The SCEC Community Thermal Model Version 1.20

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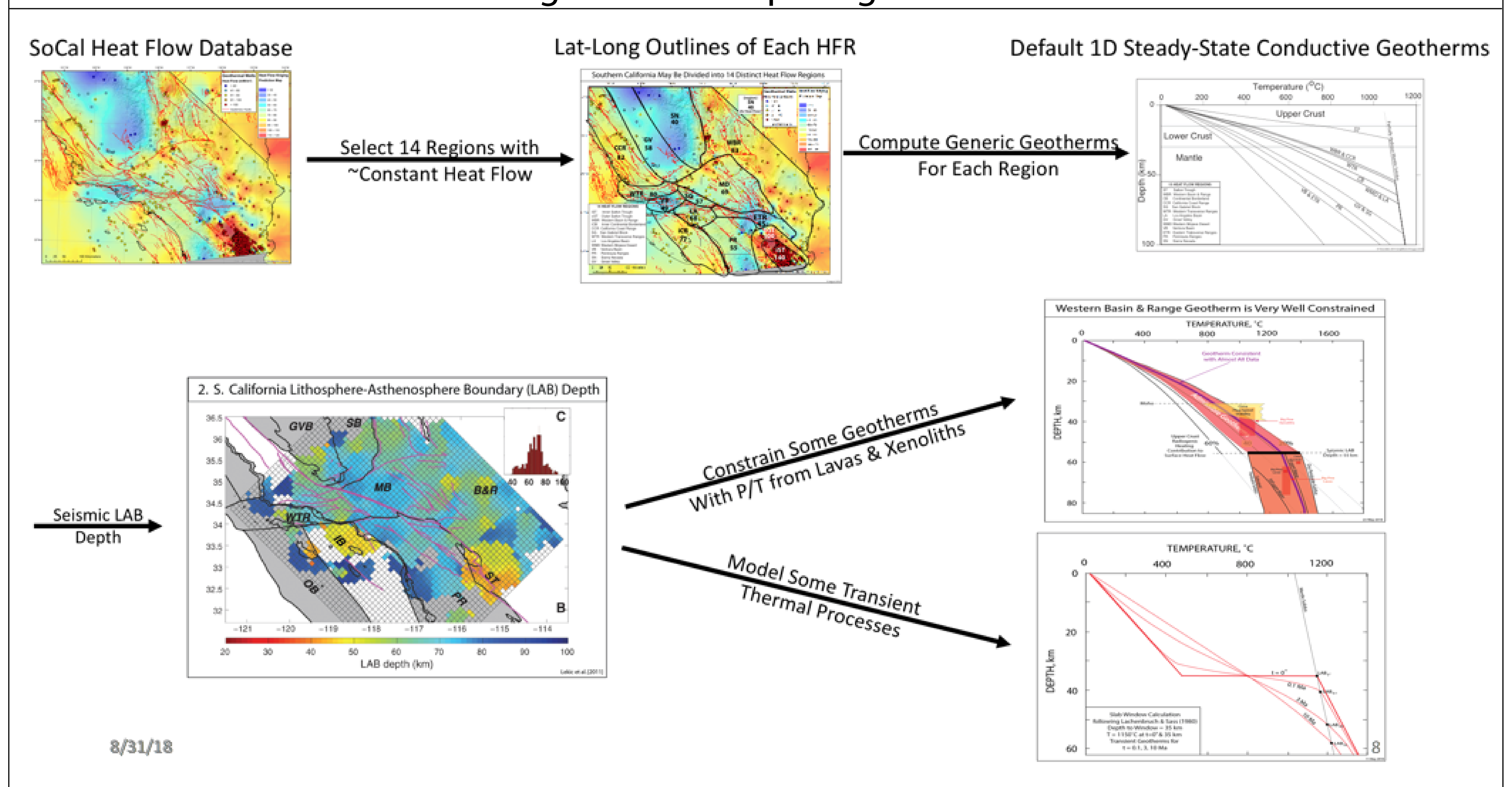
SUMMARY

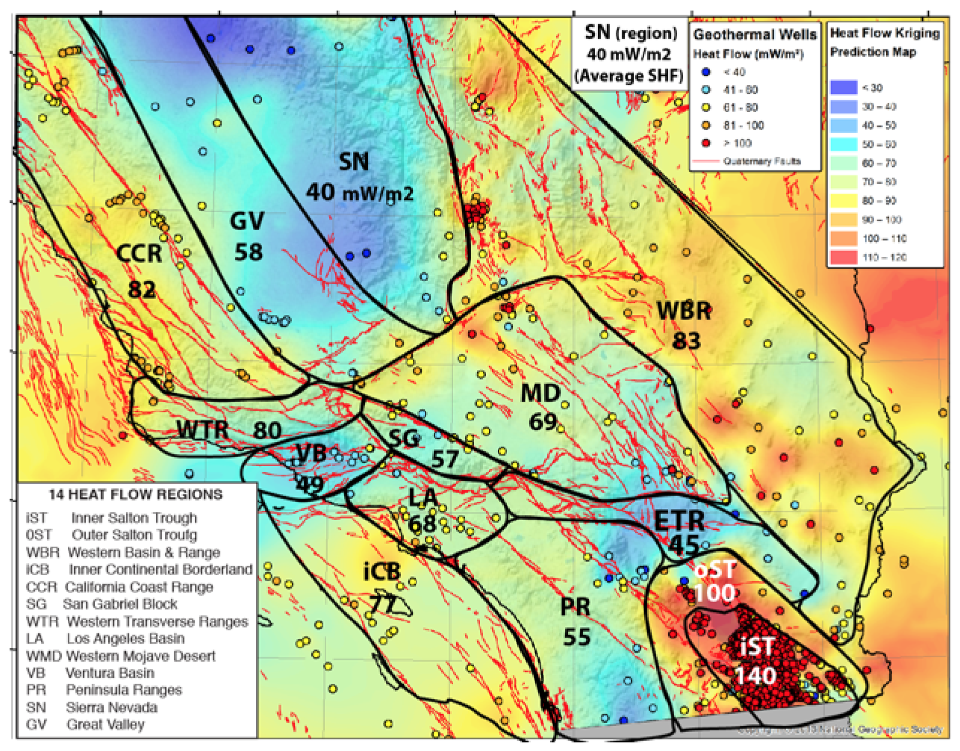
Lithospheric temperature differences are arguably the most important factor in controlling rheologic behavior in southern California. Here we describe our development of a 3D Community Thermal Model (CTM) using thermal, seismologic, geologic & petrologic data relevant to constraining the temperature field & computing a suite of 1D lithospheric geotherms.

Fig. 1 schematically shows the workflow in devoping the model. Model inputs include the observed surface heat flow (SHF), which define 14 geographically distinct heat flow regions (HFRs, Fig. 2). Seismologic estimates constrain the depth of the lithosphere-asthenosphere boundary (sLAB) (Fig. 3). Fig. 4 is a plot of SHF versus lithospheric thickness, comparing the predictions of the standard continental thermal model (tLAB, solid black line) with observed SHF and sLAB depth. Six anomalous (SHF, sLAB) pairs, shown with blue dots, are inconsistent with 1D steady-state geotherm models, which predict tLAB depths of 90 - 220 km, as discussed later (and shown in Fig. 8a). We explain these anomalies by proposing a transient thermal model involving instantaneous exposure of conductive crust and mantle lithosphere of thickness a_o to hot asthenosphere (Fig. 5) and its subsequent cooling and thickening (Fig. 6). In this model SHF lags behind conductive layer thickening, a feature shown by the (SHF, sLAB) data for the 6 anomalous heat flow regions and best fit if a_o = 50 km (Fig. 7). Adopting this transient model as well as better constraining several steady state conductive geotherms by P/T estimates for xenoliths and young erupted lavas (e.g. Ducea, 2001) our suite of refined geotherms (Fig. 8b) comprise our CTM Version 1.20, now available on the SCEC website. Compared with their standard 1D steady-state counterparts (and excluding the very warm geotherms related to current and recent magmatism), the refined geotherms span a much narrower range of temperatures, especially in the mantle lithosphere. Thus although the observed SHF distribution (Fig. 2) might seem to suggest vast lateral and depthwise differences in lithospheric temperature (Fig. 8a), the refined geotherm suite (Fig. 8b) indicates rather modest differences outside the magmatically active regions. All other factors being equal we would expect this pattern to be reflected in the depth of the brittle-ductile transition and the effective viscosity of the lower crust and upper mantle lithosphere.

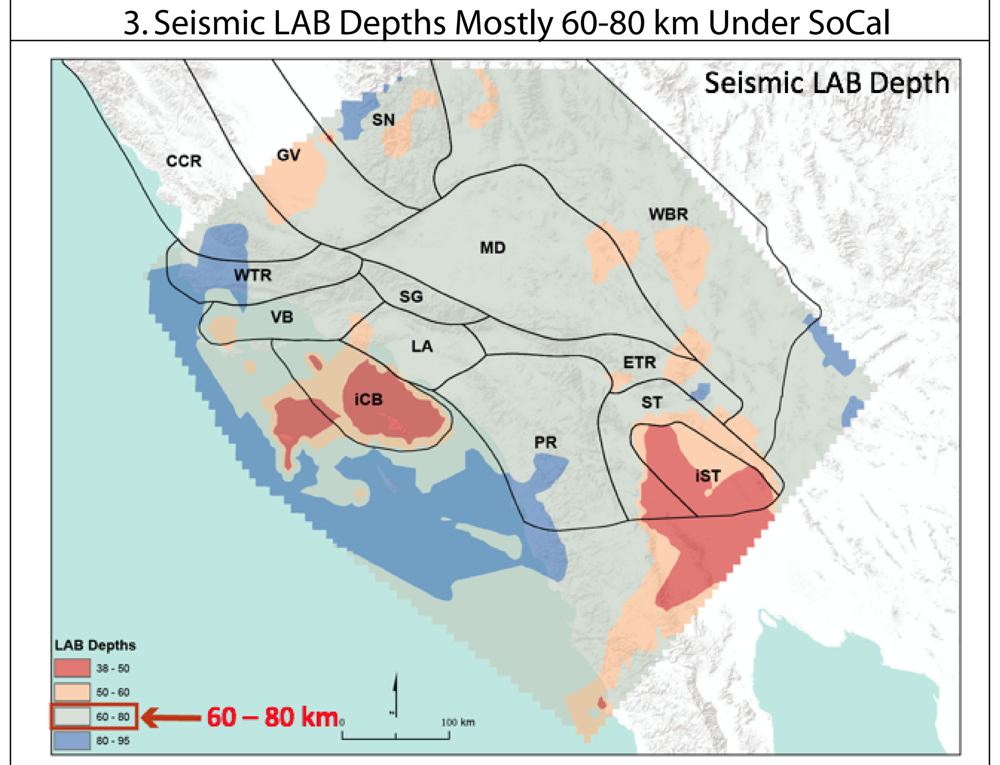
1. Work Flow Diagram for Computing CTM SoCal Geotherms



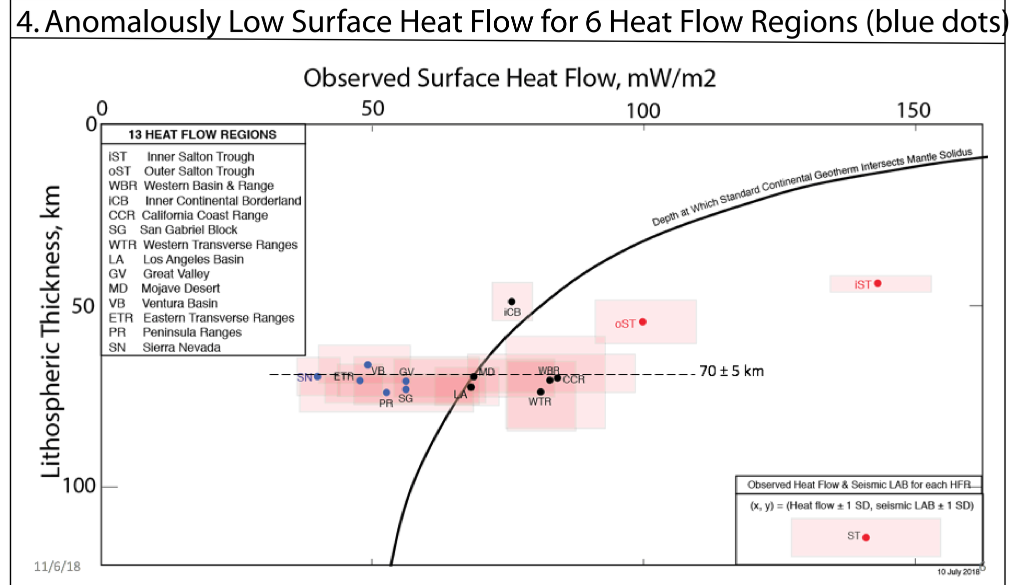
2. SoCal May Be Divided into 14 Distinct Heat Flow Regions



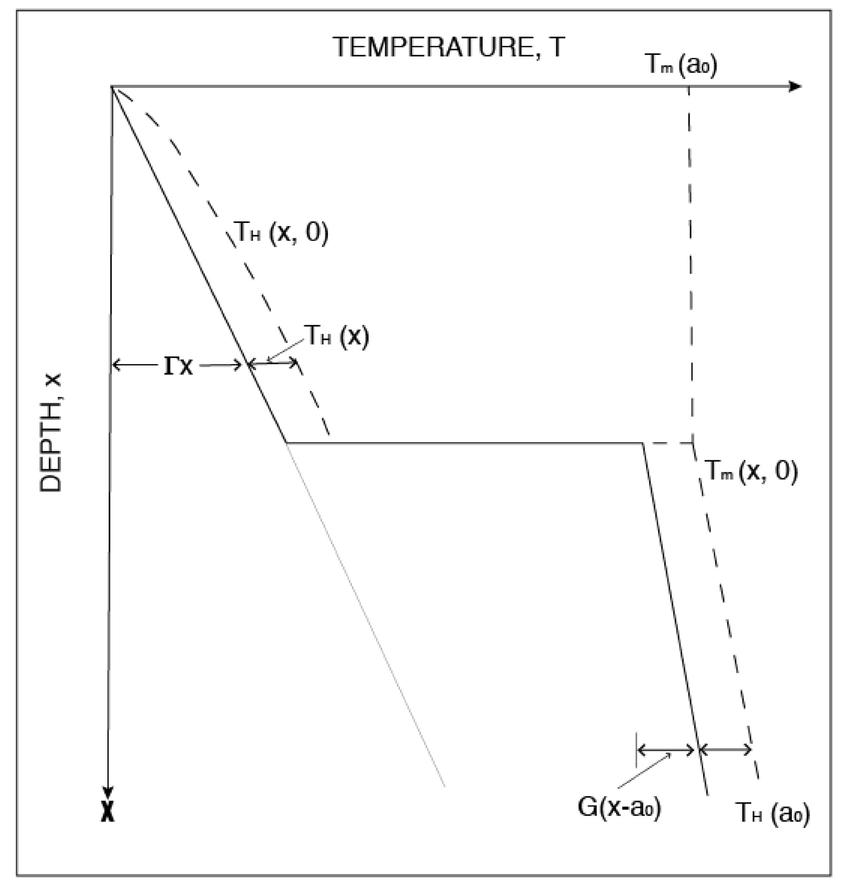
3. Seismic LAB Depths Mostly 60-80 km Under SoCal



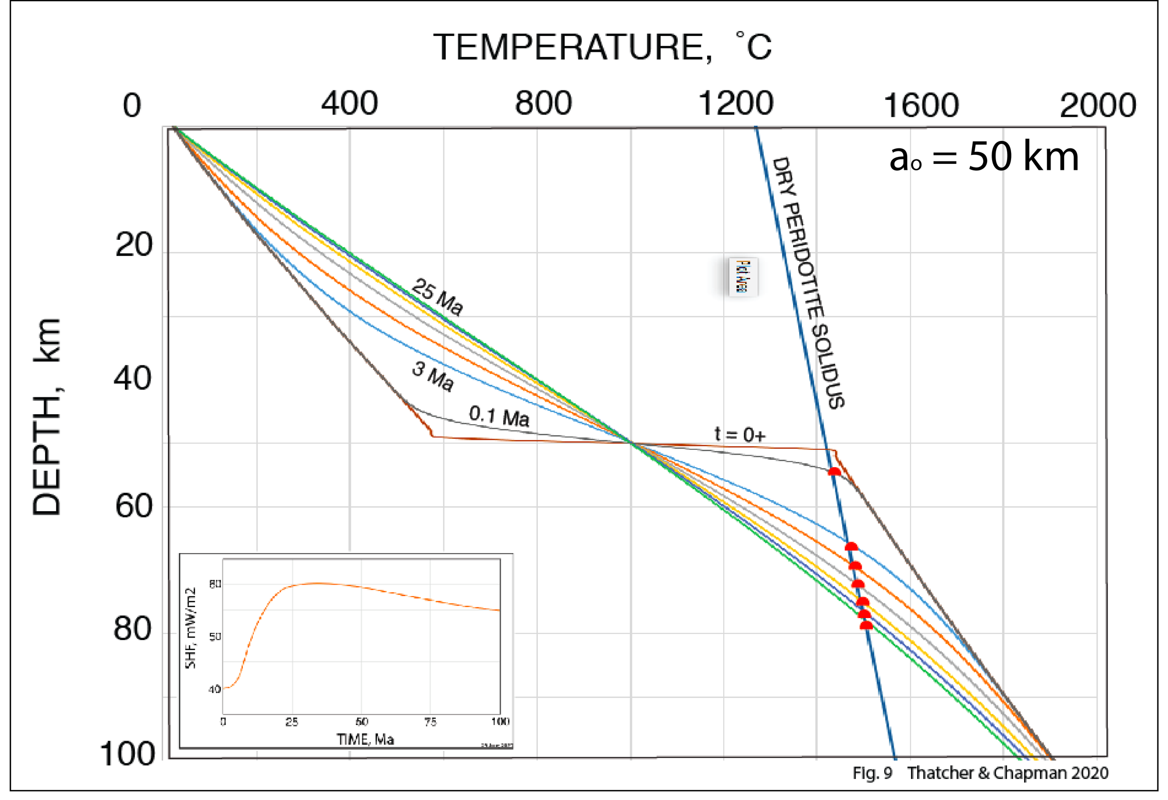
4. Anomalously Low Surface Heat Flow for 6 Heat Flow Regions (blue dots)



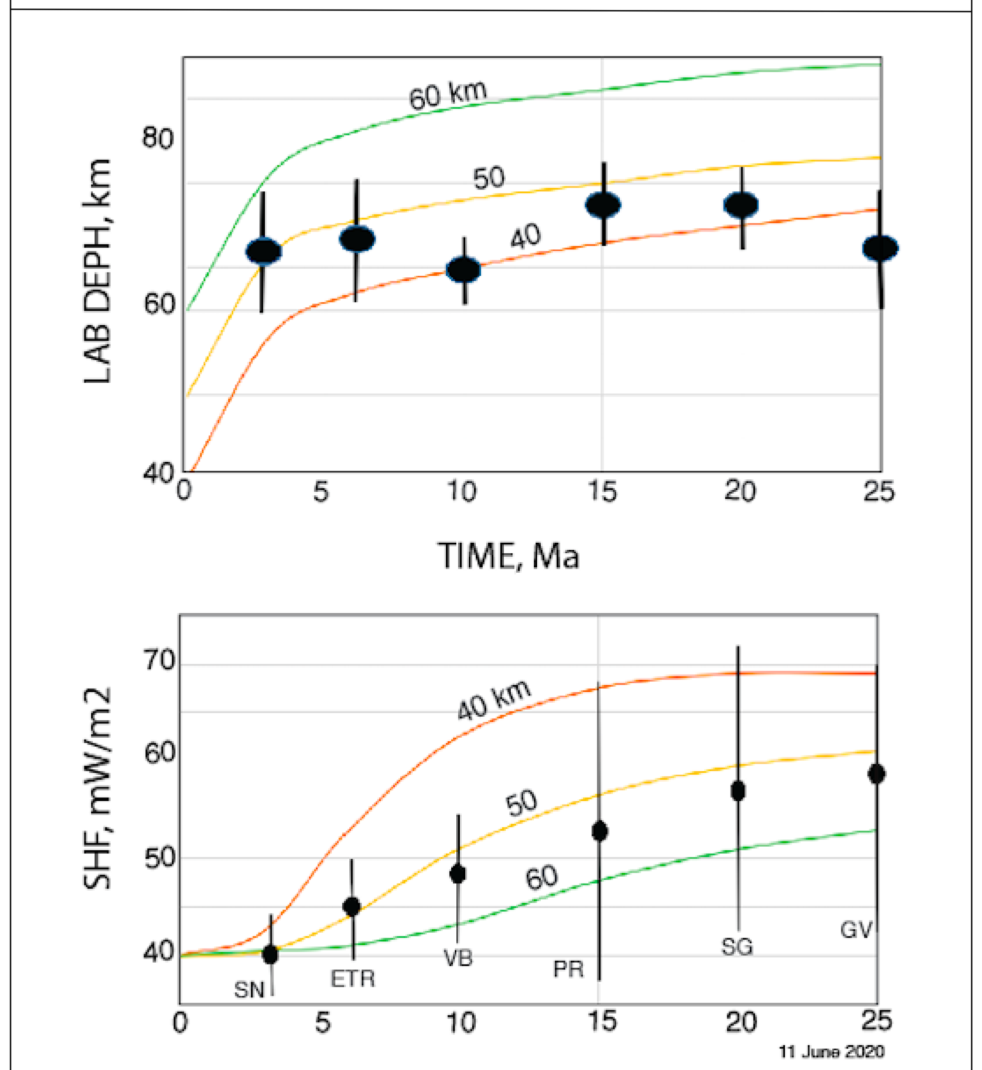
5. Initial Conditions for Transient Thermal Model



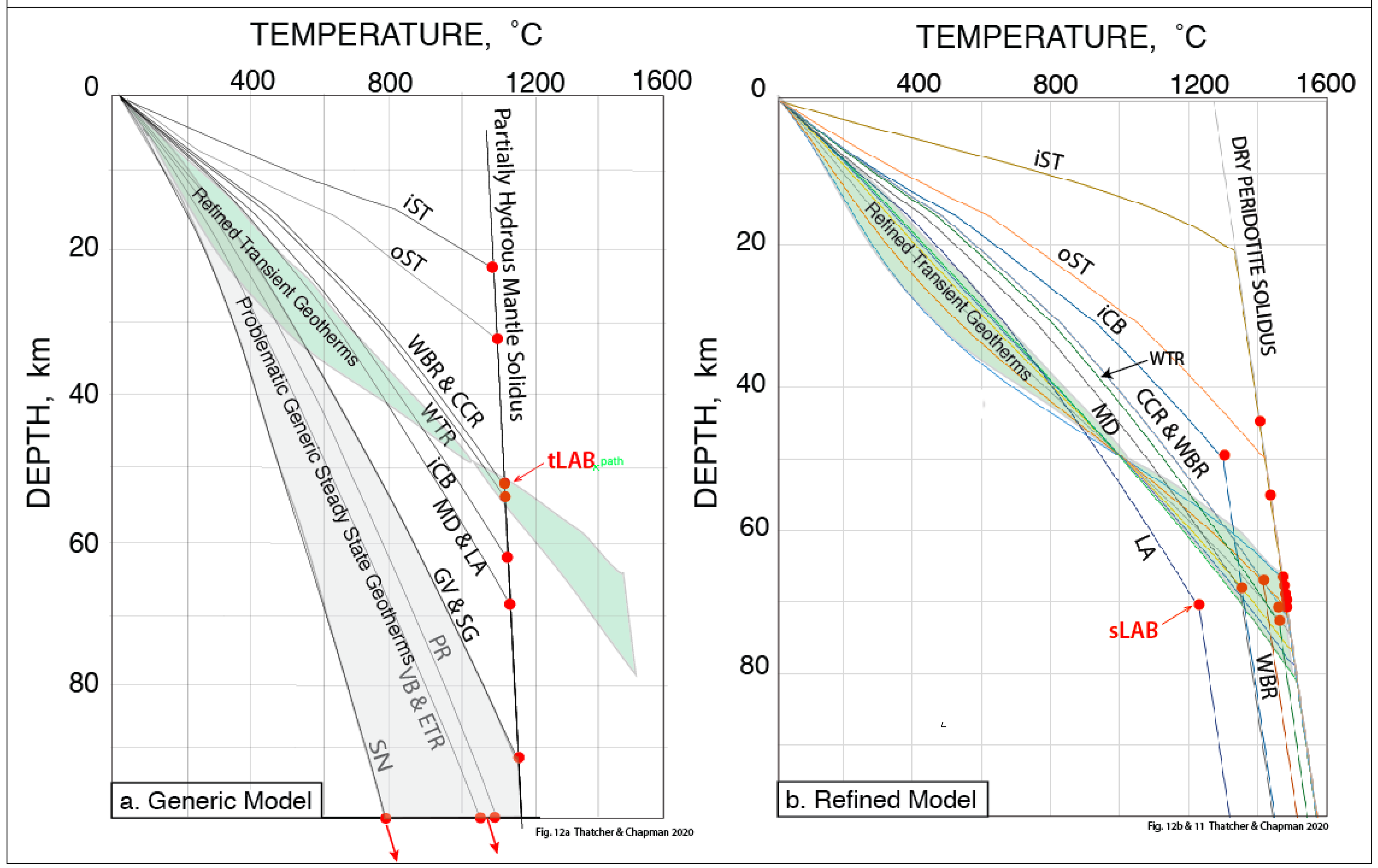
6. Transient Thermal Model Geotherms



7. Transient Model Best Fit with a_o = 50 km



8. Generic and Refined SoCal Geotherms



TAKE HOME POINTS

- Wide range in SoCal SHF, 40 -140 mW/m2, extremely unusual for continents and in such a small region
- Reflects both steady-state and transient active tectonic processes
- In contrast, LAB depth much less variable, averaging 70 km
- Combination of 1 & 2 requires transient thermal regimes & models predicting warm lower crust &upper mantle under most of SoCal
- Modeled transient thermo-mechanical processes include slab-free asthenosphere window, slab rollback and lithospheric thinning

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