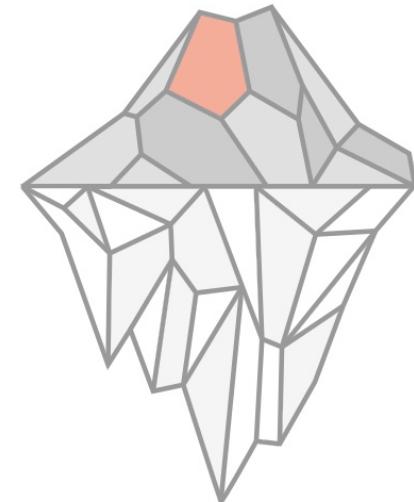


MICROBIOLOGY OF EXTREME ENVIRONMENTS



Extreme environments 3

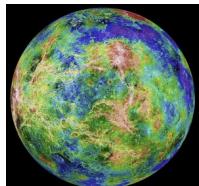
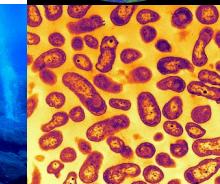
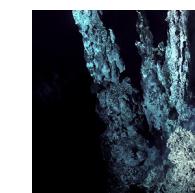
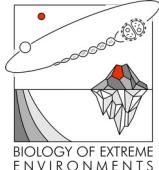
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Deep Hypersaline Anoxic Basins (DHABs)



Deep Hypersaline Anoxic Basins

Deep hypersaline anoxic basins (DHABs) brine pools/lakes of variable size occurring within fractures at the seafloor, where the dissolution of anciently buried evaporites creates dense anoxic brines

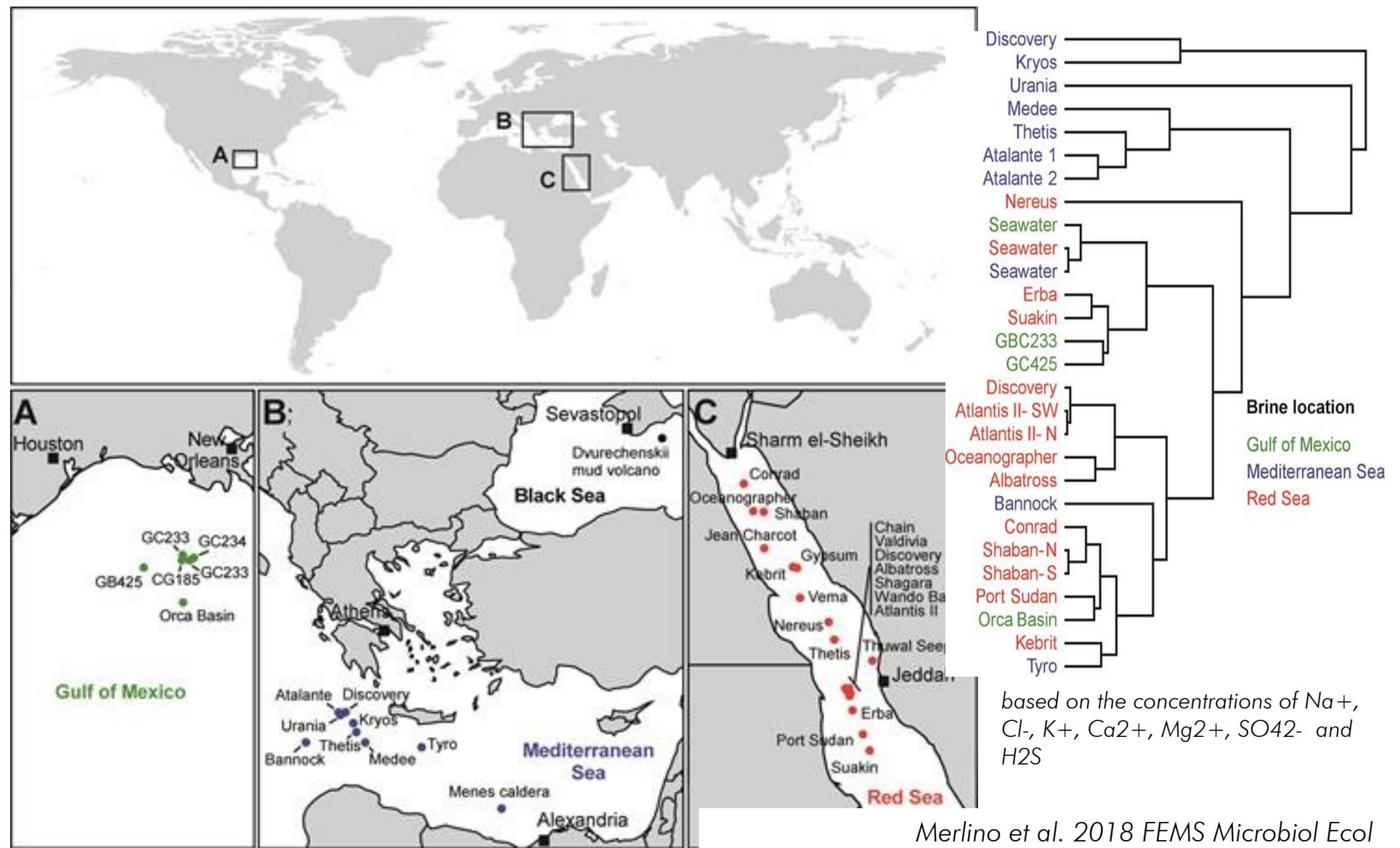
The brines are separated by the overlying water by steep chemocline/pycnocline with a variable degree of mixing. The brine has been separated from the above water column for variable length of times, up to million of years

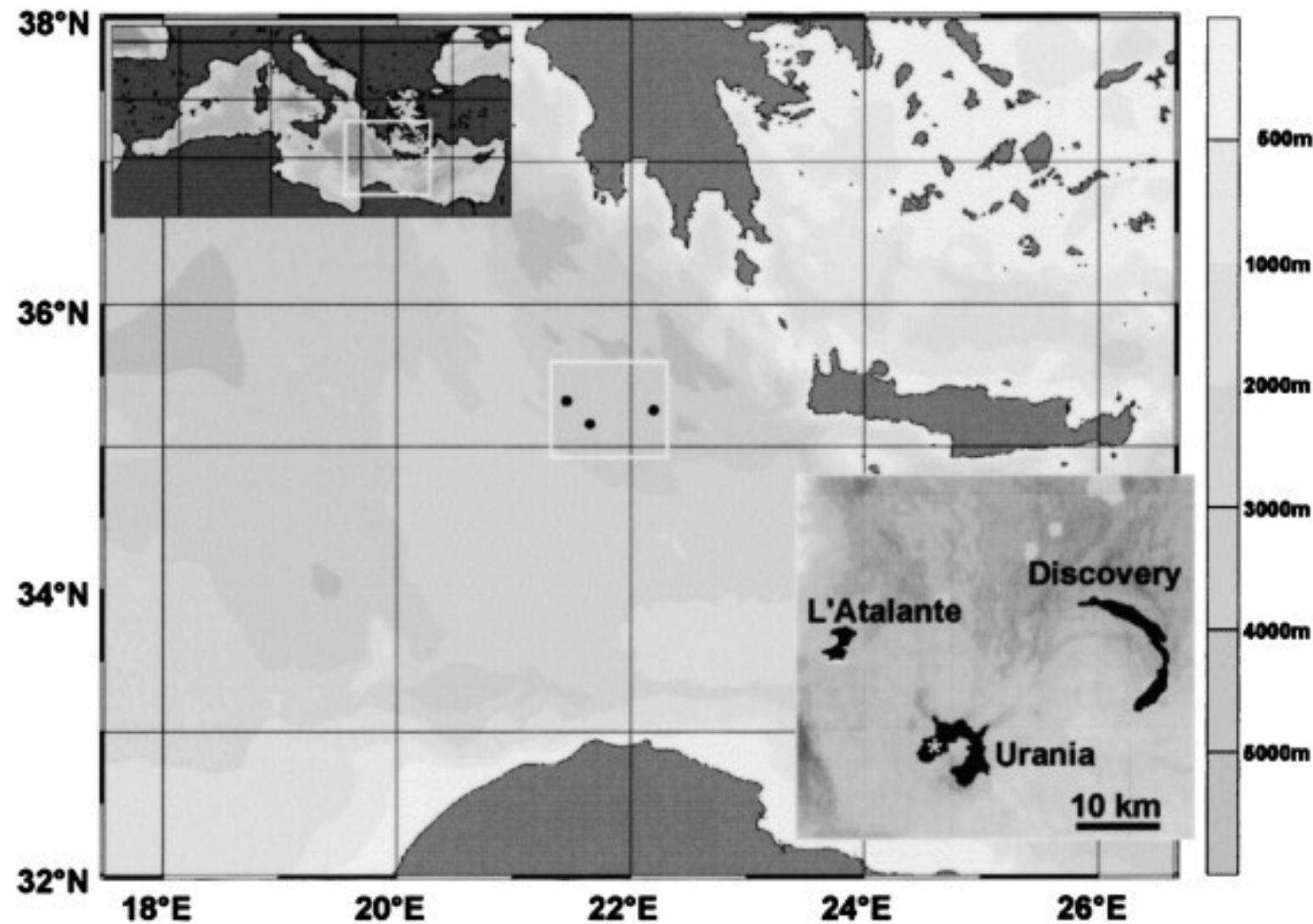
DHABs have been described in the Gulf of Mexico, the Mediterranean Sea, the Black Sea and the Red Sea, and originally discovered in the Red Sea (1964)

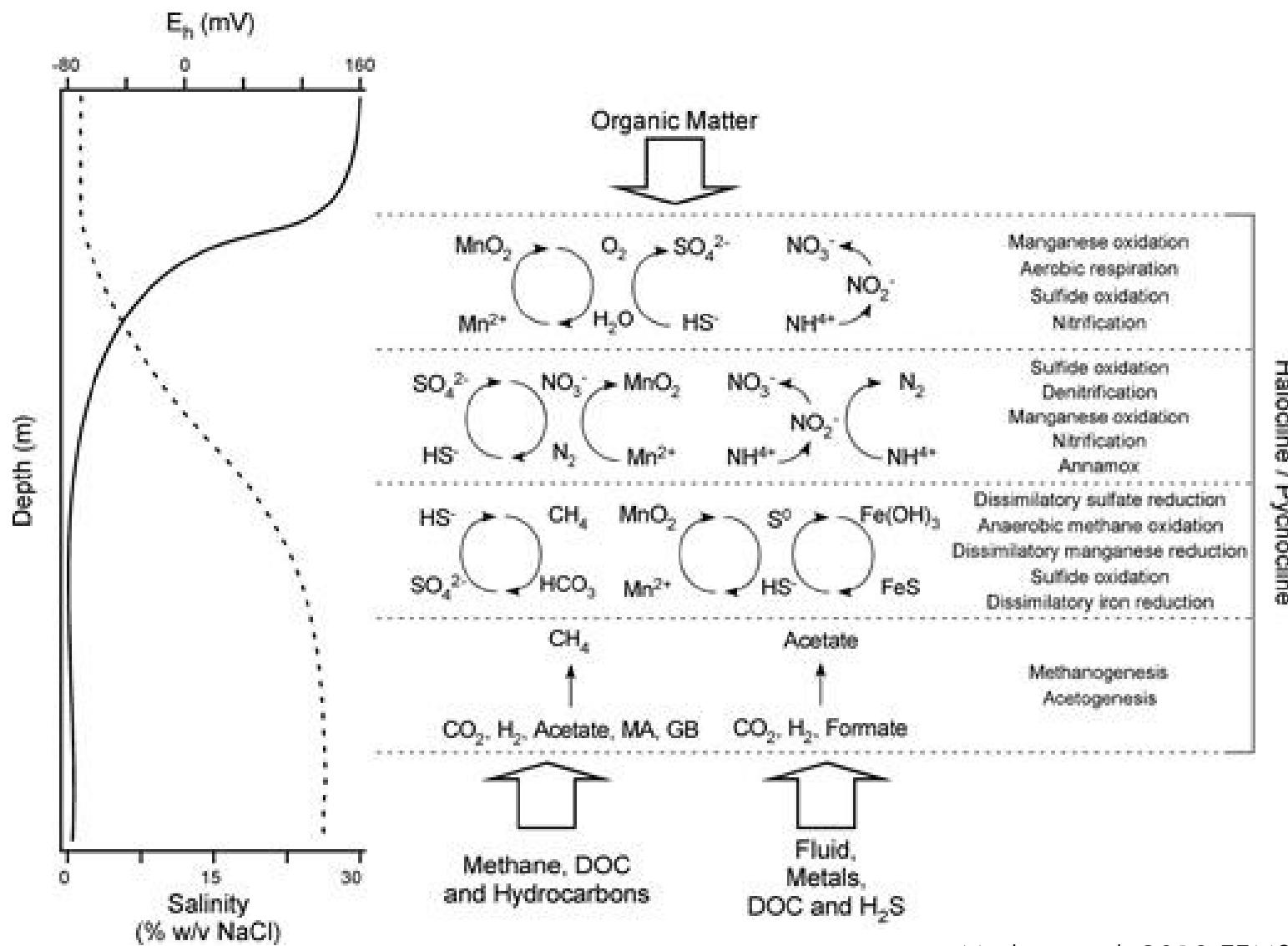
They can be classified as Thalassic (brines have the same composition of seawater) or Athalassic (brines have a non-seawater composition)

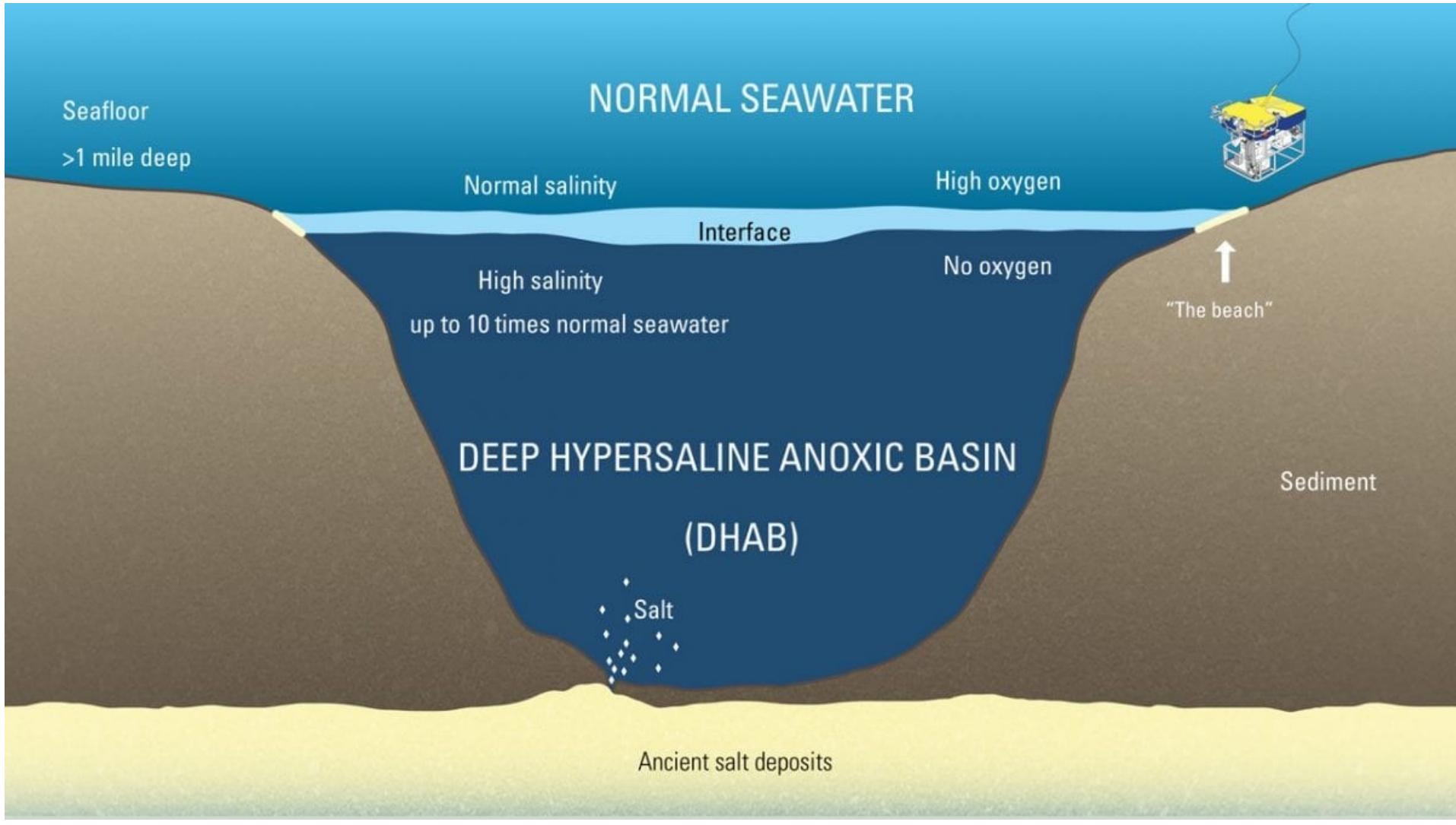
The brines (and sediments) are characterized by high salinity, toxic compounds, chaotropic salts, high hydrostatic pressures and anoxia

A chaotropic salts (CaCl_2 , MgCl_2) are salts capable of disrupting the hydrogen bonding network between water molecules, denaturing macromolecules

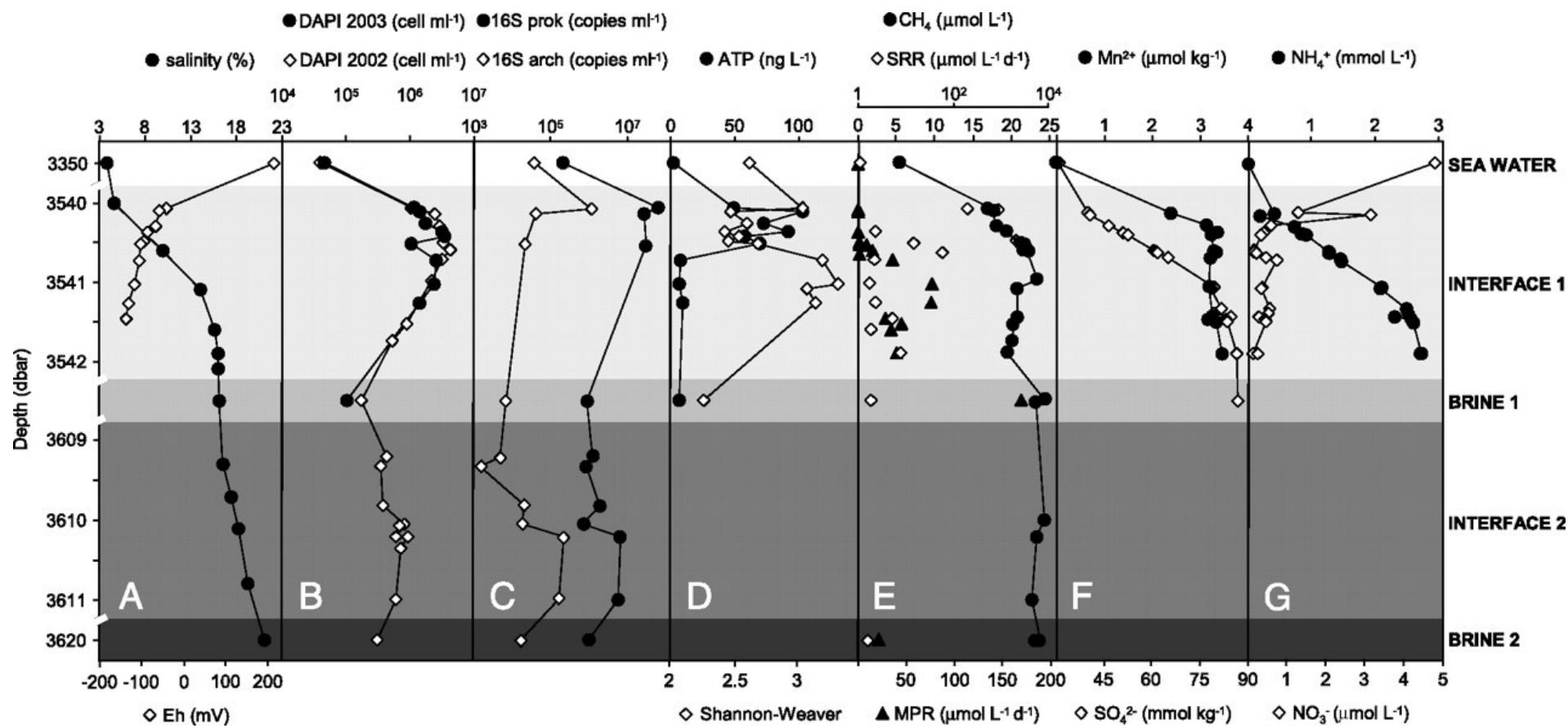


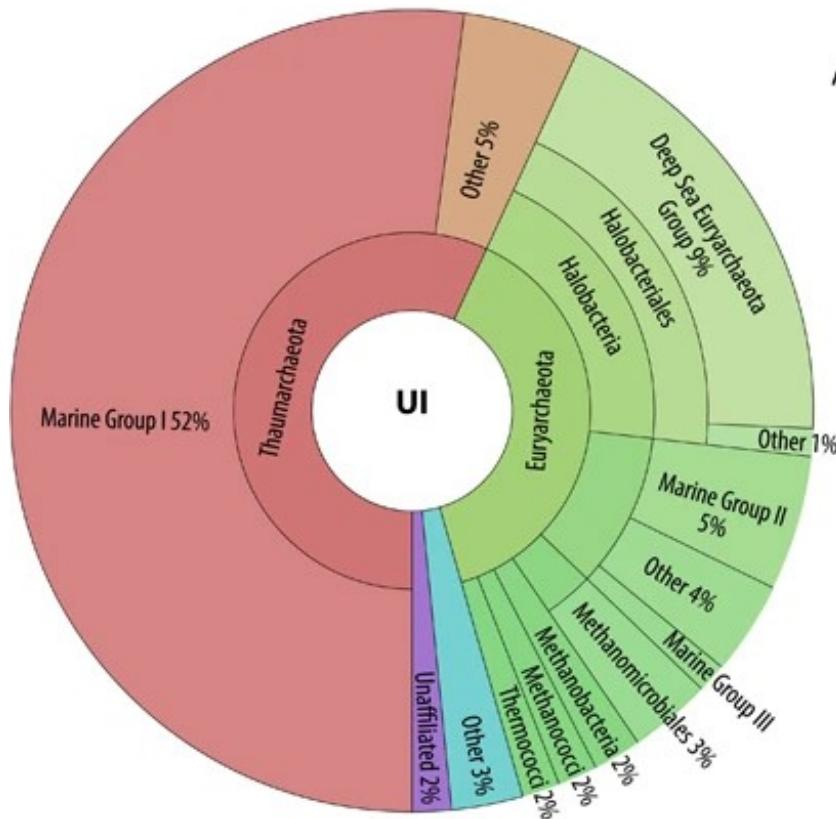




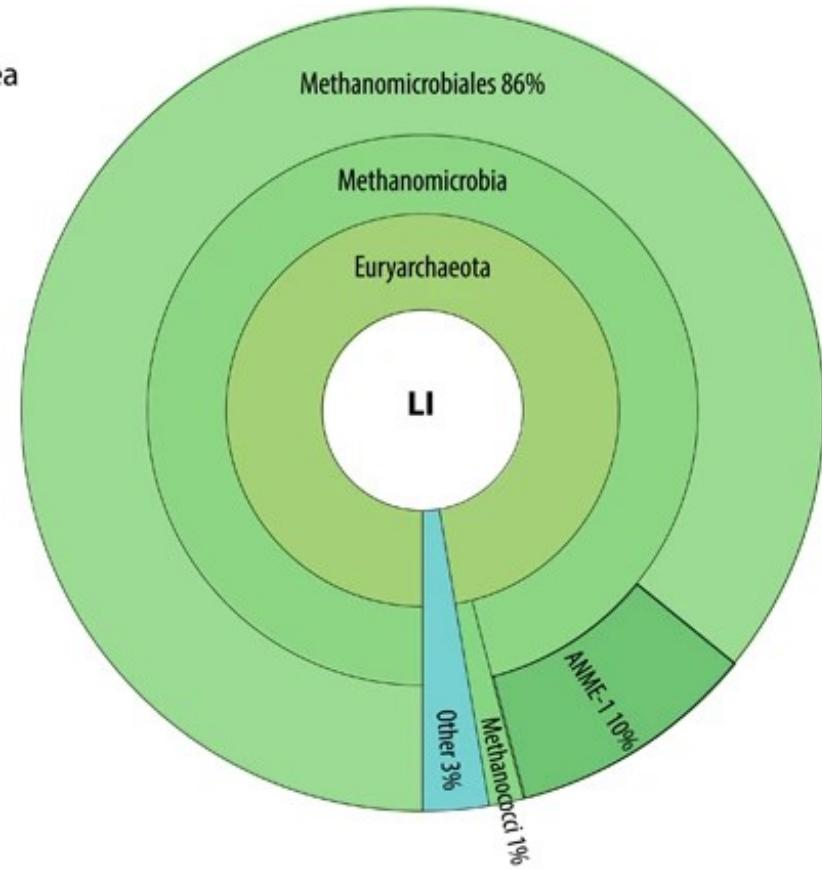


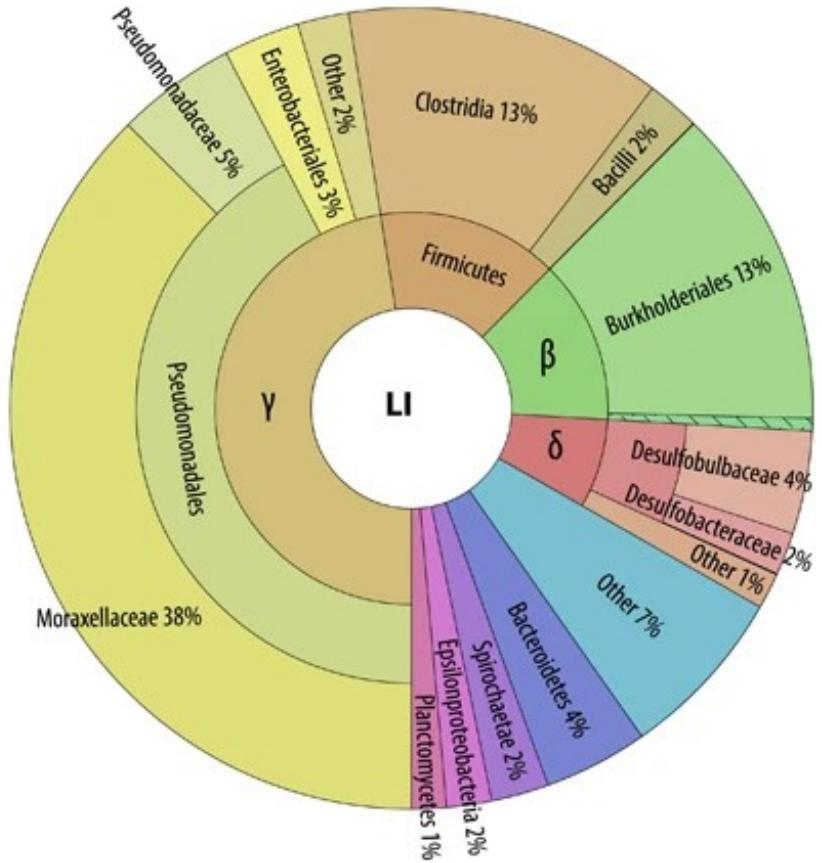
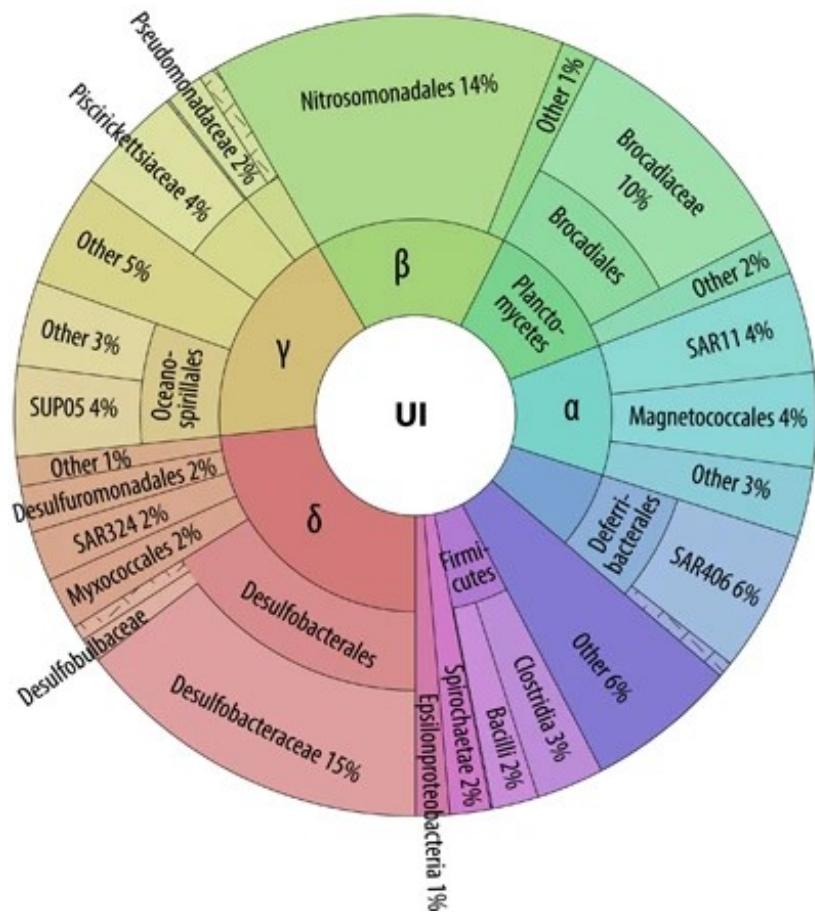






Archaea

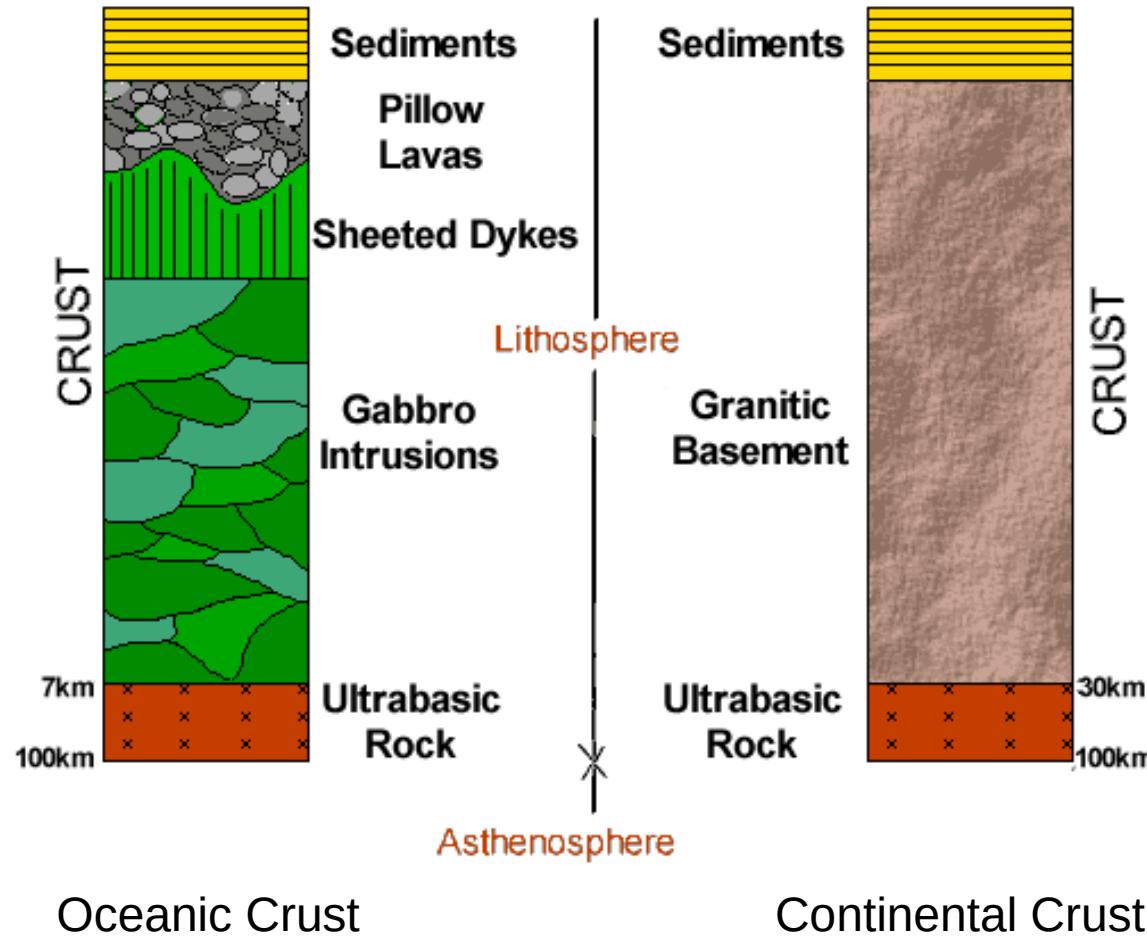


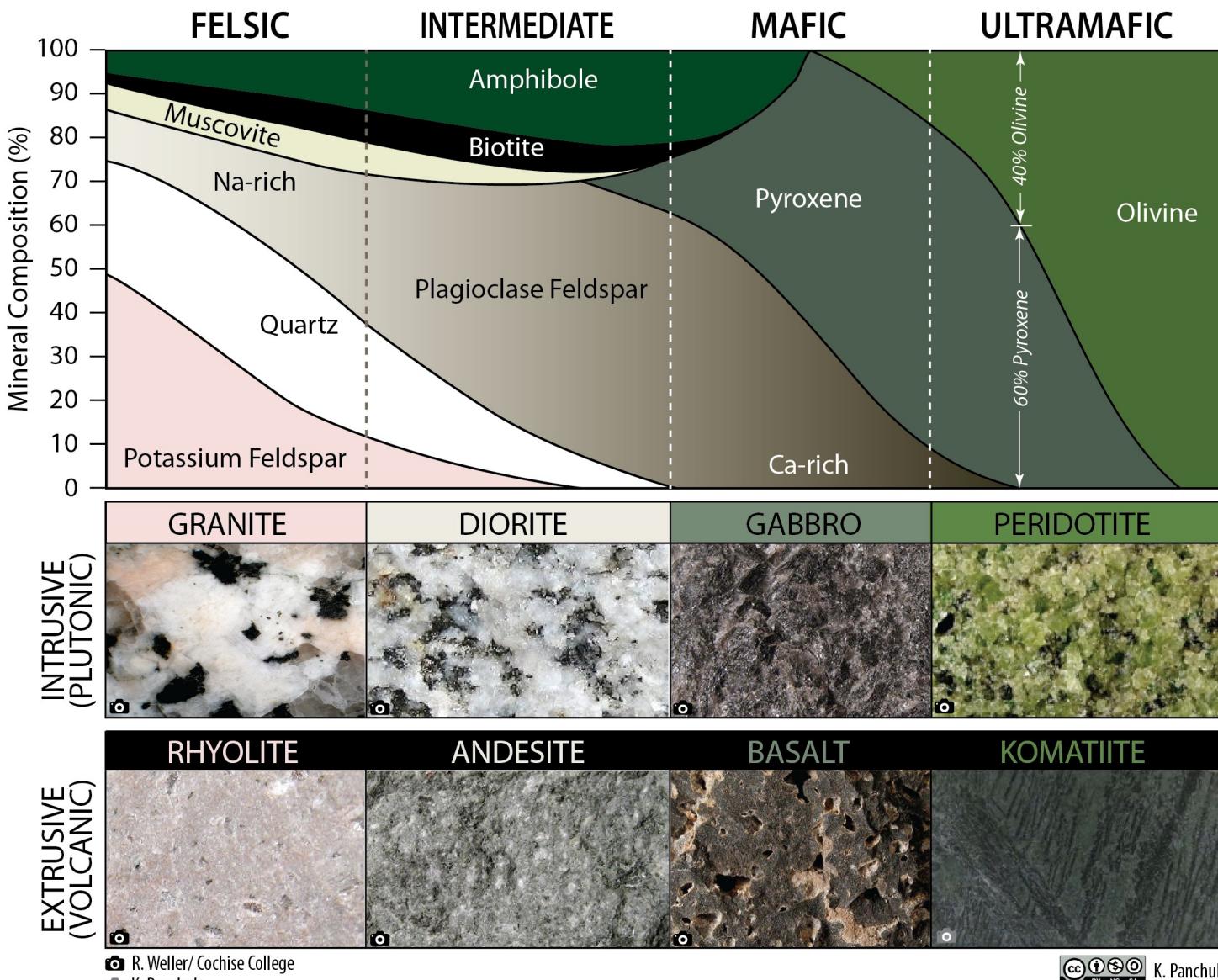




Serpentinizing environments and Ophiolites

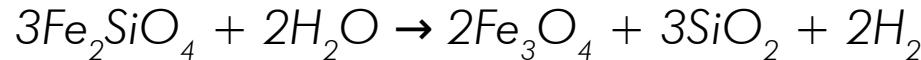
Igneous Rocks: a primer for biologist





Serpentization Reaction

The **serpentization** reaction is a hydration reaction of the iron or magnesium present in the olivine mineral producing hydrogen, alkalinity and secondary minerals:



Fe-olivine + water → magnetite + dissolved silica + di-hydrogen



Mg-olivine + water → serpentine + brucite



Serpentinization

Serpentinization is a key hydration reaction controlling or contributing to several aspect of our planet functioning

Serpentinization happens in the presence of mantle rocks (peridotite) exposed to water rich fluids. It can happen in the oceanic crust, in exposed mantle rocks, at slow spreading centers and in ophiolites.

Produces fluids that are alkaline ($\text{pH}>9.5$) and rich in hydrogen, methane and potentially other hydrocarbons. Methane and hydrocarbons might be produced both biotically and abiotically

Most studies serpentinization location for microbiology are either slow spreading centers (Lost City Hydrothermal Vent) or Ophiolites (CROMO, or Oman Ophiolites)

Metahnogens, hydrogenotrophs and alkaliphilic organisms dominate the community

Serpentinization is believed to have contributed to the origin of life, and it is probably contributing to habitability in several other extraterrestrial bodies

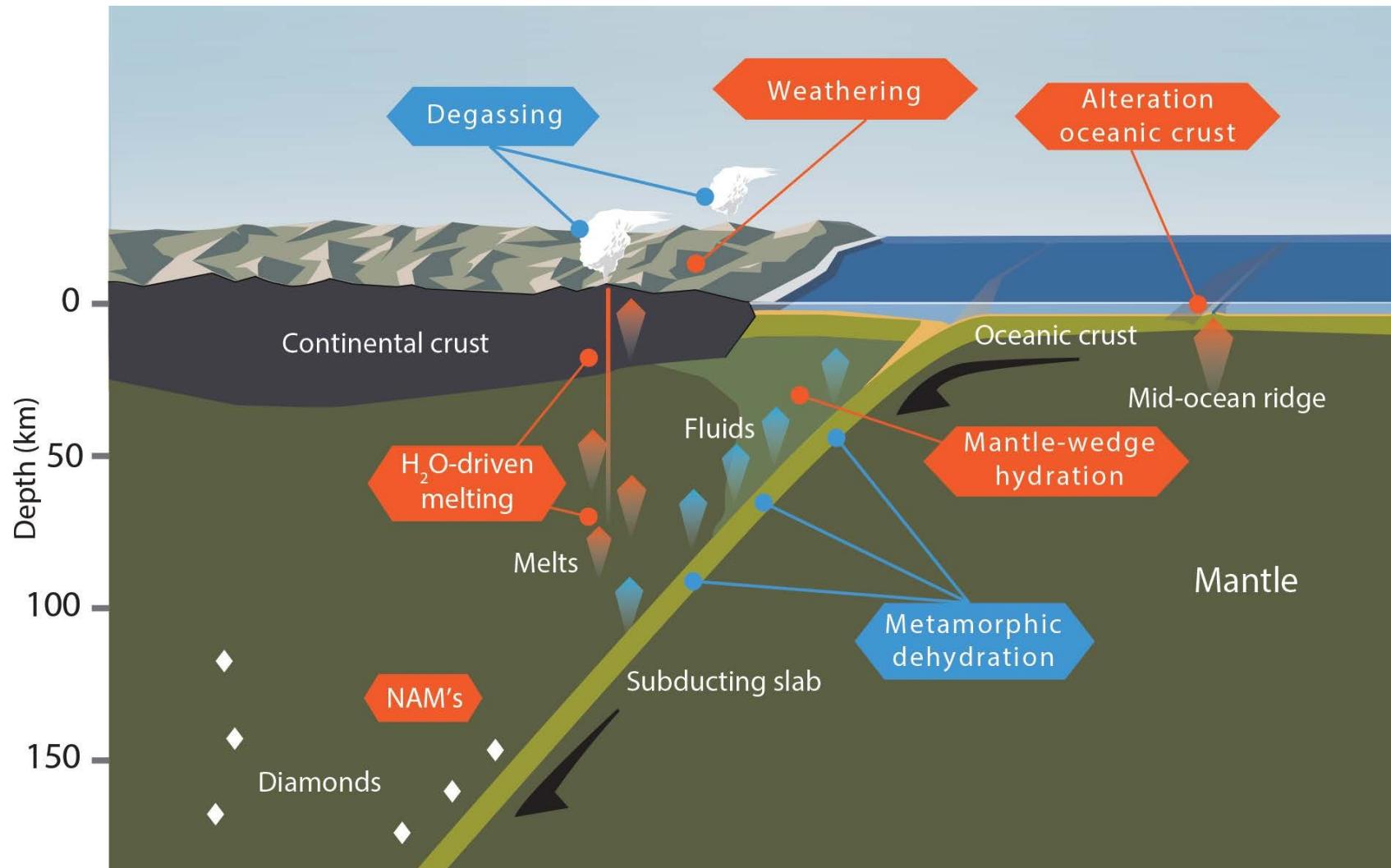


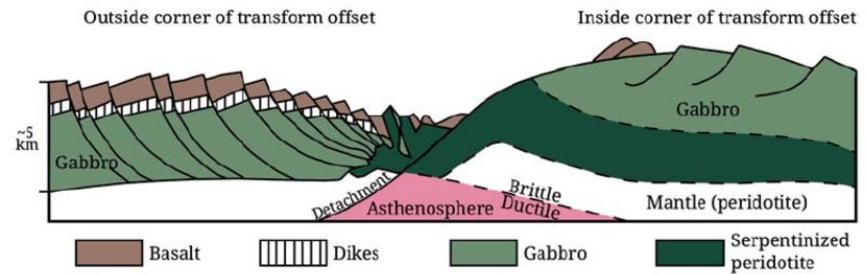
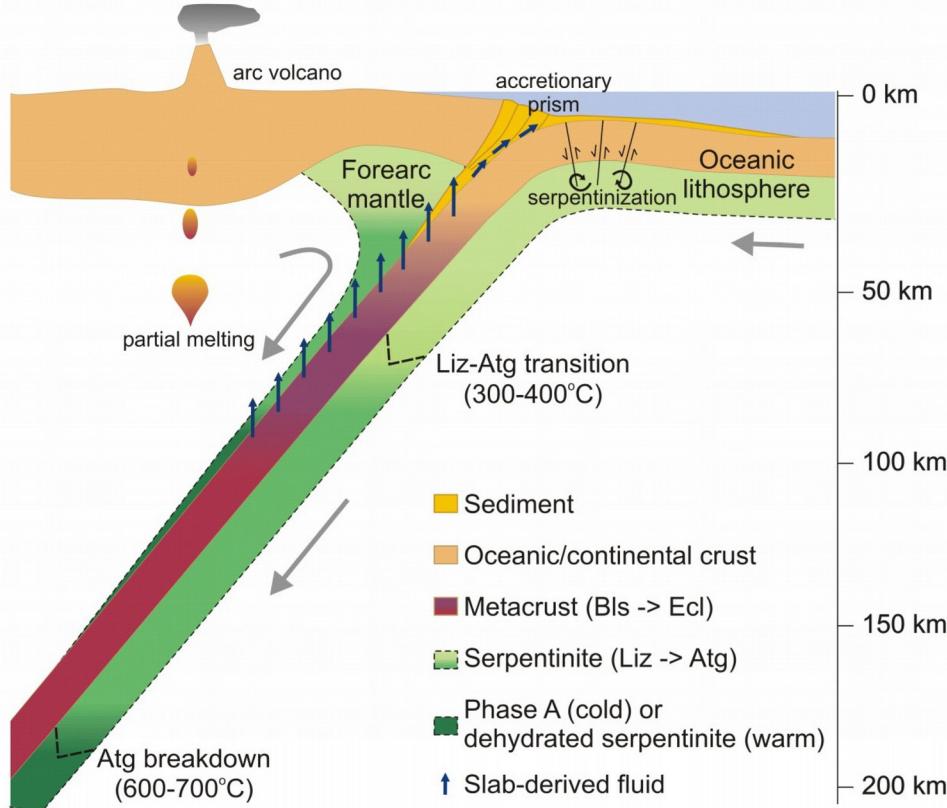
UNINA - Rettorato



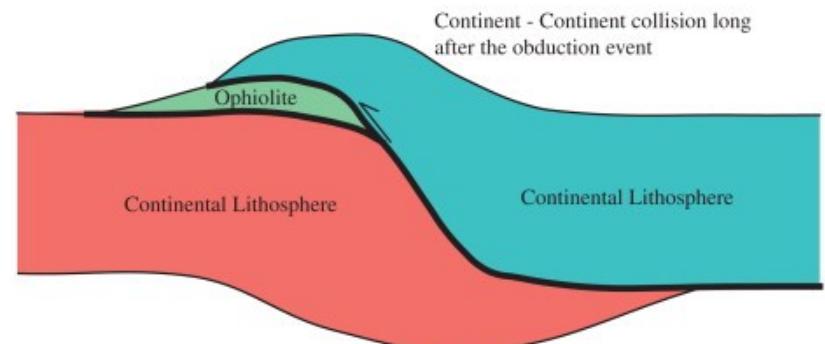
UNINA - Palazzo Congressi



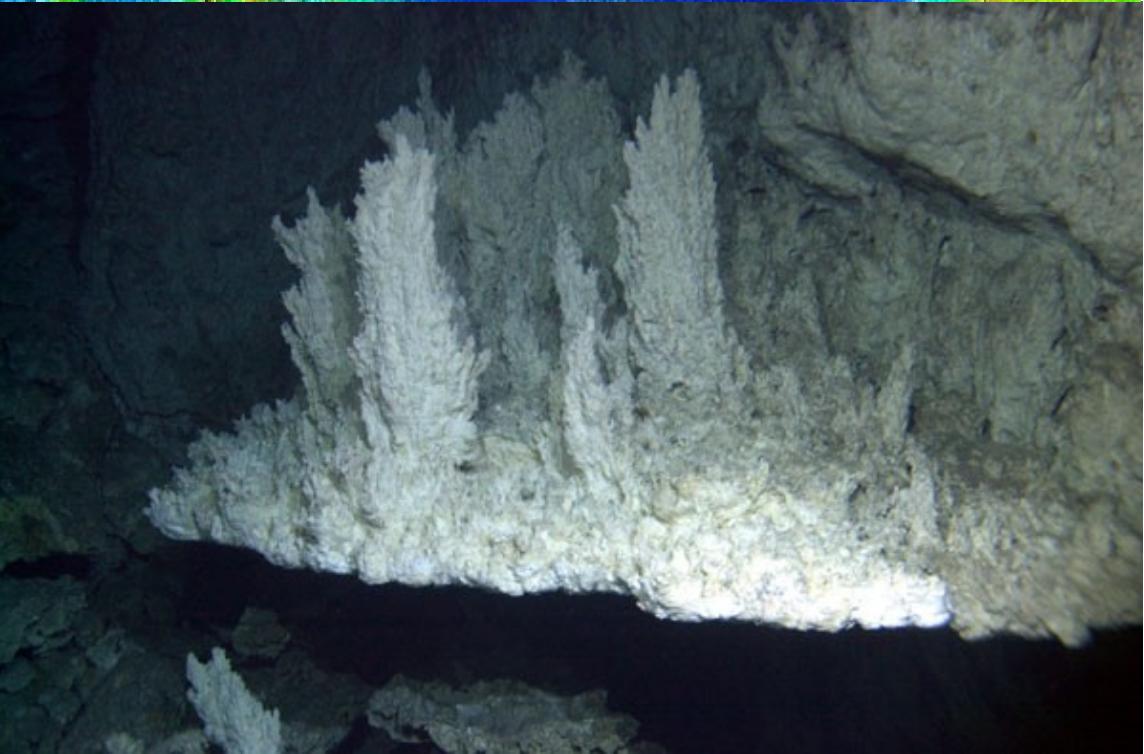
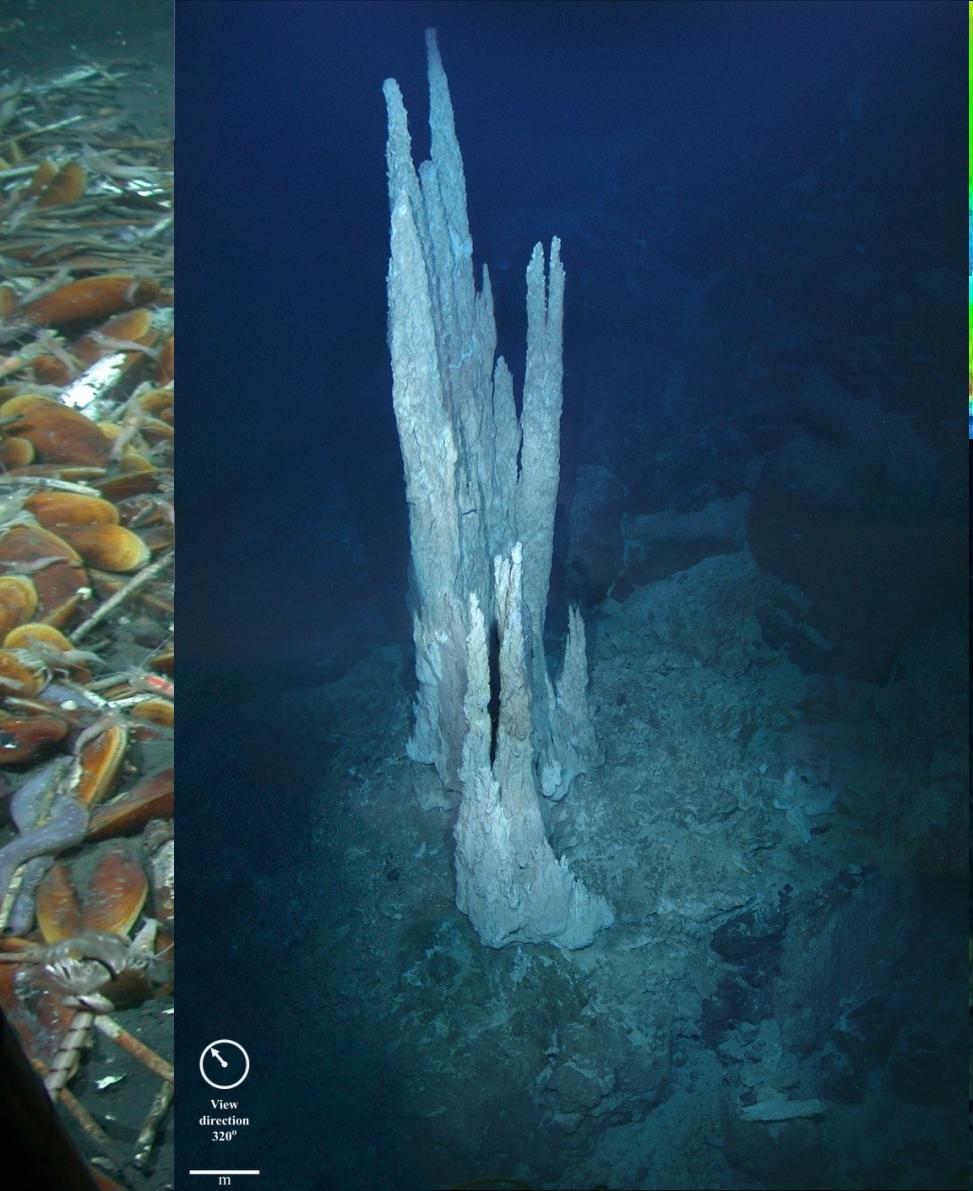


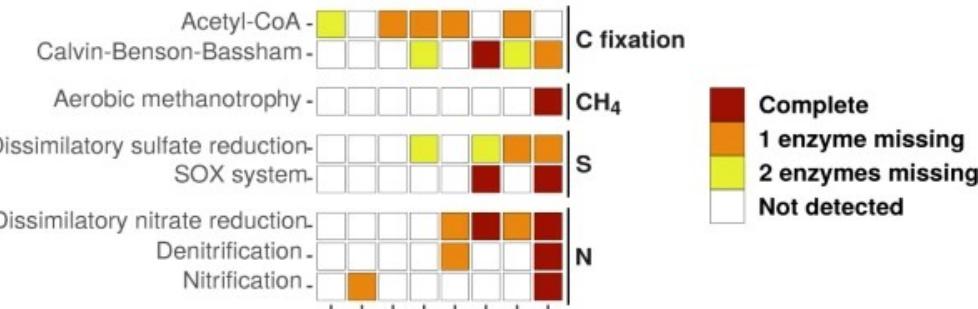
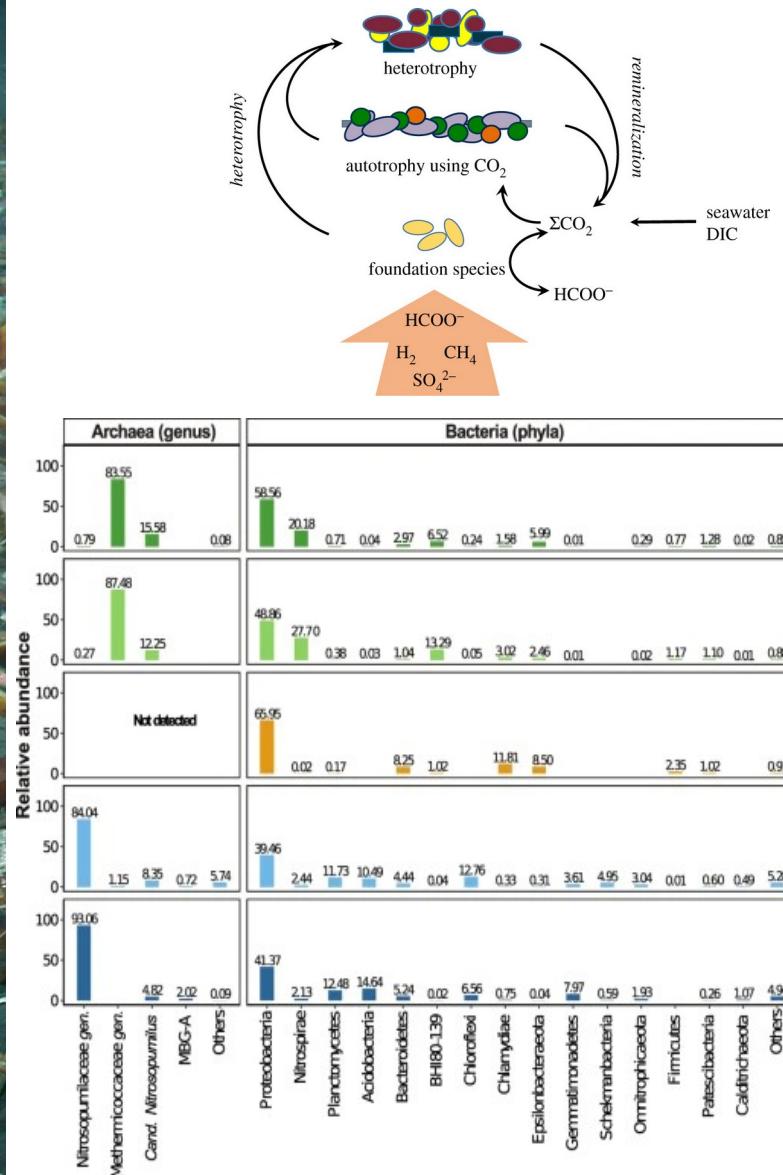


Slow Spreading Centers

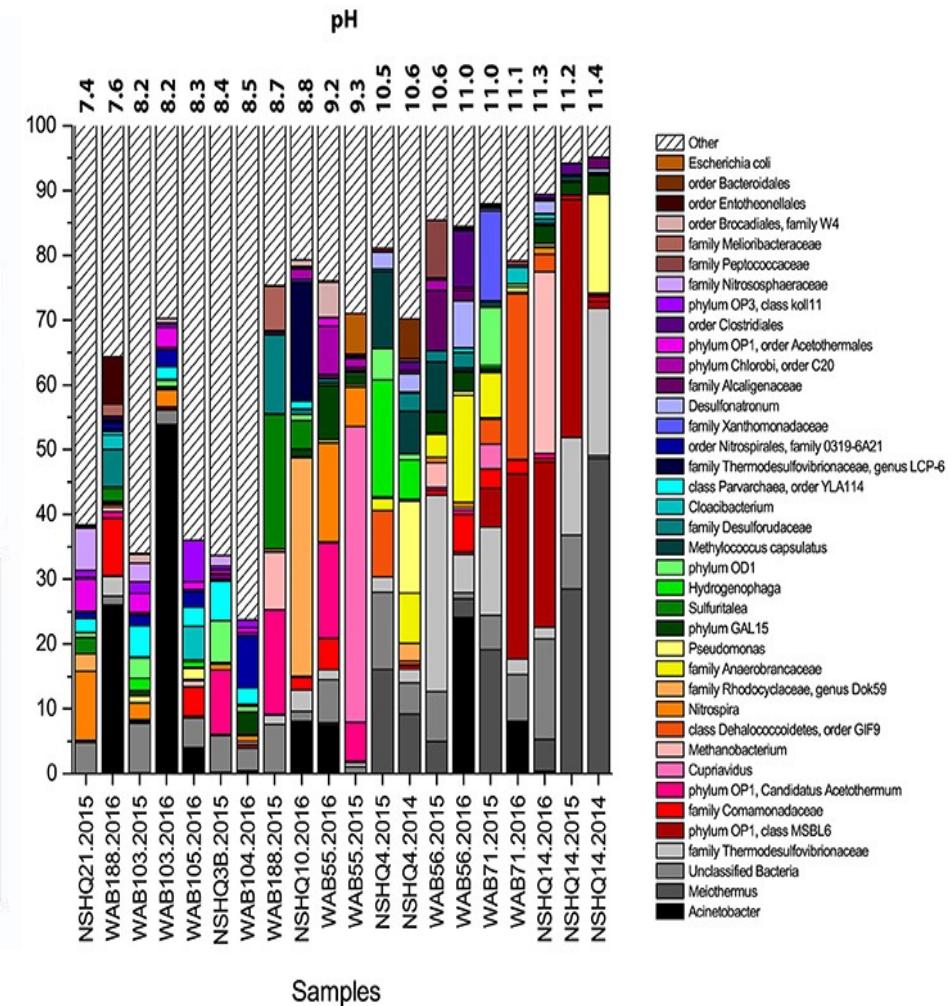
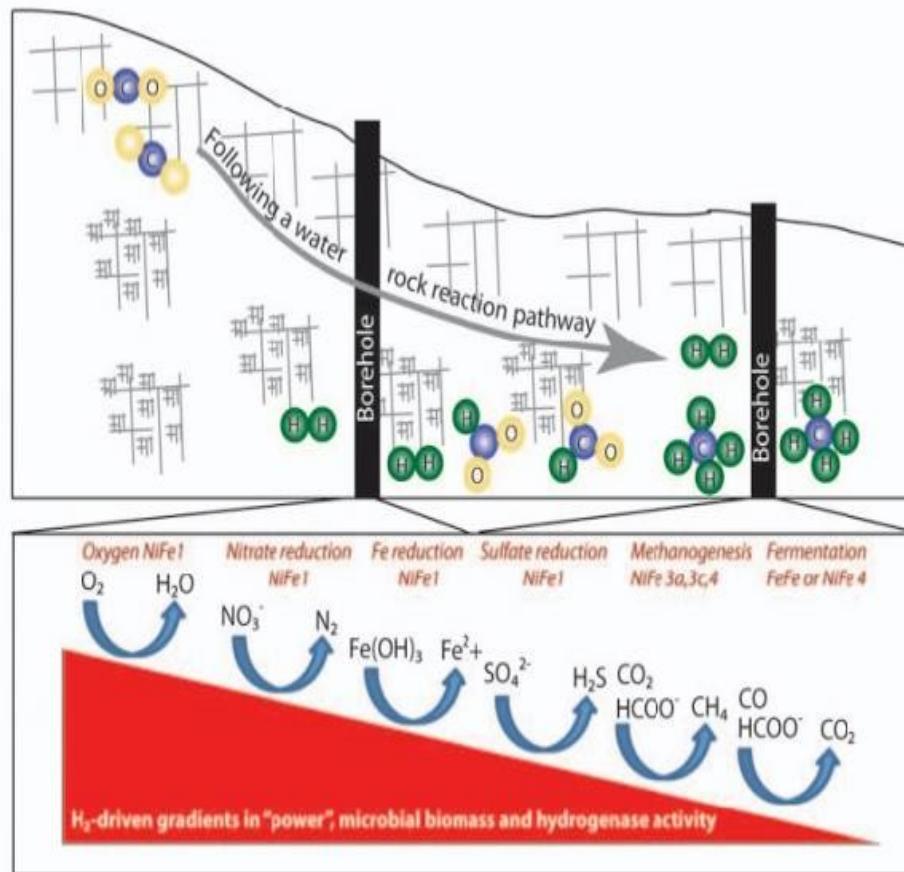


Ophiolites



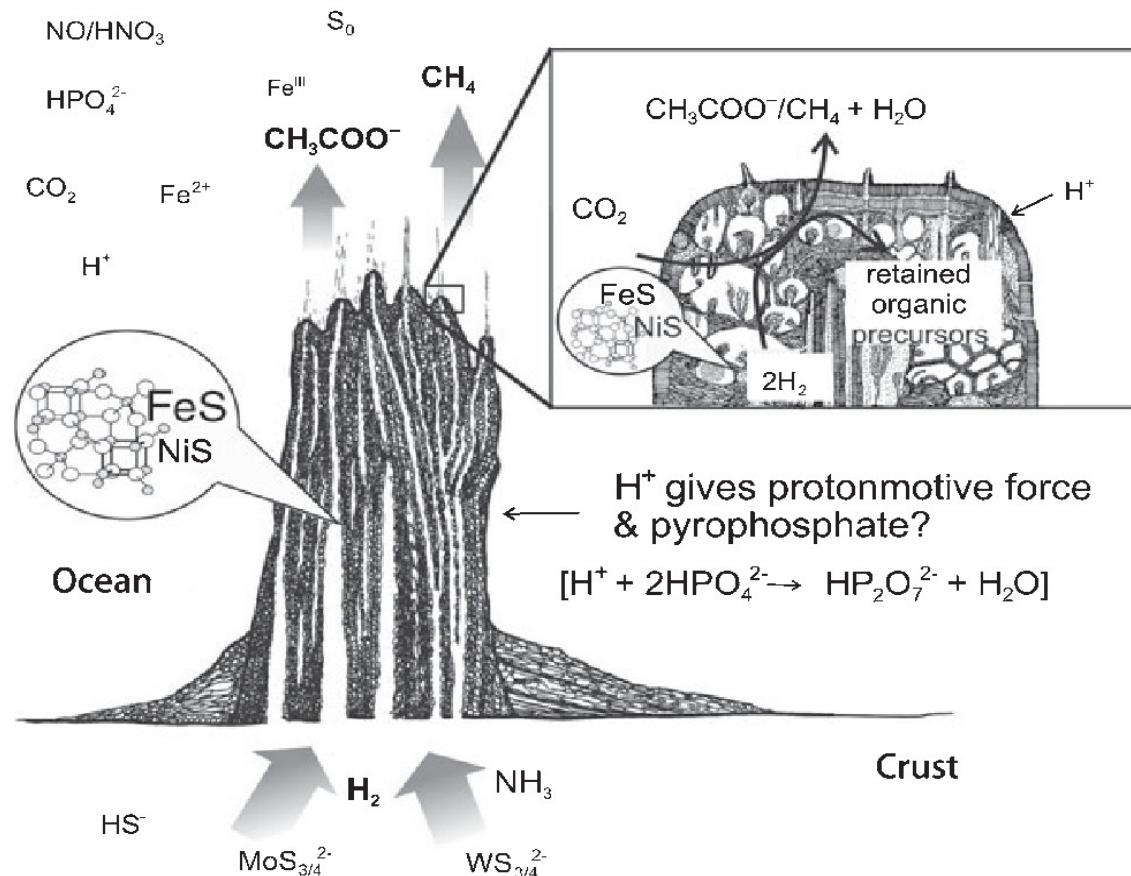






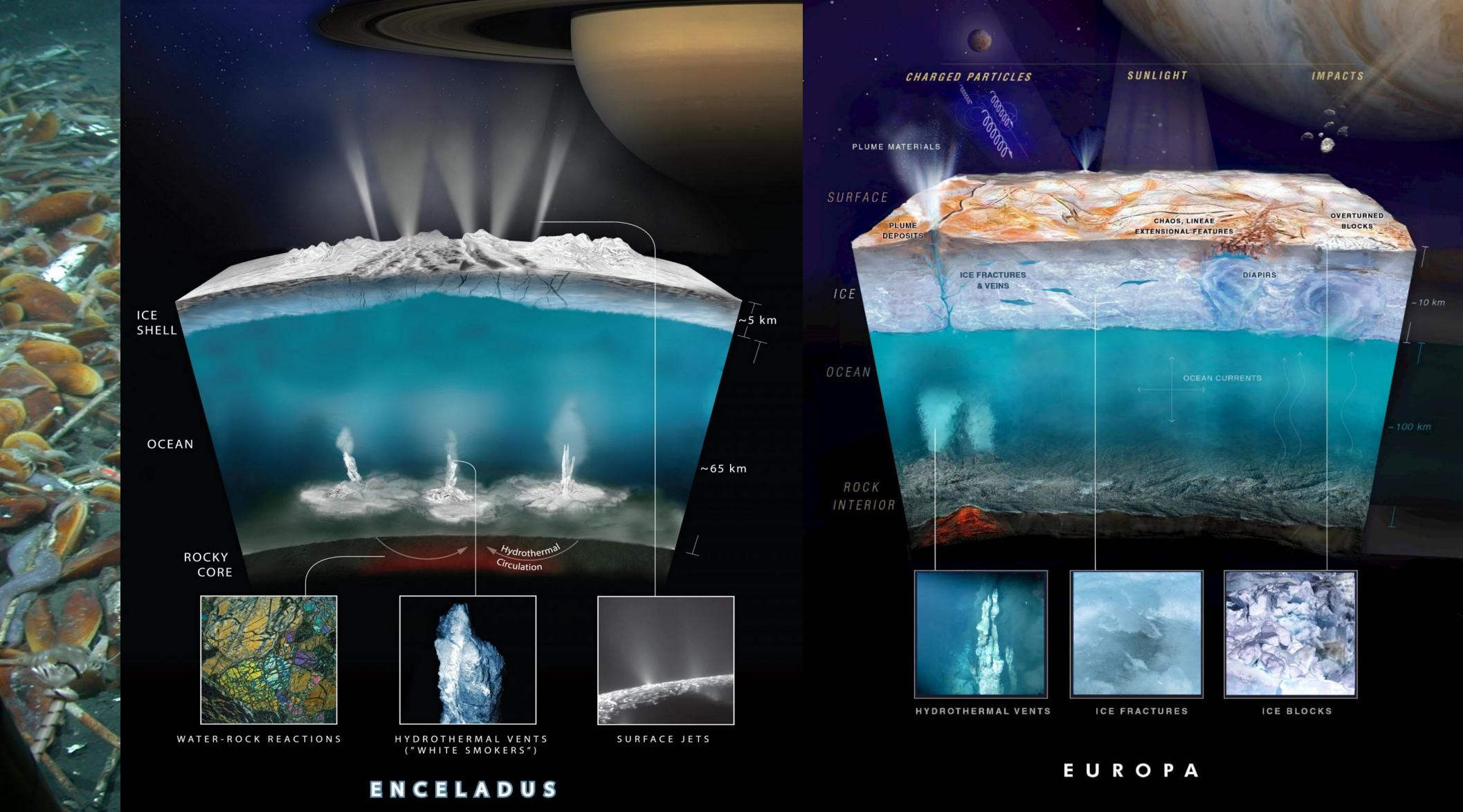
Serpentinization at the origin of Life

Cool, carbonic Hadean Ocean $\leq 20^{\circ}\text{C}$ pH ~ 5.5



Reduced, alkaline hydrothermal solution
 $\sim 120^{\circ}\text{C}$, pH ~ 11

Russell et al 2010 Geobiology



A vertical strip of a vibrant underwater ecosystem. The scene is filled with a variety of tropical fish, including orange and yellow species, swimming among intricate, multi-colored coral structures. The lighting creates highlights on the fish scales and the textured surfaces of the coral.

Hot Springs



Hot Springs

Hot Springs is a term usually used as umbrella for a number of related geothermal phenomena happening on the continent surface in area influenced by geothermal activity (generally volcanic)

Hot springs, geyser, fumaroles, moffette and mud pools are terms used to describe a series of features usually found on a continuum

The are found globally in proximity of volcanoes and other geotehramlly active areas.

Hot spring pH, temperature and salinity are highly variable, and depend on a number of different factors. This influences the diversity of microbes found in each location, varying from neutrophiles to acidophiles

Metabolic diversity in these springs can be highly variable and controlled by the local geochemistry









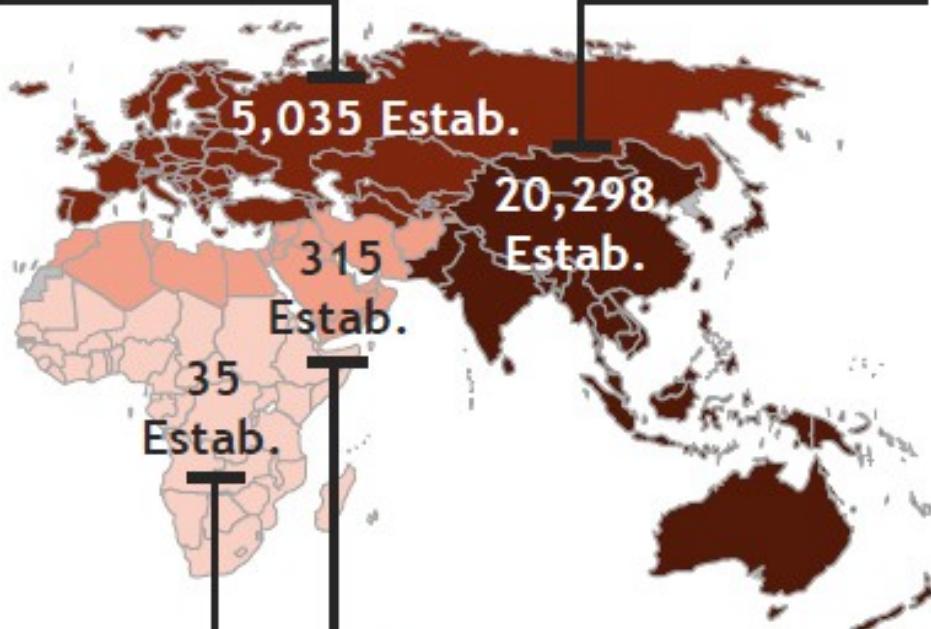
Thermal/Mineral Springs by Region

Number of thermal/mineral springs establishments and revenues

North America
\$0.5b Revenues



Europe
\$21.7b Revenues

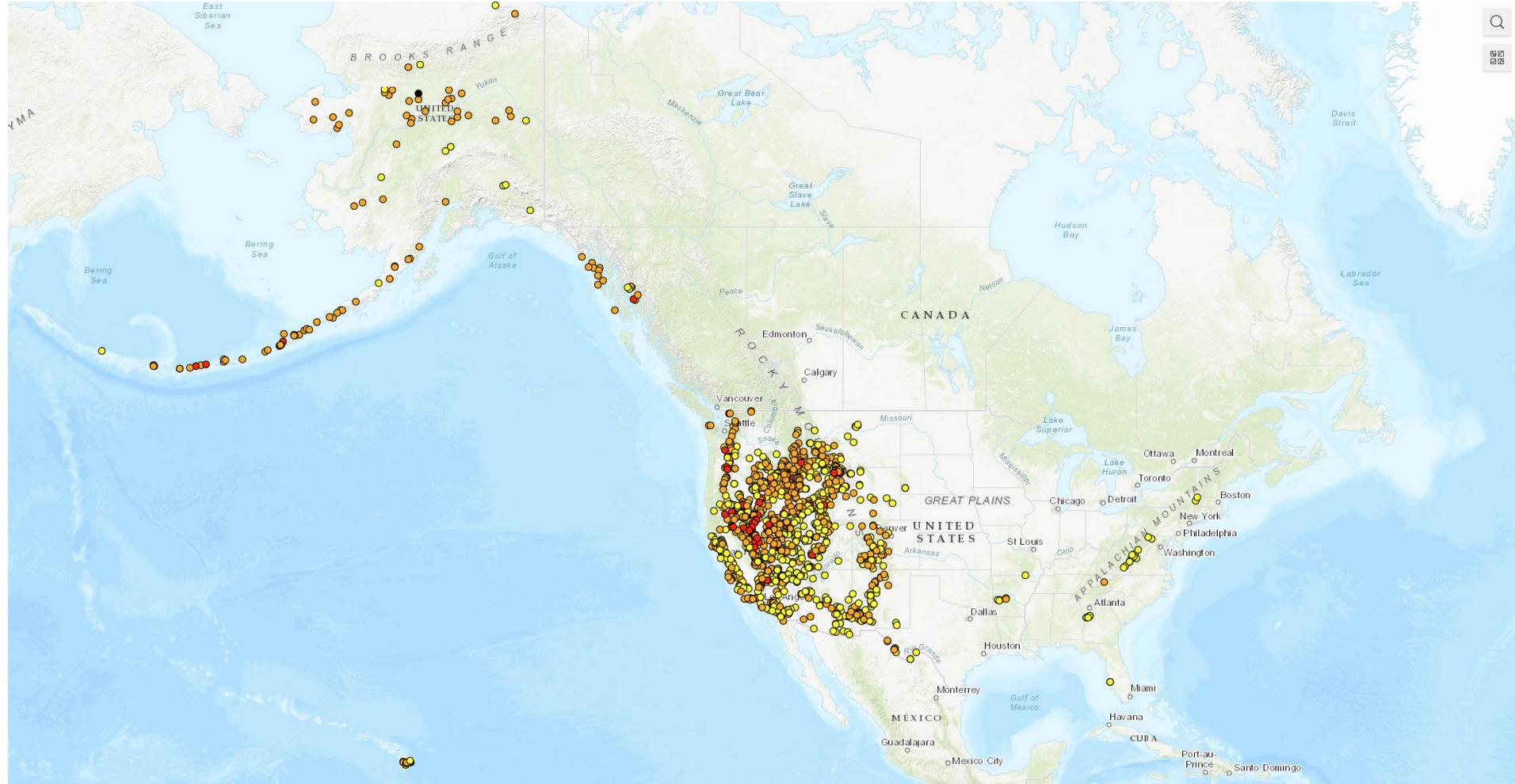


Asia-Pacific
\$26.7b Revenues

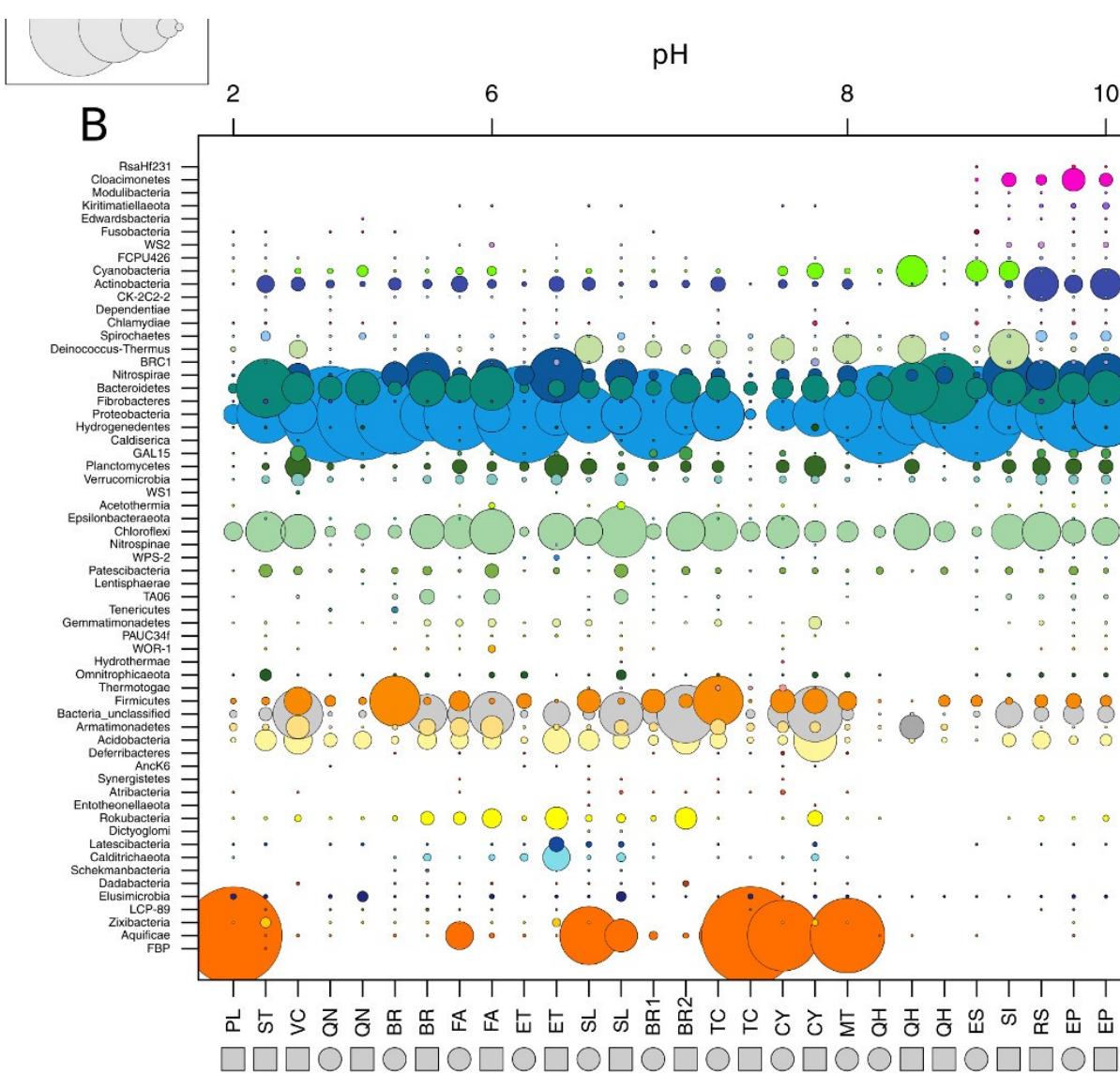
Middle East-N. Africa
\$0.2b Revenues

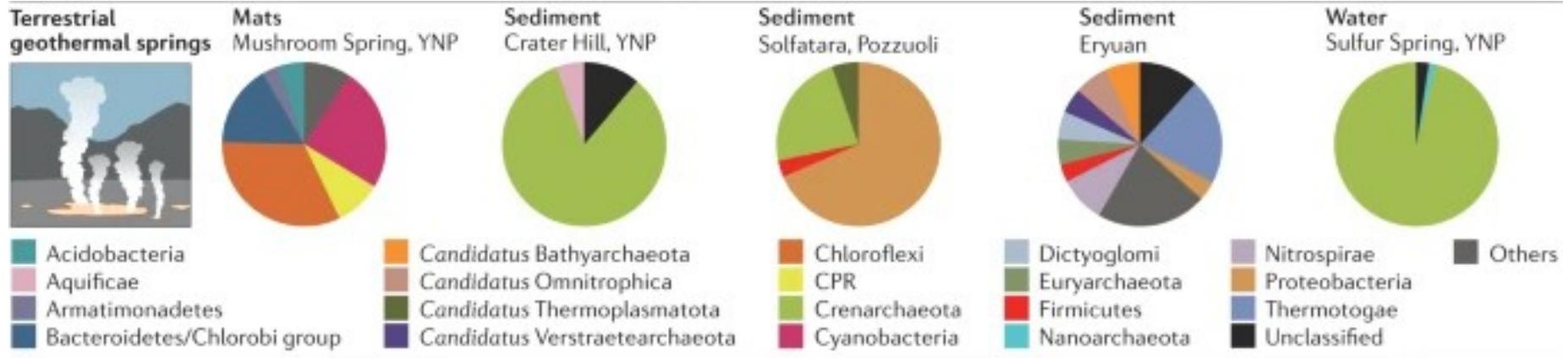
Latin America
\$0.9b Revenues

Sub-Saharan Africa
\$0.05b Revenues



NOAA







(Hyper)Acidic Volcanic Lakes



(Hyper)Acidic Volcanic Lakes

(Hyper)Acidic Volcanic Lakes are ephemeral environments present in the crater of active (but not actively erupting) volcanoes

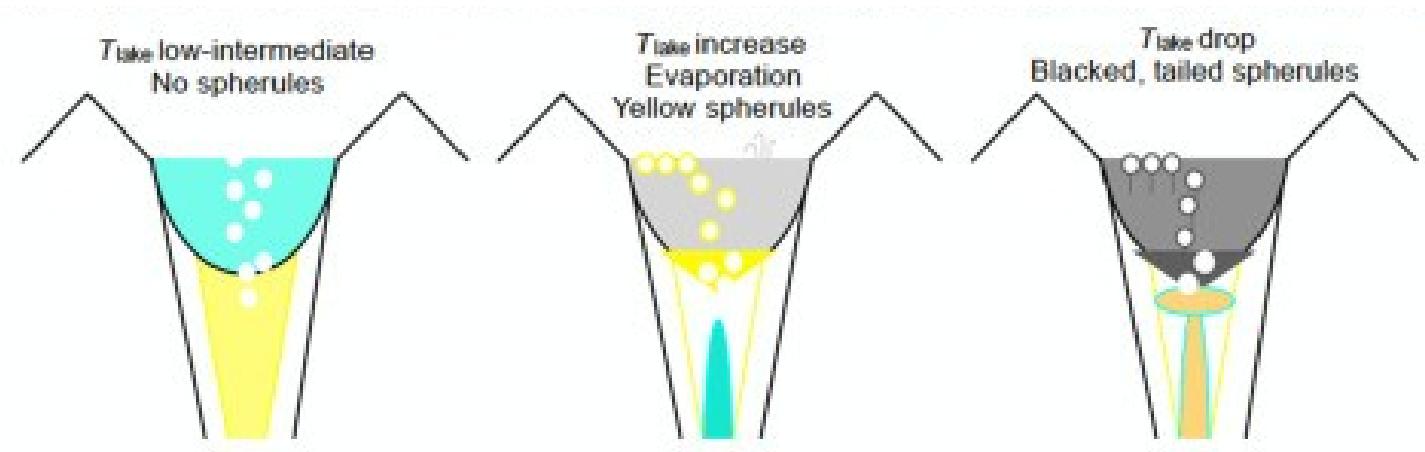
Their presence is controlled by the heat flow from the volcano and the availability of meteoric water

Volcanic acid lakes reach negative pH. The pH is highly fluctuating and depends on volcanic activity and precipitations

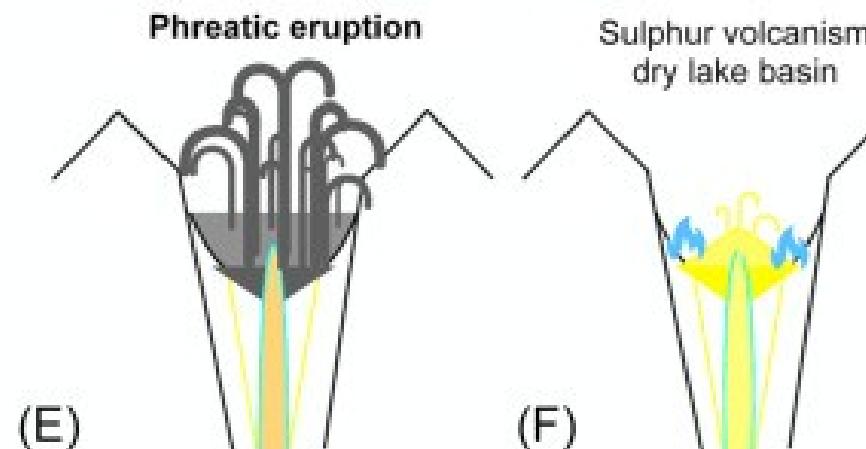
The acidity is produced by direct magmatic degassing of acid gases (HCl , HBr , HF , HI) and H_2SO_4 produced through H_2S oxidation (both biological and abiotic)

Microbial communities have been studied in a limited number of hyperacidic lakes, and appear to be highly variable and dominated by acidophilic microbes similar to acid mine drainage environments





(B) Free degassing $T < 119^{\circ}\text{C}$ (C) Degassing through sulfur pool $119^{\circ}\text{C} < T < 159^{\circ}\text{C}$ (D) Degassing through viscous sulfur seal $T > 159^{\circ}\text{C}$





OVSICORI - UNA



Readings

Merlino, G., Barozzi, A., Michoud, G., Ngugi, D. K., and Daffonchio, D. (2018). Microbial ecology of deep-sea hypersaline anoxic basins. *FEMS Microbiology Ecology* 94. doi:10.1093/femsec/fiy085.

Brovarone, A. V., Butch, C. J., Ciappa, A., Cleaves, H. J., II, Elmaleh, A., Faccenda, M., et al. (2020). Let there be water: How hydration/dehydration reactions accompany key Earth and life processes#. *American Mineralogist* 105, 1152–1160. doi:10.2138/am-2020-7380.