Hydrothermal circulation within subducting ocean crust: Implications for subduction zone temperatures

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Subduction zone temperatures are important controls on the metamorphic reaction progress of subducting material; as a result they likely affect seismicity, subduction dynamics, and formation of arc magmas. Thus, accurate subduction zone thermal models are necessary to understand key metamorphic and seismogenic processes. We show that previous thermal models had neglected a process that dramatically influences subduction zone temperatures – hydrothermal circulation within the basaltic basement aquifer of subducting crust. This circulation has been recognized as an important control on the thermal budget and evolution of ocean crust worldwide. However, previous subduction zone thermal models either do not include hydrothermal circulation in ocean crust or assume that it abruptly stops upon subduction. Hydrothermal circulation in subducting crust extracts heat from under the margin wedge and transports it seaward, resulting in a cooler subduction zone [Kummer and Spinelli, 2008]. For the Nankai margin (southern Japan), hydrothermal circulation explains long-standing, large, enigmatic thermal anomalies and reduces seismogenic zone temperatures (20°C at the updip limit and 100°C at the downdip limit) relative to a case without hydrothermal circulation [Spinelli and Wang, in review]. The effect of fluid circulation on temperatures in Nankai margin is illustrative of a process that may be important at other subduction zones. Other margins will need to be examined individually with heat flux data constraining thermal models that incorporate the effects of hydrothermal circulation.

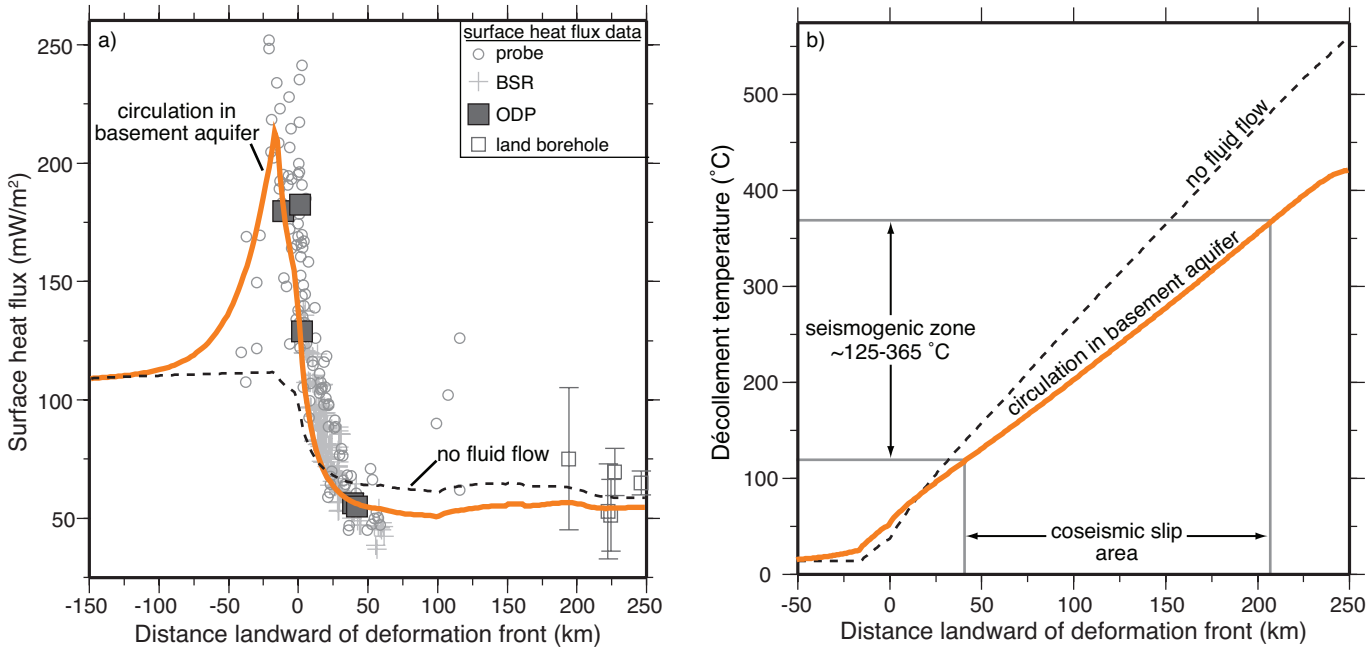

Figure: a) Measured and modeled surface heat flux along a transect off Cape Muroto, Japan. Compared to a model with no hydrothermal circulation (dashed line), simulations with vigorous heat transport in a basement aquifer (bold line) result in higher heat flux in the trench and a very steep drop in heat flux landward of the trench. b) Modeled temperatures along the plate boundary fault. With hydrothermal circulation in the subducting crust, the seismogenic zone extends from 125° to 365°C. A model with no fluid flow results in a much hotter seismogenic zone.

Kummer, T. D., Spinelli, G. A., 2008. Hydrothermal circulation in subducting crust reduces subduction zone temperatures, Geology, 36 (1), 91-94.

Spinelli, G. A., Wang, K., 2008. Effects of fluid circulation in subducting crust on Nankai margin seismogenic zone temperatures, Geology, 36, 887-890.