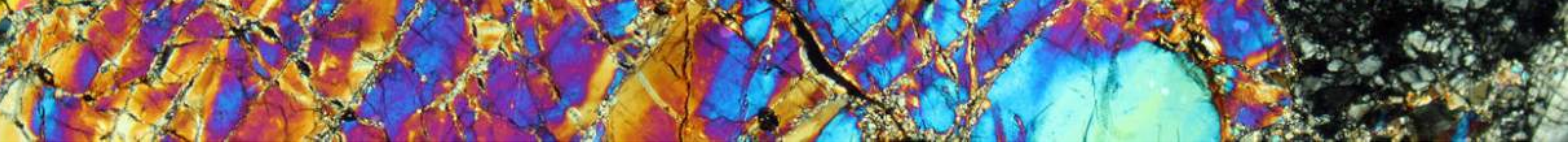


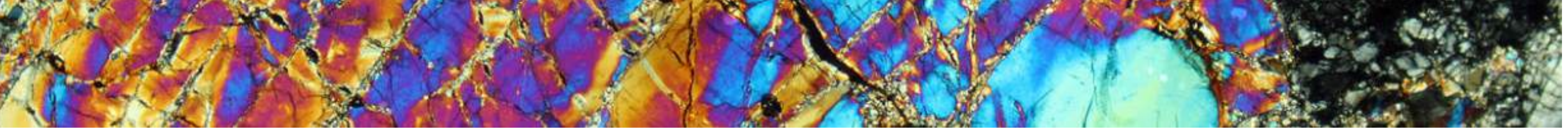
Toward a SCEC Community Rheology Model: Technical Activity Group Kickoff and Workshop

CRM ingredients

Geologic Framework	Michael Oskin, UC Davis
Geotherm (CTM)	Wayne Thatcher, USGS
Flow laws and parameters	Greg Hirth, Brown Whitney Behr, UT Austin

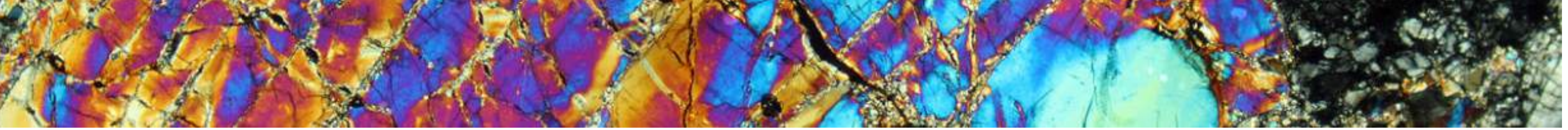
↓

Preliminary Mojave CRM	Liz Hearn, Capstone Geophysics



SATURDAY, SEPTEMBER 9, 2017 Morning: CRM description and accomplishments to date, plus speakers and discussions

09:00 - 09:15	Welcome, Motivation, Workshop Outline and Goals	*Elizabeth Hearn*
	<u>Geologic Framework and Community Thermal Model (CTM)</u>	*Michael Oskin, Wayne Thatcher*
09:15 - 09:30	Overview of the geologic framework, with emphasis on constraining the lithospheric architecture of the Mojave region	*Michael Oskin*
09:30 - 09:45	~~Tectonic modification of the Mojave Desert region during laramide shallow-angle subduction~~	~~*Alan Chapman*~~
09:45 - 10:00	Applying the depth distribution of seismicity to probe the rheology of the seismogenic crust in southern California	*Egill Hauksson*
10:00 - 10:15	Discussion: How should geologic and tectonic inferences of lithosphere composition guide the CRM?	*All*
10:15 - 10:30	Preliminary CTM, with an emphasis on the Mojave region	*Wayne Thatcher*
10:30 - 10:45	Discussion: How important are thermal versus compositional differences?	*All*
10:45 - 11:00	*Break*	
	<u>Inferring Rheology, Preliminary Mojave CRM</u>	*Greg Hirth, Whitney Behr*
11:00 - 11:15	Overview of rheologies for Mojave rock volumes and shear zones, guidance on differential stress, volatile content and other parameters for these flow laws	*Whitney Behr*
11:15 - 11:30	Inversion of seismic velocity for rheology	*William Shinevar*
11:30 - 11:45	Discussion: Geologic vs. seismic inference of rheology	*All*
11:45 - 12:15	Preliminary Mojave CRM effective viscosities and their consistency (or not) with Hector Mine Earthquake postseismic deformation	*Elizabeth Hearn*
12:15 - 12:30	Discussion: Assessing the CRM with deformation data and models	*All*
12:30 - 13:30	*Lunch*	



SATURDAY, SEPTEMBER 9, 2017 Afternoon: Workshop participants help us plan the future of the CRM

13:30 - 14:30	Disciplinary Breakout Session I What can each scientific discipline contribute to the CRM over the next year and by the end of SCEC5, for the Mojave and southern California?	*All*
14:30 - 14:45	Breakout Session I Summaries	*All*
14:45 - 15:00	*Break*	
15:00 - 16:00	Interdisciplinary Breakout Session II Identify important scientific questions than can be addressed with a CRM (and other existing resources) by the end of SCEC5 - particularly, problems that relate to the five SCEC5 science questions	*All*
15:00 - 16:15	Breakout Session II Summaries	*All*
16:15 - 17:00	Next steps for 2018 and beyond: Our TAG Other GF provinces, shear zones, delivery and sharing, future workshops and closing comments	*Elizabeth Hearn, Michael Oskin, Greg Hirth, Whitney Behr, Wayne Thatcher*
17:00	*Adjourn*	

The bouncer shows up at 5 to kick us out so this room can be prepped for the evening poster session. No lollygagging!

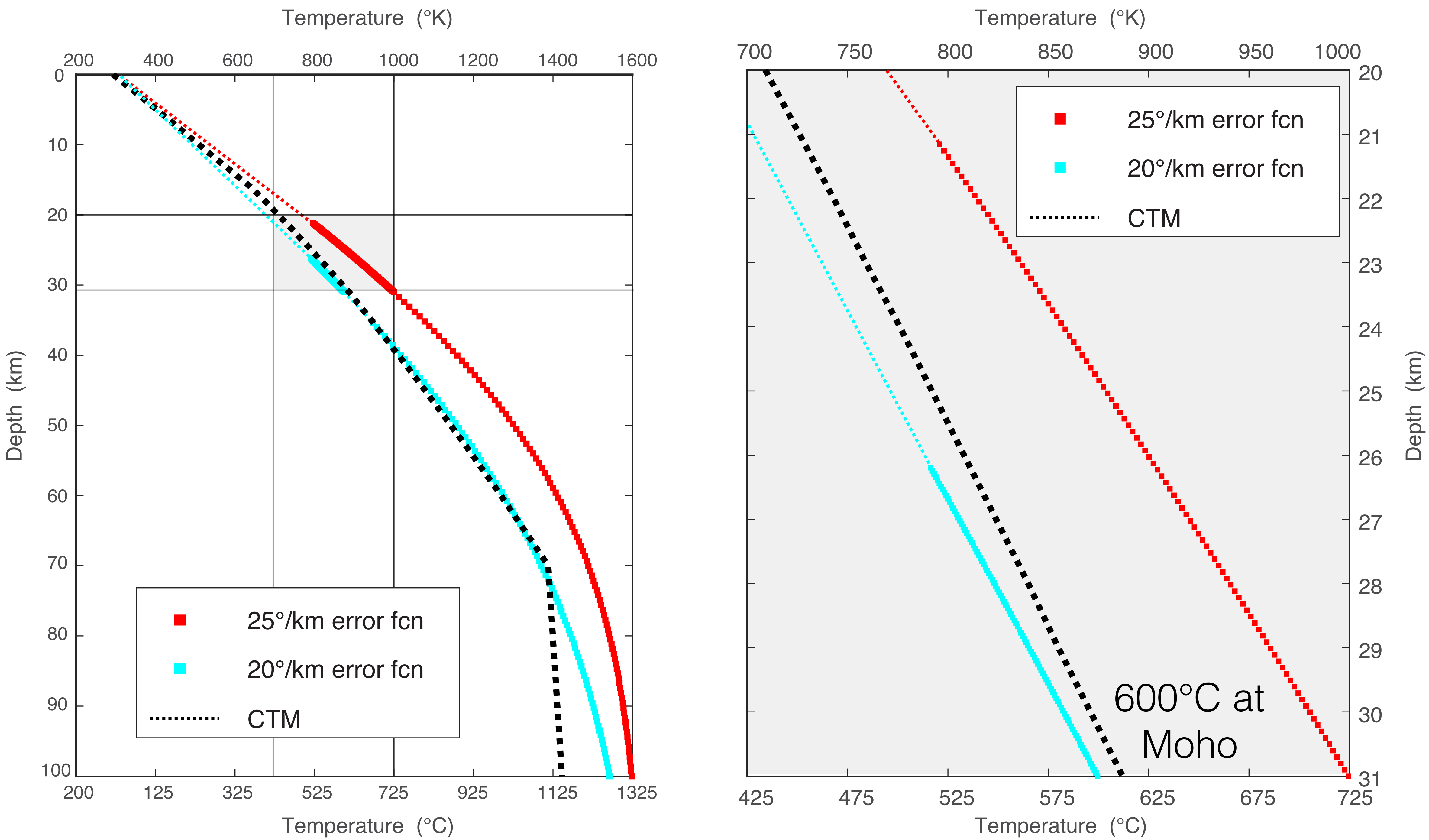
SCEC Community Rheology Model: The Mojave

Geotherm (CTM)

Geologic Framework

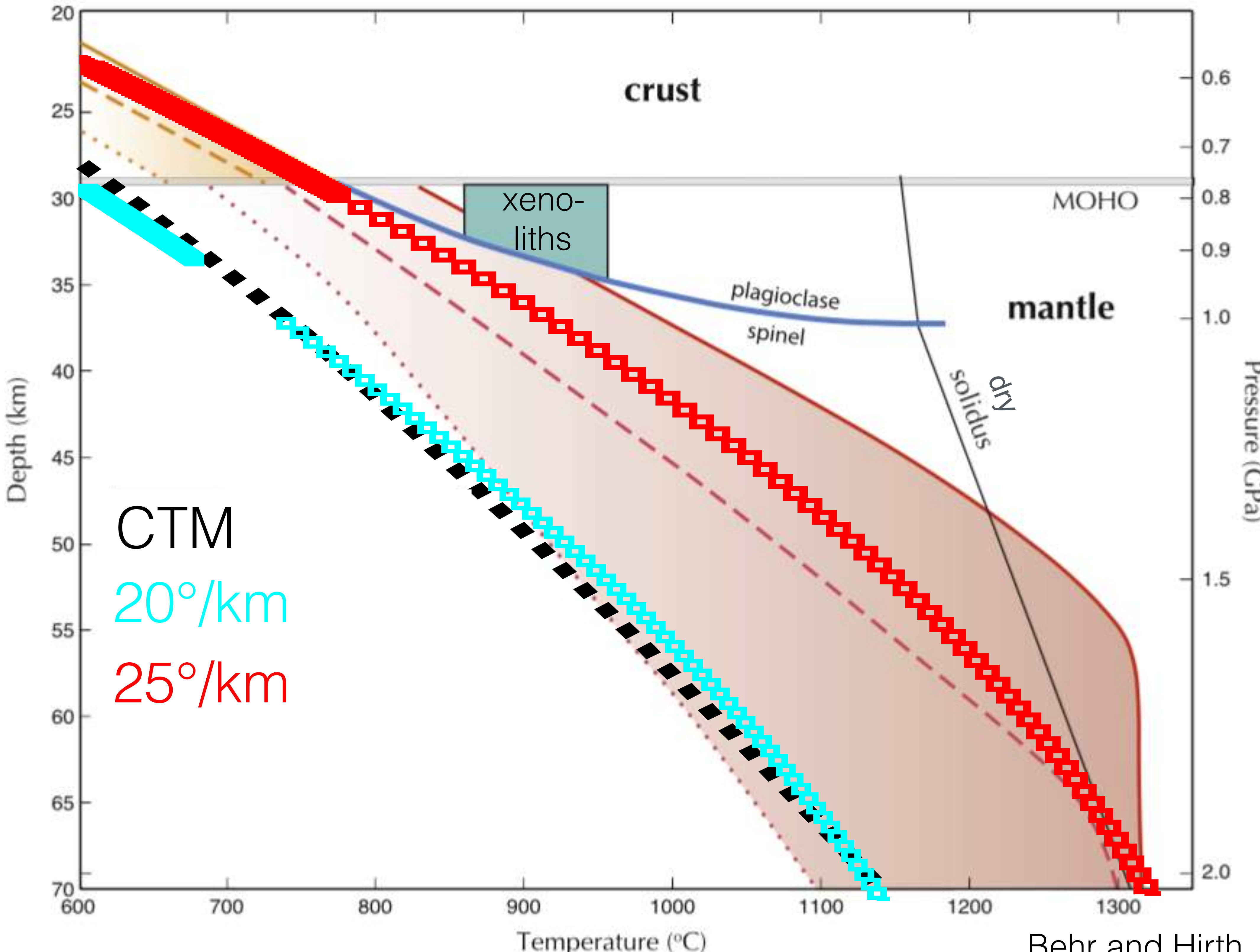
Flow laws and parameters

Mojave CTM: Temperature vs. depth



Mojave CTM has cool lower lithosphere because high heat production is modeled in the felsic crust

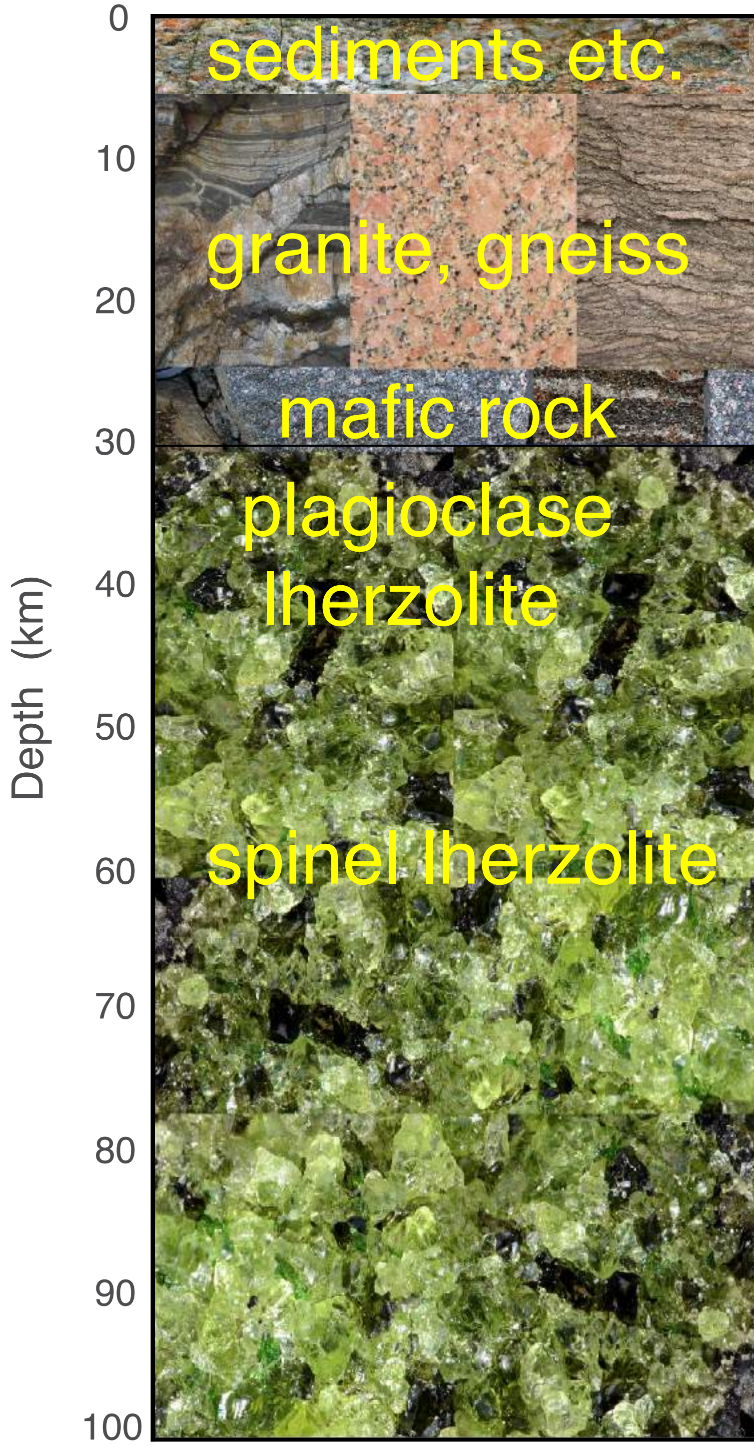
Mojave CTM: Comparison with other studies



Behr and Hirth, 2014

Mojave Geologic Framework

simplified column



geologist's description

0 - 25 ± 3 km: Mixture of Cretaceous plutonic (50-60%) and proterozoic/archean orthogniess (40-50%) and paragneiss / pelitic rocks (0-10%). Some isolated intermediate metavolcanic and Phanerozoic metasediments (in upper 5km?). Average quartz content declines linearly from 25% to 5% with depth. Wet conditions throughout. Plagioclase, amphibole, pyroxene, ±mica.

25 ± 3 to 30 ± 2 km: Underplated mafic to mafic-intermediate rocks. No appreciable quartz. Likely wet conditions, amphibole, pyroxene,

Moho 30 ± 2 km

Spinel lherzolite, with plagioclase replacing spinel where Moho is shallower than 40 km or so. Approximating the rheology as olivine is fine, although xenoliths indicate a role for orthopyroxene as well. Water content is 'damp': 10-30 ppm.

Dislocation Creep: Power-law flow equation

$$\dot{\epsilon} = A\sigma^n e^{\frac{PV-Q}{RT}} {f_{H_2O}}^r$$

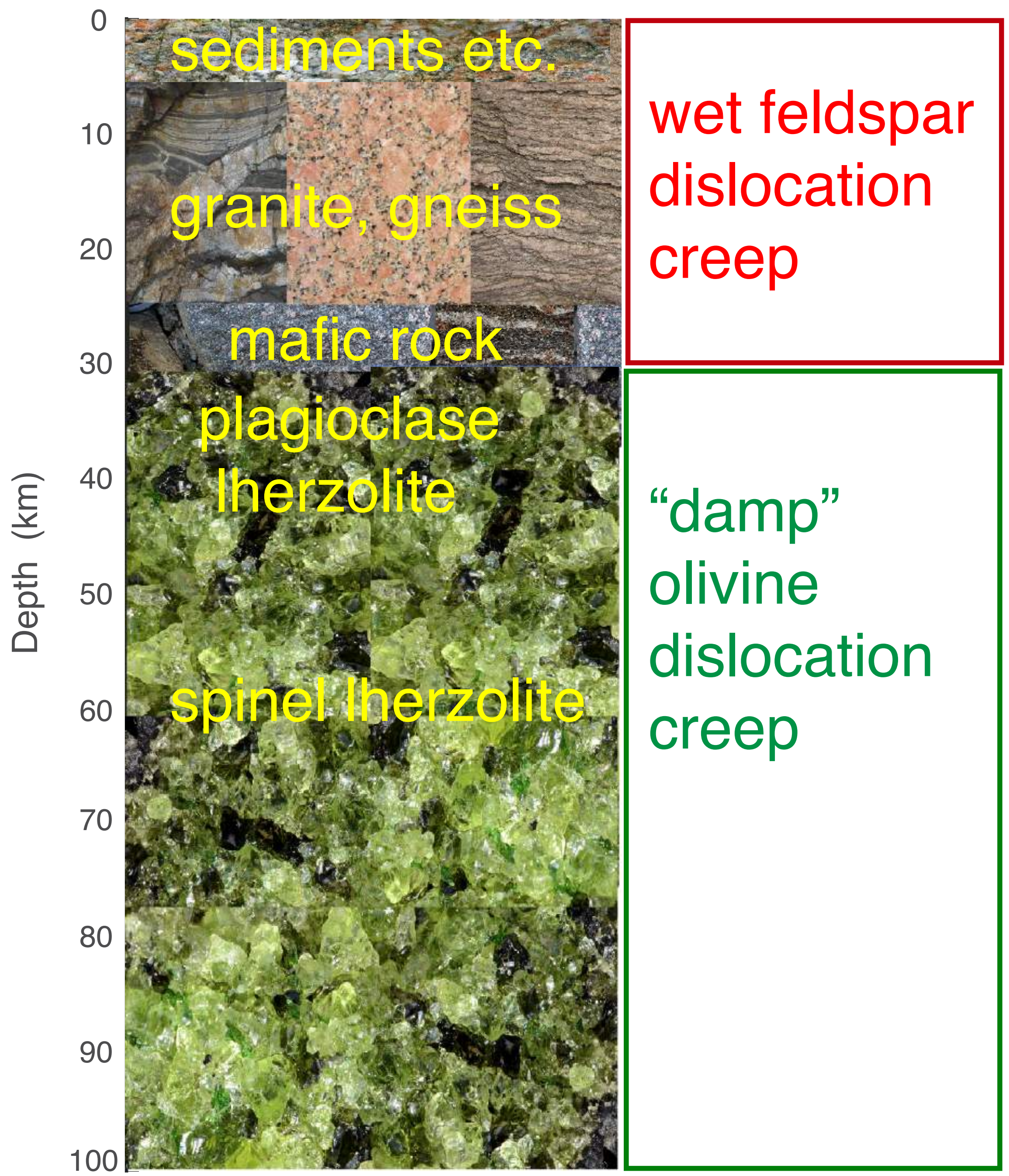
$$\eta_e = \frac{\sigma}{\dot{\epsilon}}$$

- T from Community Thermal Model
- P from density*g*depth
- assume stress or strain rate
- other parameters from flow laws

- which fugacity table or equation do I use?
- some versions have COH or H/Si (or ppm?), not water fugacity
- do they mean engineering strain rate? differential stress? torsion vs. uniaxial.
- assume what for stress or strain rate?
- some versions include another fugacity term and/or a grain size term
- some versions include a term for melt.
- what if it's actually diffusion creep?
- what about transient rheology?

Power-law flow equation guidance (Mojave)

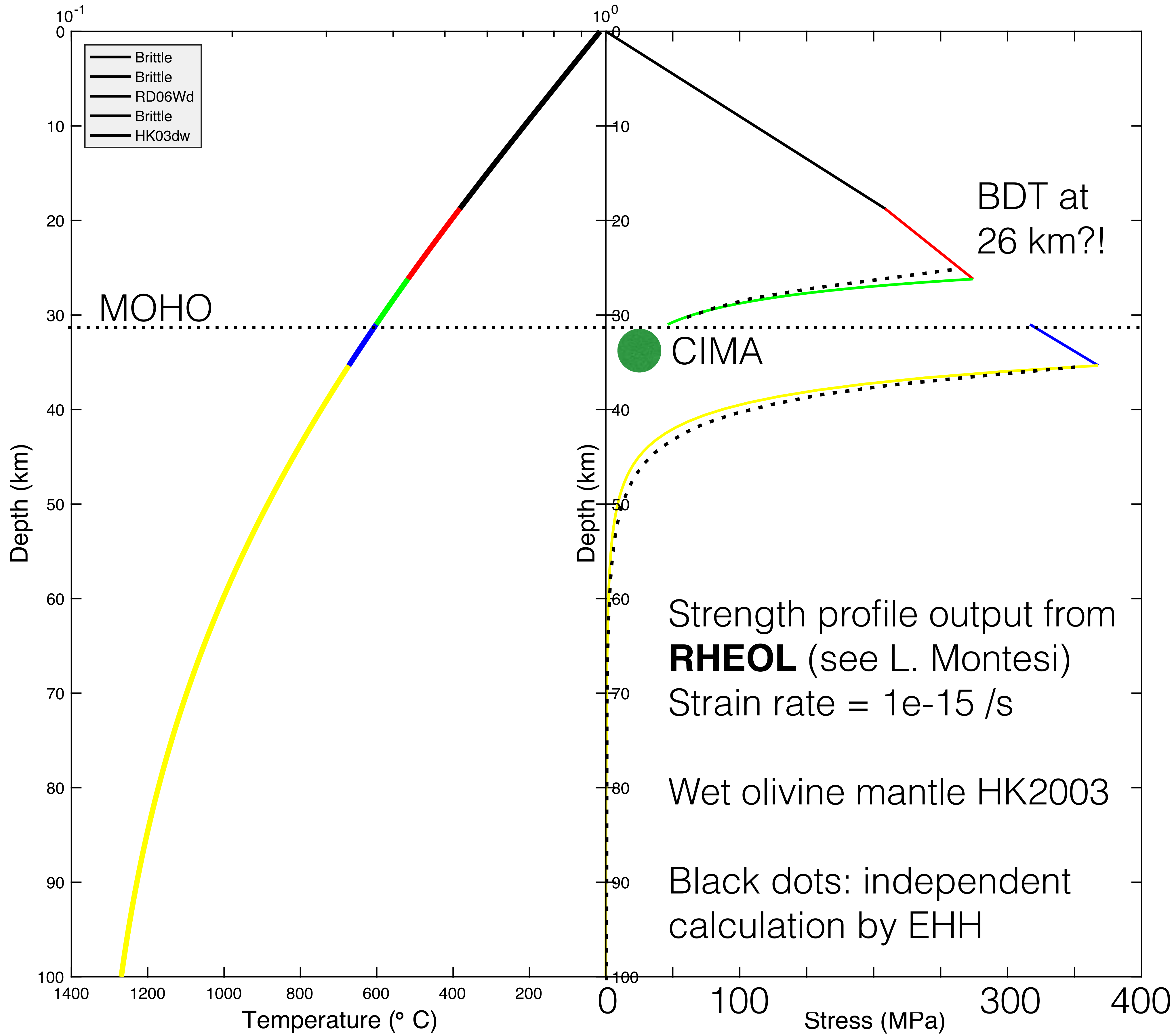
$$\dot{\epsilon} = A\sigma^n e^{\frac{PV-Q}{RT}} {f_{H_2O}}^r \qquad \eta_e = \frac{\sigma}{\dot{\epsilon}}$$



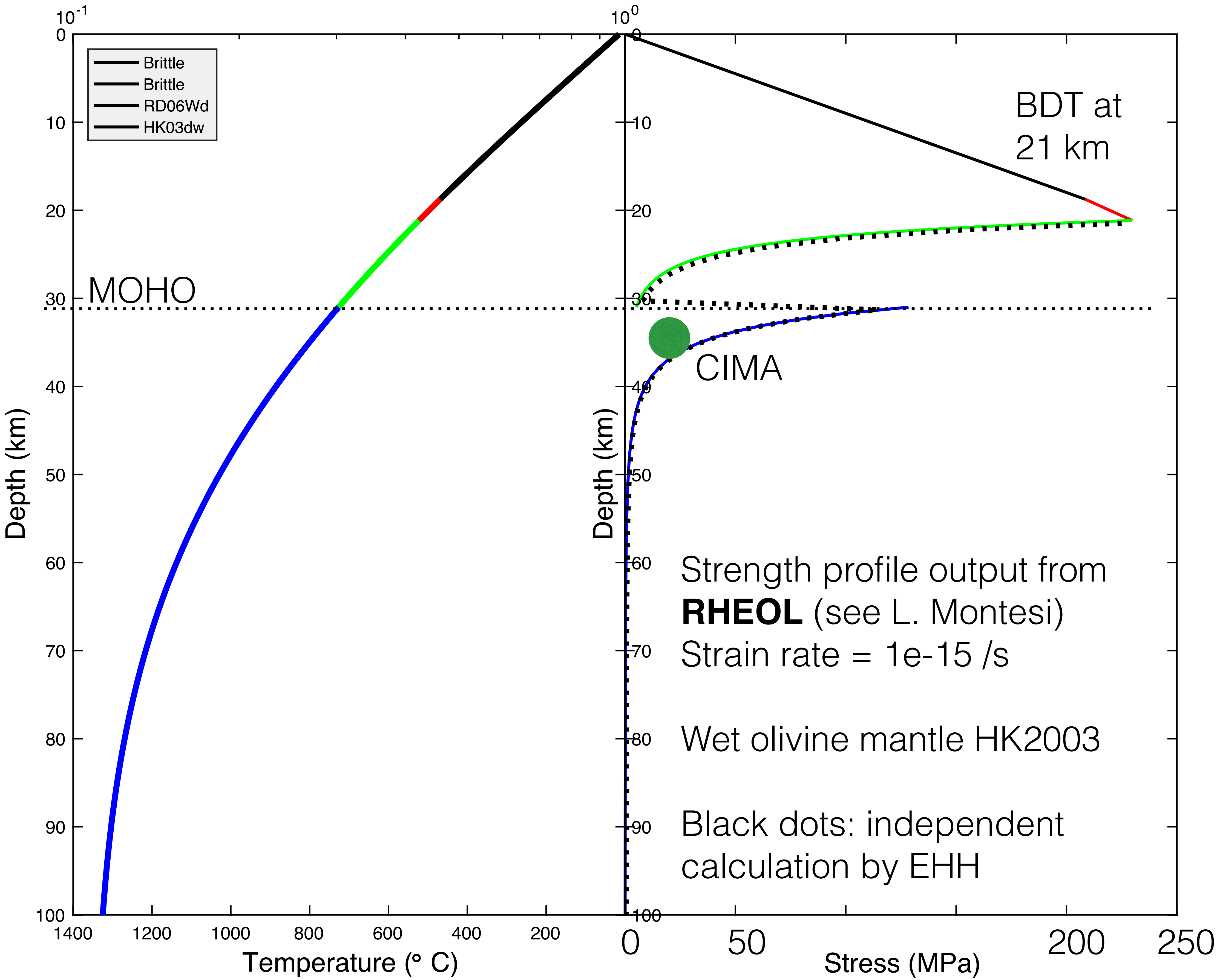
- parameters A, n, r, V and Q from Rybacki et al. (2006) for wet anorthite
- water fugacity consistent with saturation: depends on P and T (Pitzer and Sterner, 1994)

- parameters A, n, r, V and Q from Hirth and Kohlstedt (2003) for wet olivine, *constant COH equation*
- assume COH = 300 (i.e. 300 H atoms per 10^6 Si atoms).
- COH substitutes for fugacity in equation

Mojave strength profile assuming cool geotherm



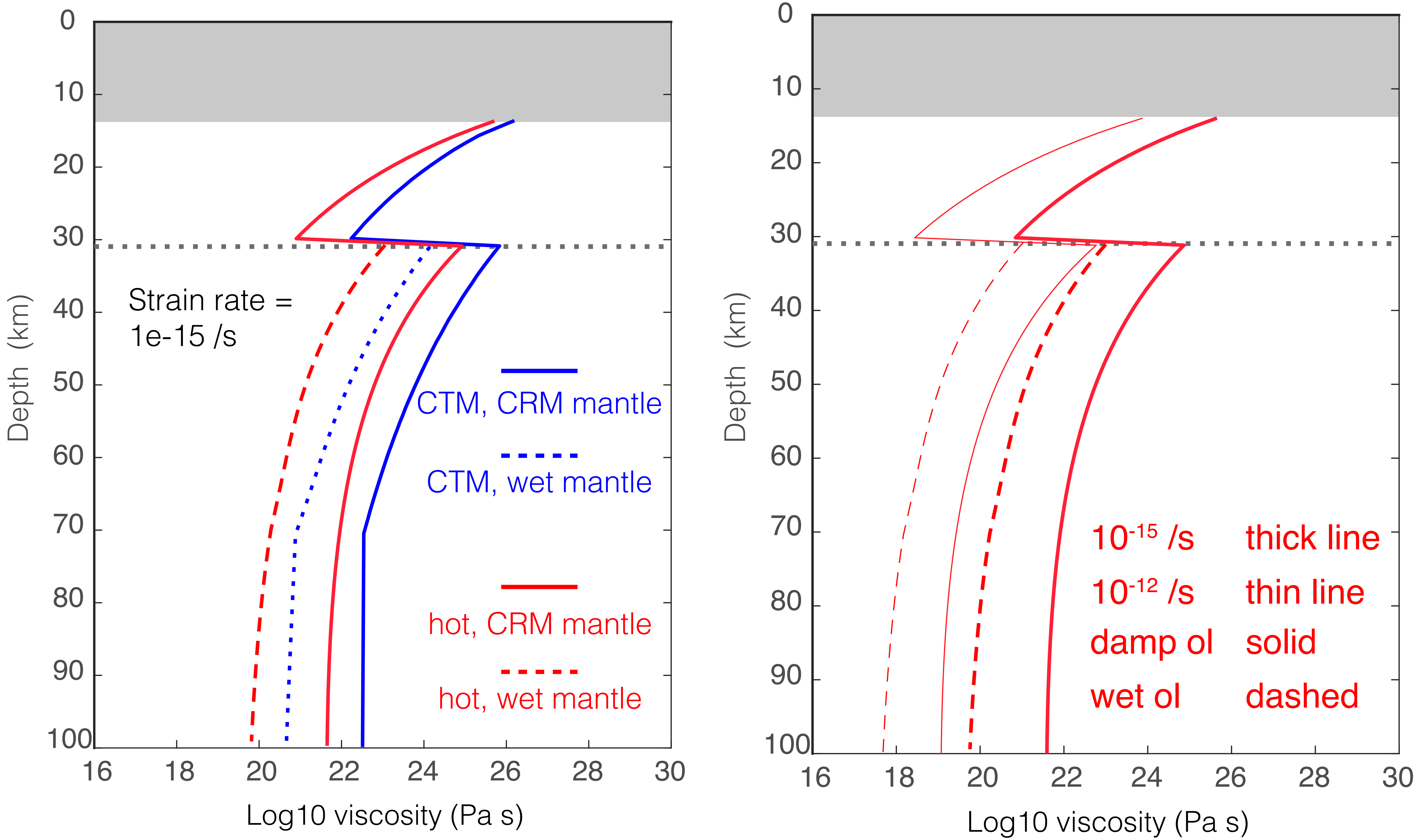
Mojave strength profile assuming hot geotherm



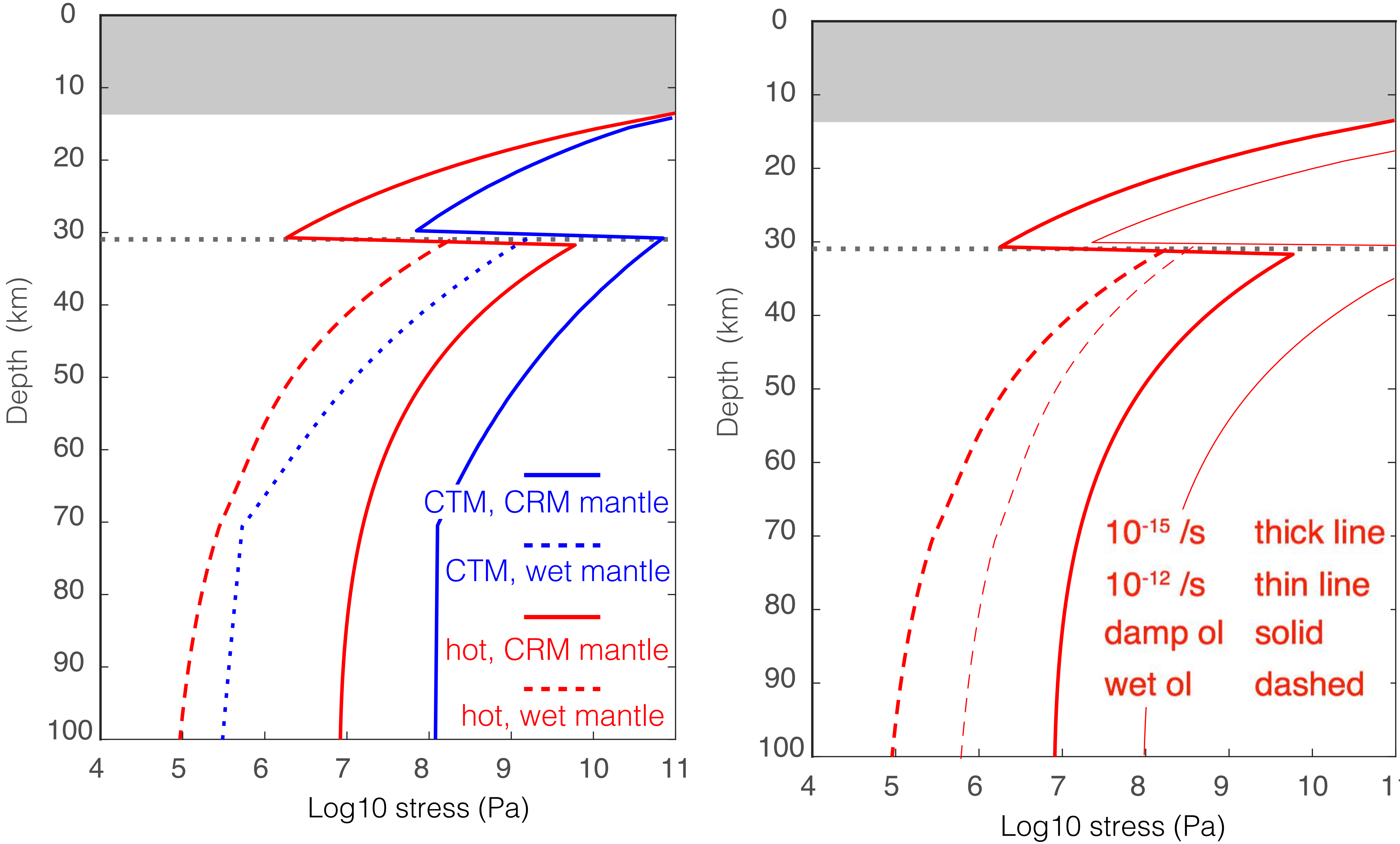
To faithfully represent the CRM I needed to
(1) read in the CTM
(2) use the “damp” olivine flow law

I calculated effective viscosity and differential stress using a MATLAB code (benchmarked to RHEO calculations)

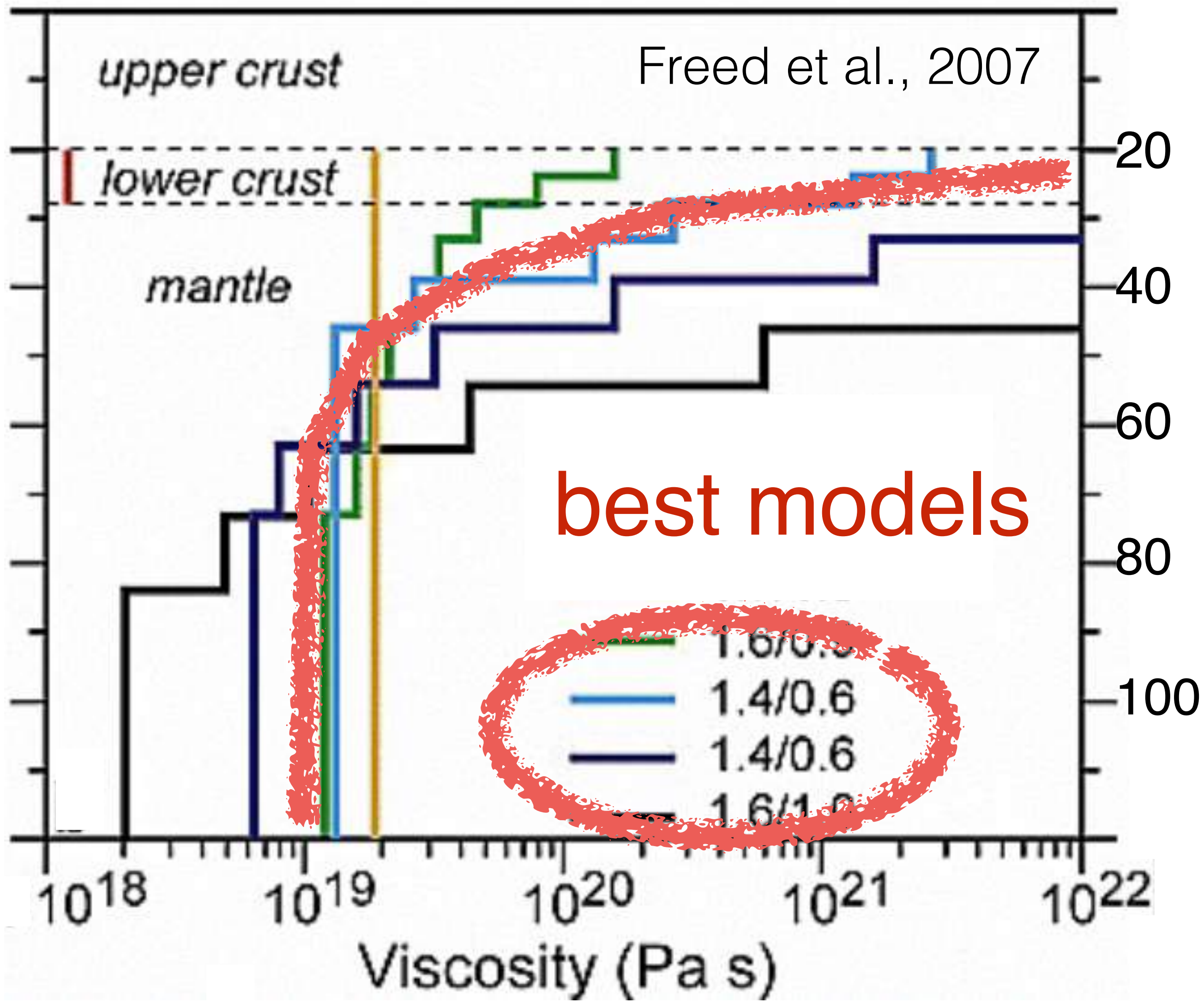
Higher temperatures, higher water content and higher strain rates: lower effective viscosities

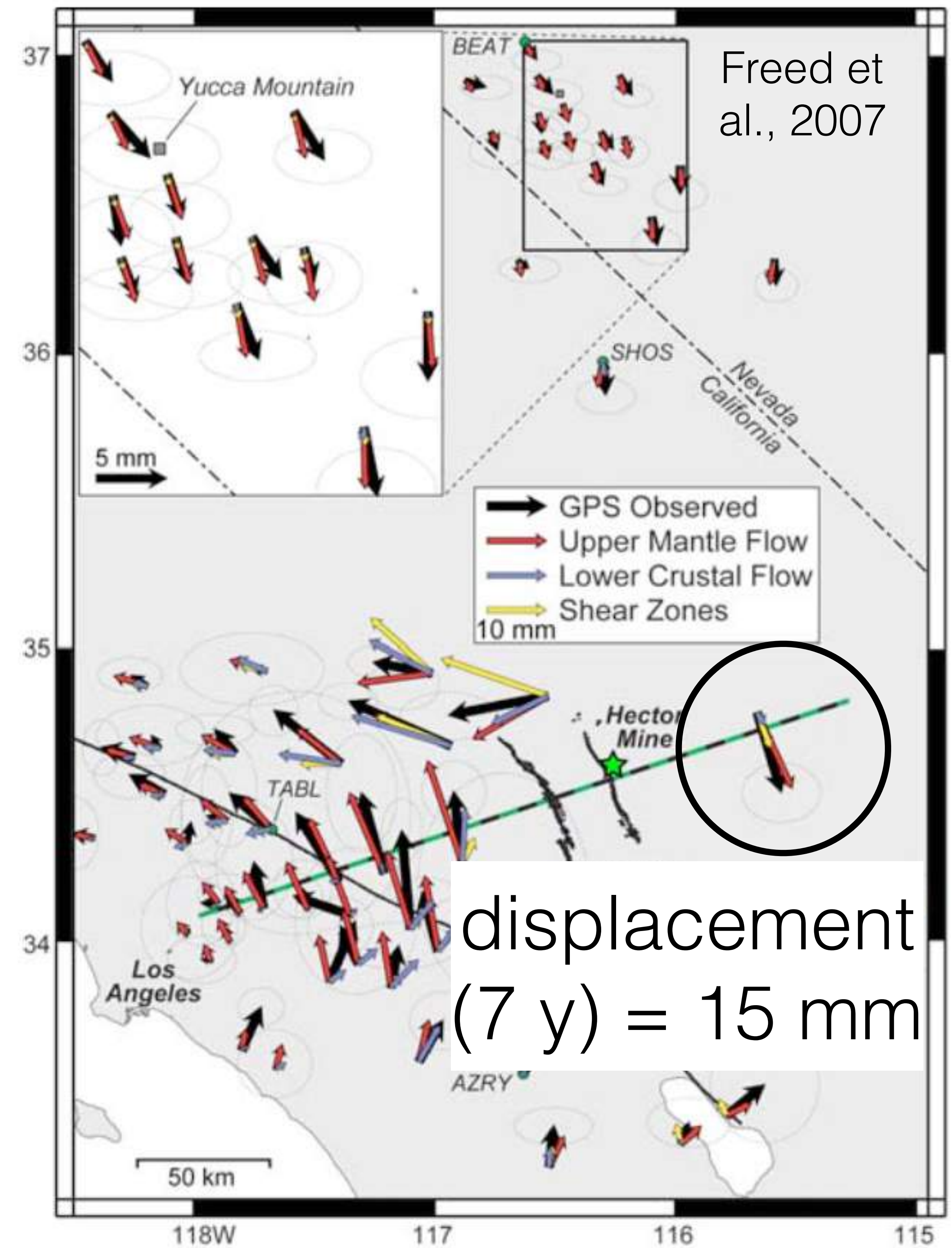


Lower temperatures, lower water content or higher strain rate: higher differential stress



Hector Mine Earthquake Postseismic Deformation: Inferred viscosity structure, excluding near-field GPS data

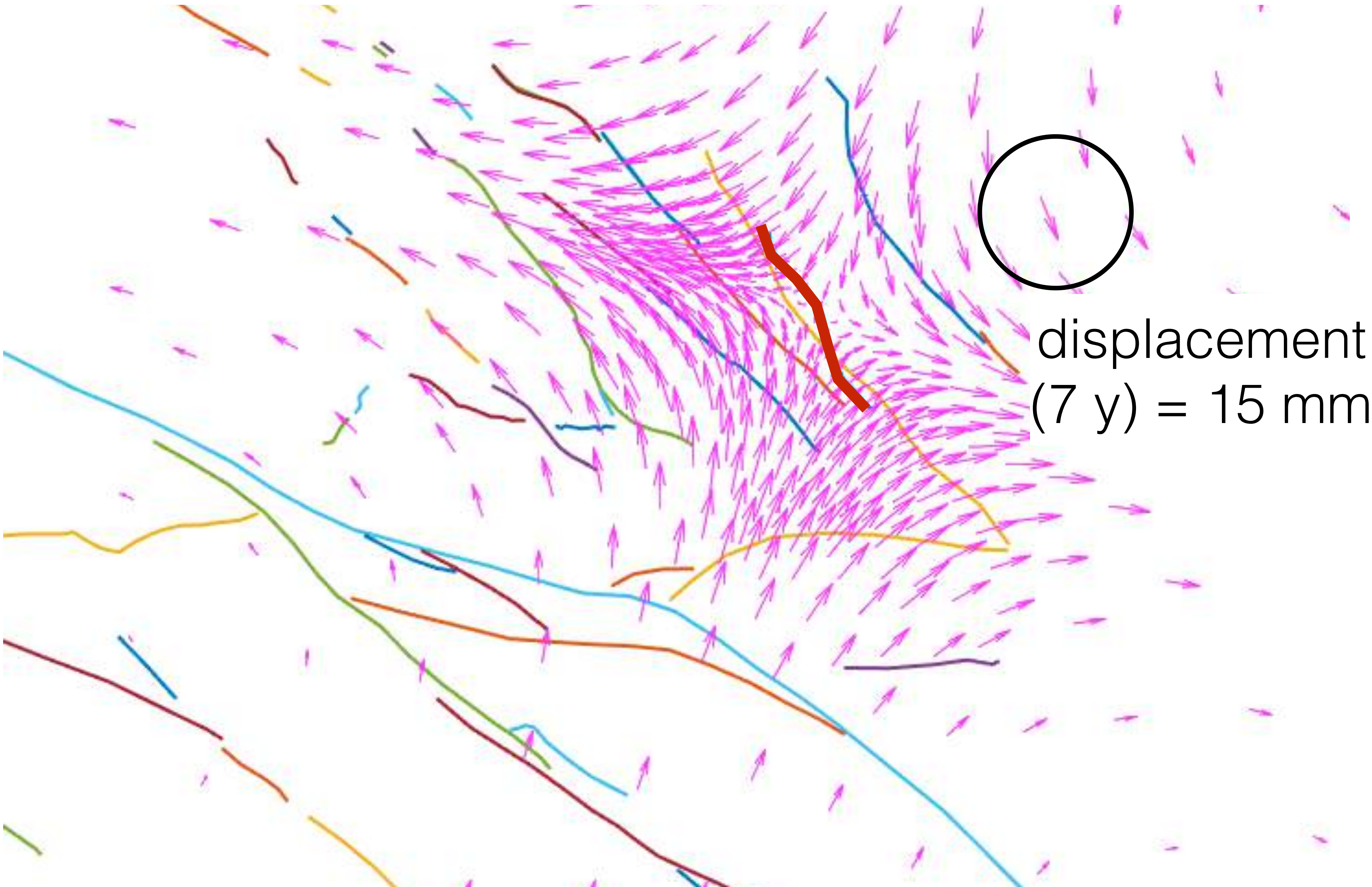




"Creme brûlée" model

Similar results for the Mojave region from post-seismic deformation models, e.g. Pollitz et al., 2000; Pollitz and Thatcher, 2010

Modeled Hector Mine post-seismic displacements (preferred viscosity structure of Freed et al. 2007)



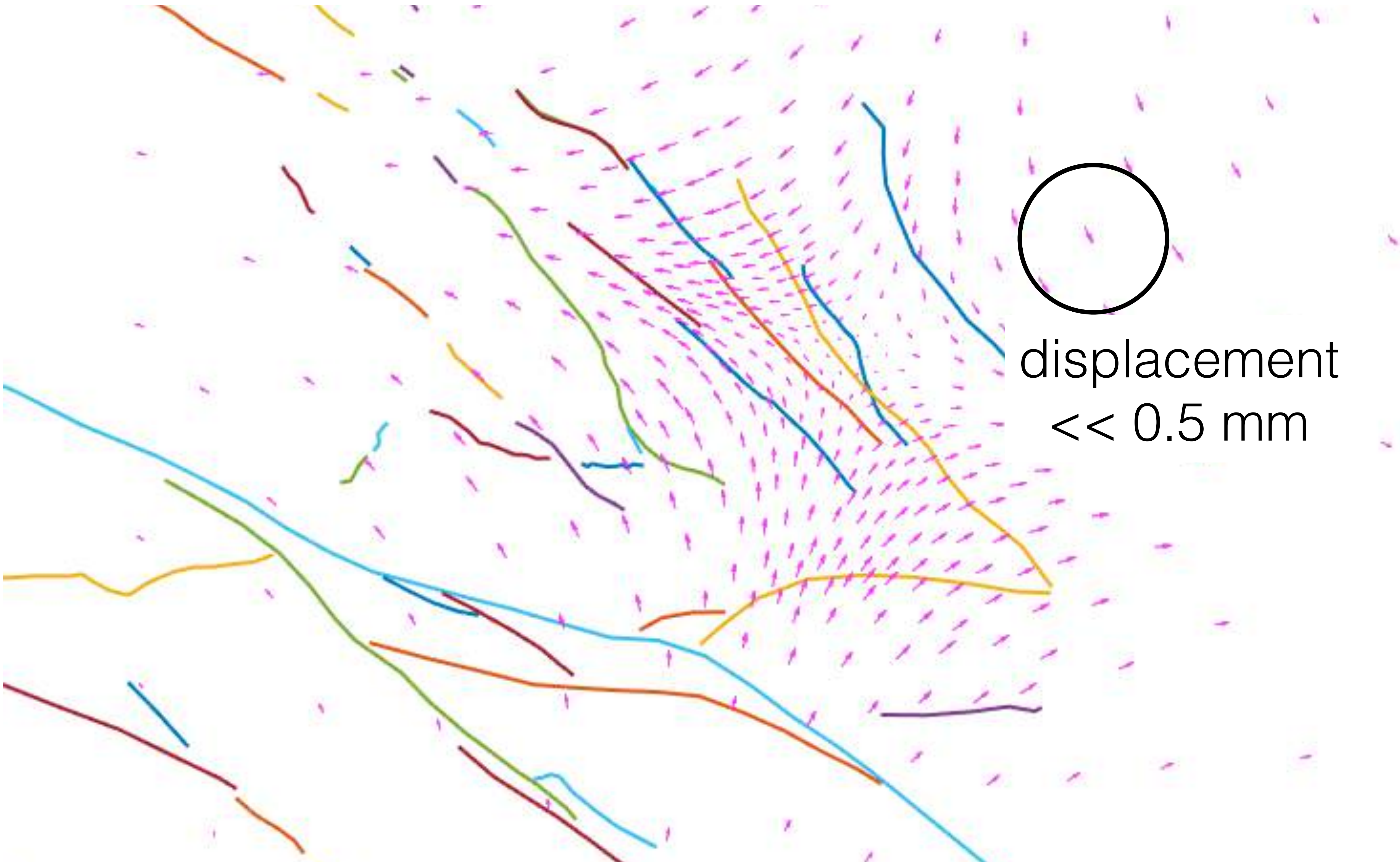
CTM geotherm, CRM rheologies

assumes pre-earthquake strain rate of 10^{-15}/s

earthquake changes stresses

Depth (km)	eff viscosity_o Pa s	differential stress_o MPa	n
0-15	elastic	large	
15-20	1.5E+25	14,000	3
20-25	1.1E+24	1100	3
25-31	1.5E+23	150	3
31-40	2.5E+25	25000	3.5
40-55	2.2E+24	2200	3.5
55-80	1.3E+23	130	3.5
80-120	1.0E+23	100	3.5
120-200	1E+21	1	3.5

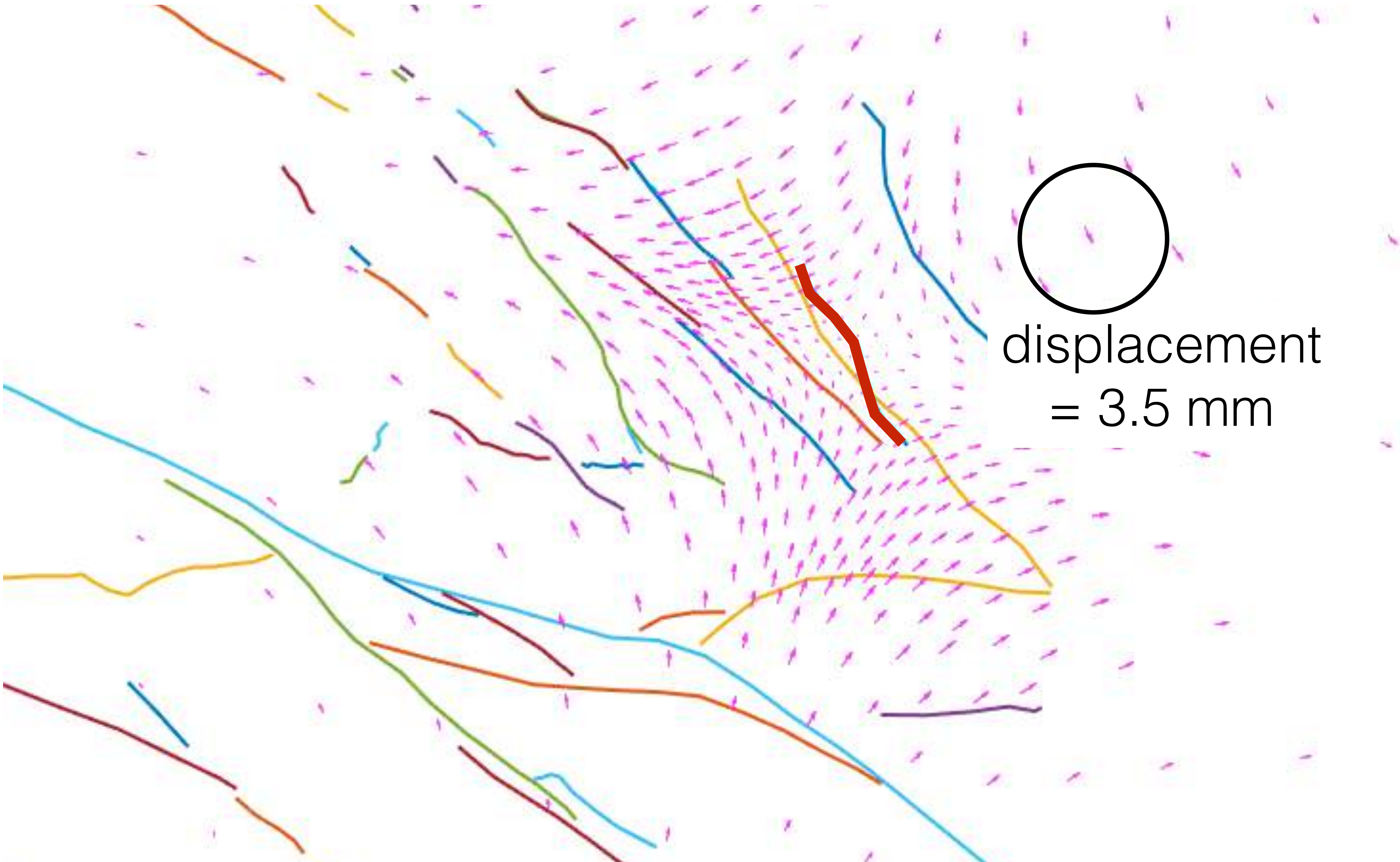
Modeled Hector Mine post-seismic displacements (Mojave CTM and CRM)

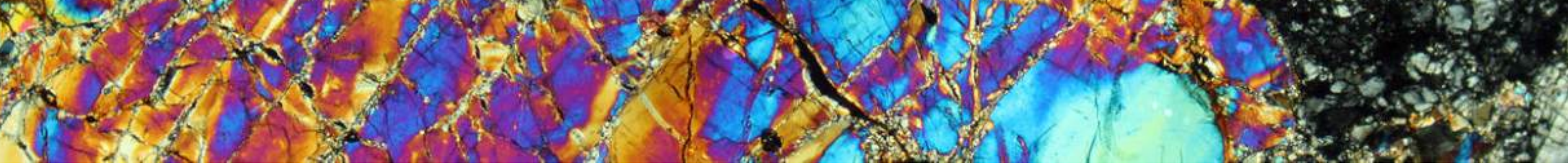


Modeled power-law flow parameters: CRM but using hot geothermal and wet (not damp) olivine

Depth (km)	eff viscosity_o Pa s	differential stress_o MPa	n
0-15	elastic	large	
15-20	6E+24	6000	3
20-25	1.7E+23	170	3
25-31	2.2E+22	22	3
31-40	3.4E+22	34	3.5
40-55	2.3E+21	2.3	3.5
55-80	2.5E+20	0.25	3.5
80-120	7.3E+19	0.07	3.5
120-200	1.0E+19	0.01	3.5

Modeled Hector Mine post-seismic displacements. Hot geotherm, wet olivine flow law.





Mojave CRM/CTM **is not** consistent with mantle relaxation needed to explain intermediate- to far-field post seismic deformation

Mojave CRM/CTM **is** consistent with afterslip or shear zone creep (not modeled) within a strong lithosphere

Thoughts

- add ductile shear zones (separate rheological entity)
- increase background strain rate
- increase temperatures (more like Basin and Range CTM)
- assume higher COH in mantle
- continue testing CRM with numerical models!