Mapping the Deep Subsurface Biosphere on a Sphere

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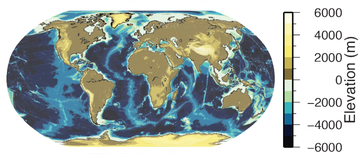
Motivation

We wanted to develop an user-friendy interface to assist researchers with future deep-life research. Our goals include,

- cataloging basic metadata for existing deep-life samples in continental crust, ocean crust, and ocean sediments,
- calculating the depth to key isotherm limits for psychrophiles (20˚C), mesophiles (45˚C), thermophiles (80˚C), and hyperthermophiles (122˚C),
- showing the location of these deep-life samples on various map projections, and
- indicating whether the deep-life samples for each site are located above, across or below a chosen isotherm.

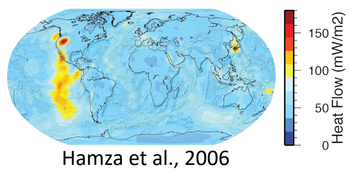
Data

Topography



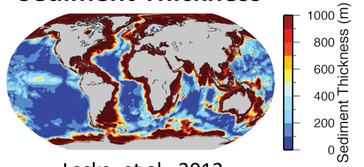
ETOPO1, 2018

Heat Flow



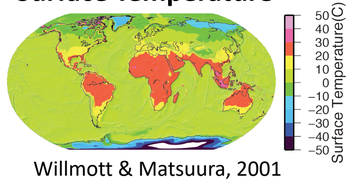
Hamza et al., 2006

Sediment Thickness



Laske, et al., 2012

Surface Temperature



Willmott & Matsuura, 2001
HYCOM, 2018

Methods

The depth to a chosen isotherm (Z_t) at given geographic location (x, y) is calculated for continental crust, ocean crust, and ocean sediments, as shown by the equations below. The depths for the various regions are merged to create anisotherm surface. This isotherm surface is combined with surface elevation and sediment thickness data to create an "elevation" map of the chosen isotherm. We then place the location of deep-life samples and use various symbols to indicate whether the data are located above, below or intersect the isotherm.

Continental Crust (after Magnabosco et al., 2018)

$$Z_T(x,y) = (T - T_{surf}(x,y)) * \left(\frac{\lambda_{rock}}{Q(x,y) * 10^{-3}} \right)$$

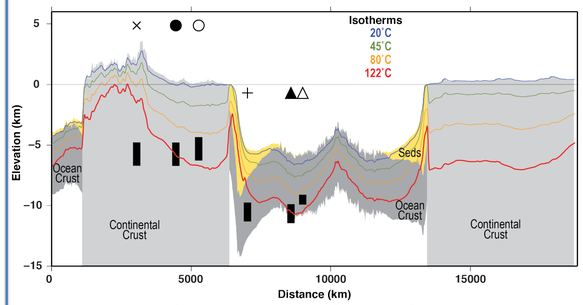
Ocean Crust (after Heberling et al., 2010)

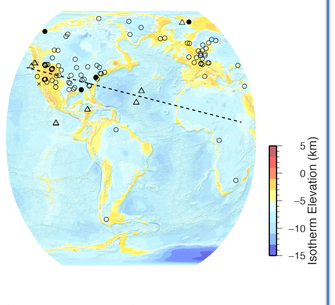
$$Z_T(x,y) = \left(\frac{T * \lambda_{bas}}{Q(x,y) * 10^{-3}} \right) + \left(1 - \frac{\lambda_{bas}}{\lambda_{sed}} \right) * Z_{sed}(x,y)$$

Ocean Sediments (after LaRowe et al., 2017)

$$Z_T(x,y) = (T - T_{surf}(x,y)) * \left(\frac{\lambda_{grains}^{(1-\phi)} * \lambda_{pores}^{(\phi)}}{Q(x,y) * 10^{-3}} \right)$$

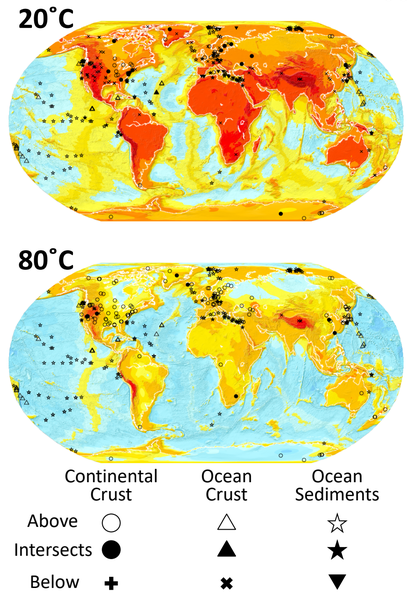
Z_t = depth to isotherm T at given x, y location
T_{surf} = land surface temperature at given x, y location
Q = heat flow at given x, y location
Z_{sed} = sediment thickness at given x,y location
λ_{rock} = thermal conductivity of continental rock (3.0 mW/m)
λ_{bas} = thermal conductivity of ocean basement (2.0 mW/m)
λ_{sed} = thermal conductivity of ocean sediments (0.8 mW/m)
$\lambda_{grains}^{(1-\phi)}$ = thermal conductivity of ocean sediment grains (porosity dependent)
$\lambda_{pores}^{(\phi)}$ = thermal conductivity of ocean sediment pores (porosity dependent)

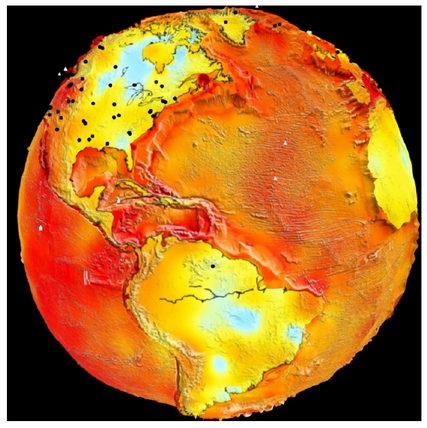




Representative cross section of isotherm elevations superimposed on simple geology. The location of the cross section is indicated on the map of the 122˚C isotherm elevation map with the description of the various symbols indicated.

Results

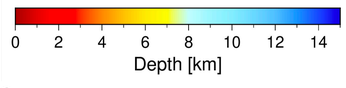




Deep Biosphere Cesium Globe

http://portal.gplates.org/cesium/?view=Biosphere

122˚C isotherm



Acknowledgments

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