<table>
<tr><td rowspan="3">SEIZE/
SF</td><td colspan="2">Collaborative Research: The Thermal State of 20-25 Ma Lithosphere Subducting at the Costa Rica Margin, Implications for Hydrogeology, Fluxes, and the Seismogenic Zone</td></tr>
<tr><td colspan="2">Carol Stein (Northwestern U.), Fisher, Silver, Harris, Wheat, Wang</td></tr>
<tr><td>10/1/00 – 9/30/04</td><td>OCE 00-01892, OCE 00-01941, OCE 00-01944</td></tr>
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18-24Ma lithosphere on the Cocos Plate near the Nicoya Peninsula, Costa Rica (Fig. 1) has significantly variable heat flow. East Pacific Rise (EPR) sourced seafloor has heat flow ~70% less than conductive lithospheric cooling models suggest, but only ~50% of average values for its age; while heat flow for Cocos-Nazca Spreading Center (CNS) sourced seafloor is consistent with conductive models but ~50% higher than average values for its age (Fisher et al., 2003). To explore this issue 360 new heat flow measurements, seismic reflection, and sediment cores were taken during two "TicoFlux" cruises on the R/V Maurice Ewing and R/V Melville. Some of the highlights from this project have been:

- Closely-spaced heat flow measurements (Fig. 1) show a remarkably abrupt (2-5km wide) transition between thermal regimes; suggesting a shallow (<600m) hydrothermal origin, not a change in overall thermal plate structure (Fig. 2). The transition is more closely associated with basement outcrops on the EPR-generated crust than with the EPR/CNS crust contact, indicating the importance of the outcrops in regional heat extraction (Fisher et al., 2003).

- Seamount heat flow measurements in the cold part of the TicoFlux region show significant water recharge and discharge. Modeling suggests that to match the cold EPR-generated crust heat flow, 3-30m/yr lateral flow rates and permeabilities of 10^{-10}-$10^{-8}m^2$ are needed in the upper 600m of basement (Hutnak et al., sub. 2003). This study, and generalizations from it, indicate the major role of seamounts in controlling hydrothermal circulation throughout the oceanic crust (Harris et al., sub. 2003).

- The thermal state of the incoming crust controls the seismogenic zone updip limit in the Middle America Trench near the Nicoya Peninsula. The updip limit for the low heat flow EPR-generated subducted crust is deeper than for the high heat flow CNS-generated subducted crust (Newman et al., 2002); as expected if approximately the same temperature is required. Thermal modeling (Harris and Wang, 2002) shows how main subduction thrust thermal structure is affected assuming different depths of hydrothermal cooling in the incoming plate. There are large along-strike variations in seismicity and the thermal regime, but the updip limit of seismicity (hypocenter locations from Newman et al. 2002) is consistent with temperatures of 100-150 C.

- It is often suggested that increased hydrothermal activity from flexure and faulting causes anomalously low heat flow vs. age in incoming plates at subduction zones. However, global heat flow data shows no significant difference between heat flow near the trench and global means for the same age crust (Fig. 3). However, average heat flow in the overriding plate is ~60% of that in the incoming plate (Stein, 2003).

- Lower heat flow (~20 mWm^{-2} less vs. the incoming cold Cocos plate) associated with the ODP/Leg 170 sites near the Middle American Trench near Nicoya (e.g. Langseth and Silver, 1996) seems to be associated with locally vigorous hydrothermal circulation, rather than incoming plate flexure and faulting (Hutnak et al, sub. 2003).

- At least 8 AGU abstracts and 1 for the NSF-MARGINS Theoretical Institute.
- A completed MS thesis (Friedmann), and 3 completed undergraduate senior theses (MacKnight, Bodzin, Cleary) based on this research project.

References:

Fisher, A. T., C. A. Stein, R. N. Harris, K. Wang, E. A. Silver, M. Pfender, M. Hutnak, A. Cherkaoui, R. Bodzin, and H. Villinger, Abrupt thermal transition reveals hydrothermal boundary and role of seamounts within the Cocos Plate, Geophys. Res. Lett., 30, doi10.1029/2002GL016766, 2003.

Harris, R. N., A. T. Fisher, and D. S. Chapman, Fluid flow through seamounts and implications for global mass fluxes, Geology, submitted 2003.

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Hutnak, M., A. T. Fisher, C. A. Stein, R. Harris, K. Wang, E. Silver, G. Spinelli, M. Pfender, H. Villinger, P. C. Pisani, H. Deshon, B. MacKnight, The thermal state of 18-24 Ma upper lithosphere subducting below the Nicoya Peninsula, northern Costa Rica margin, SEIZE margin volume, submitted, 2003.

Stein, C. A., Heat flow and flexure at subduction zones, Geophys. Res. Lett., No. 23, 2197 doi 10.1029/2003GL018478, 05 December 2003.

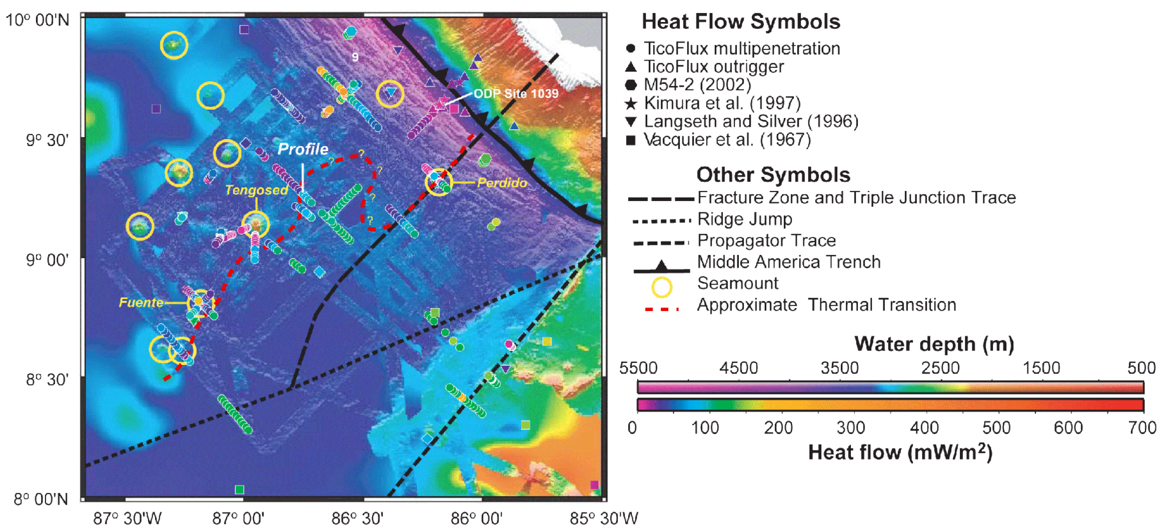

Figure 1. TicoFlux study area with heat flow measurements, bathymetry, and tectonic boundaries. For its crustal age, heat flow on the EPR-generated crust (NW region) is unusually low but that on the CNS-generated crust (SW region) is unusually high. The thermal boundary near the trench is located near the fracture zone trace separating CNS and EPR crust, but occurs closer to the seamounts on EPR crust farther away from the trench (after Hutnak et al., submitted, 2003).

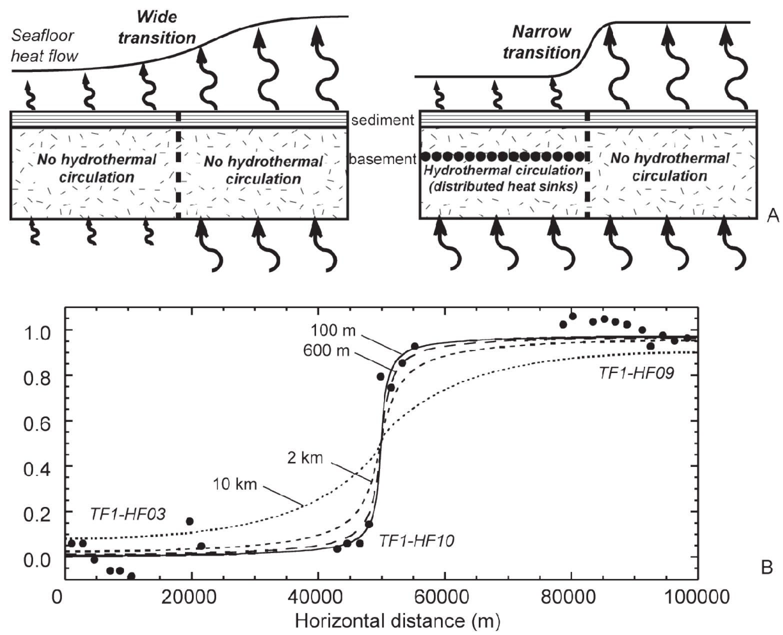

Figure 2: Conceptualization, heat flow data, and thermal models for thermal transition in the TicoFlux area. Top) Cartoons show the expected variation in heat flow depending on a deep (left) or shallow mechanism (right). (Bottom) Heat flow measurements show an abrupt increase, consistent with models of shallow (<600m) hydrothermal circulation. Location of this profile is shown on Figure 1.

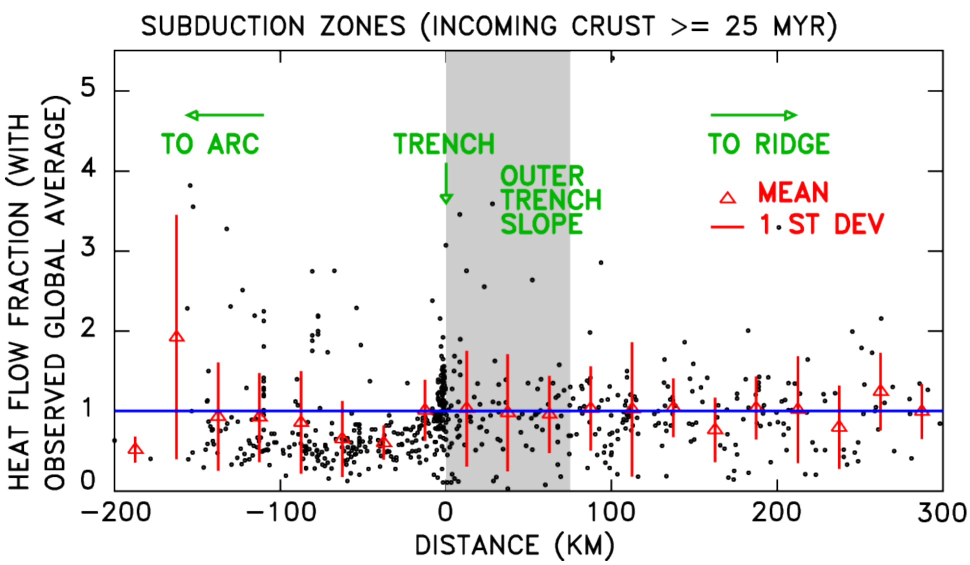

Figure 3. Heat flow fraction (measured with respect to observed global average for that age) with distance from the trench axis. Within the faulted outer trench slope, heat flow is not different than global averages (Stein, 2003).