A Thermal Model of the Southern California Lithosphere: SoCal likes It (Mostly) Hot

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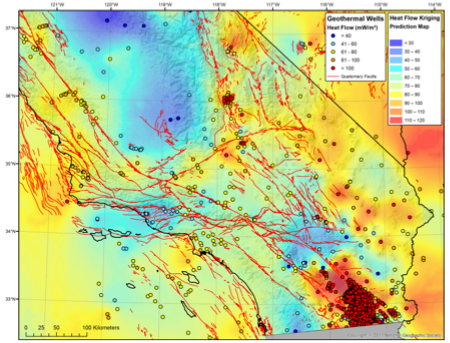
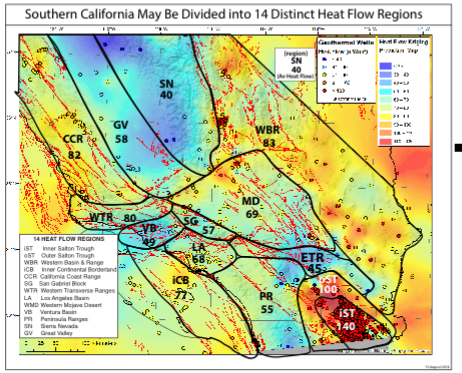
WHAT IS THE CTM & HOW IS IT BUILT?

1 SoCal Heat Flow Database



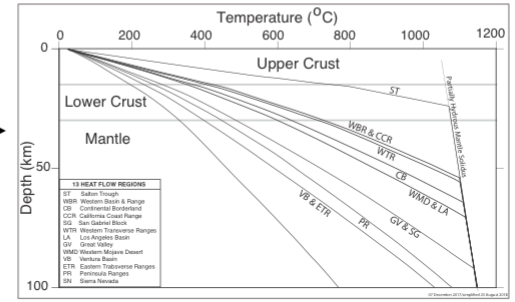
Select 14 Regions with ~Constant Heat Flow

2 Lat-Long Outlines of Each HFR

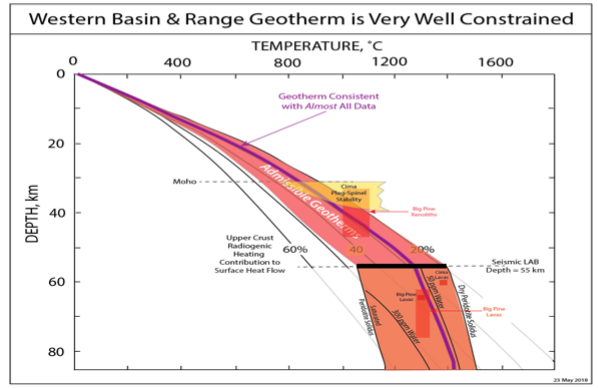


Compute Generic Geotherms For Each Region

Default 1D Steady-State Conductive Geotherms

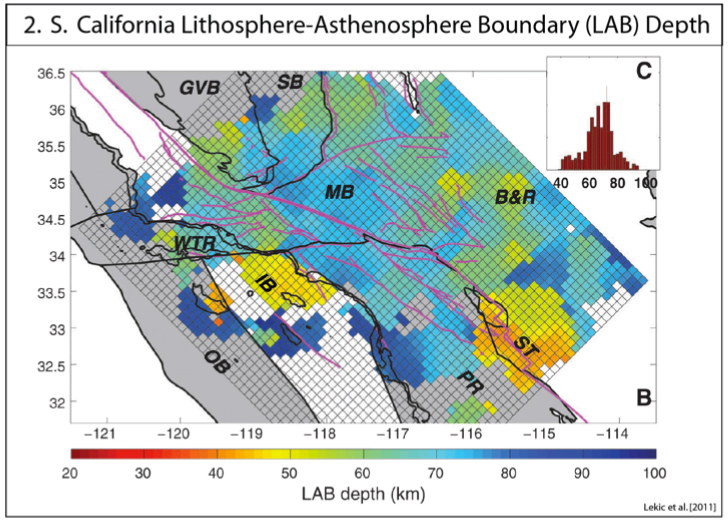


3 14 Refined 1D Geotherms



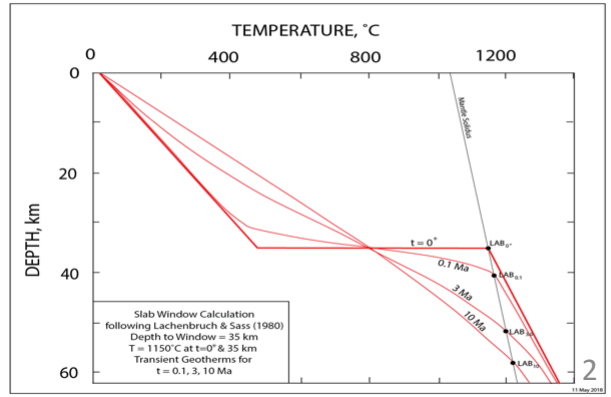
Seismic LAB Depth

2. S. California Lithosphere-Asthenosphere Boundary (LAB) Depth



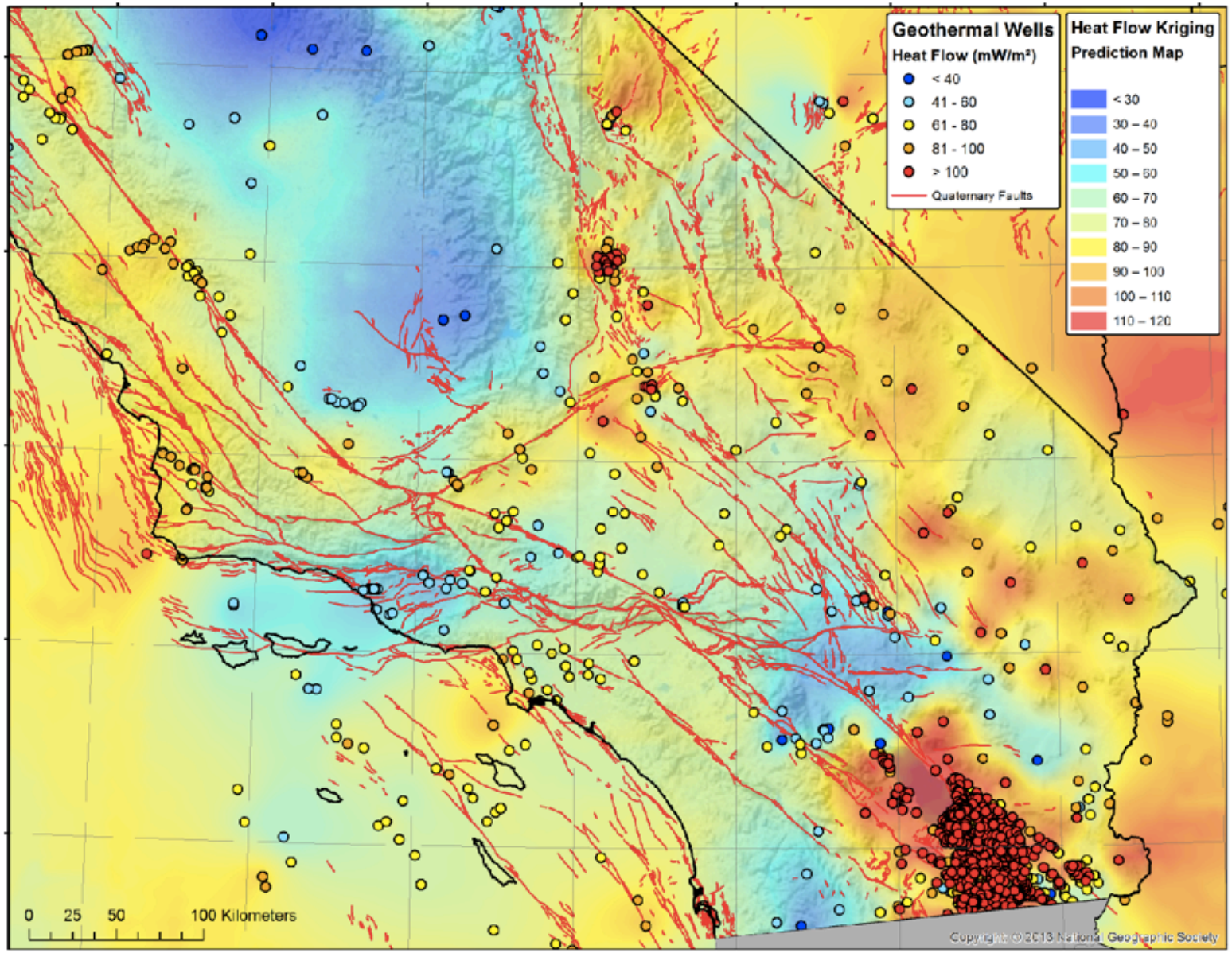
Constrain Some Geotherms With P/T from Lavas & Xenoliths

Model Some Transient Thermal Processes

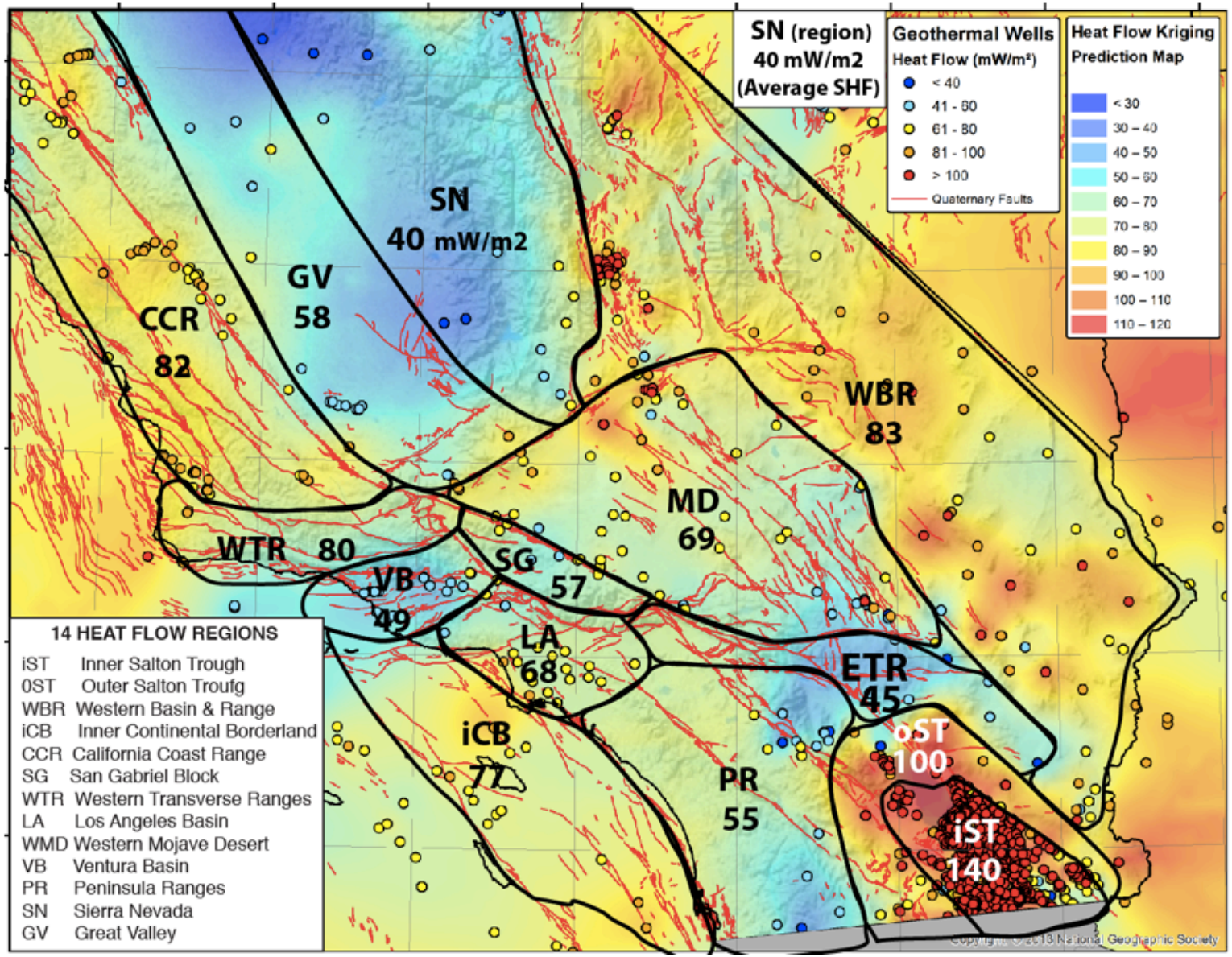


Southern California Surface Heat Flow Map

Factor of 4 Variation Across SoCal

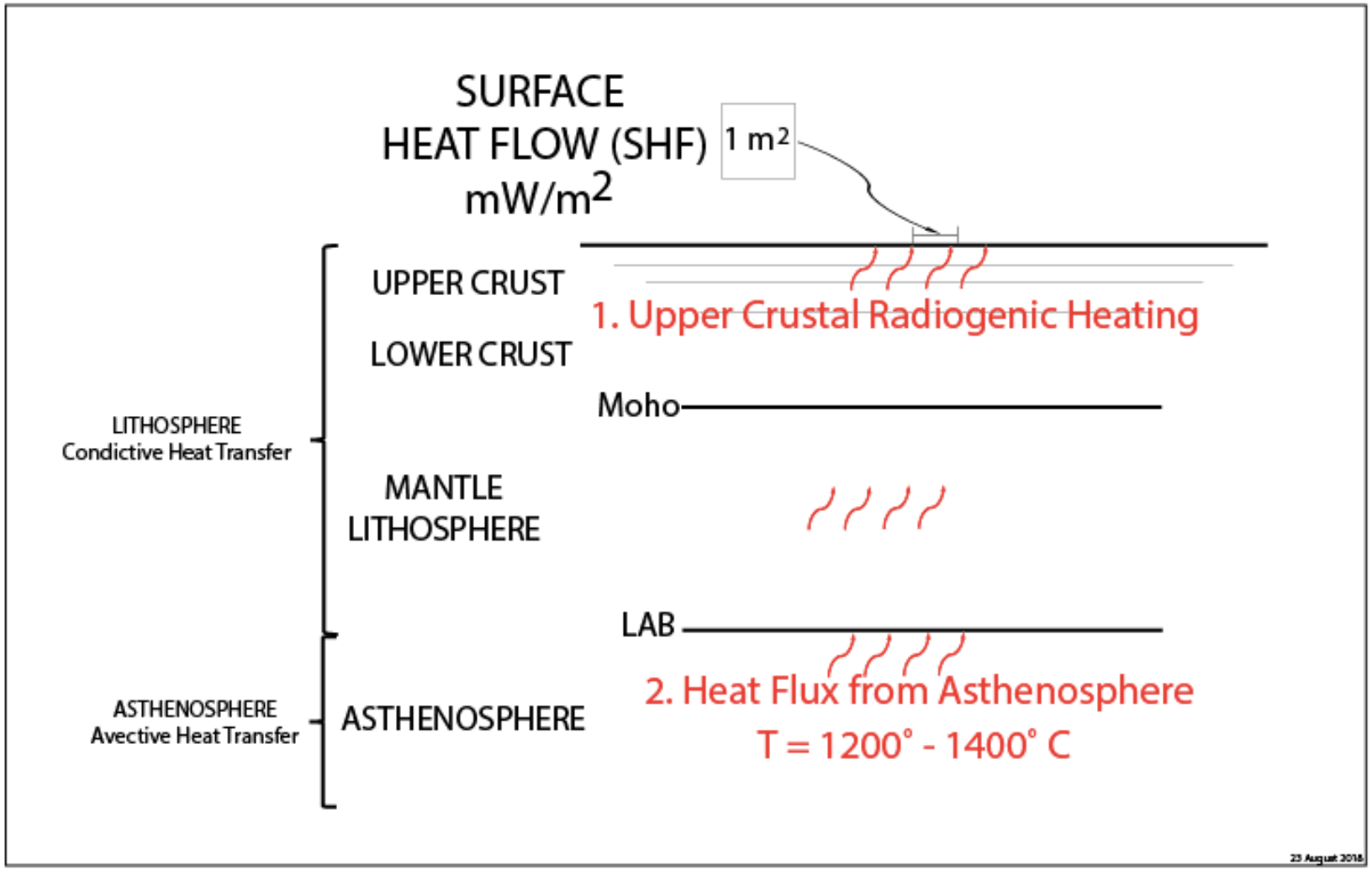


SoCal Can Be Divided into 14 Distinct Heat Flow Regions Each of which Has ~ Constant Surface Heat Flow



To Model Geotherms Need to Constrain Just Two Main Sources: Upper Crustal Radiogenic Heating & Hot Asthenosphere

Trouble! Usually Neither Known Well



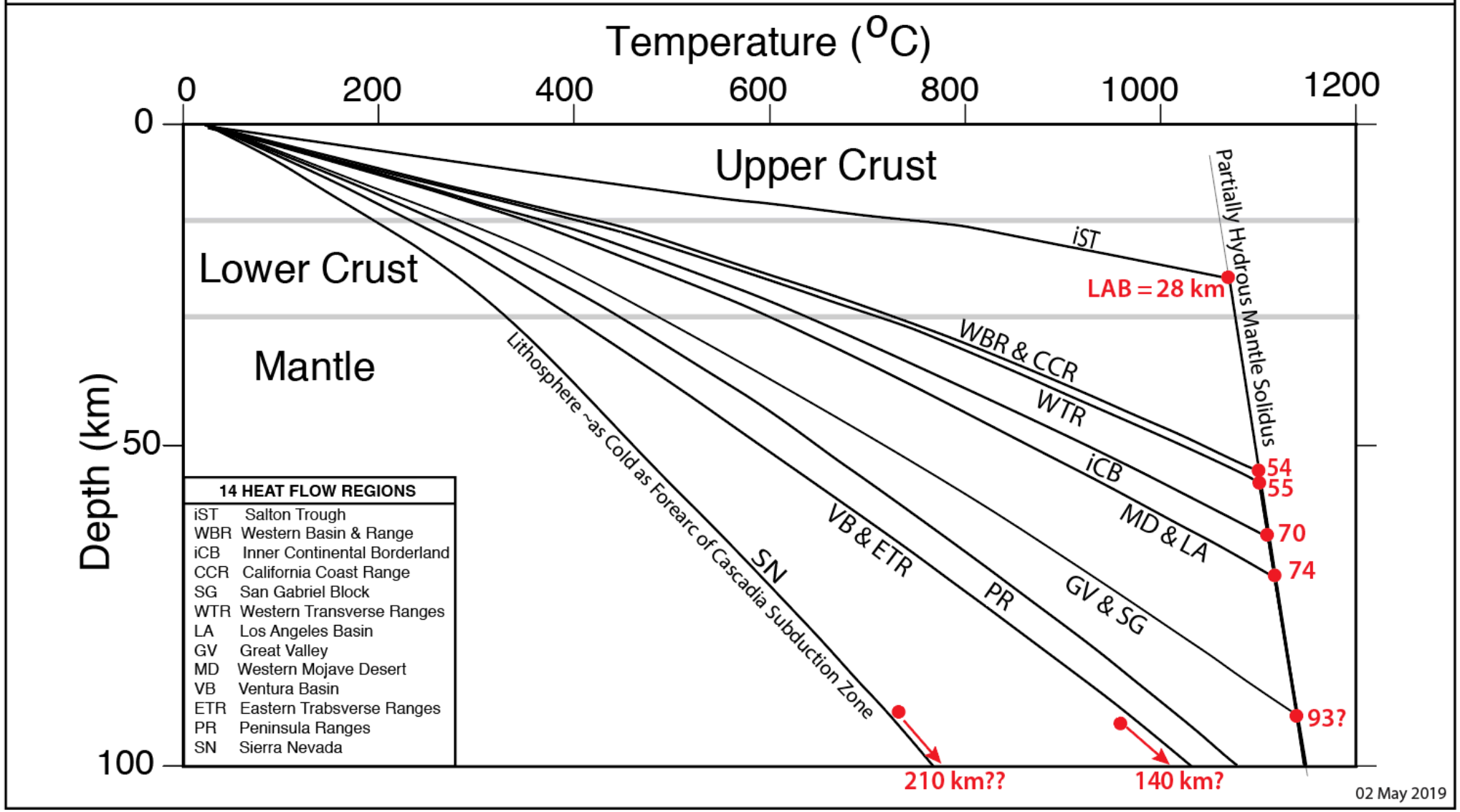
To Compute Generic Candidate SoCal Geotherms Make Two Simple Commonly Adopted Assumptions

- 1. Radiogenic Heating Contributes 40% of Observed Surface Heat Flow

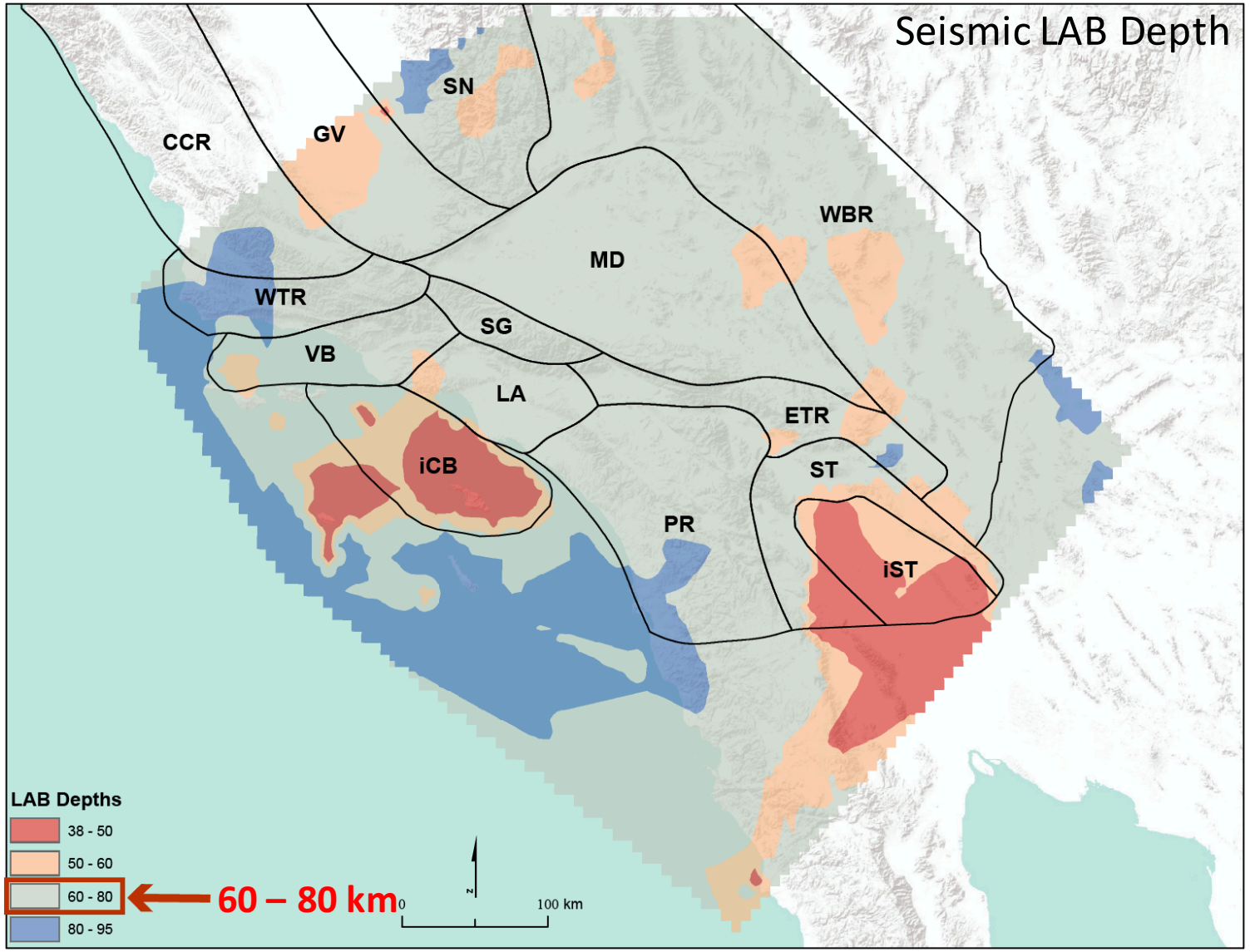
- 2. LAB Depth at Intersection of 1D Steady State Geotherm & Mantle Solidus

Steady State 1D SoCal Geotherms for Standard Continental Thermal Model

If Correct Imply Some Surprisingly Thick Lithospheric Keels Beneath SoCal

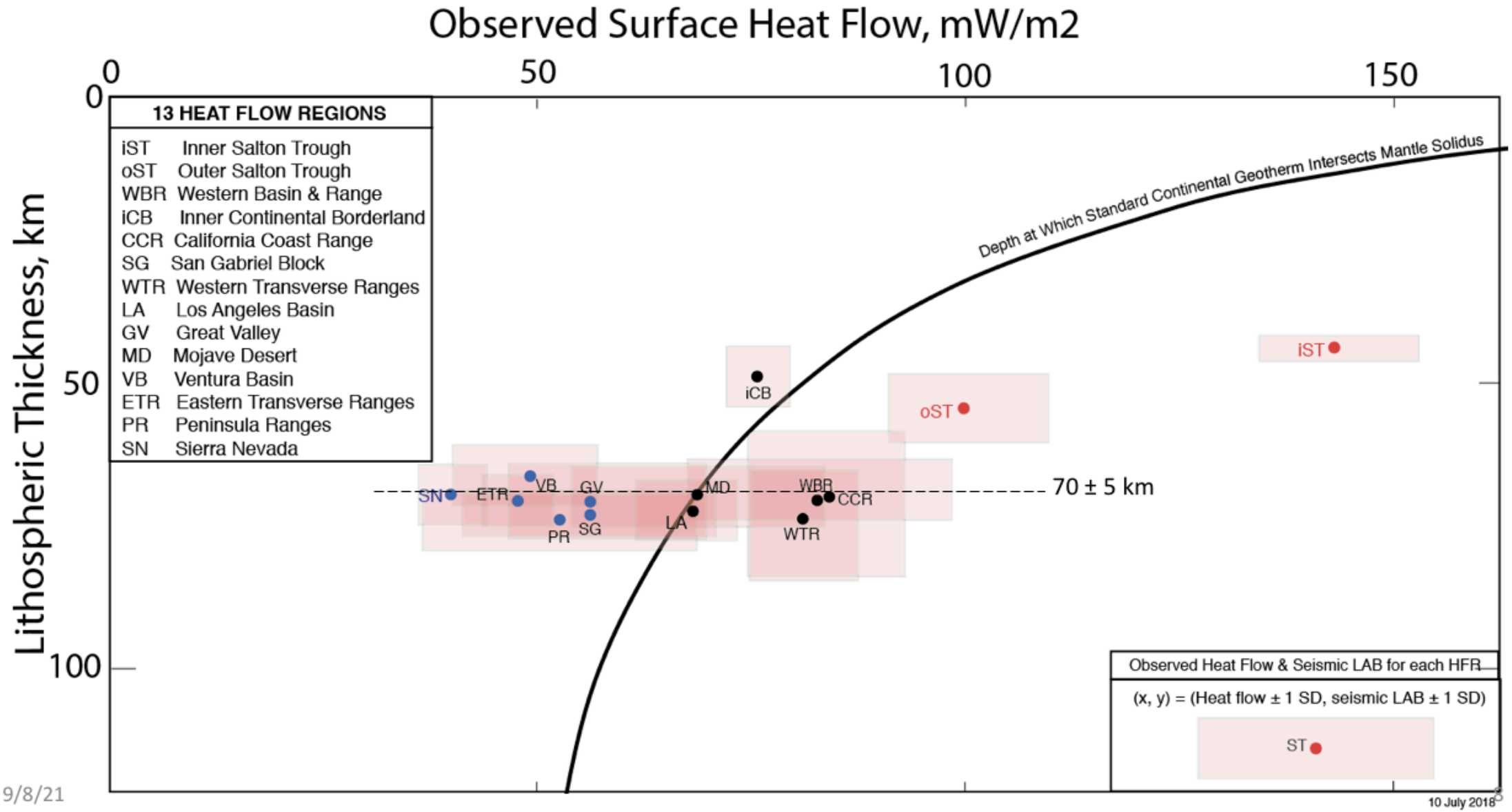


BUT Almost All SoCal sLAB Between 60 and 80 km except for iCB & ST

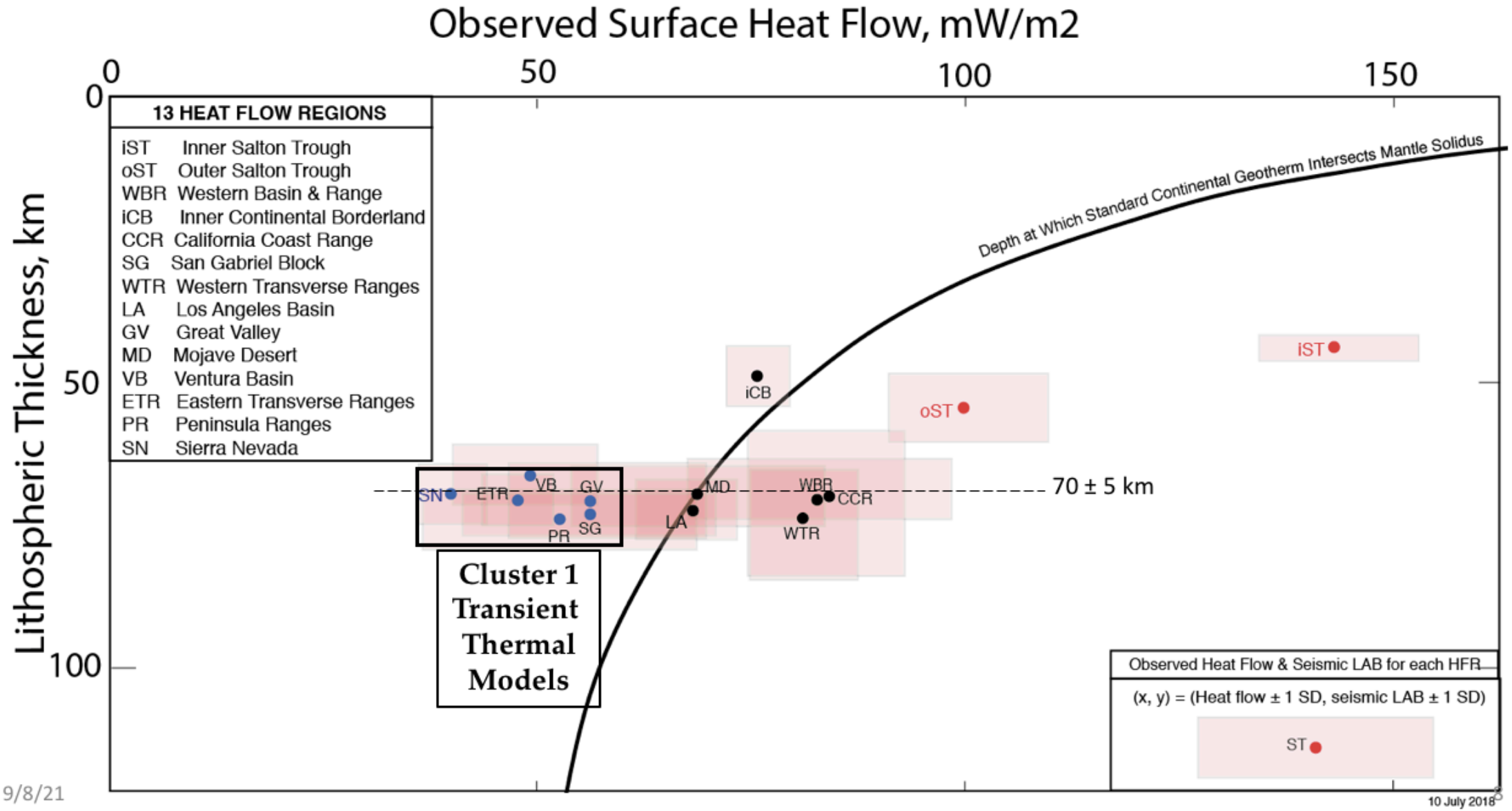


There is Strong Evidence That Under SoCal
Seismic LAB = Thermal LAB
From Here Onward We Accept This

Surprising Result!--LAB Depth 70 ± 5 km for 11 of 14 SoCal HFRs

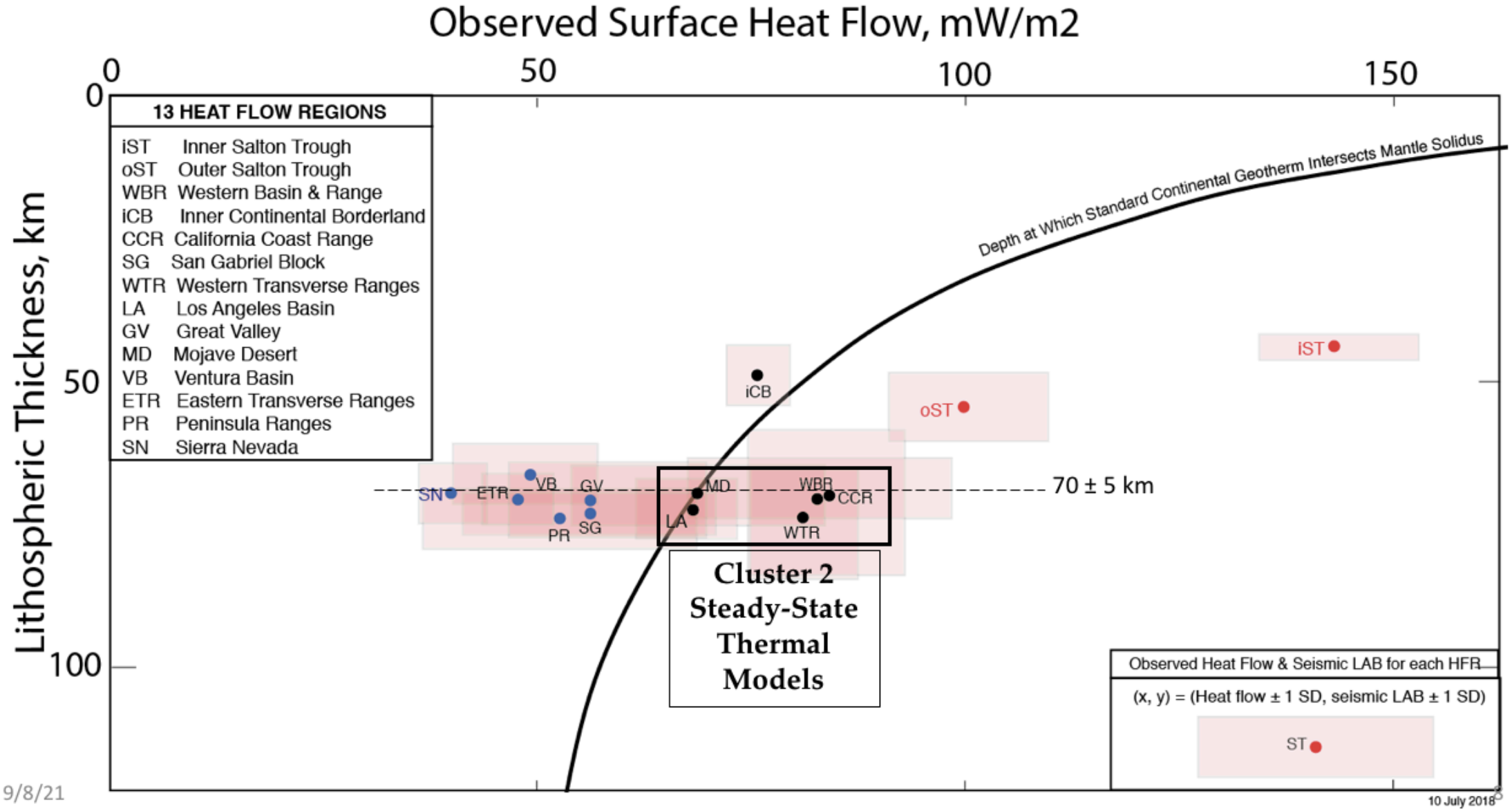


Surprising Result!--LAB Depth 70 ± 5 km for 11 of 14 SoCal HFRs
Cluster 1: Low SHF and 70 km LAB Incompatible with Steady State Geotherms

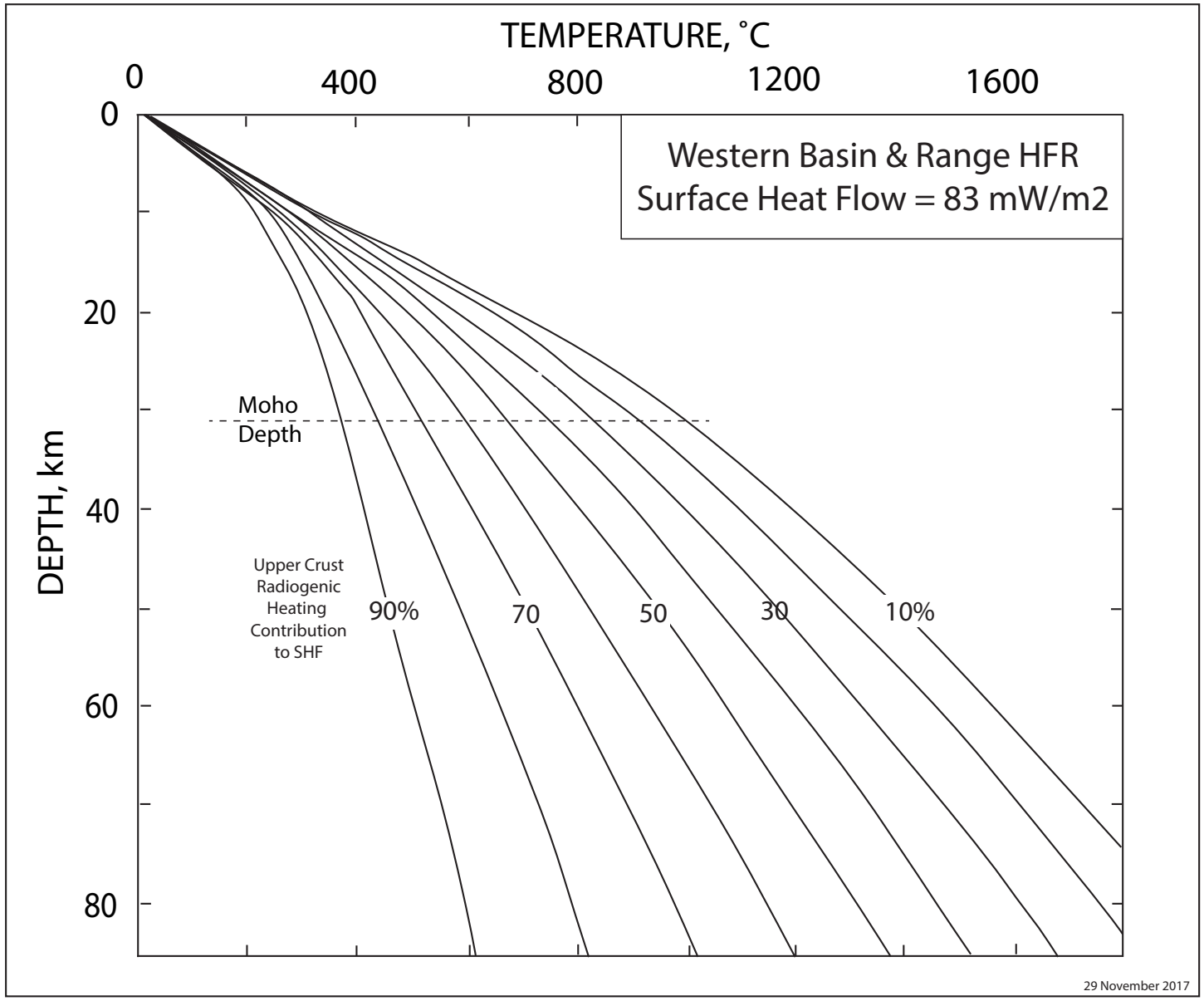


Surprising Result!--LAB Depth 70 ± 5 km for 11 of 14 SoCal HFRs

Cluster 2: SHF and 70 km LAB Consistent with Steady State Geotherms

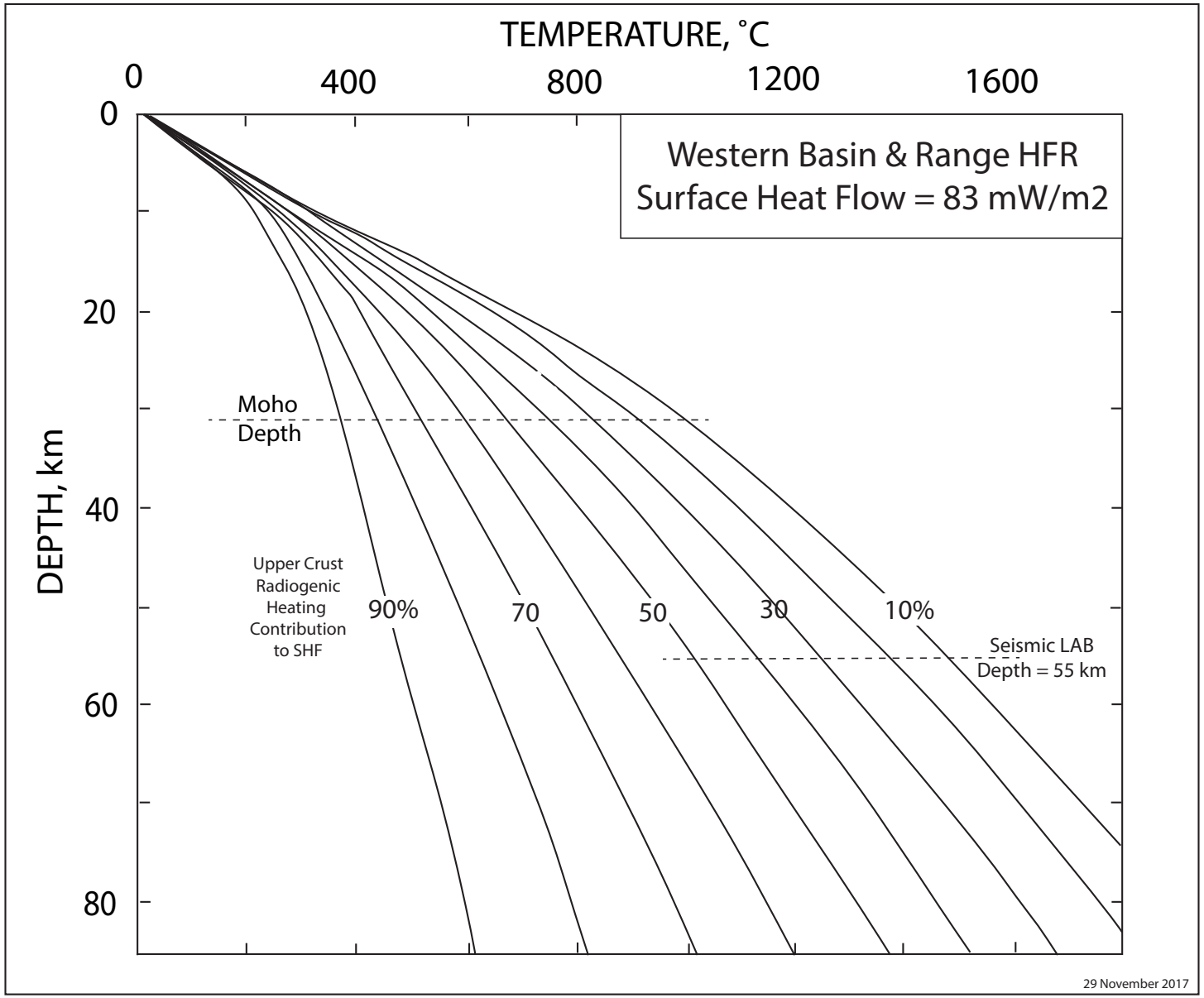


Radiogenic Heat Production of Crust Generally Poorly Known
So Large Range in Possible Geotherms

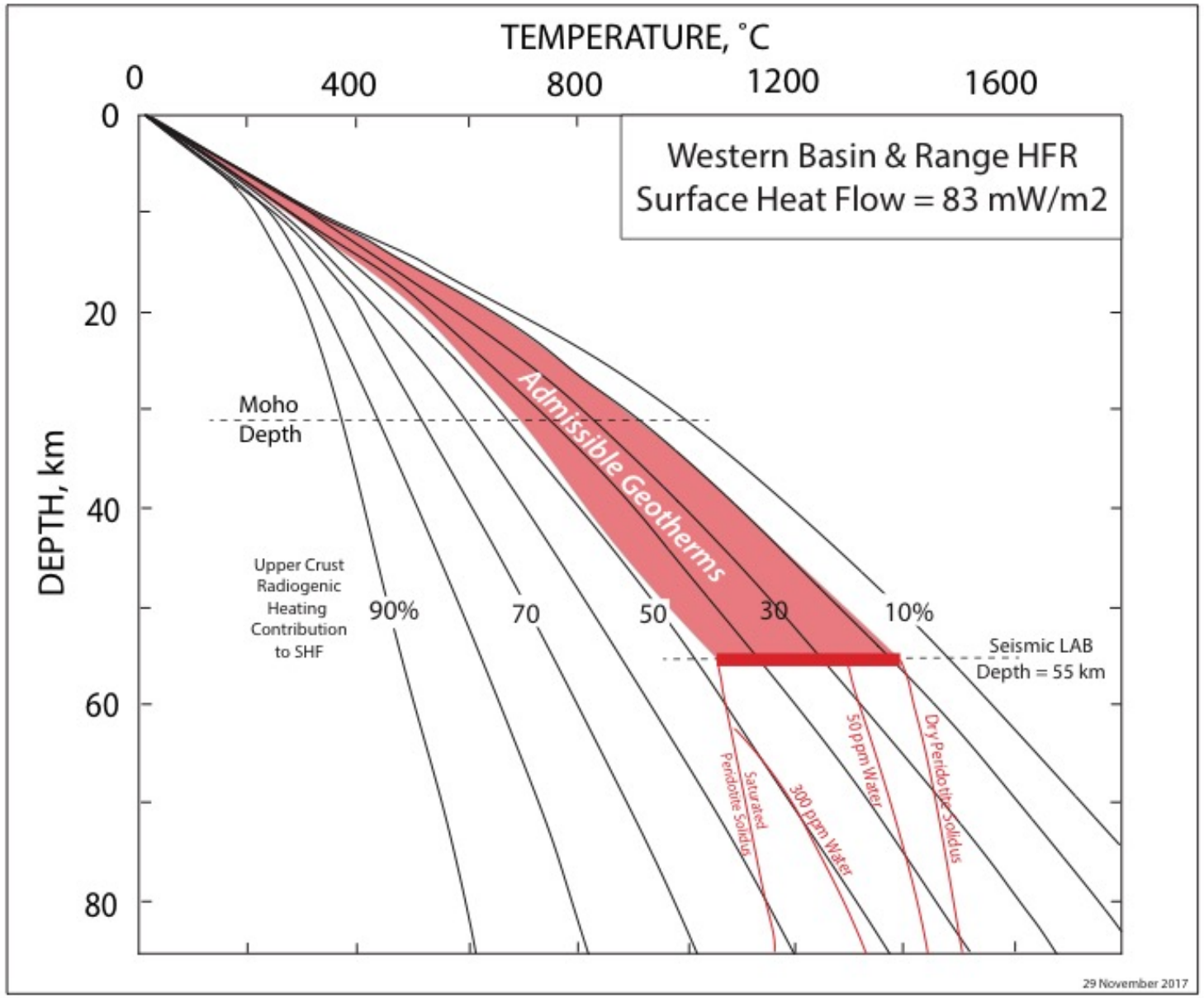


If Seismic LAB = Thermal LAB

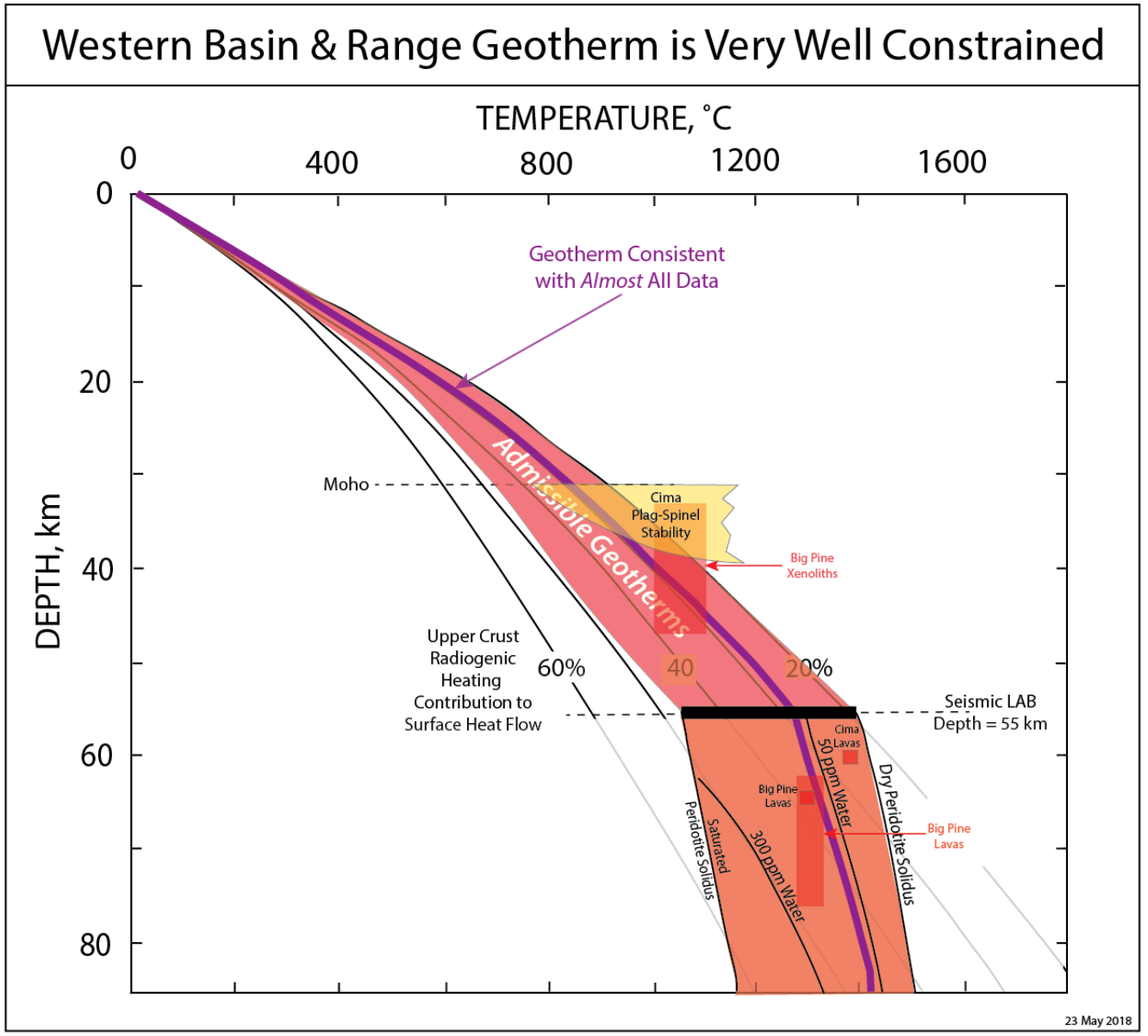
There are Better Constraints Because .....



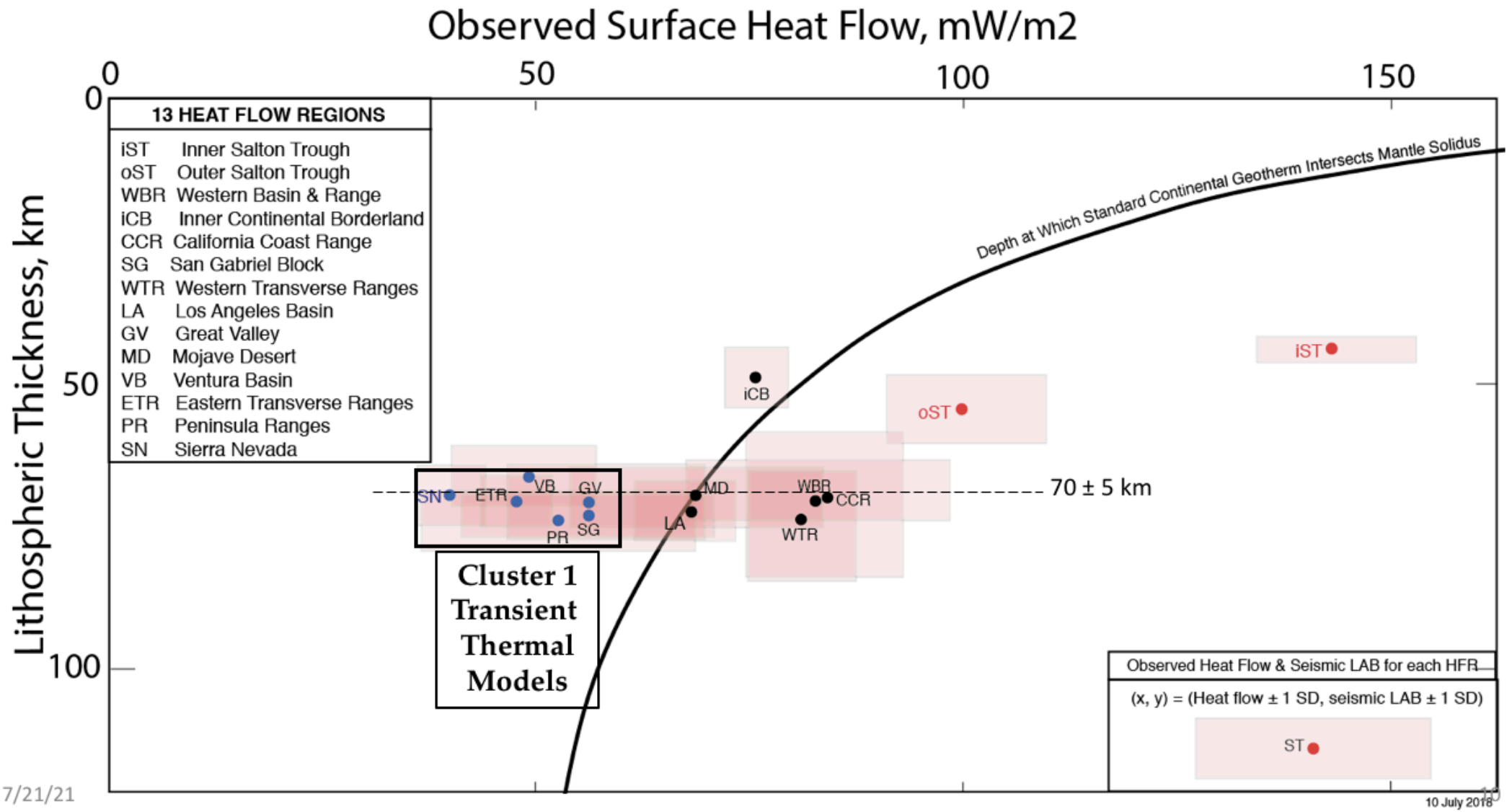
…. Admissible Geotherms Must Pass Between Saturated and Dry Peridotite Solidi Temperatures at LAB



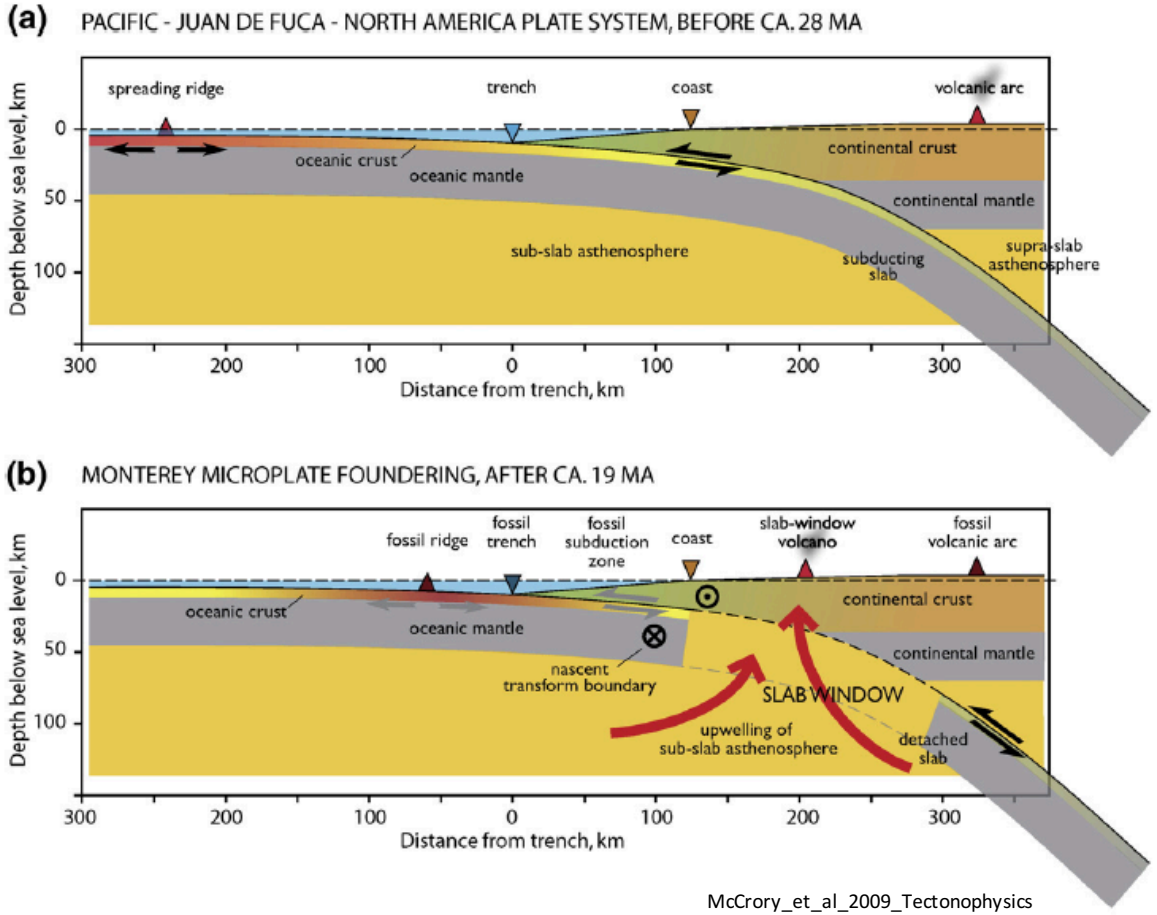
Further Powerful Constraints on Admissible Geotherms if Xenoliths Found & P-T Conditions Determined



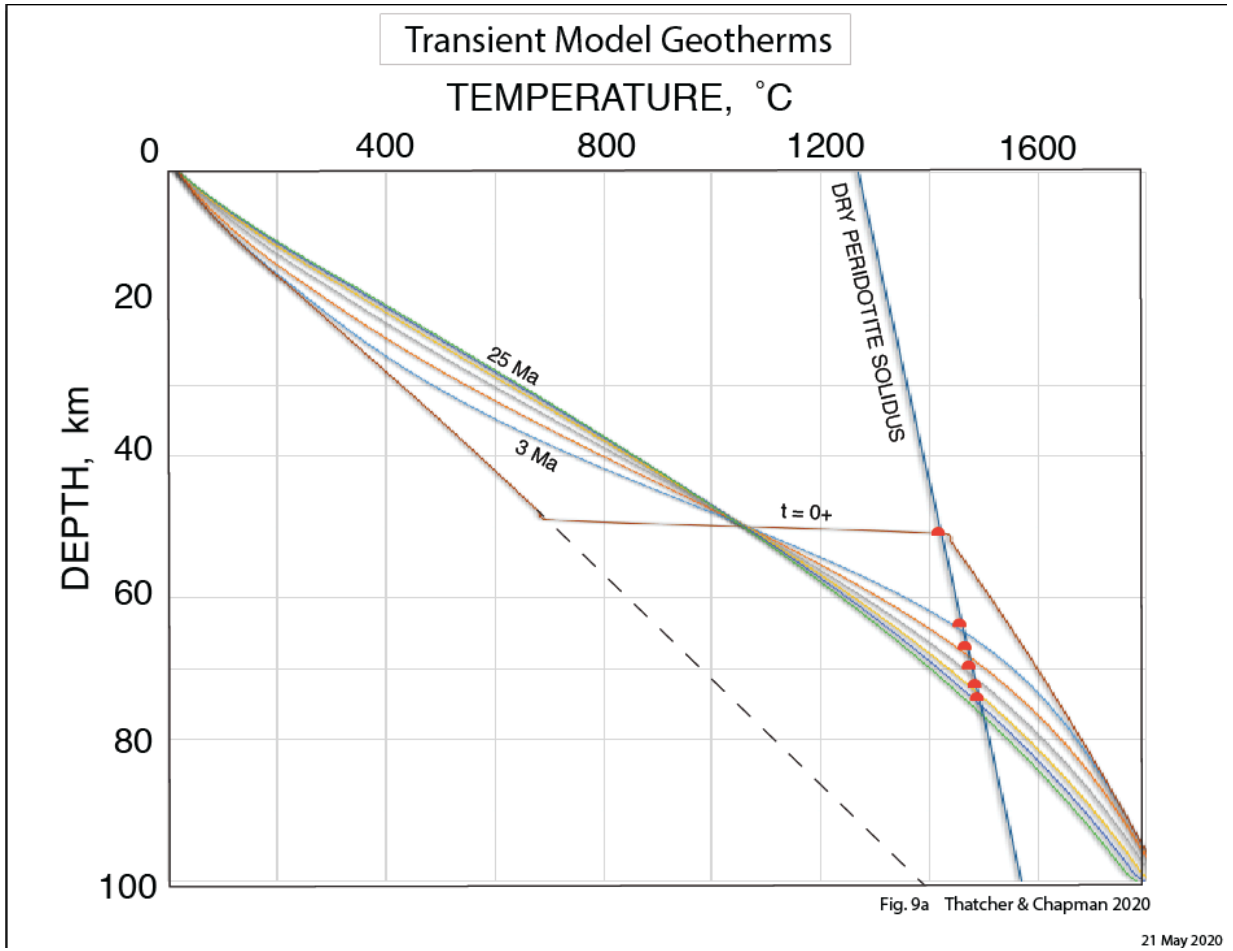
Back to Anomalously Low Surface Heat Flow Regions



Asthenosphere Exposure at Base of 50 km Thick Lithosphere Models Geotherms in 6 Low Heat Flow Regions

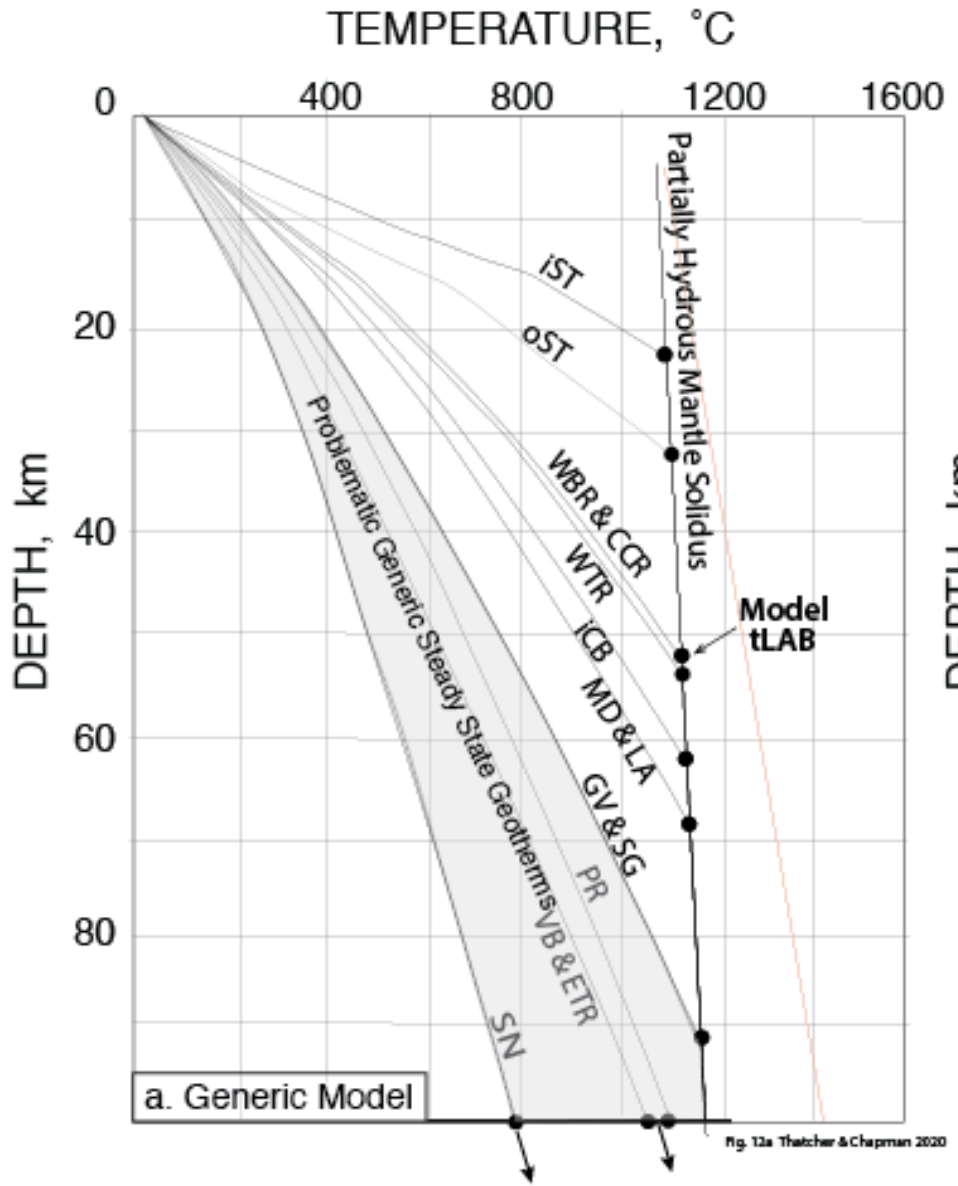


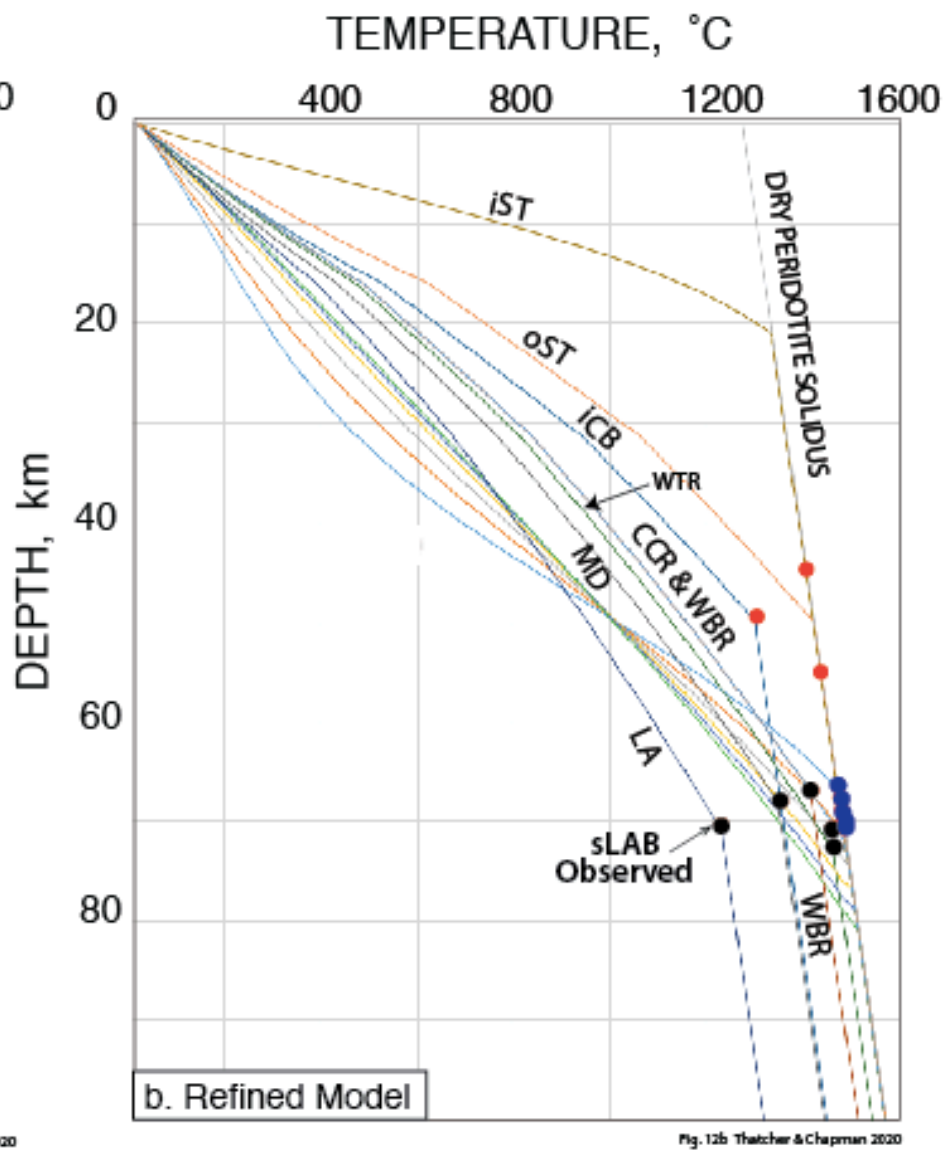
McCrory_et_al_2009_Tectonophysics



Generic versus Refined

Note Much Smaller Range in Refined Geotherms





Generic versus Refined

Smaller Range Due to Modeled Transient Effects

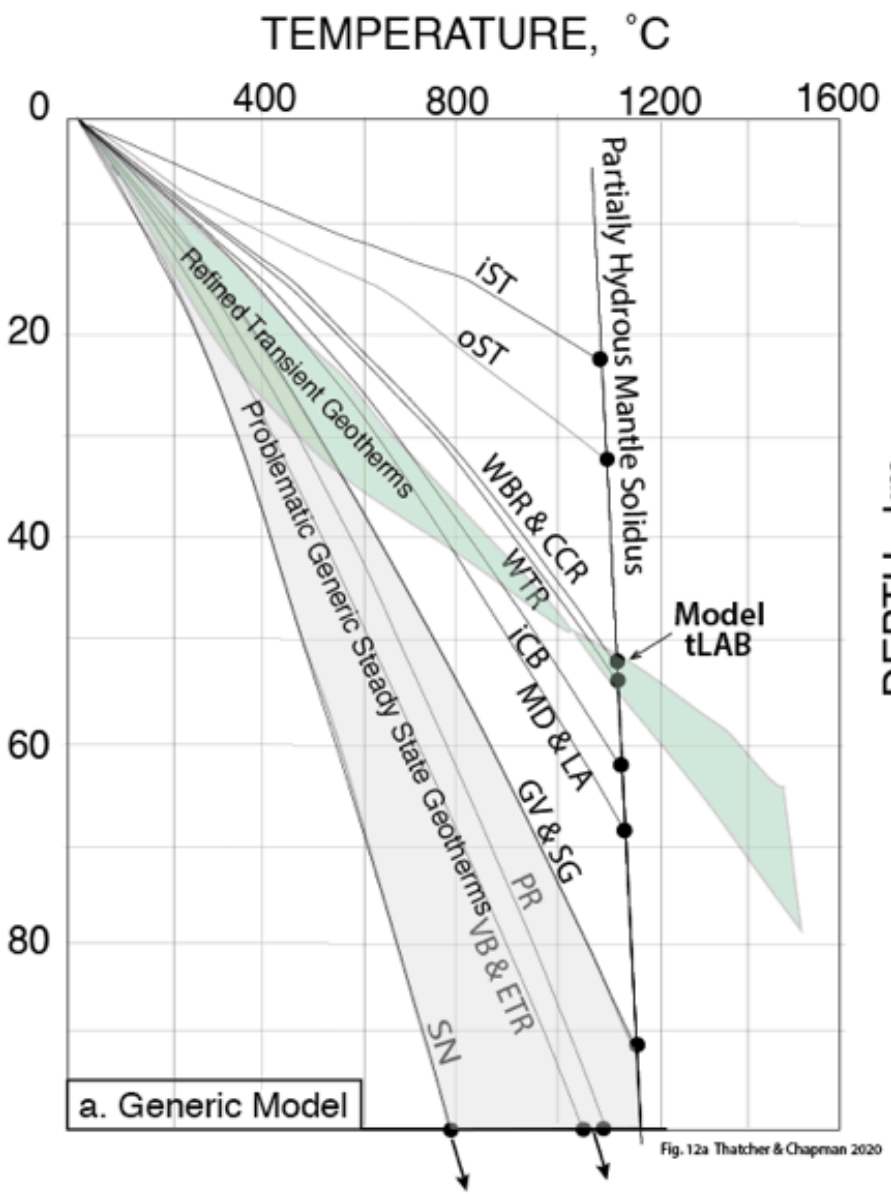


Fig. 12a Thatcher & Chapman 2020

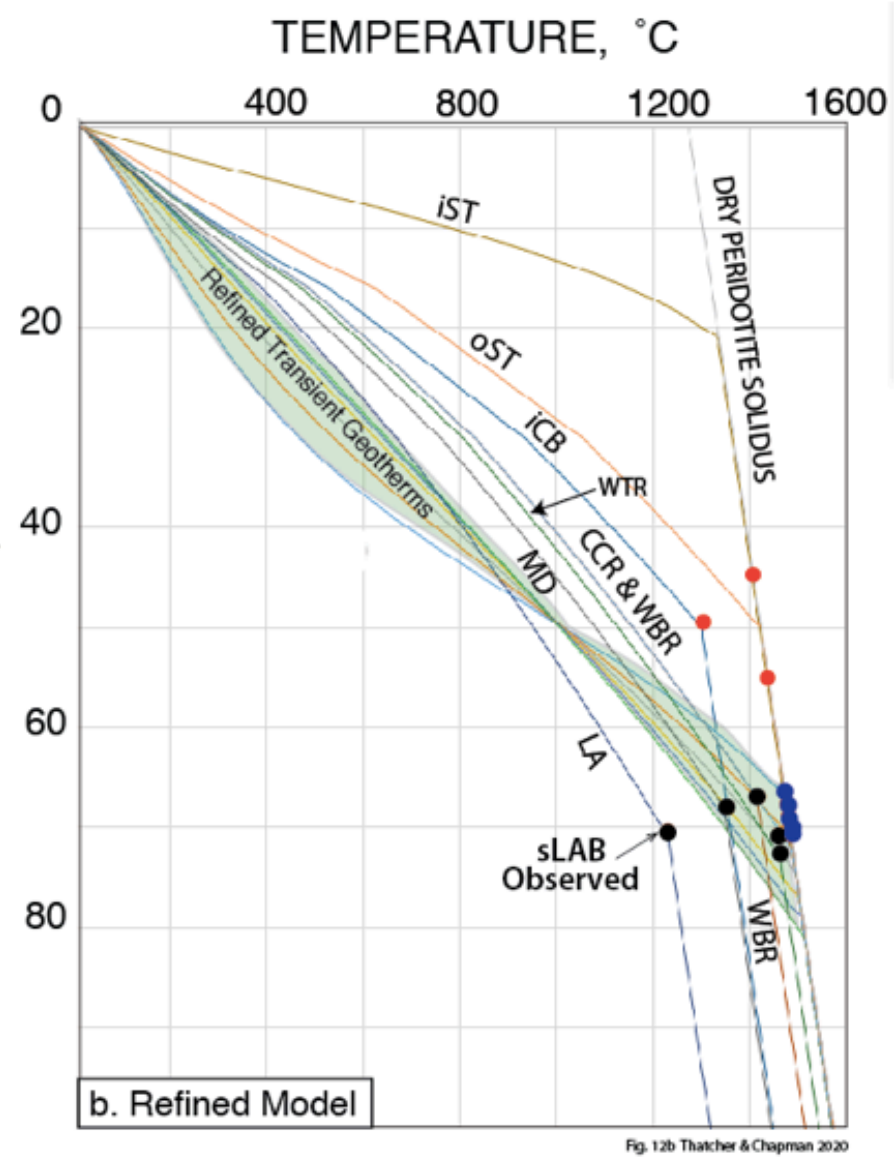


Fig. 12b Thatcher & Chapman 2020

TAKE HOME POINTS

1. Wide range in SoCal SHF, 40 → 140 mW/m2

2. In contrast, LAB depth much less variable, averaging 70 km

3. Combination of 1 & 2 requires transient thermal regimes, with models predicting warm lower crust and upper mantle under most of SoCal

4. Late Cenozoic Pacific-North America plate interactions identify causative transient processes we successfully model here