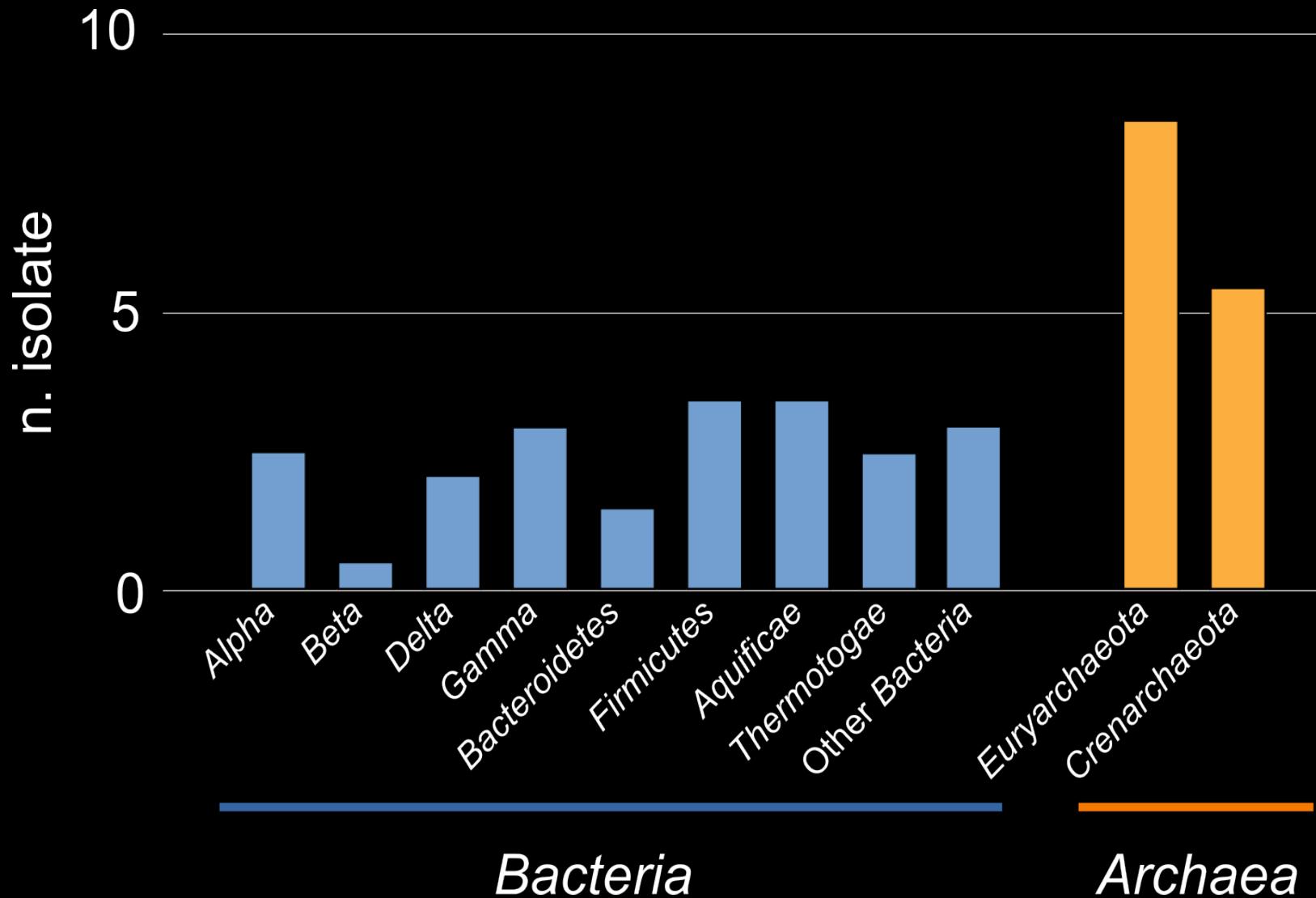
Galenea microaerophila P2D^T gen. nov. sp. nov.



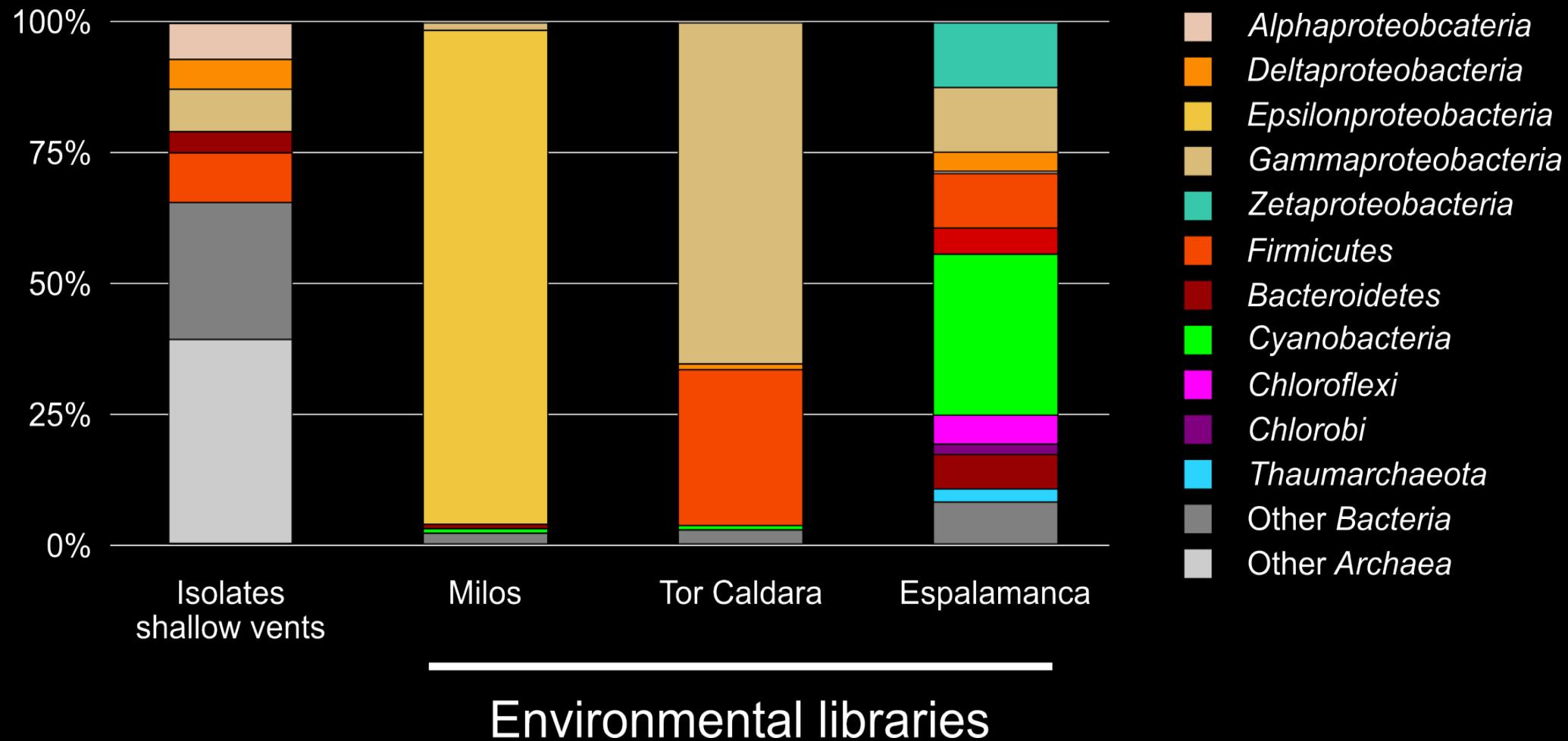
- *Gammaproteobacteria*
- Mesophilic
- Chemolithoautotroph
- Thiosulfate oxidizer
- Microaerophile



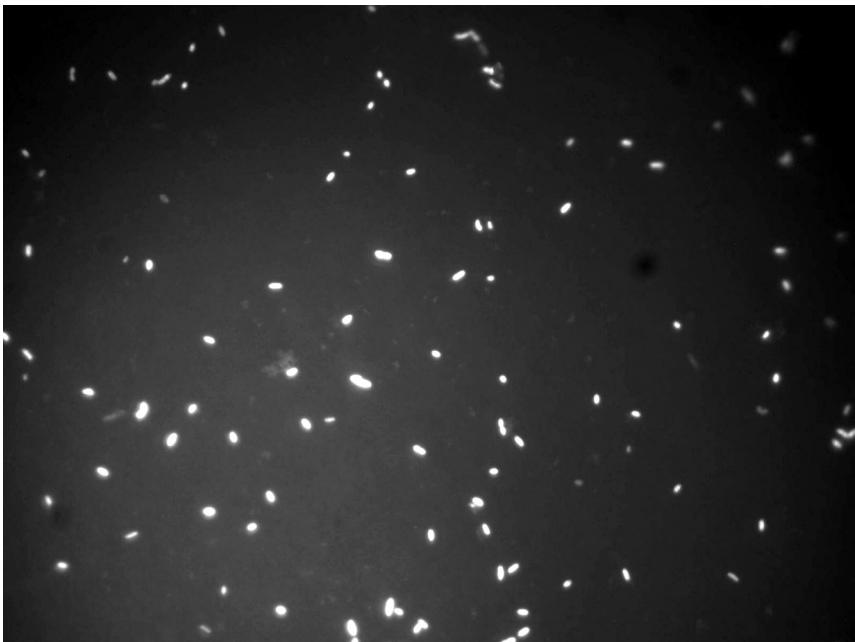
Isolate Diversity



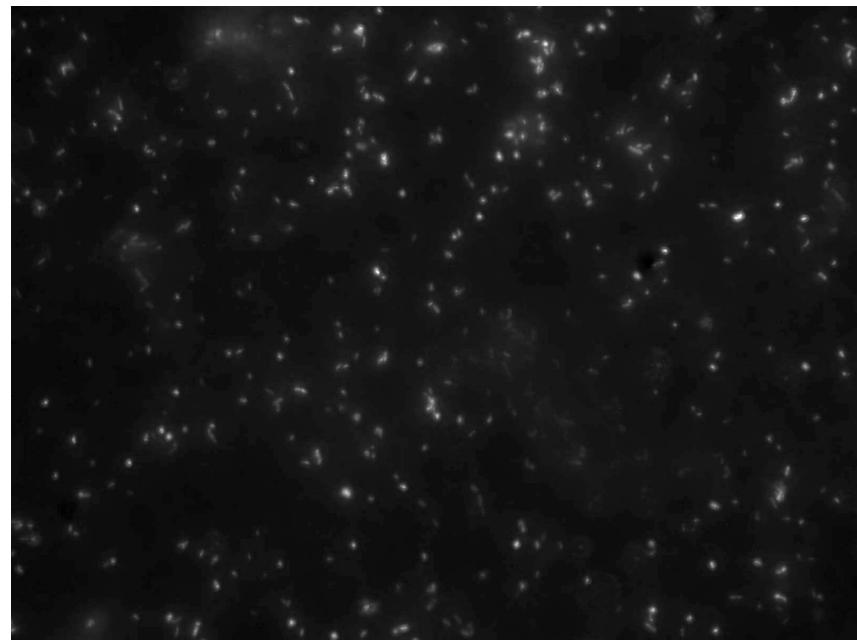
Isolate Diversity



Epsilonproteobacteria enrichments



***Epsilonproteobacteria* strain MB-1A**
Milos enrichment
CO₂ + thiosulfate + nitrate, 35°C
av. similarity to *Arcobacter defluvii* 95%



***Epsilonproteobacteria* strain TC-3**
Tor Caldara enrichment
CO₂ + thiosulfate + nitrate, 30°C
av. similarity to *Sulfurimonas autotrophica* 93%

We really need ecologically relevant isolates from shallow-water vents. Can we devise new ways to coerce these microbes into the confined space of our lab to be able to peak into microbial dark matter in a new way?

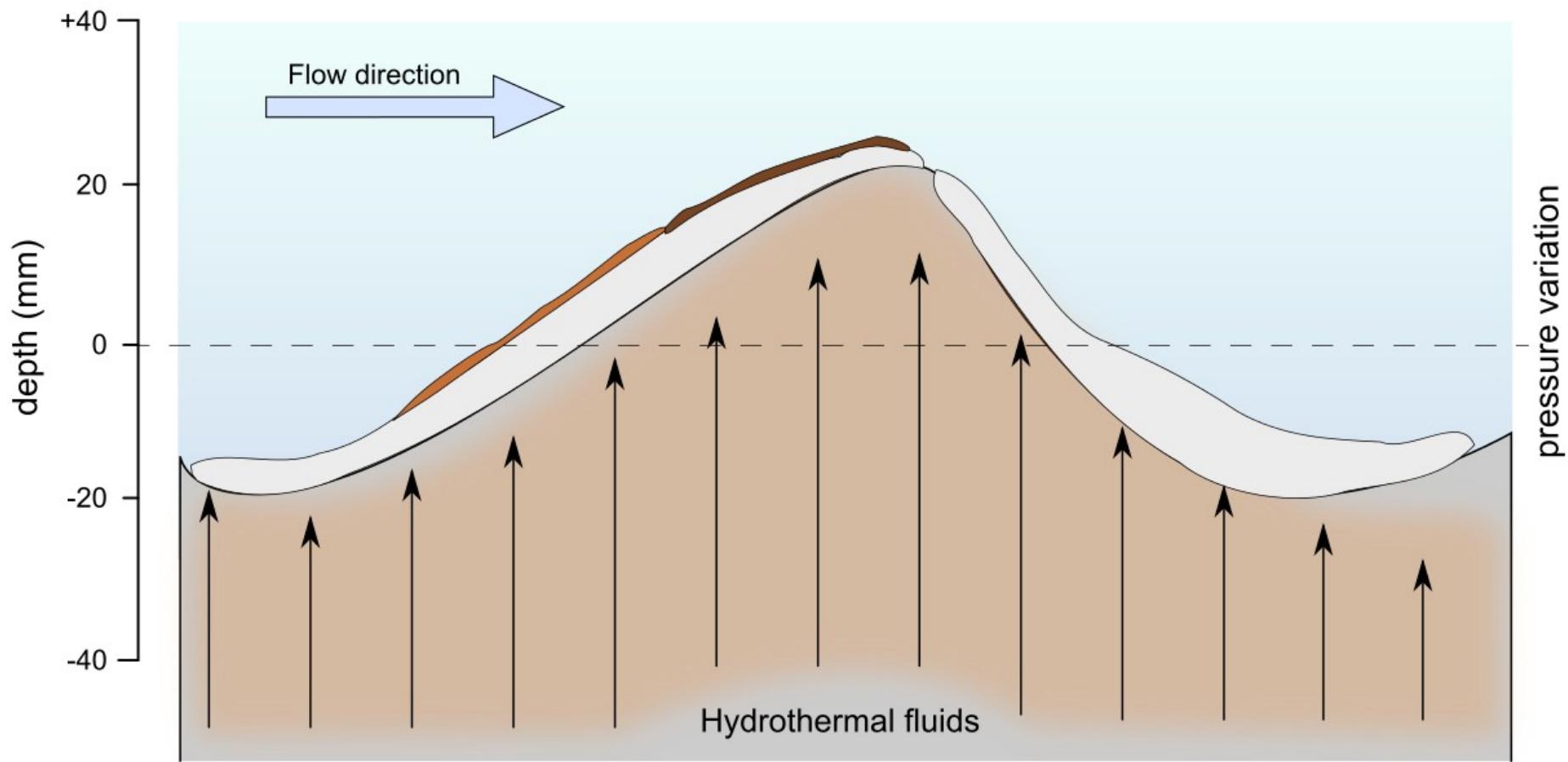




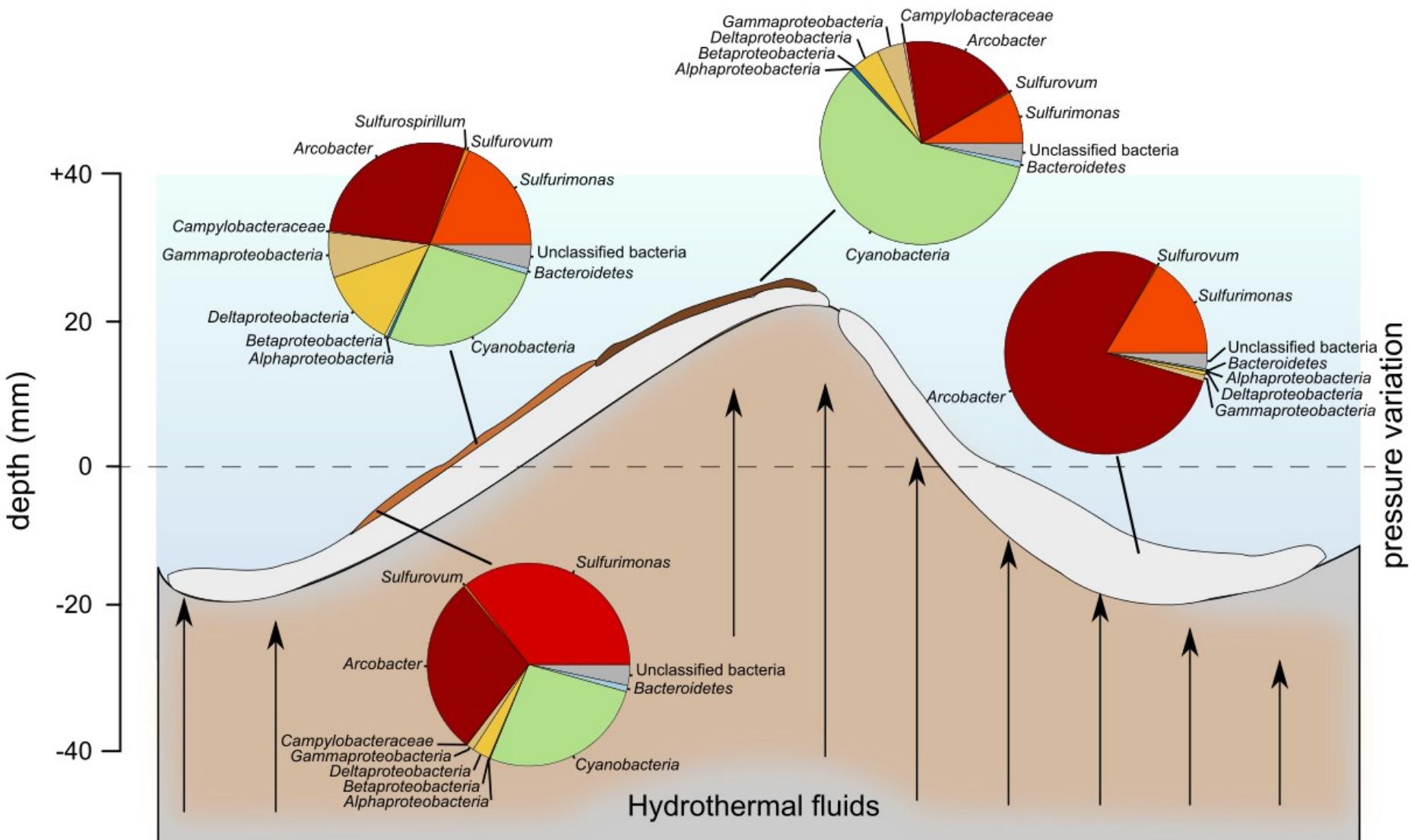
SeaBioTech (KBBE.2012.3.2-01, 311932)



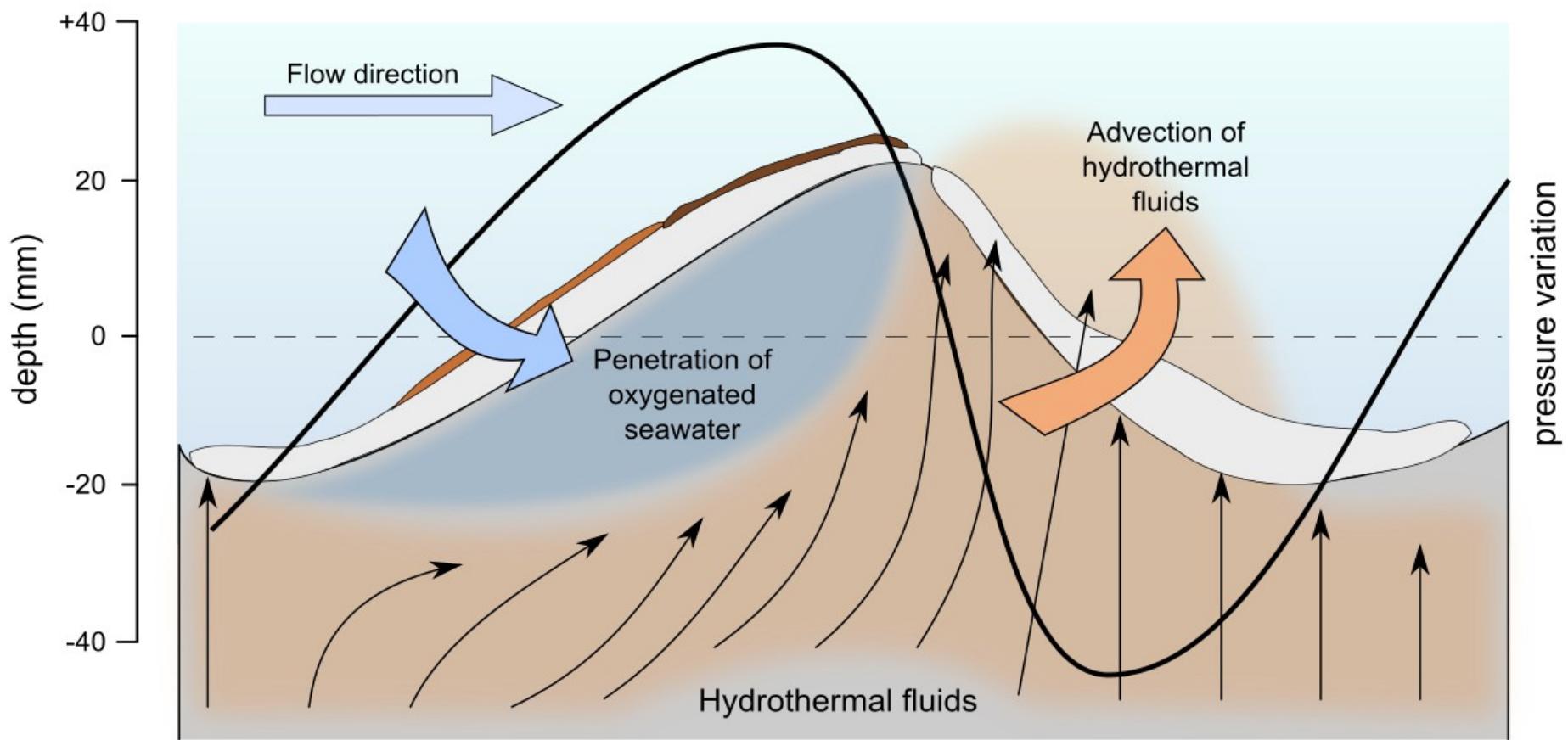
Small scale distribution

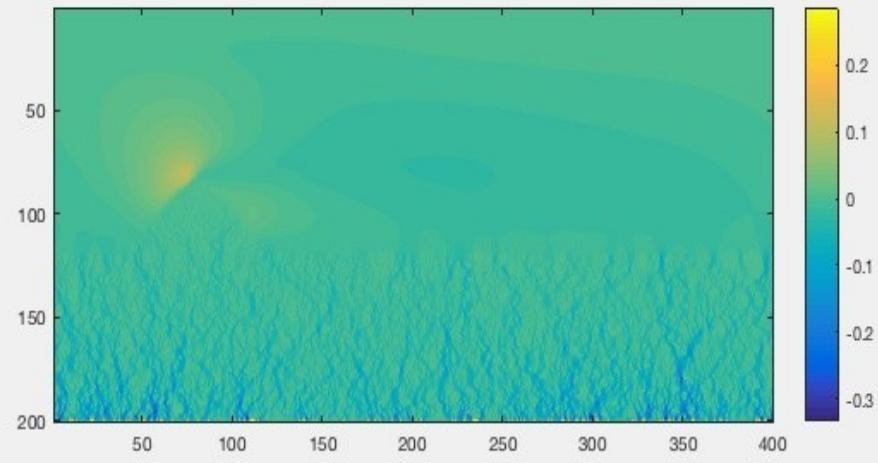
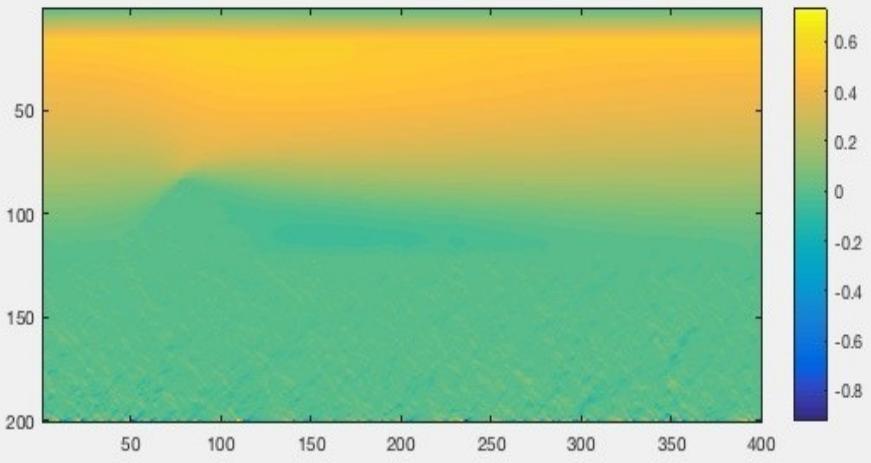
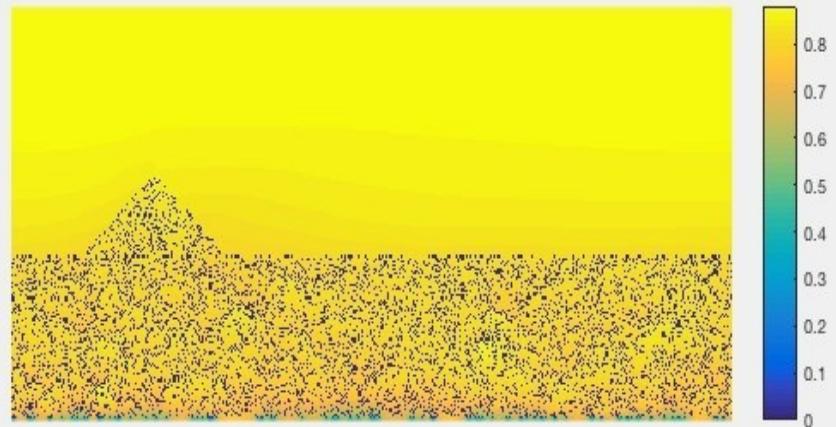
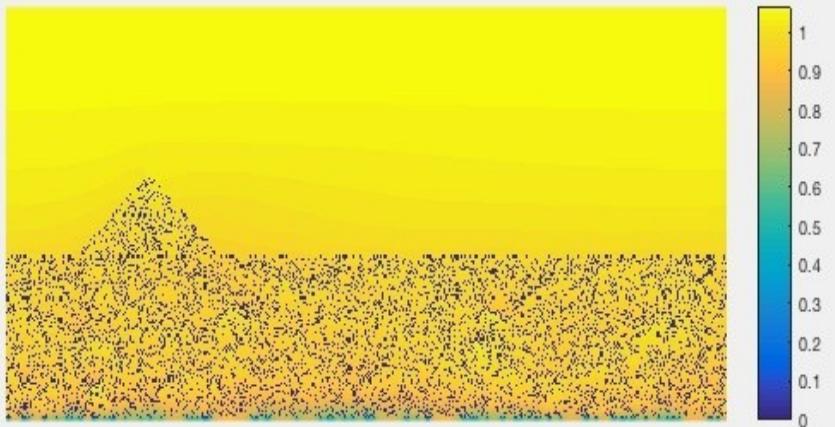


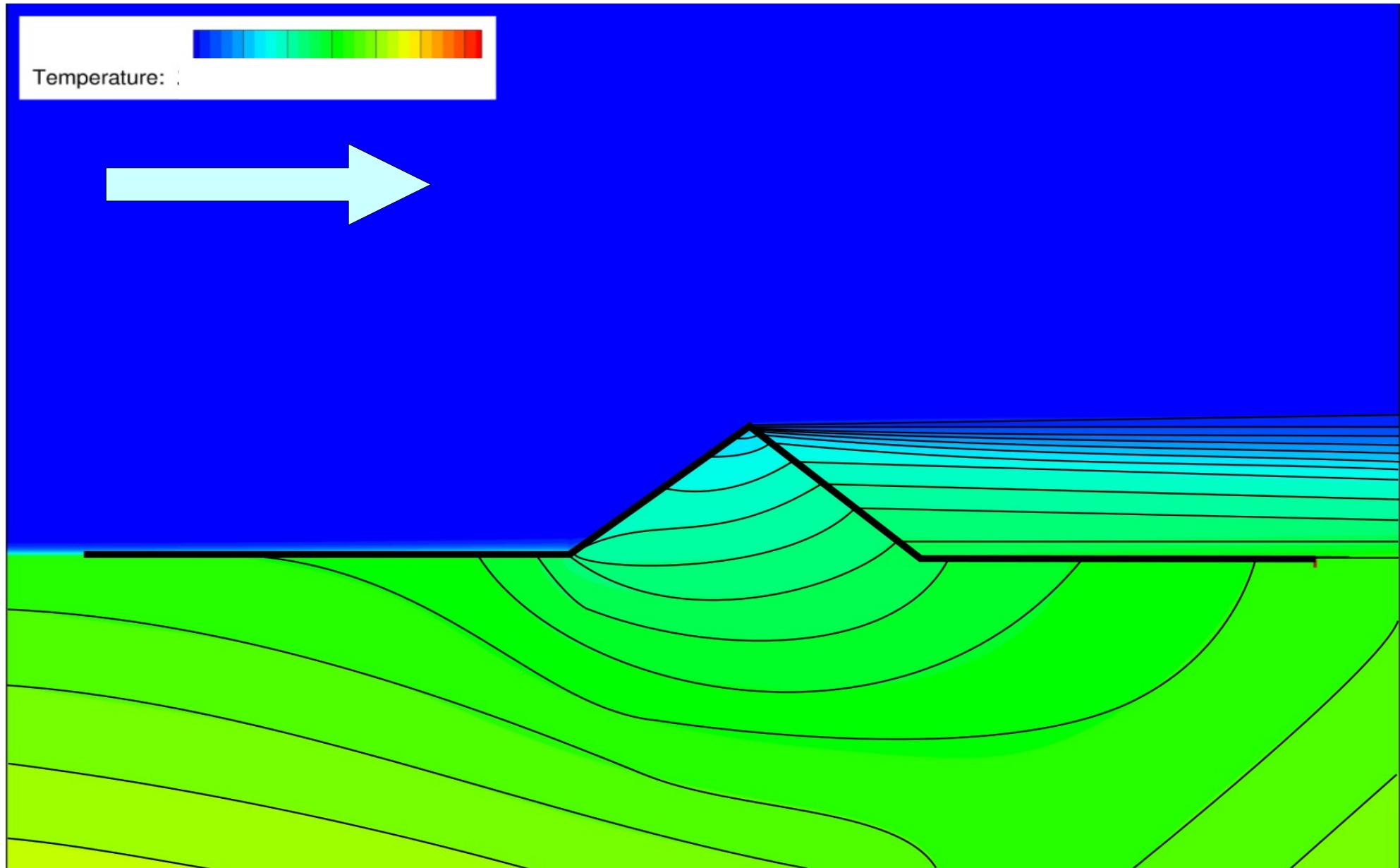
Small scale distribution



Small scale distribution

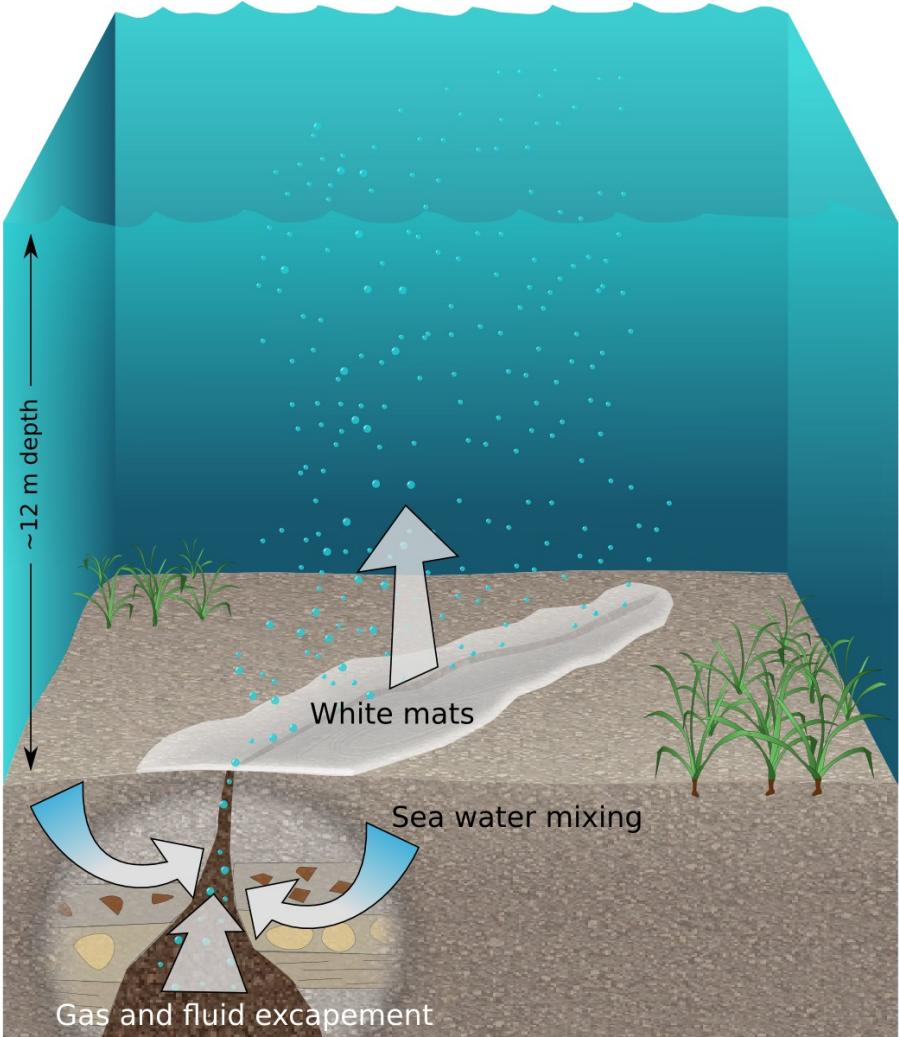




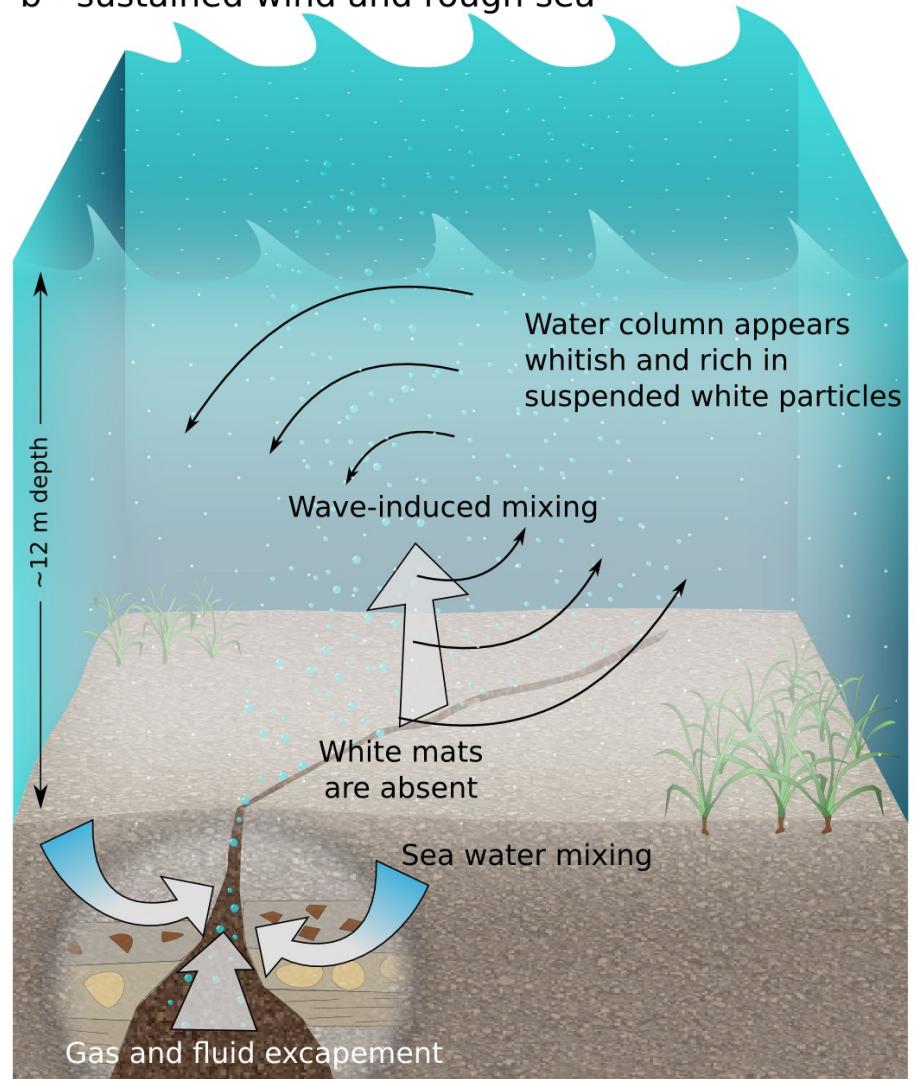


Milos shallow-water vents

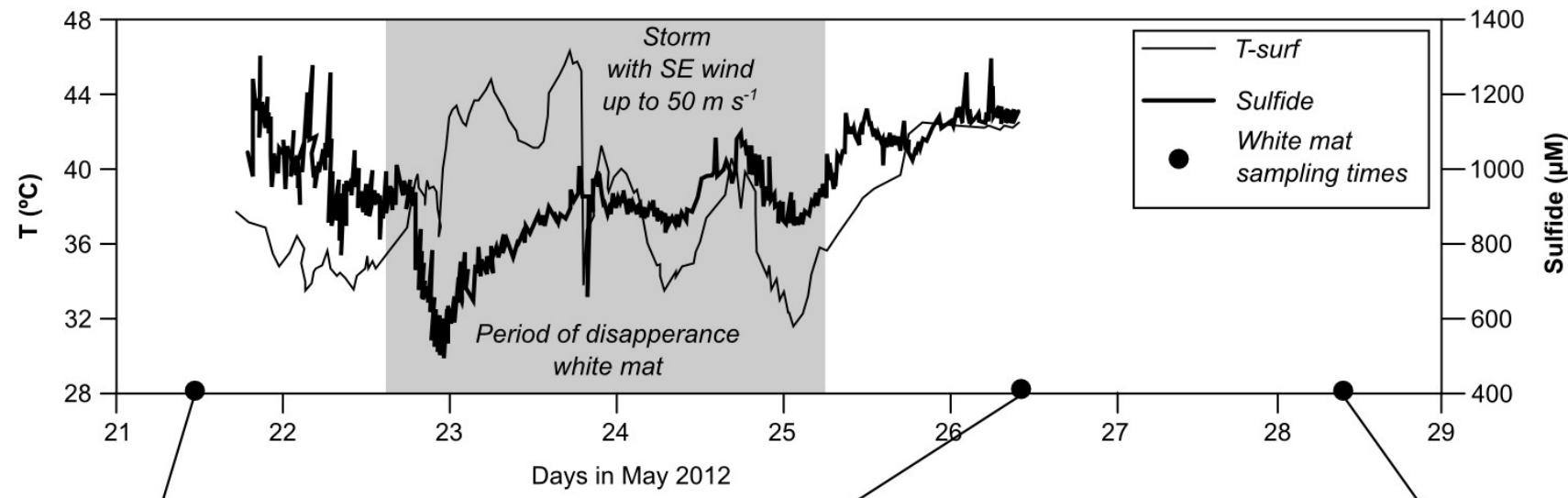
a - light wind and calm sea



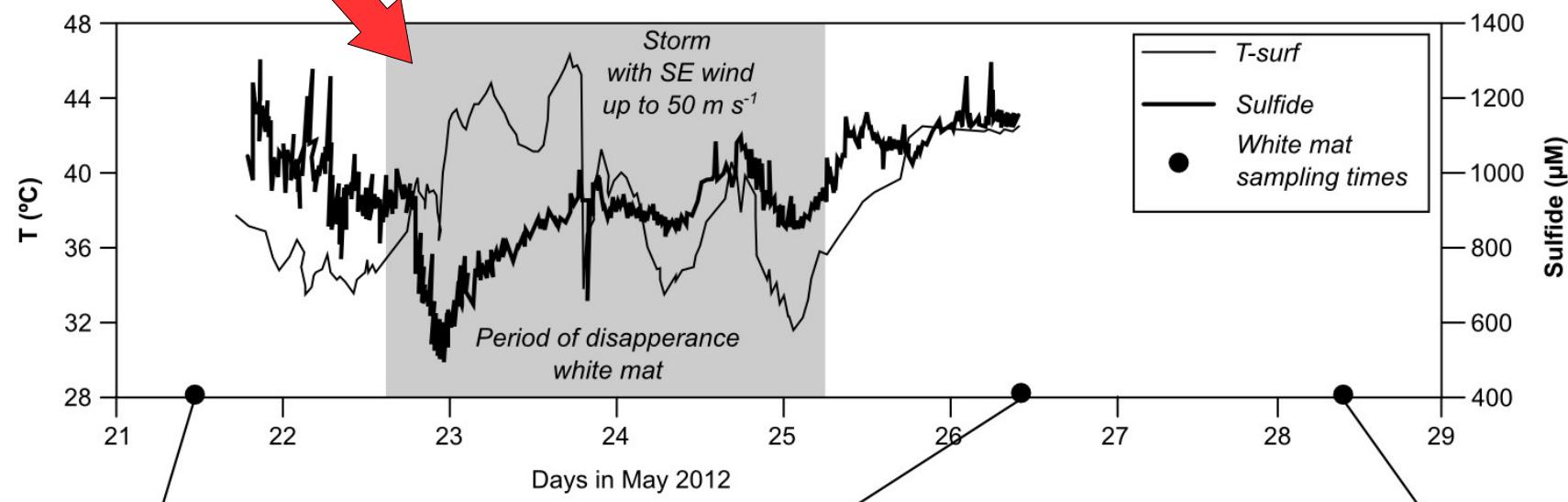
b - sustained wind and rough sea



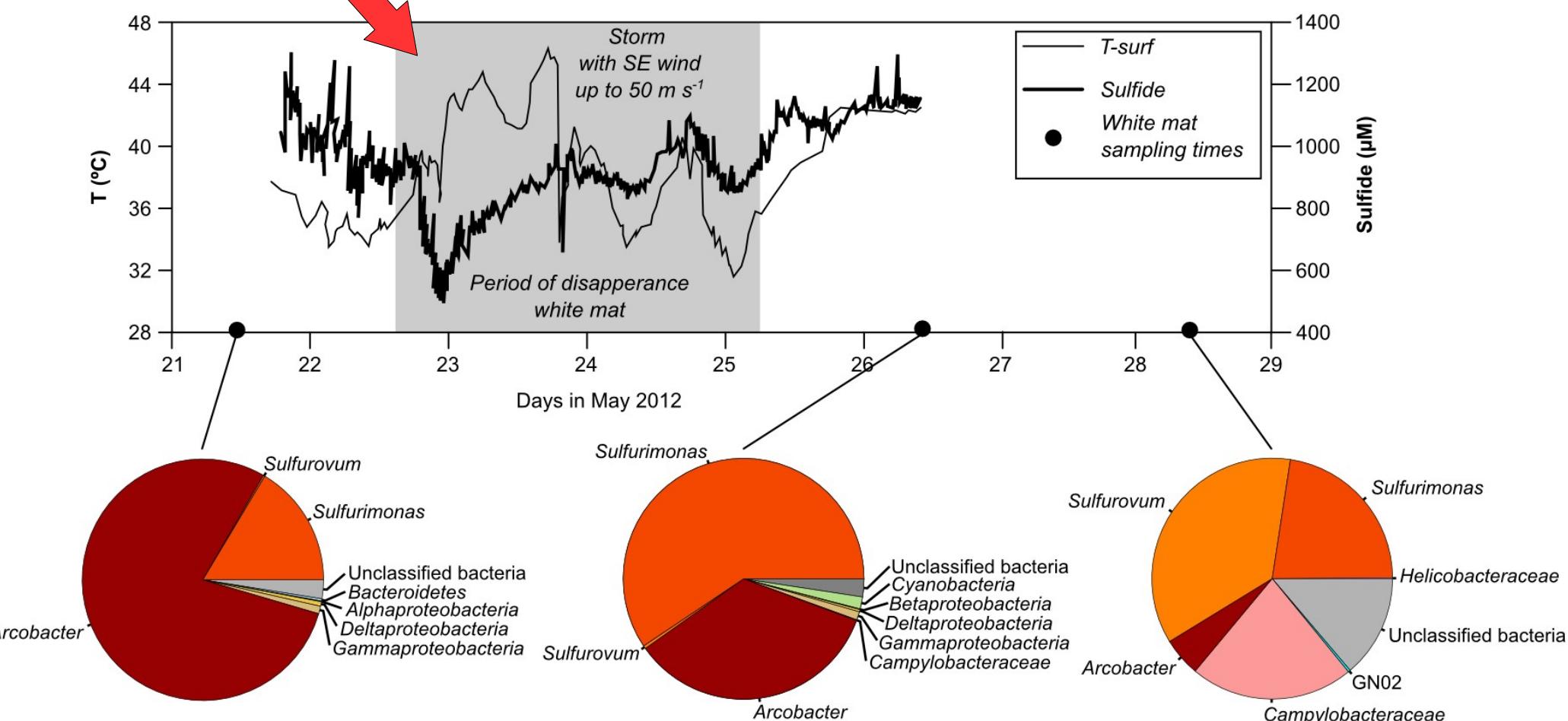
Temporal variability



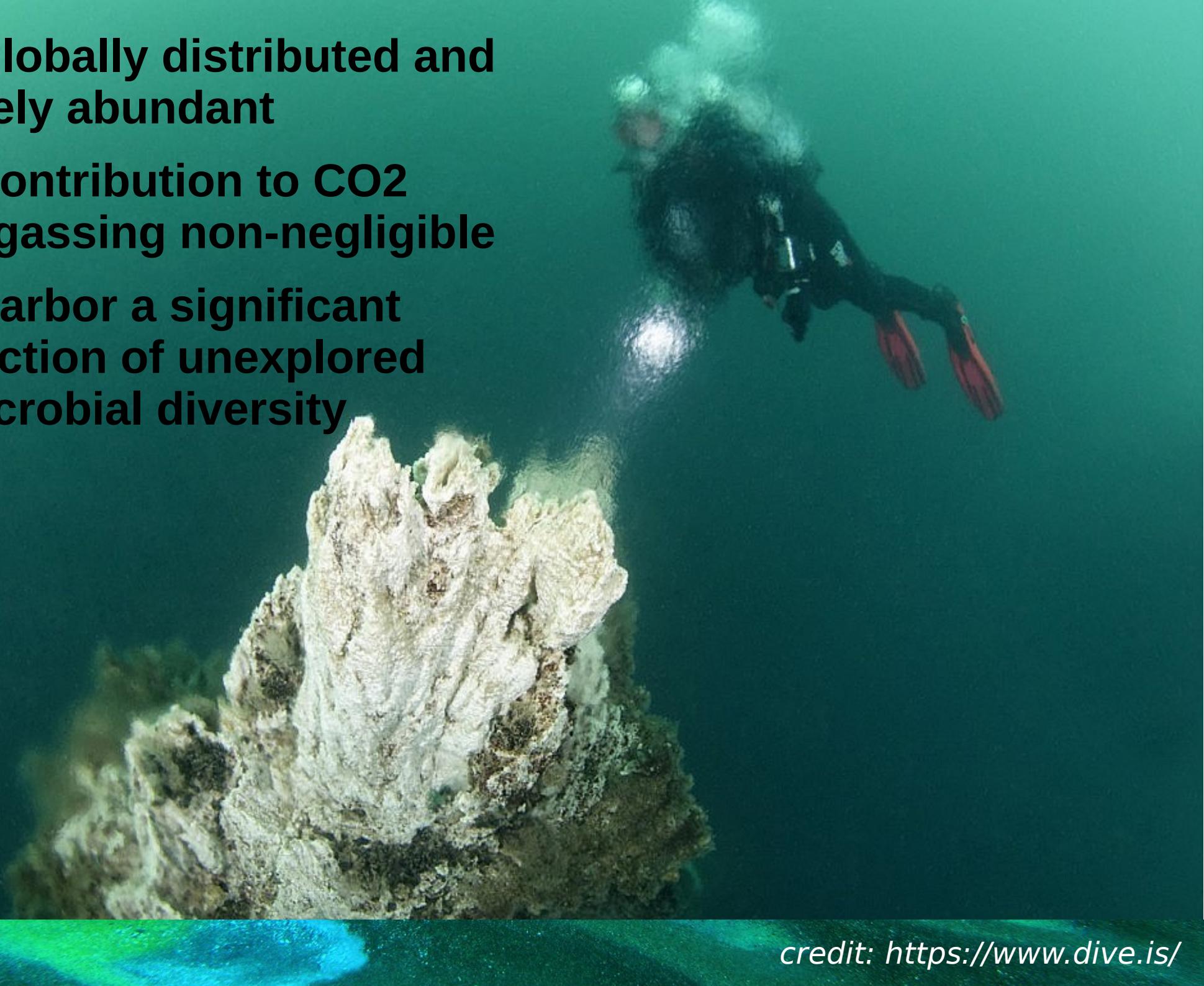
Temporal variability



Temporal variability



- Globally distributed and likely abundant
- Contribution to CO₂ degassing non-negligible
- Harbor a significant fraction of unexplored microbial diversity



credit: <https://www.dive.is/>

Readings

Price, R. E., and Giovannelli, D. (2017). "A Review of the Geochemistry and Microbiology of Marine Shallow-Water Hydrothermal Vents," in Reference Module in Earth Systems and Environmental Sciences (Elsevier).
doi:10.1016/B978-0-12-409548-9.09523-3.