Thermal regime of the Nankai subduction zone: influence of the recent sedimentation history

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The seismogenic zone, which represents the region where earthquakes occur, has been related to a specific range of temperatures. It is thus important to construct reliable thermal models to determine its limits, in terms of depth.

The thermal modelling of the central part of the Nankai subduction zone, presented here, is based on a two-dimensional, steady-state finite element code, which solves the heat equation for conductive and advective heat transfers. Detailed surface heat flow measurements, from deep and shallow seas are the main constraints on the subsurface thermal structure. Among others, frictional heating along the plate and the seaward boundary condition, greatly influence the calculated surface heat flow and associated temperature field.

A previous steady state numerical model considering the subduction of the slab without taking into account recent sedimentation history enable to evaluate the order of magnitude of frictional heating. The comparison of the calculated surface heat flow profile with the observed data indicates that the frictional heating should be almost negligible in the studied area and that the shear stress in the seismogenic zone along the plate interface is very low.

Here, the influence of the temperature, and hence of the sedimentation history, along the seaward boundary on the calculated surface heat flow is investigated. The geotherm along this boundary is a function of the age of the subducting plate but also of the sedimentation rate. In regions where sedimentation is rapid and recent, it prevents the shallow sedimentary layers from reaching a steady thermal regime. As a result, the conductive heat flow measured at a shallow depth can be significantly less than the actual heat flow entering from the bottom of the formation. In the present study, Hutchinson's theory (1985) of one-dimensional heat transfer is used to calculate the temperature in the sediment section during compaction. In that case, the thermal effect of sedimentation history is evaluated through numerical modeling assuming the sedimentation rate, the thermal properties of the sediments and the temperature at the basis of the model.

On the Nankai Through off Kumano, the 1km thick section of sediments is assumed to have been deposited mainly during the last 1 Ma, even though during the last 10,000 years the sedimentation rate was very low. In that case, the results show that, taking into account the effect of recent rapid sedimentation and assuming a 20 Ma old plate leads to a value of surface heat flow of 87 mW/m^2. Such a value is estimated to be about 20% lower than the heat flow value measured on the floor of the trough which reaches ˜110 mW/m^2. Such a large heat flow difference cannot be attributed only to the effects of fluid expulsion associated with subduction and accretion of the sediments brought into the trough as they are thought to contribute to less than 5% of the perturbation.

Thus, the results suggest that the underlying oceanic lithosphere is either anomalously warm or younger than the assumed age of 20 Ma. Actually, when the age of the oceanic plate is assumed to be 15 Ma, then the calculated heat flow fit the measured one.