Hydrogeological and seismic responses to incoming materials at the non- accreting margin, offshore the Osa Peninsula, Costa Rica

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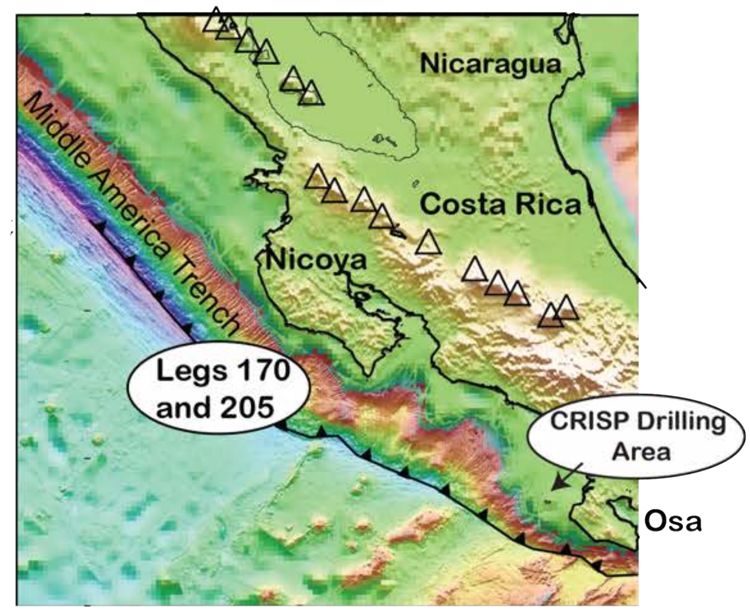


Outline

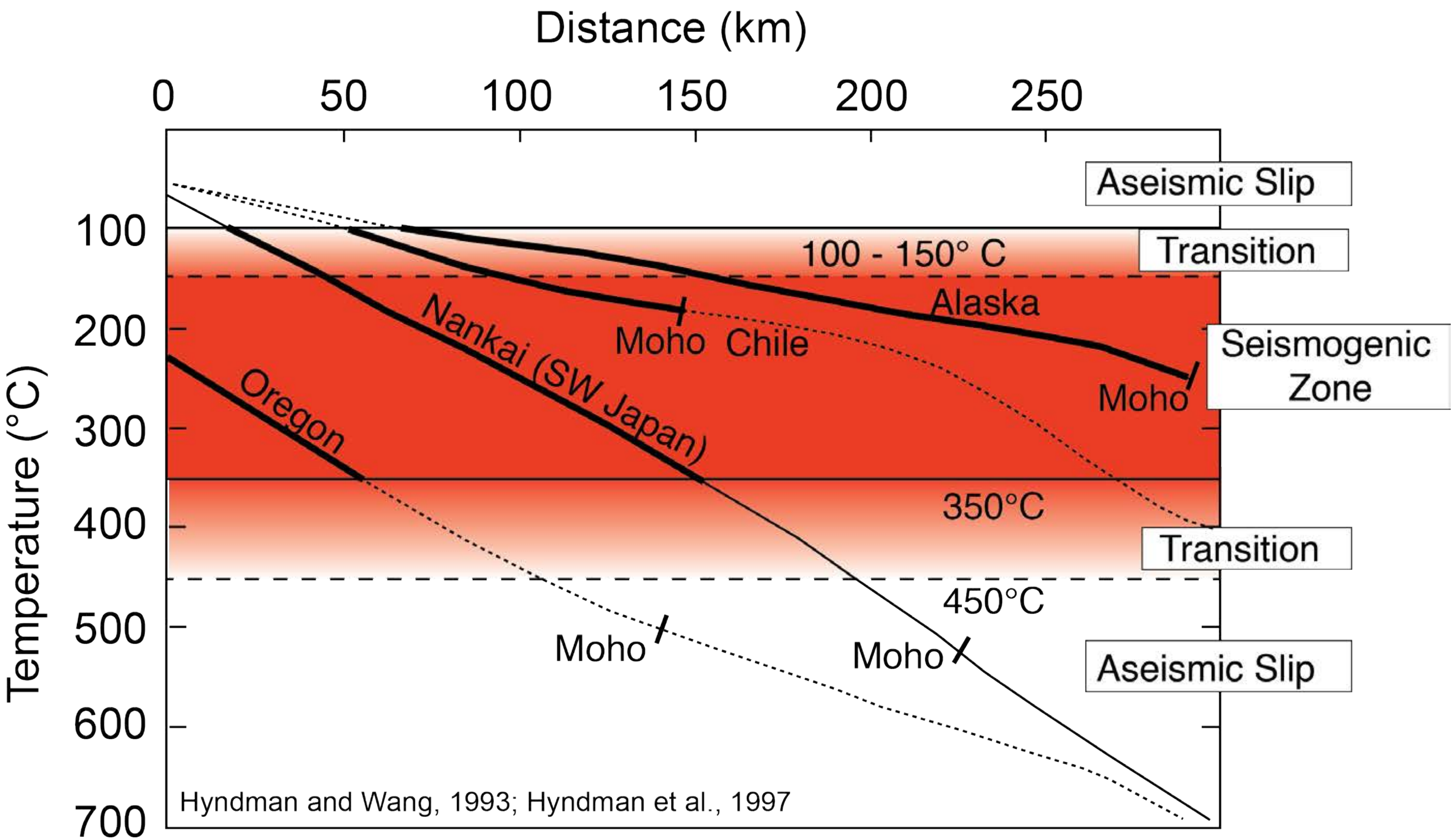
1. Thermal models & updip limit of seismicity
2. Tectonics Setting & Heat Flow offshore Costa Rica
3. CRISP Drilling Results
4. Importance of subducting bathymetric relief

GeoPRISMS Theoretical & Experimental Institute for the SCD Initiative

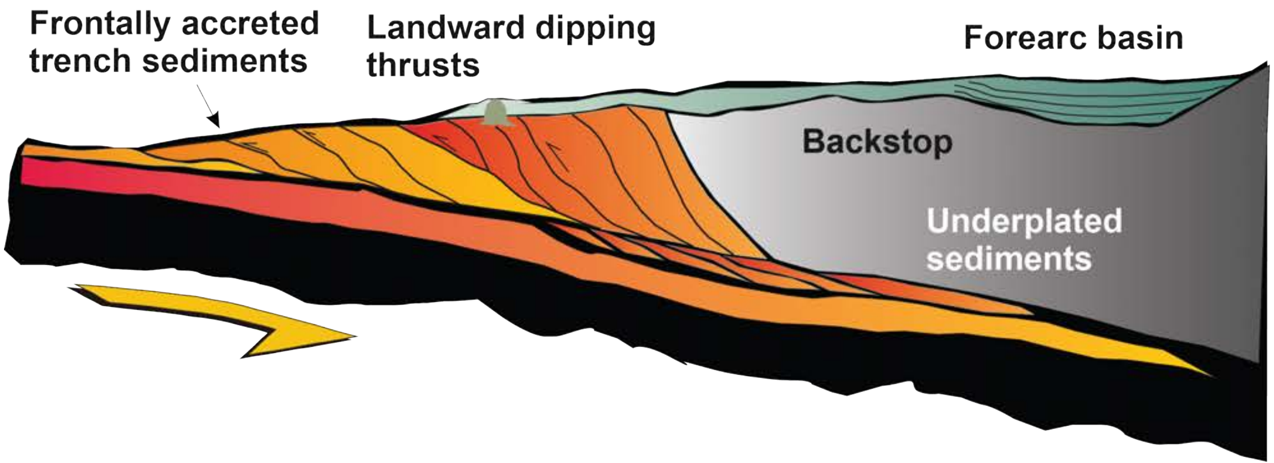
Geo PRISMS *Geodynamic Processes at Rifting and Subducting Margins*

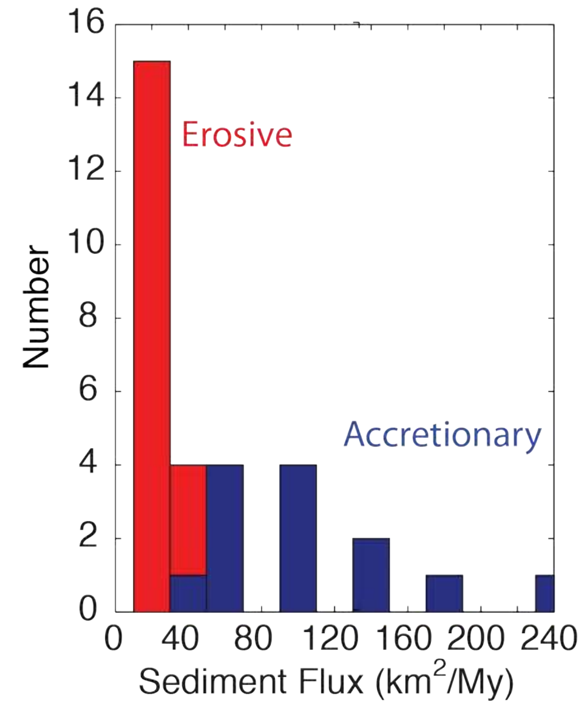
NSF

Hypothesis: Temperature along subduction thrust controls the updip (100-150° C) and downdip (~350° C) extents of seismicity



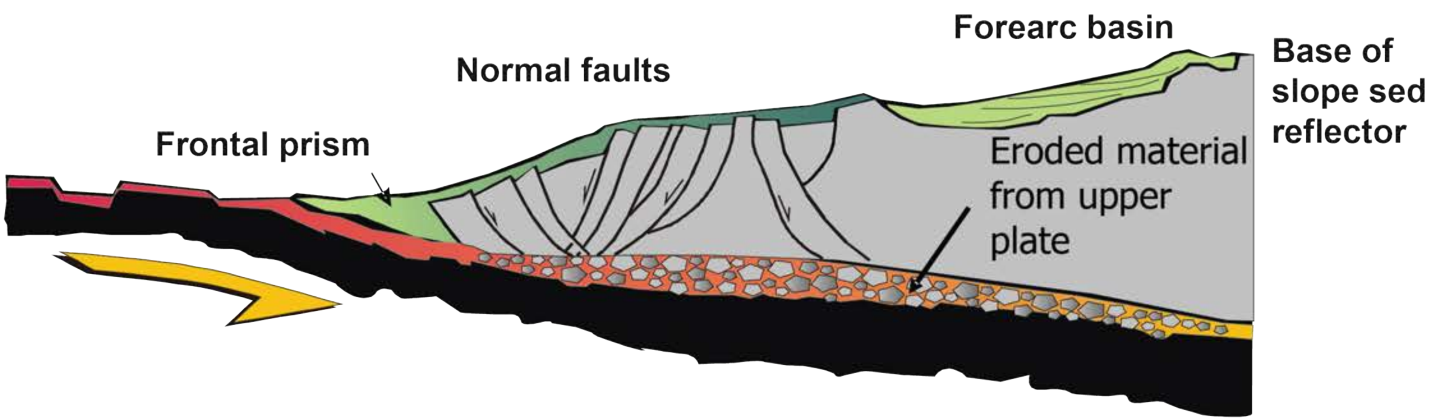
Accretionary Margin





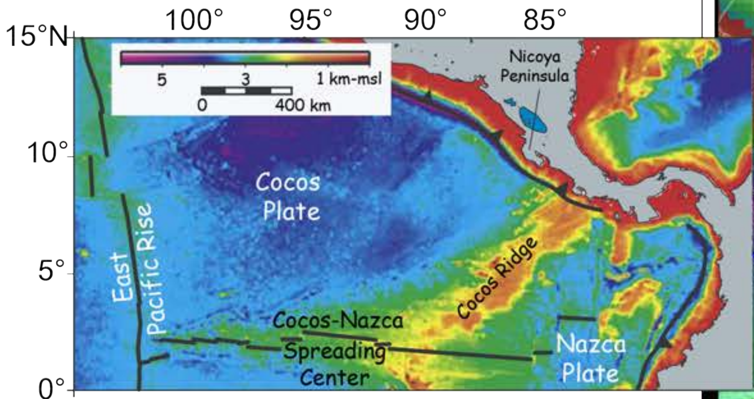
Clift and Vannucchi, 2004

Erosive Margin



Vannucchi et al. 2001

Tectonic Setting

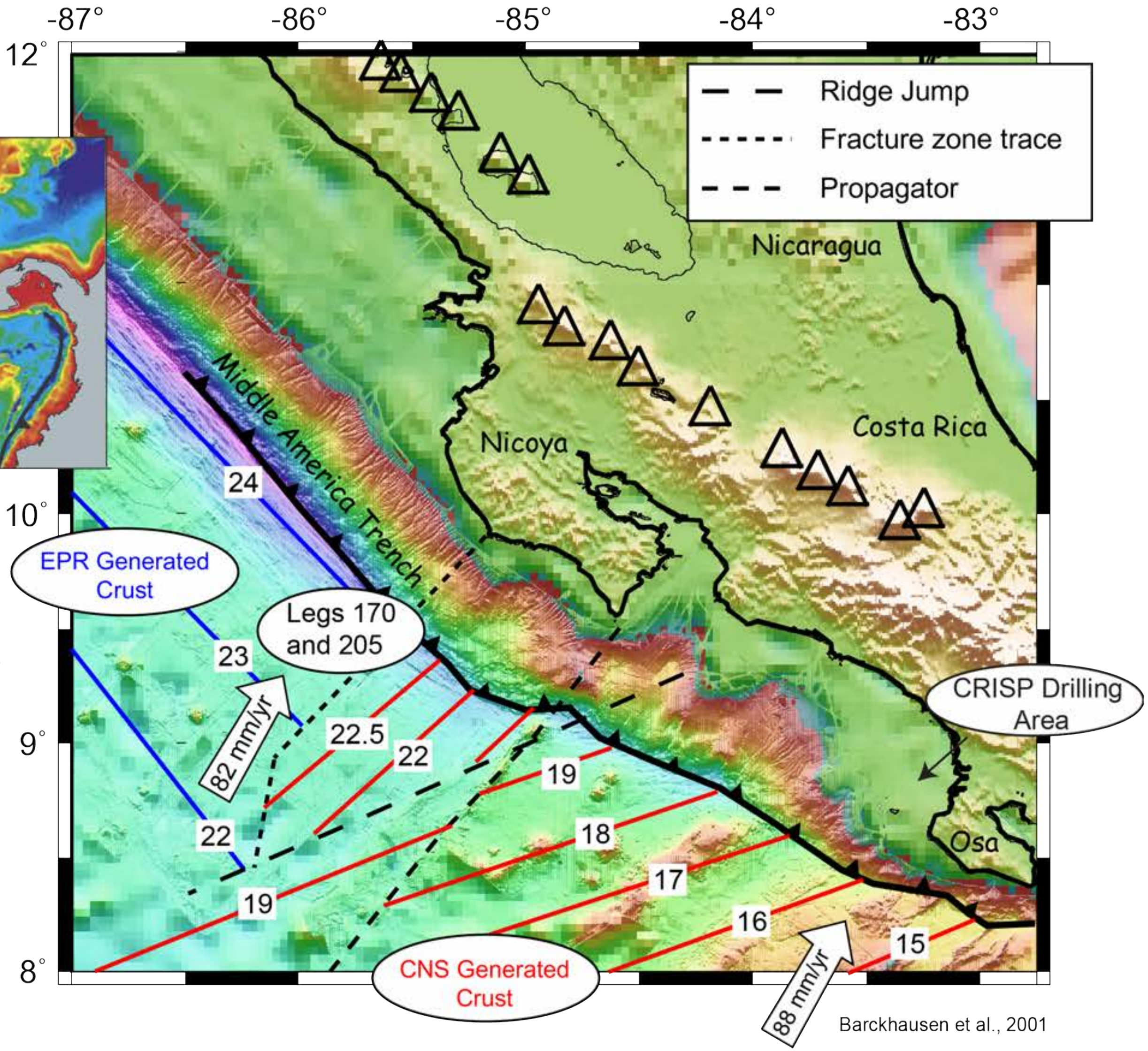


Cocos plate origin:

1. East Pacific Rise (EPR) - half spreading rate 70 mm/yr
2. Cocos-Nazca Spreading Center (CNS) - half spreading rate 35 mm/yr

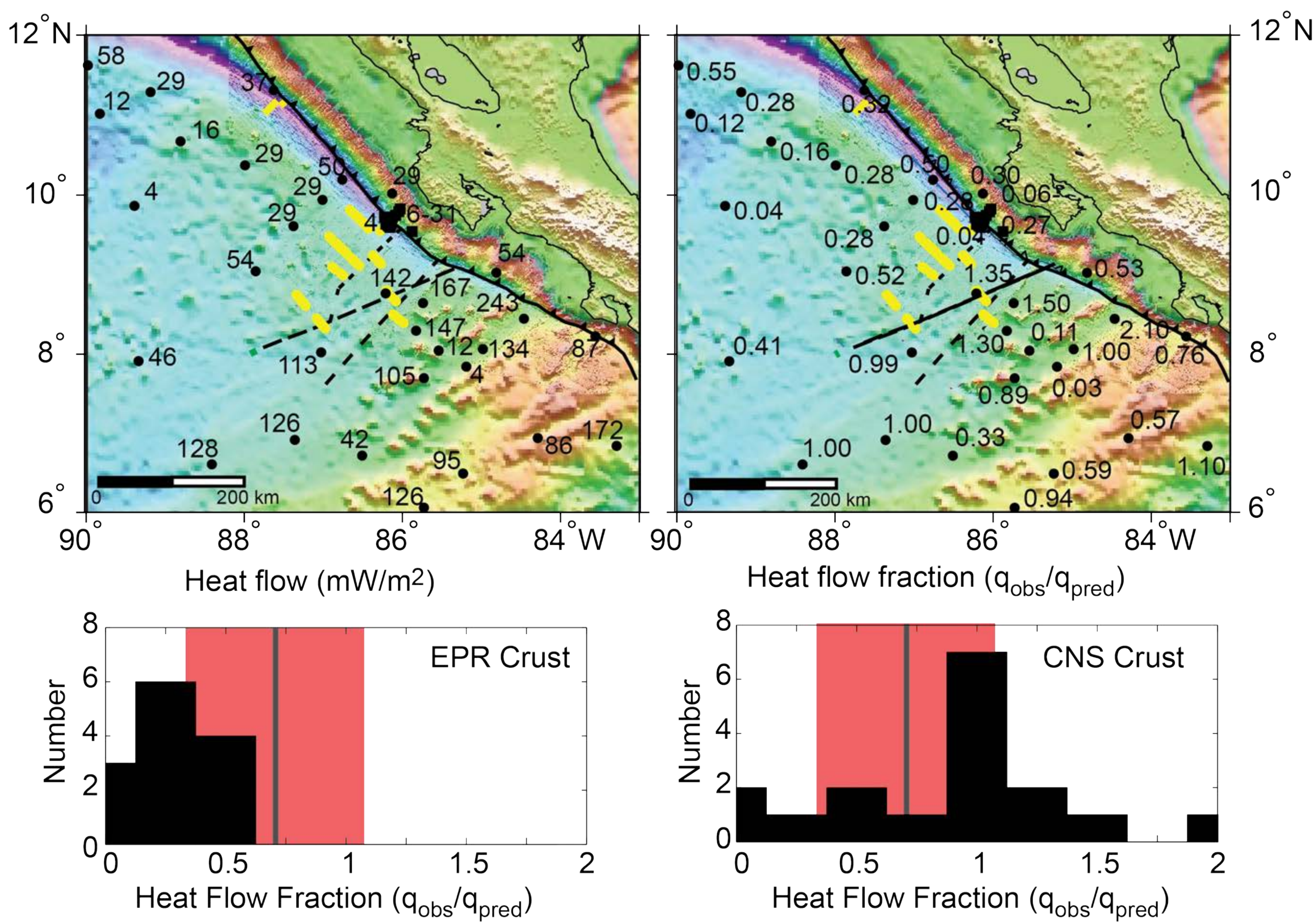
Cocos Ridge - an aseismic ridge generated by Galapagos volcanism.

Along strike variations in bathymetry, age, and thermal structure and sediment thickness.

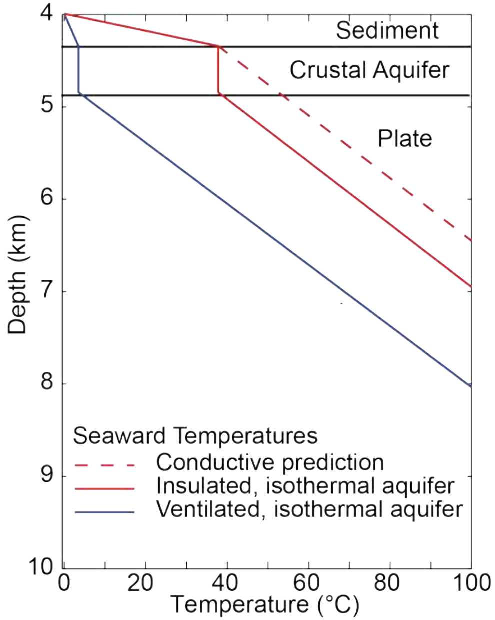


Note embayments along margin generated from subducting bathymetric relief

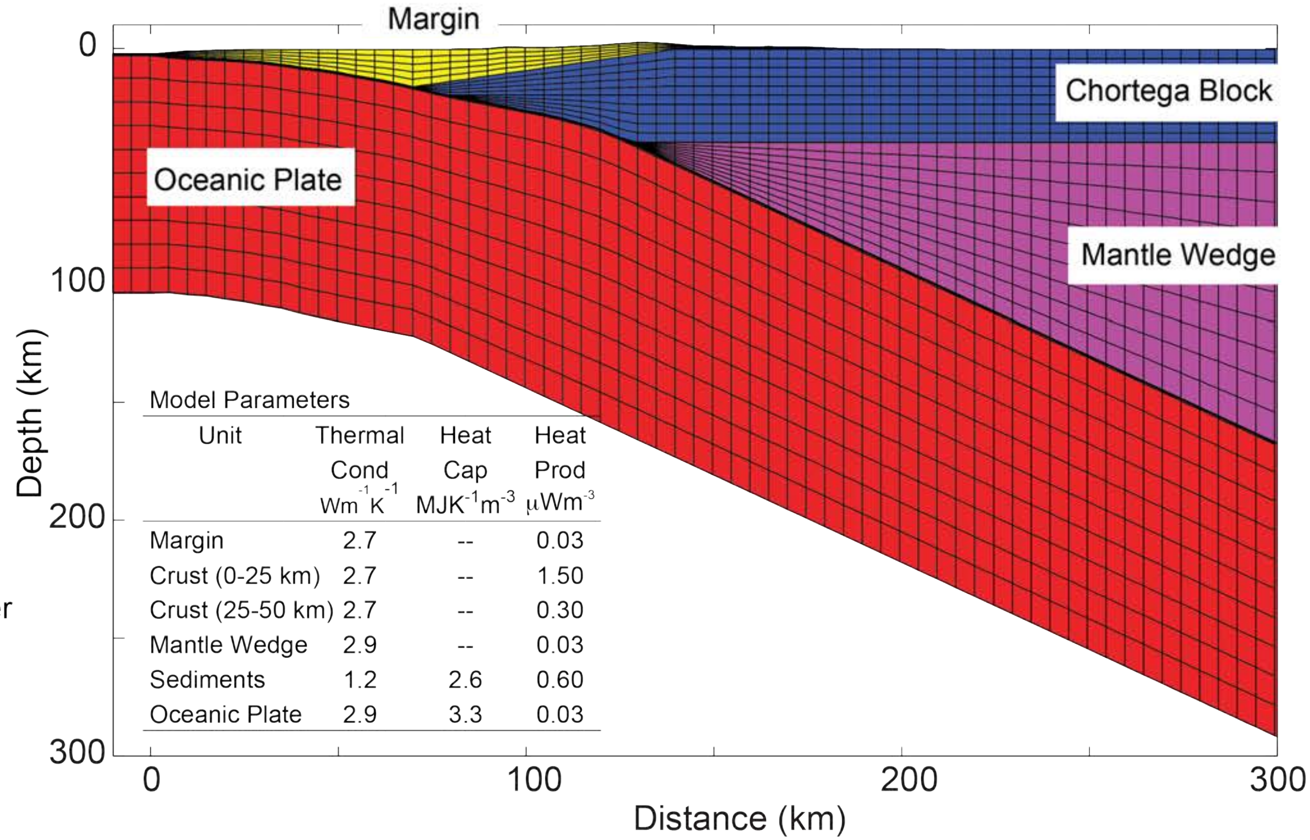
Regional heat flow



Subduction zone thermal models

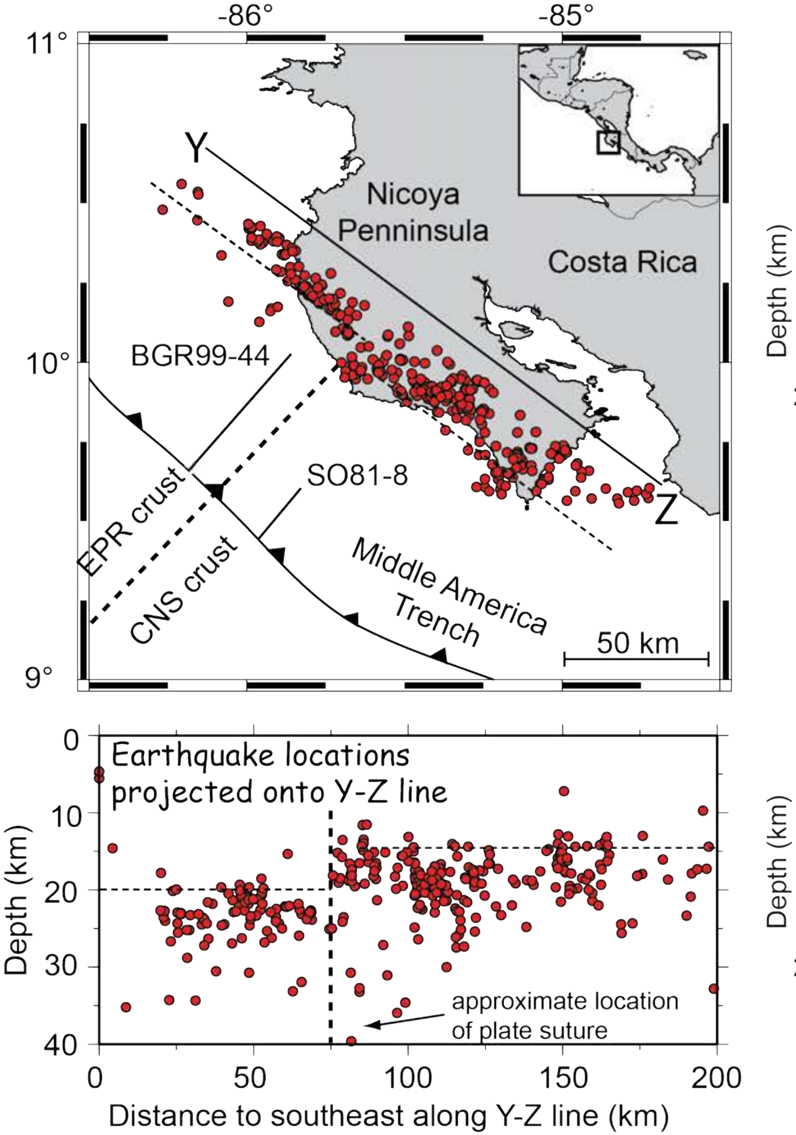


Use a Nusselt model approach to simulate fluid flow in oceanic aquifer (Wang and Spinelli, 2008)

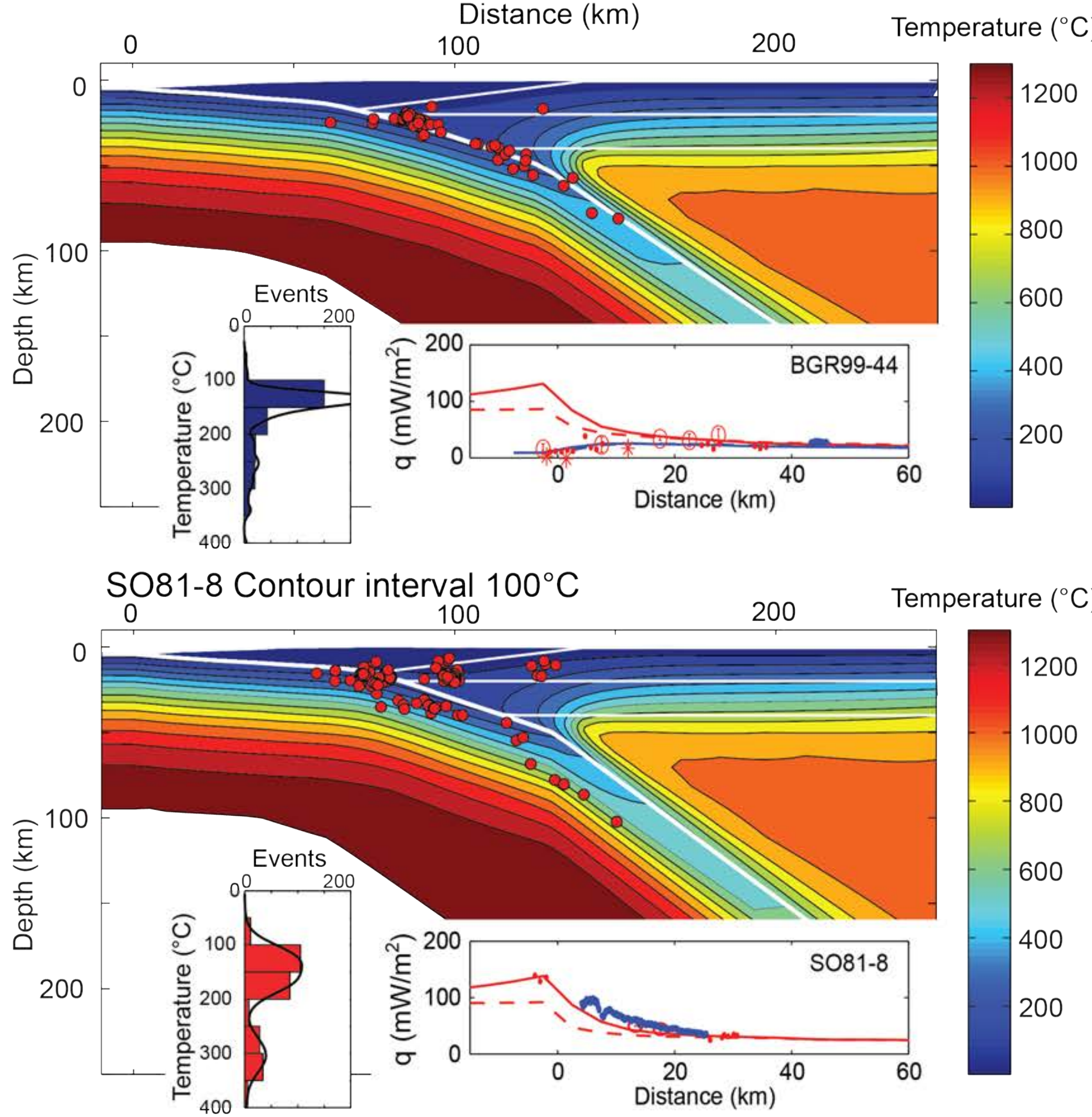


Unit	Thermal Cond $Wm^{-1}K^{-1}$	Heat Cap $MJK^{-1}m^{-3}$	Heat Prod μWm^{-3}
Margin	2.7	--	0.03
Crust (0-25 km)	2.7	--	1.50
Crust (25-50 km)	2.7	--	0.30
Mantle Wedge	2.9	--	0.03
Sediments	1.2	2.6	0.60
Oceanic Plate	2.9	3.3	0.03

Temperature and the updip limit of Seismicity, Nicoya Peninsula

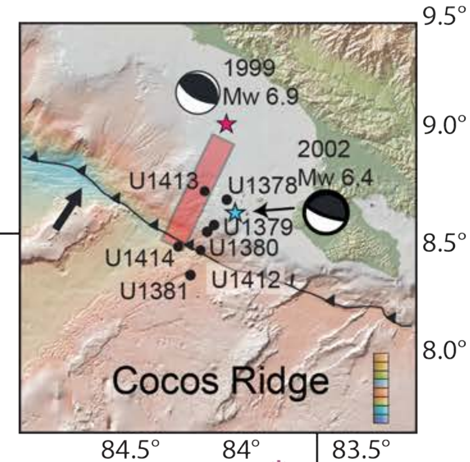


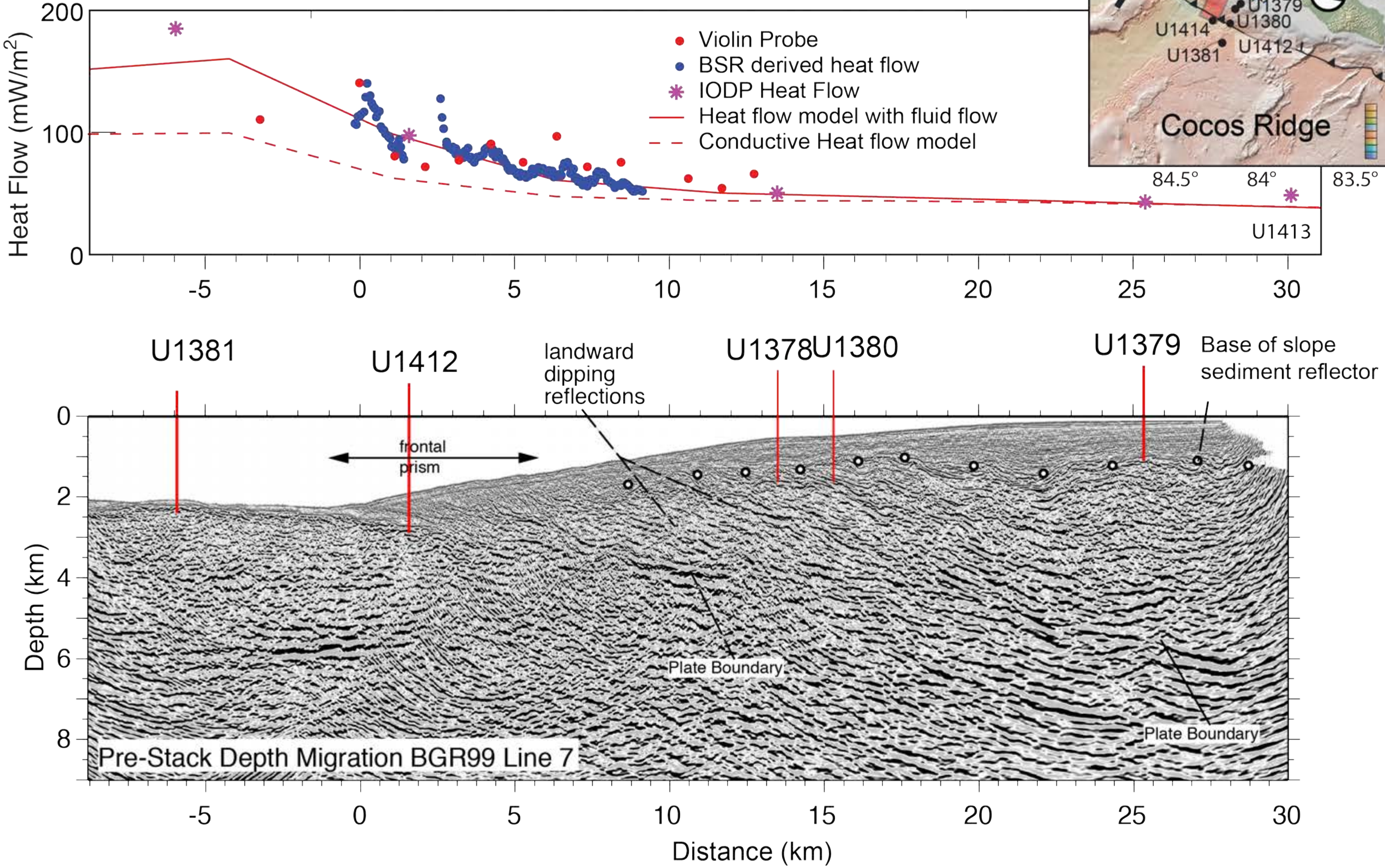
Newman et al., 2002



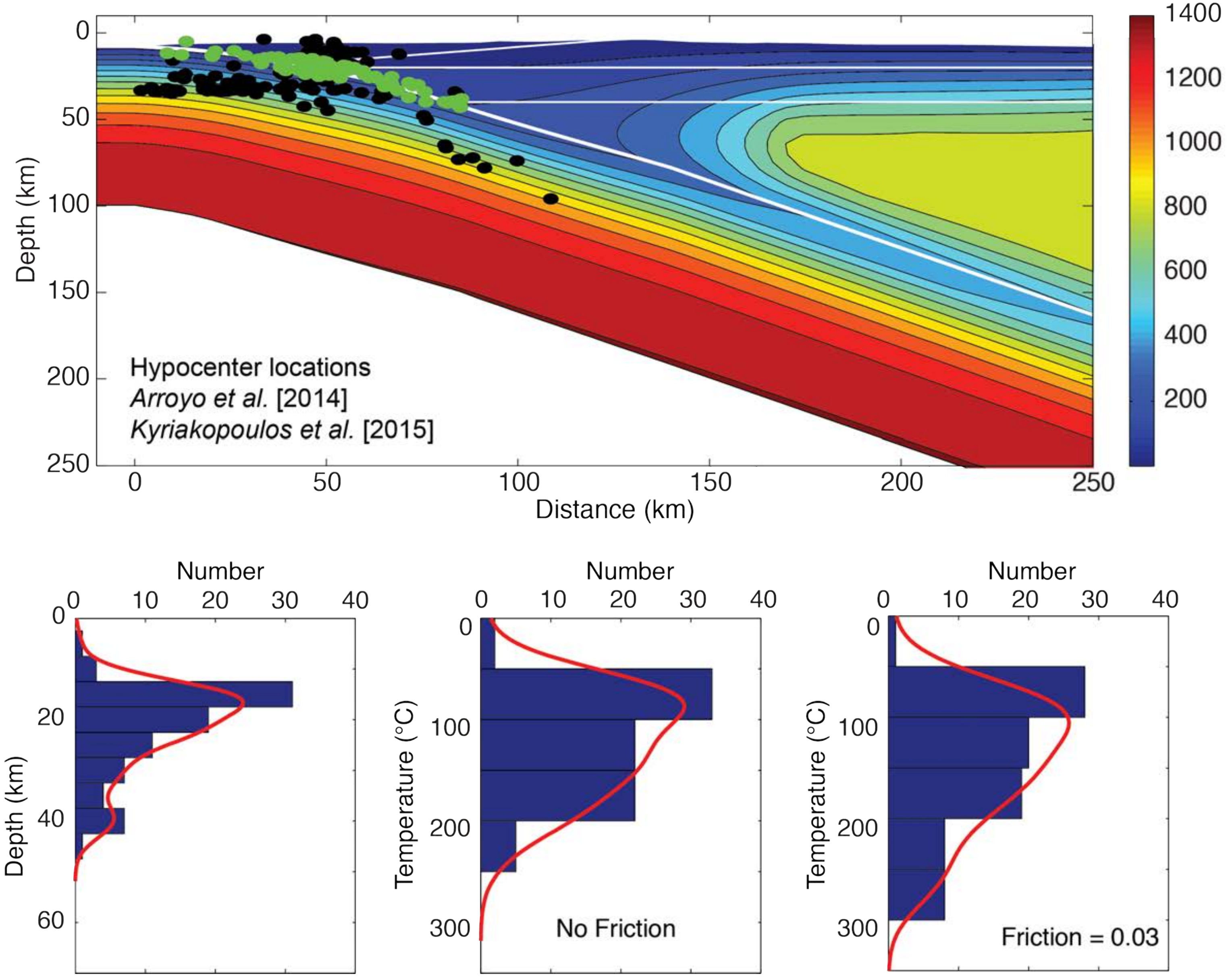
Harris et al., 2010

Heat flow and thermal model along CRISP drilling transect





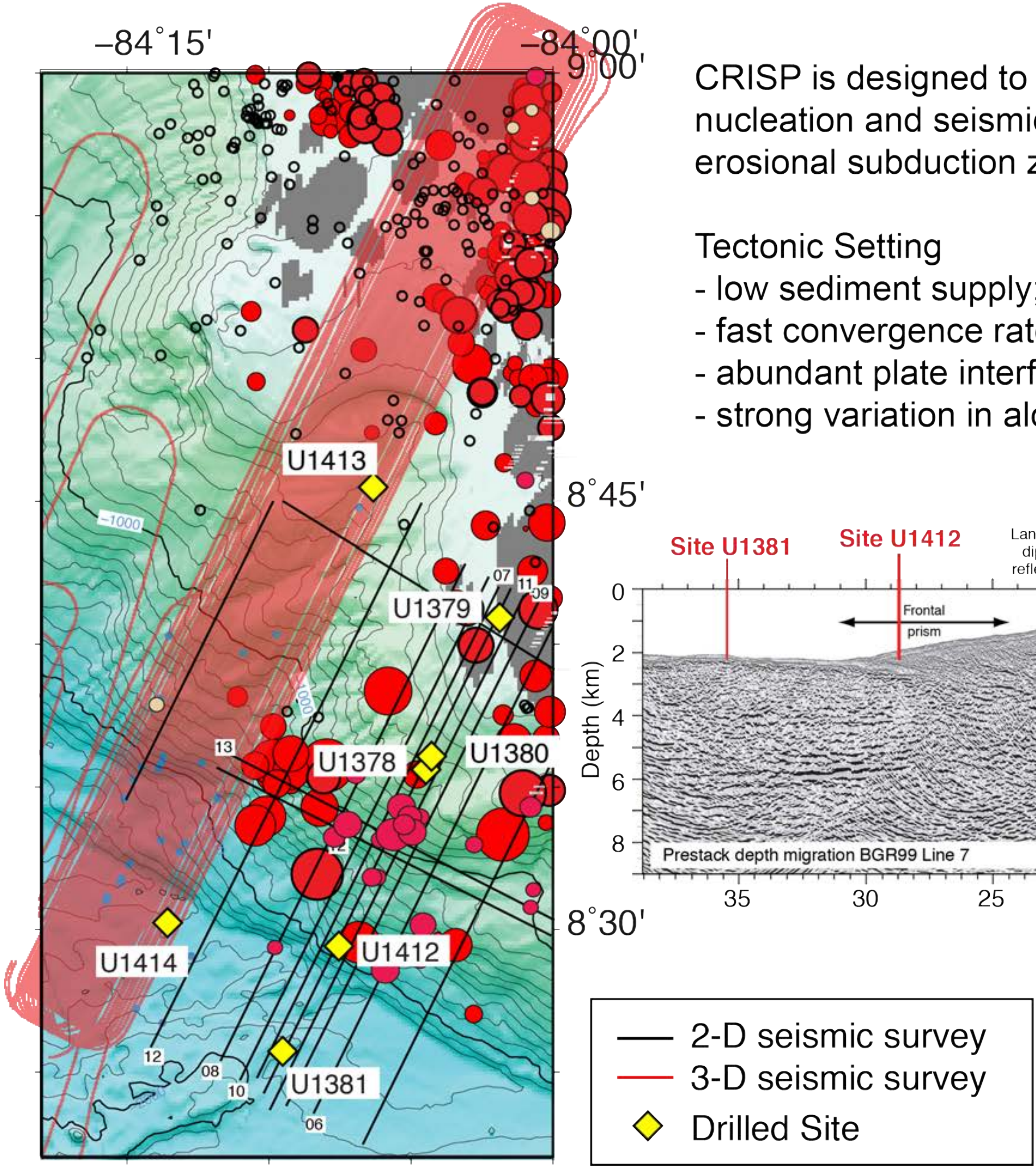
Temperature and the updip limit of Seismicity, CRISP drilling transect

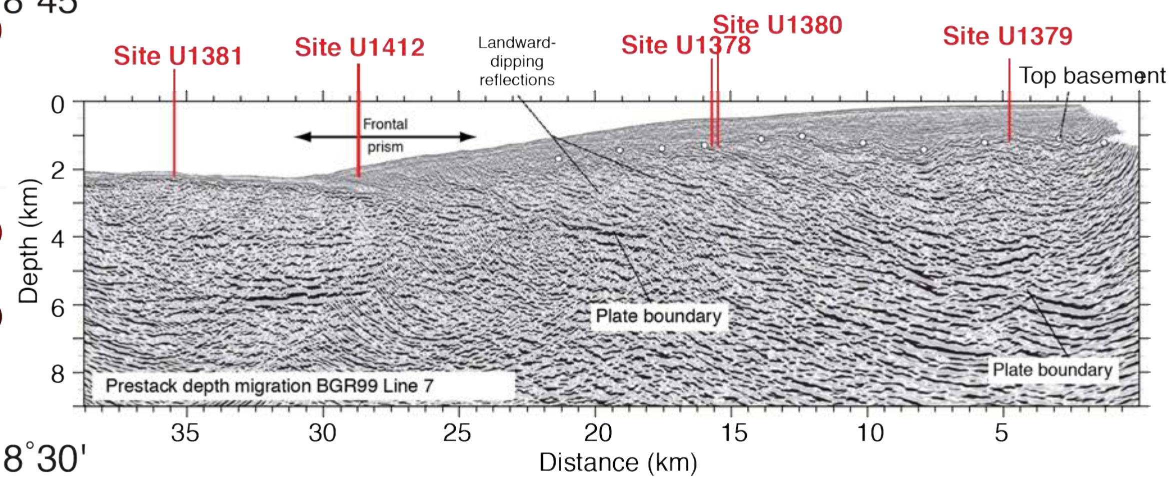


Costa Rica Seismogenesis Project (CRISP)

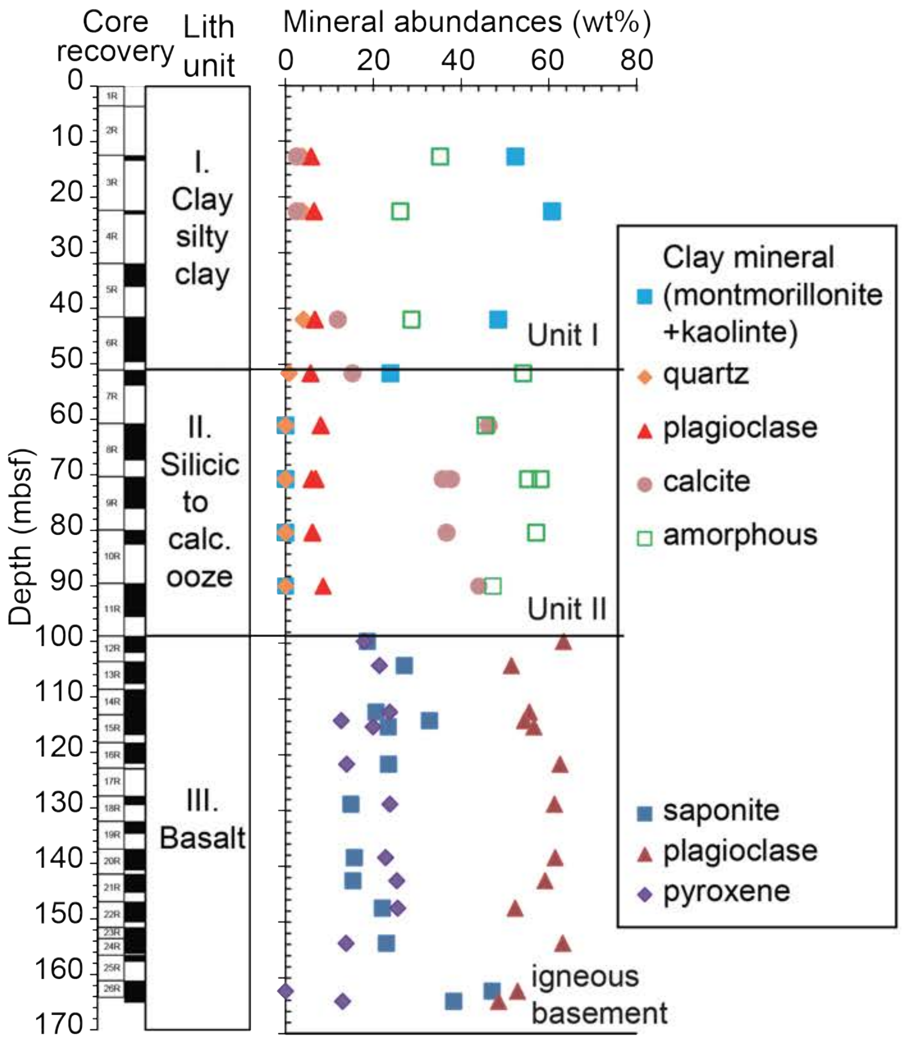
CRISP is designed to elucidate the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones.

Tectonic Setting
- low sediment supply;
- fast convergence rate;
- abundant plate interface seismicity;
- strong variation in along-strike subducting plate relief.





Reference Site U1381, Osa



Sediment compostion, Nicoya

Hemipelagic (~135 m)	Weight %
Opal	10%
Smectite	60%
Pelagic (~215 m)	
Carbonate Ooze	100%
Total fluid influx ~ 23 m^3/yr.	

Spinelli and Underwood (2004)

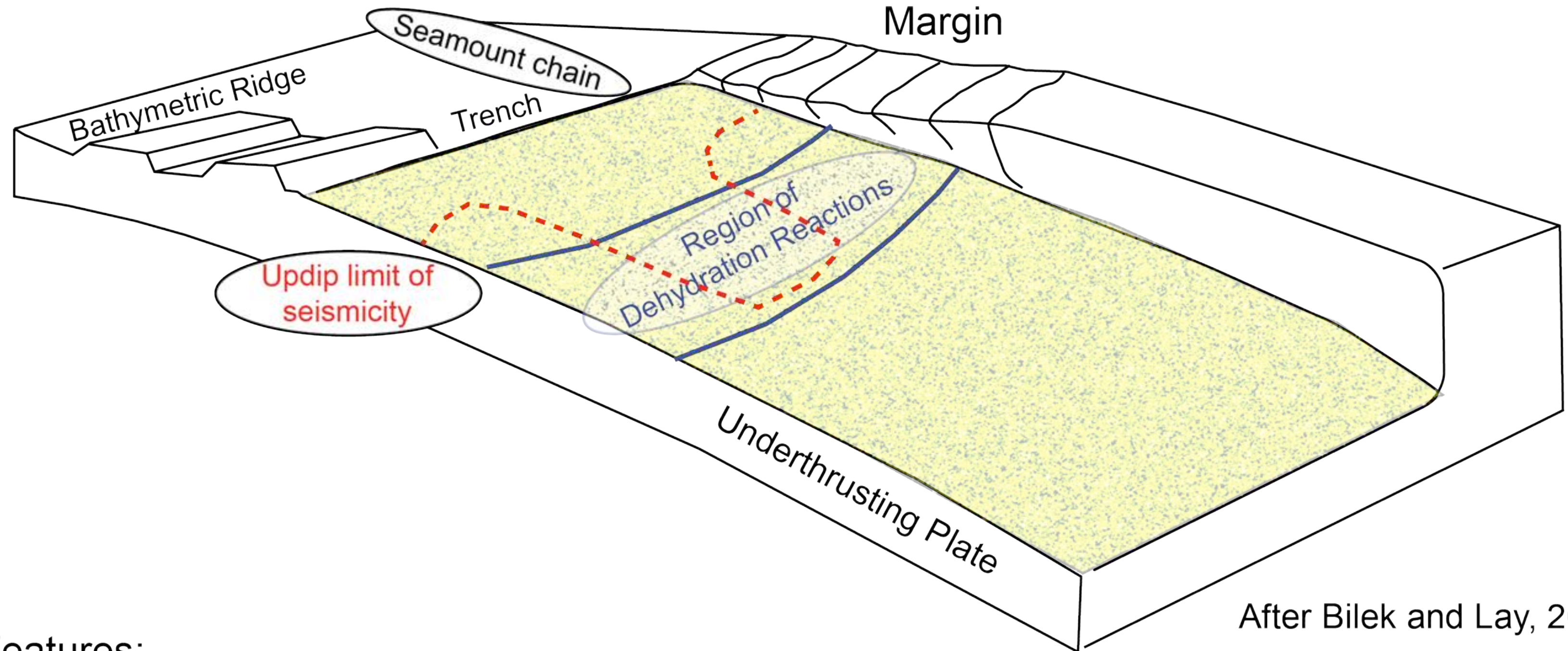
Sediment compostion, Osa

Hemipelagic (50 m)	Weight %
Clay minerals	50
Calcite	15
Amorphous	30
Pelagic (50 m)	
Biogenic amorphous silica	50
Calcite	50
Total fluid influx ~ 3.2 m^3/yr.	

Kameda et al., (2015)

Approximately 10x more fluid entering subduction zone offshore Nicoya Peninsula than CRISP drilling transect. Primarily due to greater sediment thickness at Nicoya. On a per meter basis amount of fluid entering subduction zone is similar because most fluid is in pore space.

Model for updip limit of seismicity in region of CRISP drilling transect



After Bilek and Lay, 2002

Features:

- Seismcity patch are elongated downdip of subducting bathymetric features (Bilek et al., 2003)
- Bathymetric highs may be capped with velocity weakening nannofossil chalk (Ikari et al., 2013)
- Shallow seismicity updip of dehydration reactions (Kameda et al., 2015).

Envision plate boundary as corregated surface with bathymetric highs capped by nannofossil chalk and troughs infilled by hemipelagics and pelagics. If bathymetric highs are indentors facili-ating frontal and basal erosion then plate boundary must pass over bathymetric highs and may pass through nannofossil chalk.

Conclusions

1. Knowledge of the thermal structure of the incoming plate is critical for thermal models of the shallow subduction thrust. Using global models of lithospheric cooling are not an always appropriate boundary condition for thermal models of the shallow subduction zone.

2. Variations in heat flow are observed along the Middle America Trench offshore Costa Rica. Offshore the Nicoya Peninsula, these changes correlate with the changes in the updip extent of seismicity and generally correlate with the 100 -120° C isotherm. Offshore the Osa Peninsula the updip limit of seismicity correlates with the 70-90° C isotherm.

3. Variation in fluid influx at Nicoya Peninsula is ~10x greater than along CRISP drilling transect at Osa Peninsula. Even though there are compositional differences in incoming sediment, the difference in fluid flux is primarily due to the difference in incoming sediment thickness of ~350 m at Nicoya and ~100 m at CRISP transect.

4. In the CRISP drilling region patchy seismicity is correlated with the subduction of bathymetric relief (Bilek et al., 2003; DeShon et al., 2003). Shallow updip limit of seismicity at temperatures less than 100° C may be due to velocity weakening nannofossil chalk (Ikari et al, 2013) capping bathymetric highs. Updip limit of seismicity is seaward of dehydration reactions.