

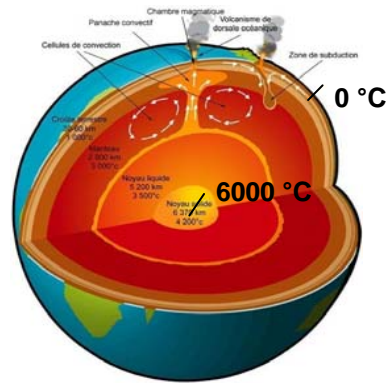
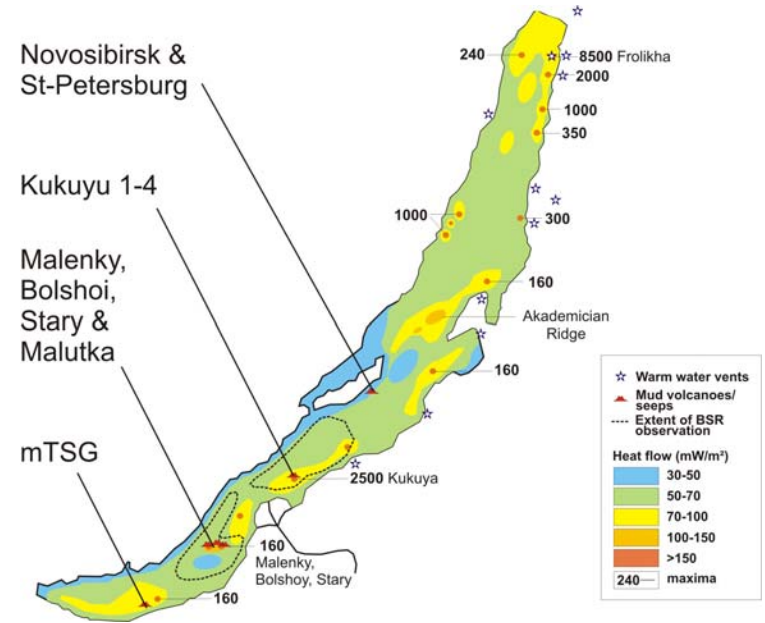
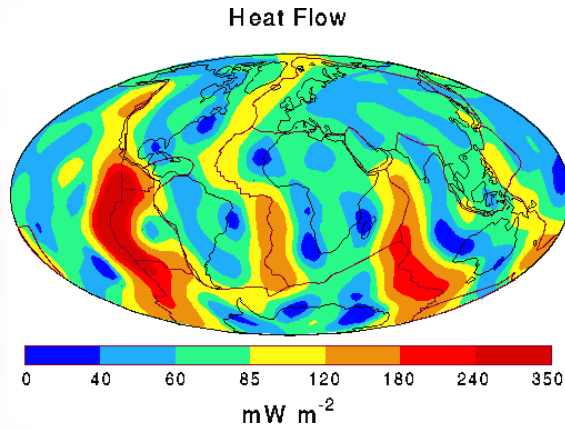
# Heat Flow Measurements in Marine Environments

Jeffrey Poort



*University Pierre et Marie Curie, Paris  
Sorbonne Universités*

# What is heat flow?



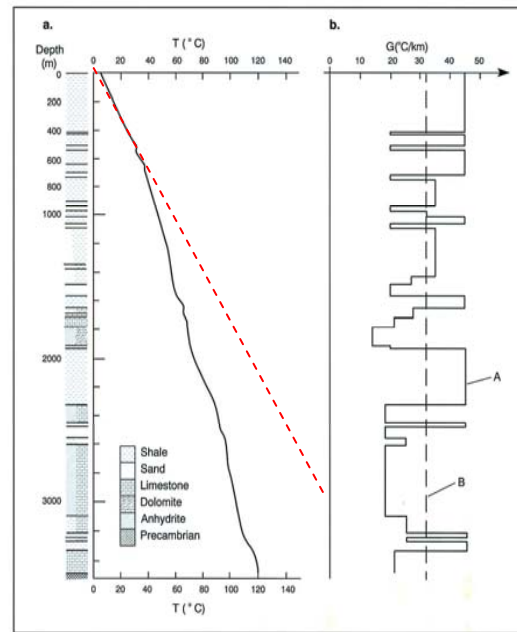
Because of the temperature difference, a **flow of heat from the Earth's center to the surface:**

- 1) by convection
- 2) by advection
- 3) by conduction

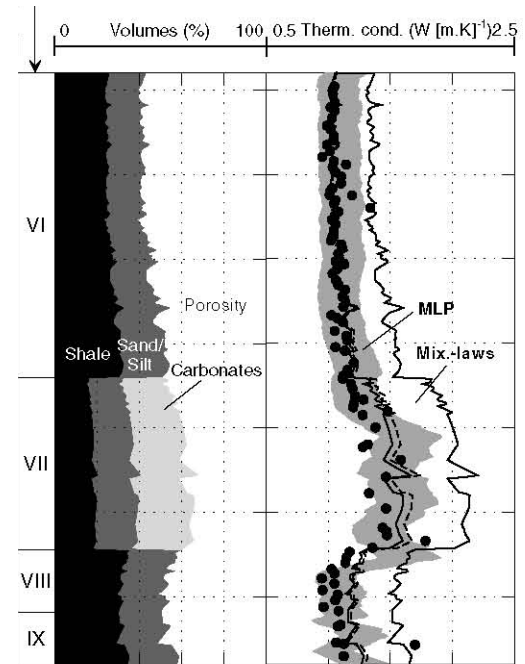
# What is heat flow?

$$Q_s = -\lambda \frac{\partial T}{\partial z}$$

## Geothermal gradient

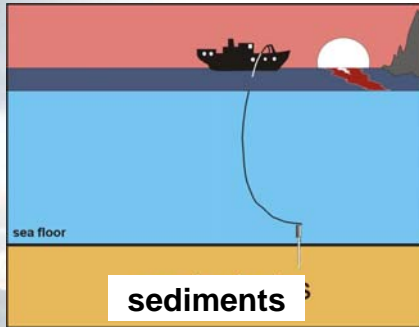


## Thermal conductivity



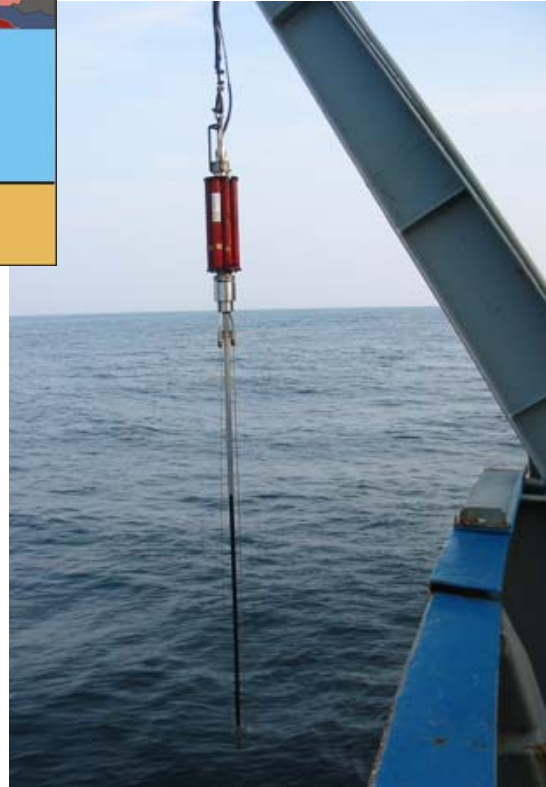
Heat flow (conductive) **constant** under stationary conditions  
→ comparable for different areas and depth intervals

# How is heat flow measured?



**Increase of only  
0.05-0.06 °C/m**

- High precision
- temperature
- sensor needed!



**Heat flow probe**  
- 2-7m active length  
- gradient & conductivity in situ  
- direct data transfer → pogo method possible

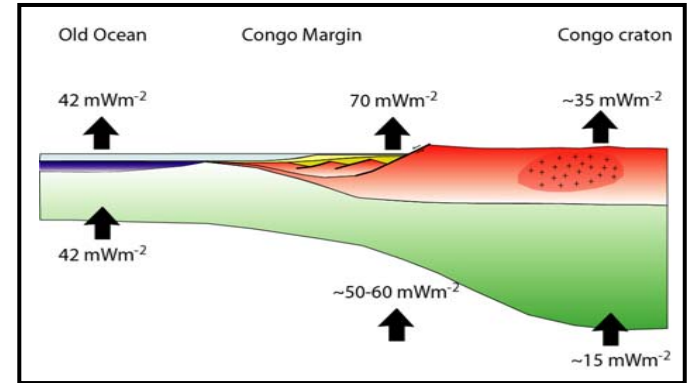
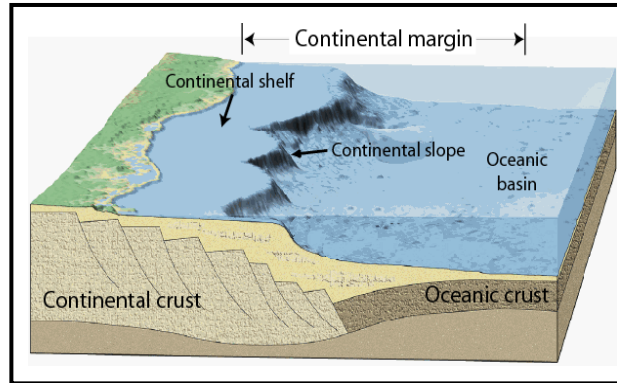


**Corer equipped with loggers**  
- 2-15 m active length  
- only conductivity in situ → conductivity on cores  
- autonomous THP loggers

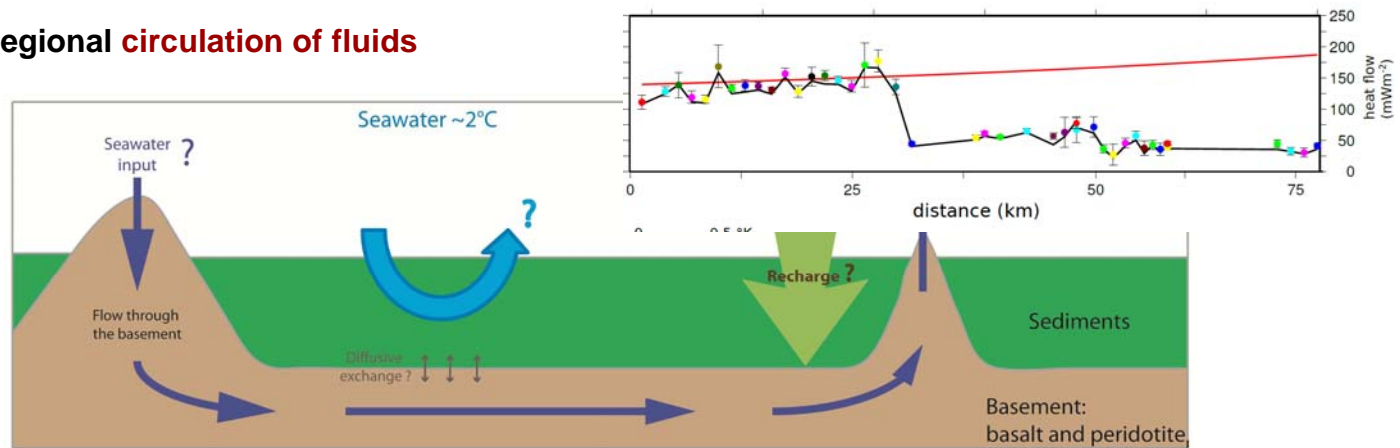
# Why is heat flow measured?

## 1) Sedimentary basin and lithosphere scale

Models of **basin and lithosphere evolution** → hydrocarbon maturity



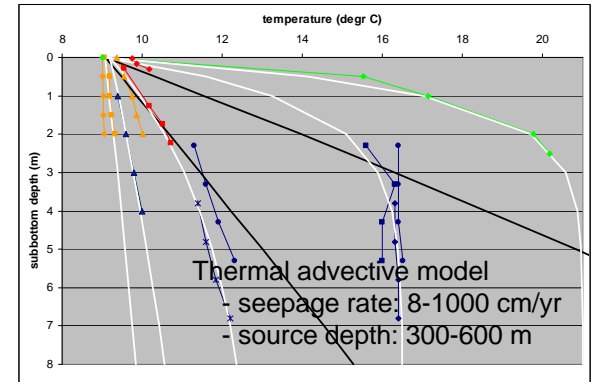
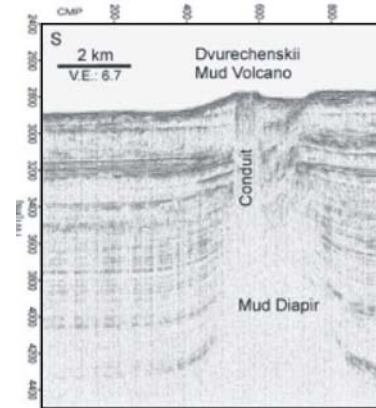
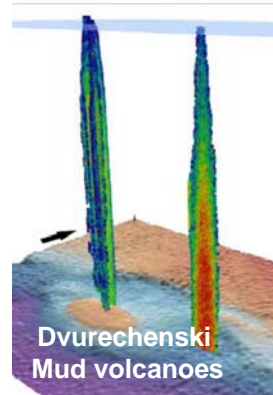
## Regional **circulation of fluids**



# Why is heat flow measured?

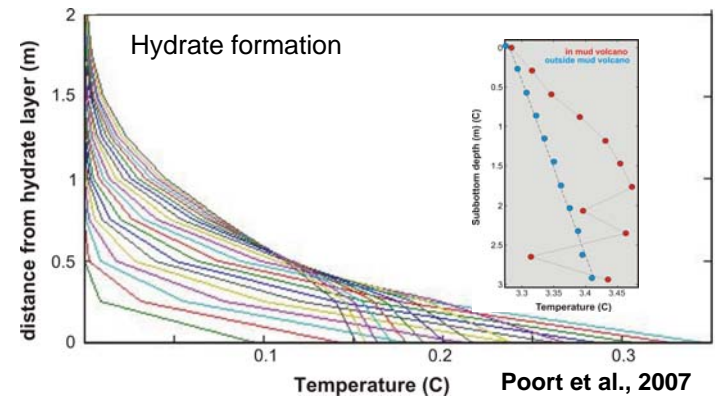
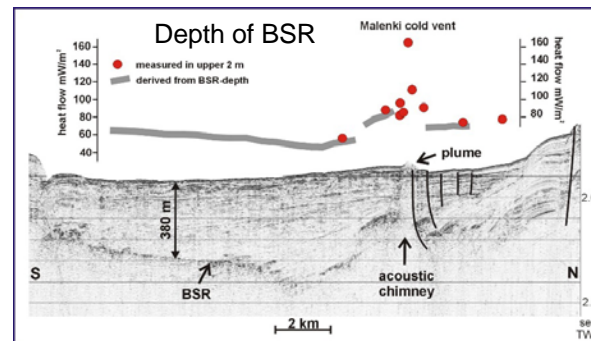
## 2) Scale of fluid escape structure (seeps, mud volcanoes, etc.)

### Activity and source of fluid system

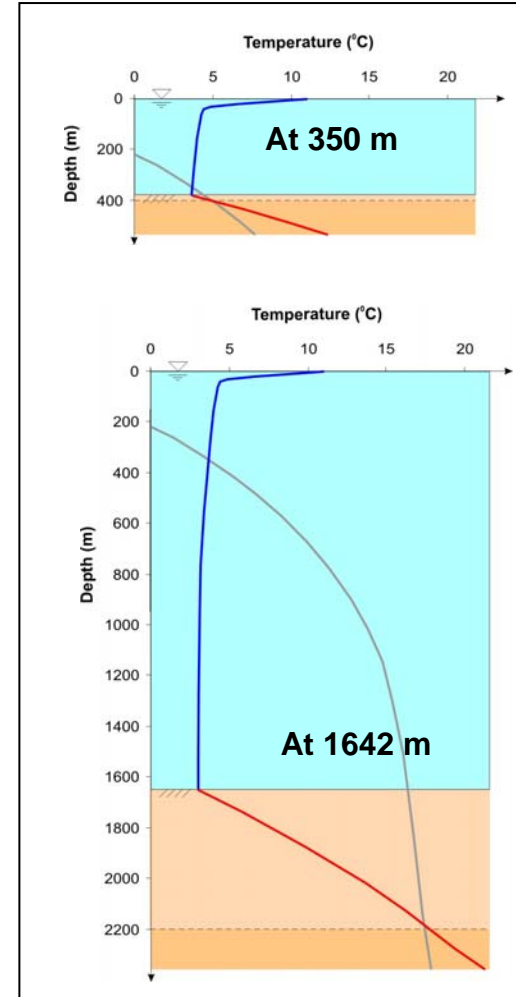
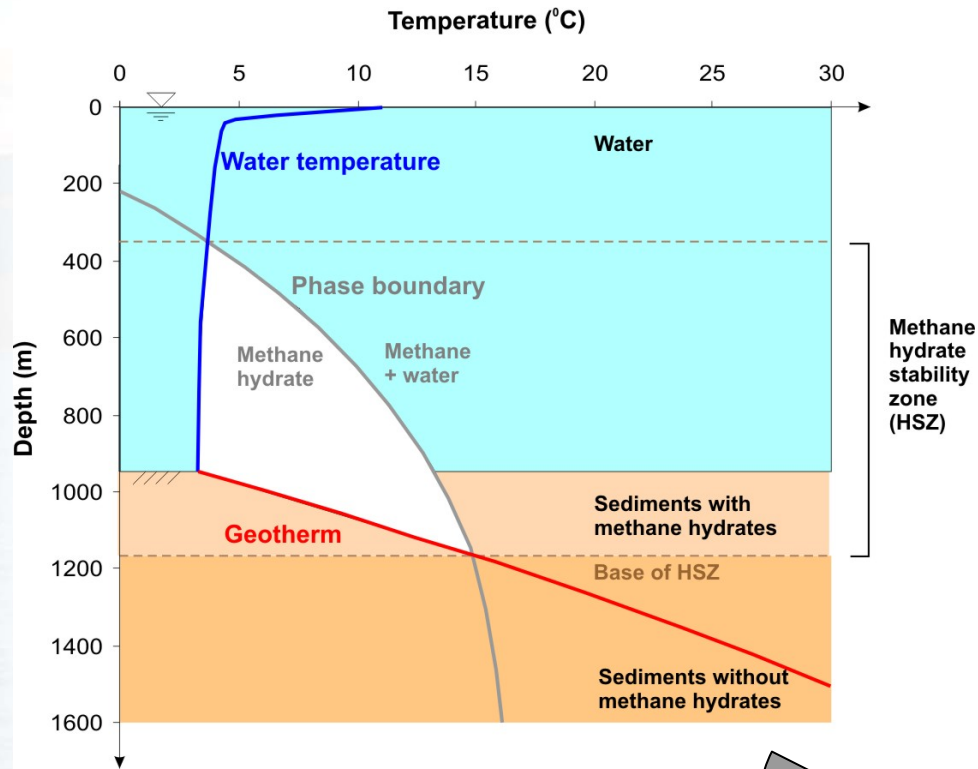


Kutas & Poort, 2007

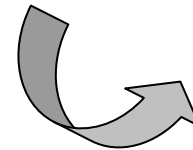
### Hydrate stability and dynamics



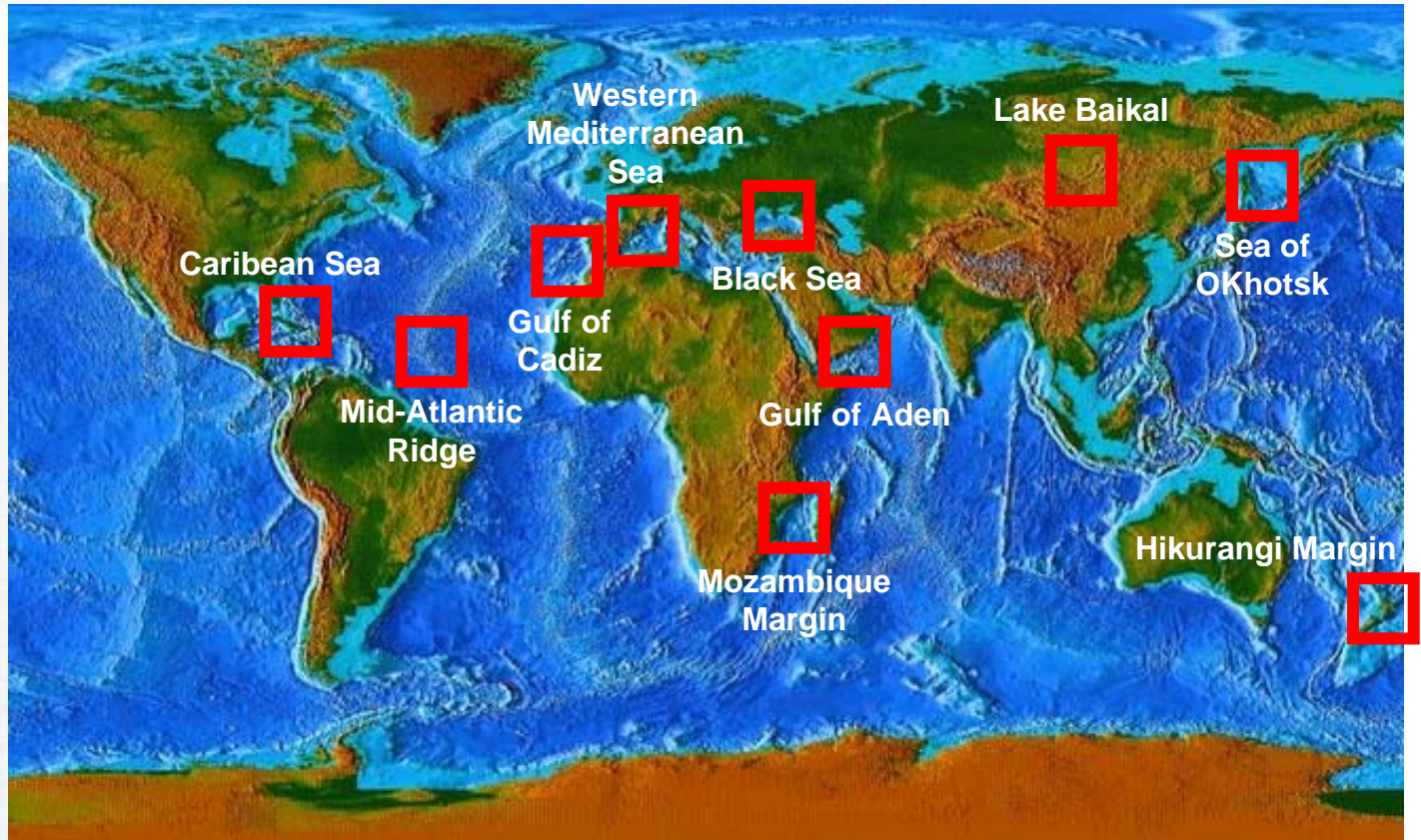
# Hydrate lower boundary



**Methane gas in fresh water!**



# Study areas

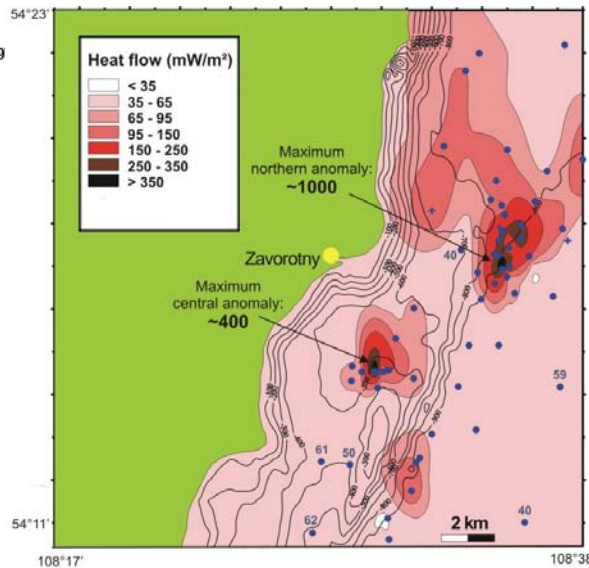
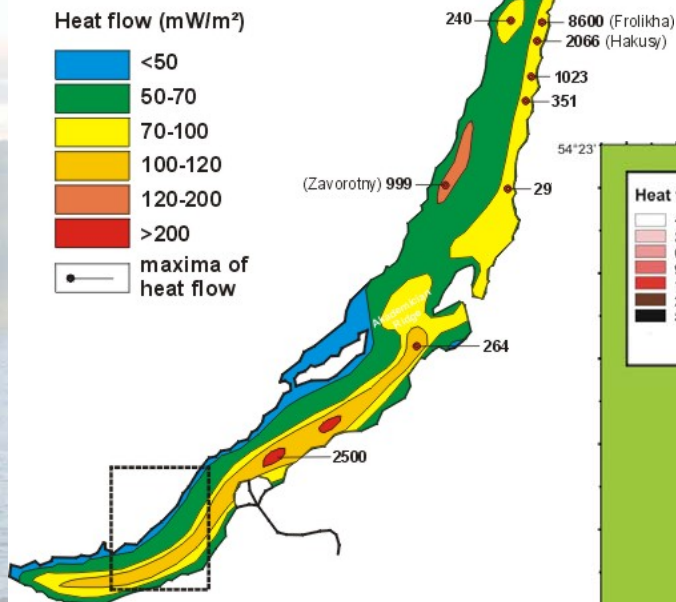




# Heat flow in Baikal

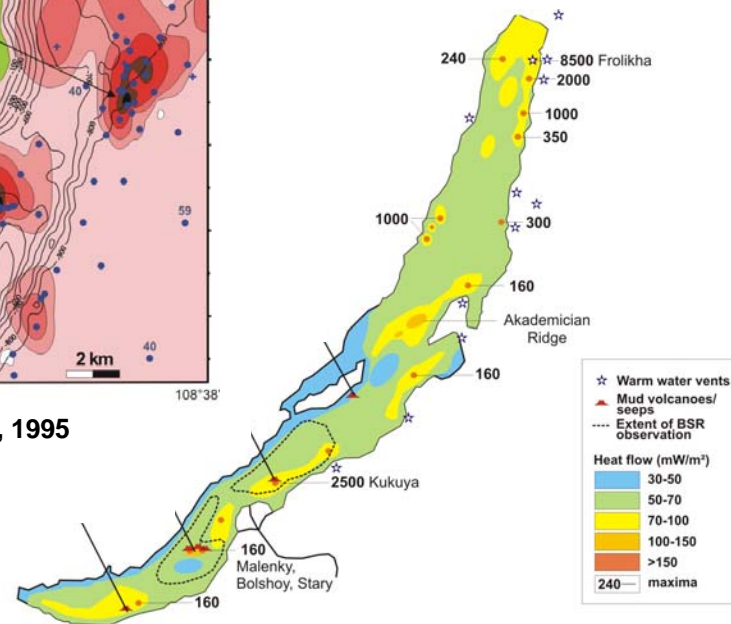
## Regional heat flow contouring

**Golubev et al., 1983**



Golubev & Poort, 1995

+ rift formation modeling (Poort et al., 1998)  
 → absence of a regional scale anomaly

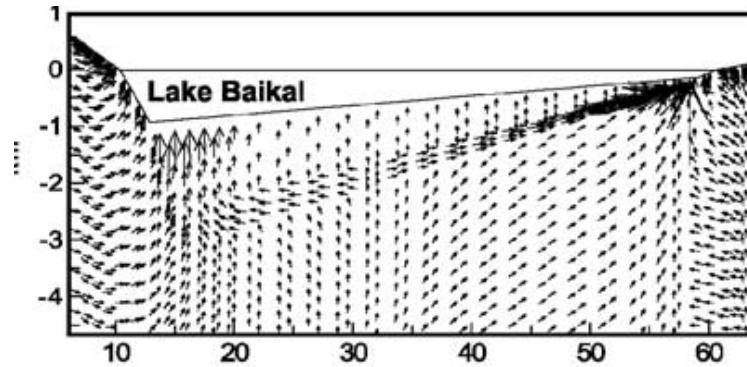


Poort & Klerkx, 2004

# Heat flow in Baikal

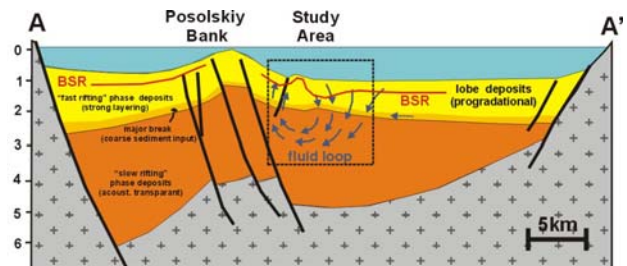
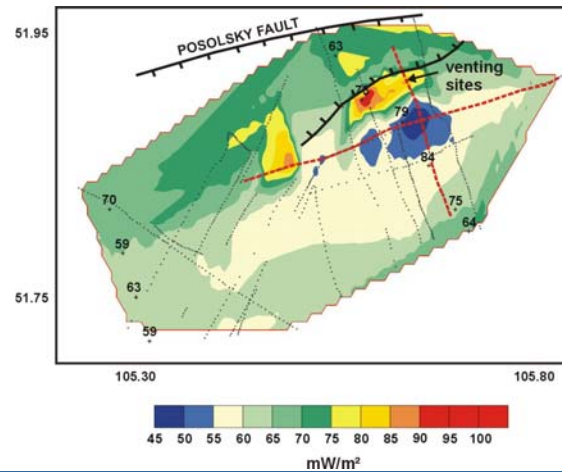
## Regional scale fluid circulation

Topography driven water circulation (basin-scale)



Poort & Polyanski, 2002

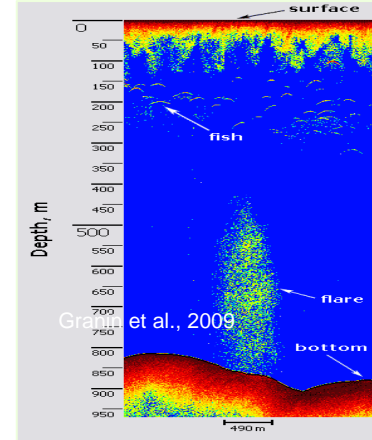
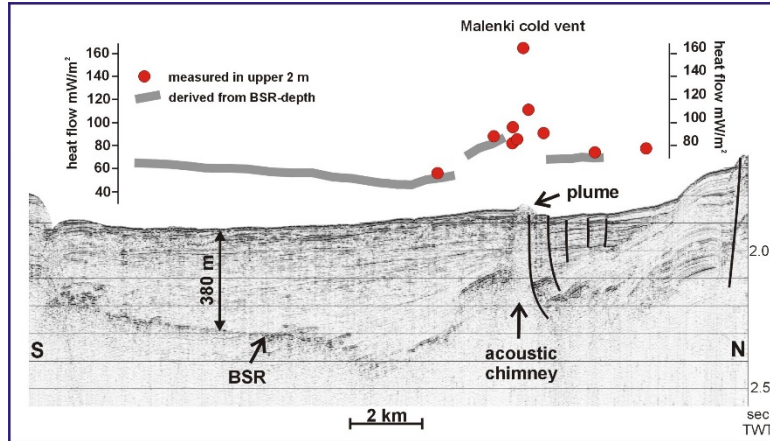
BSR-derived Heat Flow (sub-basin scale)



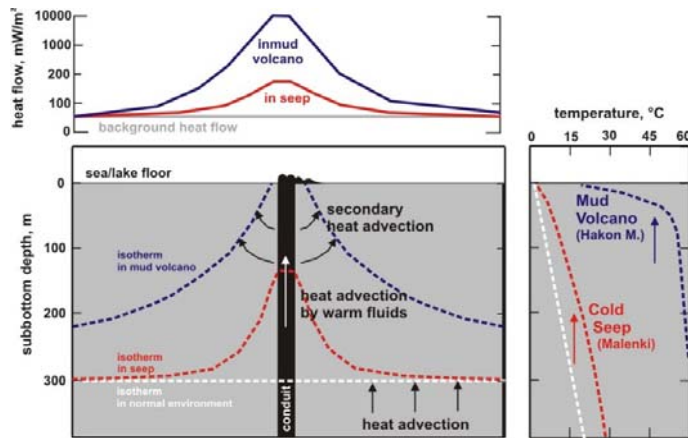
Vanneste & Poort, 2003

# Heat flow in Baikal

## Seeps and mud volcanoes

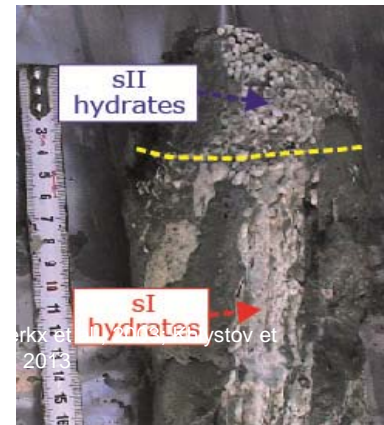


### 1) Warm upflowing fluids



De Batist et al., 2003

### 2) Gas hydrates

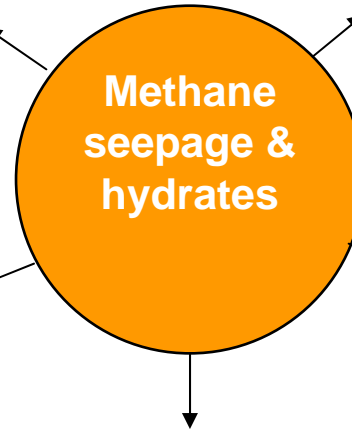
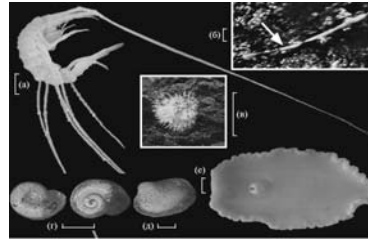


# Class@Baikal 2014

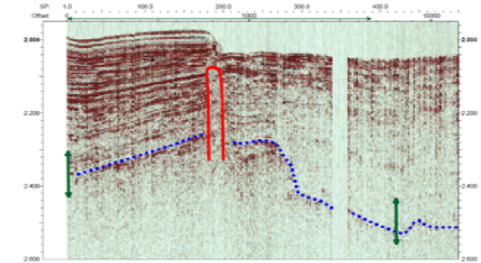
Dynamics of seep systems



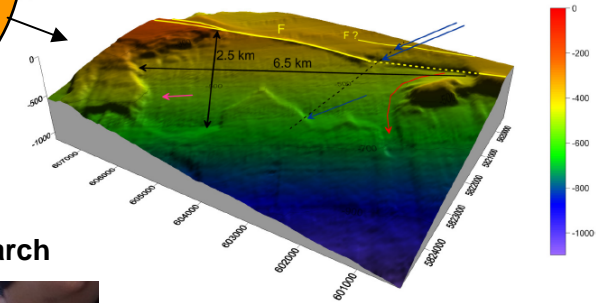
Link with biosphere



Link with deep the geosphere



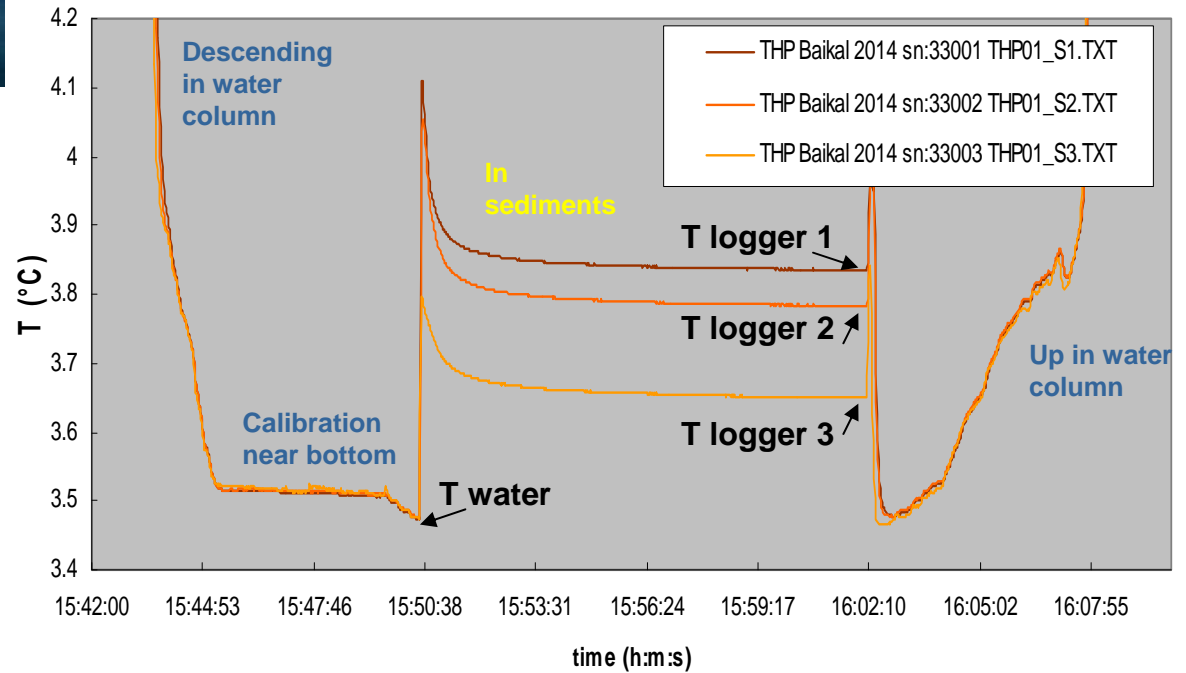
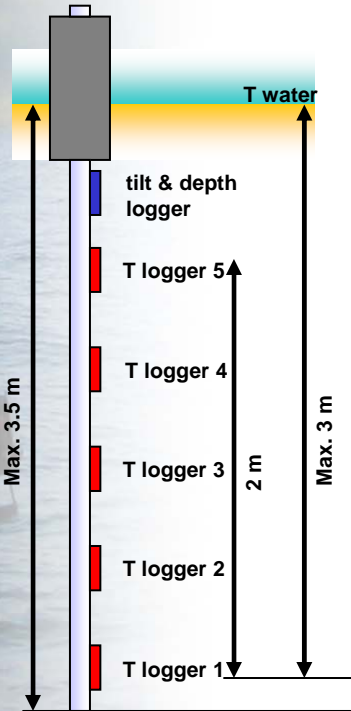
Link with geohazards & climate



Training-Through-Research



# Methodology





# Hydrate dynamics or water infiltration

Hypothesis for K-2 mud volcano: Poort, Khlystov et al., 2012

