SCEC 2017 CTM Project Report

In our 2017 research we assume the seismic LAB (sLAB) and thermal LAB (tLAB) are coincident, accepting evidence presented in several recent papers while noting some dissenting views. Under this assumption it is clear that a number of the steady state conductive we have computed are problematic and in 2017 we began exploring this matter further. For example, the cooler geotherms imply implausibly thick thermal lithospheric keels extending from ~100 to as much as 250 km depth beneath several parts of southern California. Such local features, if they existed, would inevitably be thermally eroded by adjacent warmer crust and upper mantle. Furthermore, seismic estimates of LAB depth beneath these cool HFRs are ~60-85 km, much shallower than the predictions of the standard thermal model.

Fig. 1 explicitly shows this behavior. For each of our 14 Heat Flow Regions (HFRs) we plot observed SHF against sLAB depth and compare it with the predicted tLAB depth of the standard continental model (solid black curve). The 6 lowest SHF regions on this plot (blue dots) lie significantly to the left of the standard curve. The warmest regions lie to the right and below the standard curve (red dots). The remaining 6 regions, with SHF averaging ~60-80 mW/m^2, agree acceptably with the model (black dots). Nonetheless, it seems clear that more sophisticated models are required to quantify the thermal state of a number of HFRs. We explored this matter further, noting that in several parts of southern California late Cenozoic plate interactions have perturbed the thermal field and steady state conductive conditions probably do not apply. Referring to Fig. 1, we think this is likely in the HFRs where the thermal gradient is highest (red dots, iST, oST) and where it is lowest (SN and other blue dots).

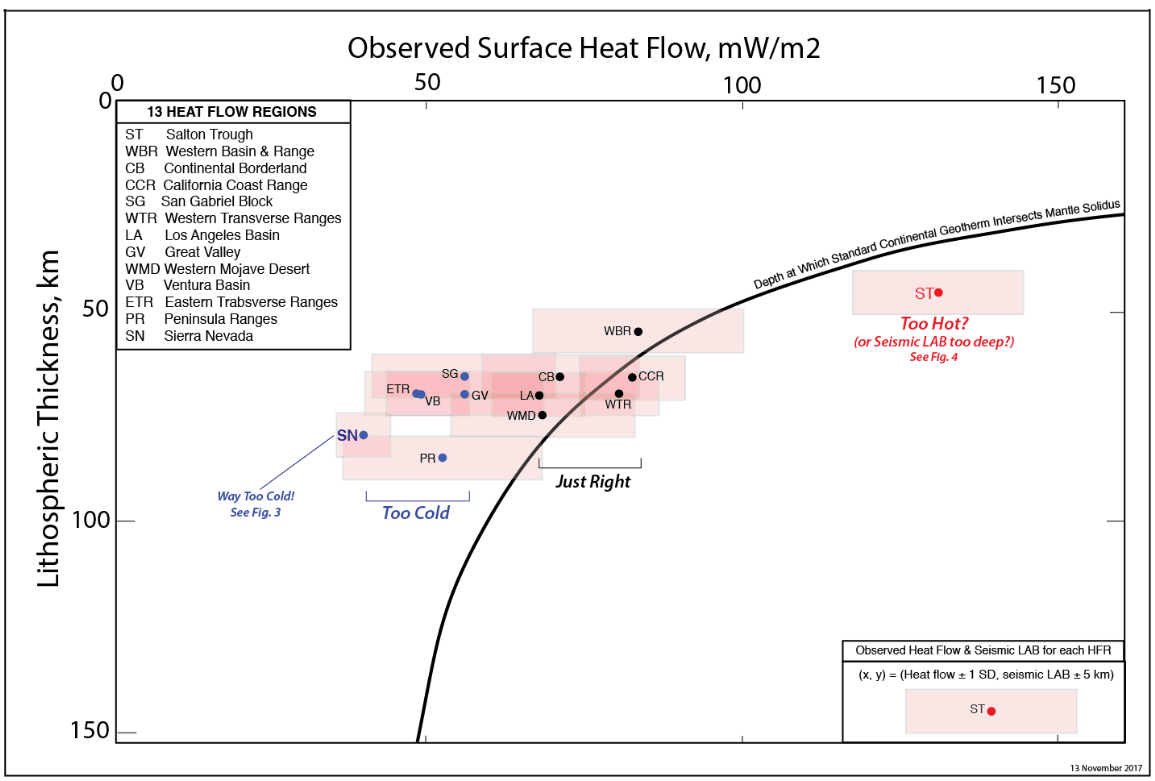

Fig. 1: Lithosphere thickness related to surface heat flow. Solid curve shows predicted *thermal* lithosphere thickness as a function of observed surface heat flow for standard continental thermal model. Dots with pink boxes show *seismic* lithosphere-asthenosphere boundary depth for 13 southern California HFRs plotted against observed heat flow for each region

To quantitatively address these issues we computed transient slab free asthenospheric window geotherms appropriate for the Sierra Nevada (SN) region. This calculation shows that a sudden detachment of lower crust and/or upper mantle lithosphere 3 – 10 Ma BP would significantly heat the lower crust and upper mantle lithosphere relative to the 1D steady-state conductive model yet not be seen in today's SHF.

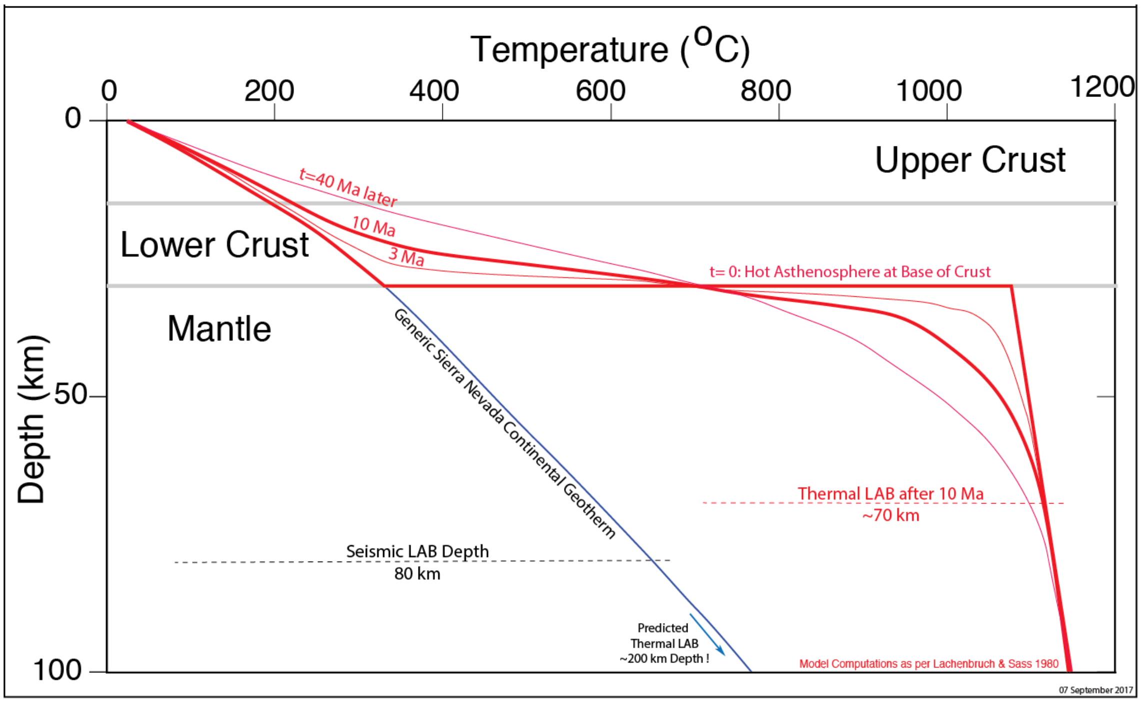

Fig. 2: Hypothesized removal of Sierra Nevada lower crust and/or upper mantle lithosphere 3-10 Ma ago would not yet perturb present SHF yet have an enormous effect on present day geotherm

We also used a dynamical steady-state thermo-mechanical model for the Salton Trough in which lithospheric extension is accommodated by magmatic intrusion and rapid accumulation of sedimentary infill.

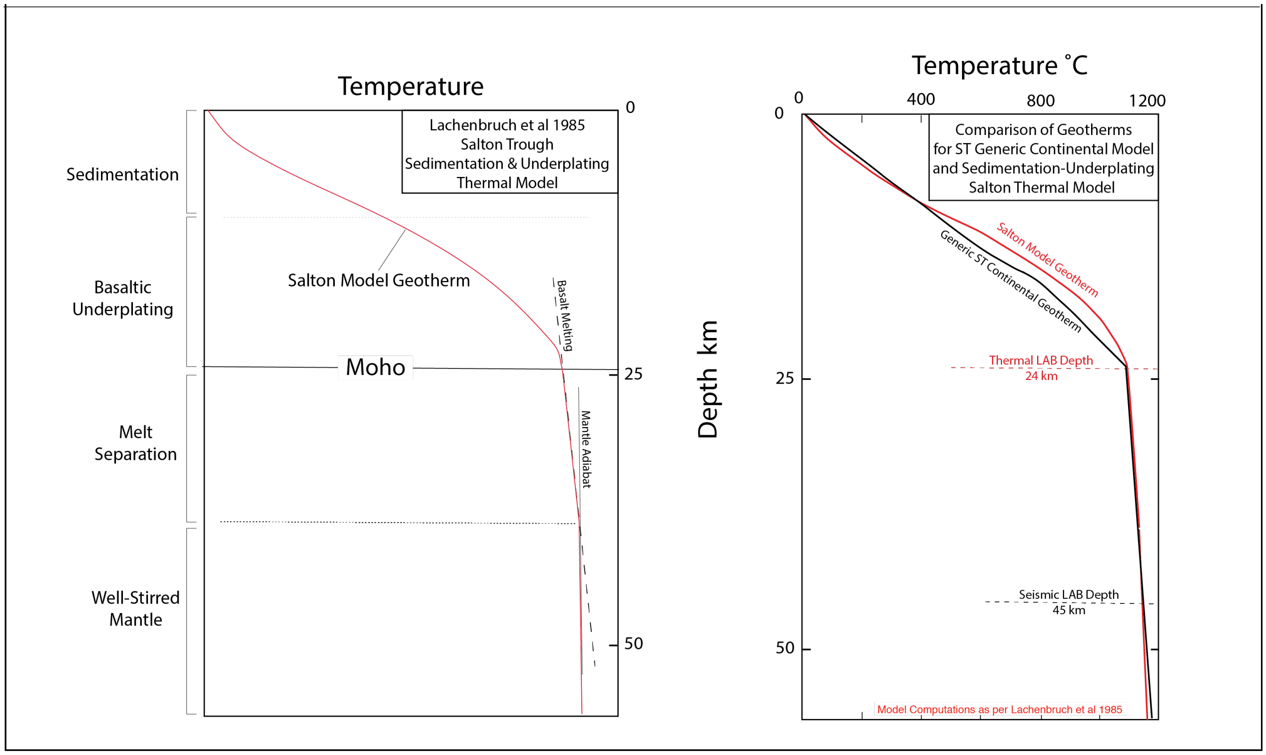

Fig. 3: Comparison between standard continental geotherm and sedimentation/underplating model geotherm for Salton Trough (ST) show fortuitous agreement. However, both model results disagree with seismically estimated LAB depth