1 **Strain and retrogression partitioning explain long-term stability of crustal roots in stable continents**

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4 TABLE DR1. THERMAL AND MECHANICAL PARAMETERS

Parameter	Continental Crust	Retrogressed Amphibolites	Garnet-Pyroxene CC	Upper Mantle	Fault
Reference temperature (K)	293	293			
Dislocation creep viscous rheology	Wet quartzite[a]	Wet quartzite[a]	Dry Maryland Diabase [b]	Wet dunite [c]	0.1 *Wet quartzite[a]
Reference density (kg·m^{-3})	2600	2600	2950	3370	2600
Thermal expansivity (K-1)	-1.00E-04	-1.00E-04	-1.00E-04	2.80E-05	-1.00E-04
Compressibility (Pa^{-1})	8.00E-11	8.00E-11	-	-	8.00E-11
Heat capacity (J K^{-1} kg^{-1})	1000	1000	1000	1000	1000
Thermal diffusivity (m^2 s^{-1})	9E-07	9E-07	9E-07	9E-07	9E-07
Latent heat of fusion (kJ kg^{-1} K^{-1})	250	250	250	-	250
Radiogenic heat production (W m^{-3})[d]	5.00E-07	5.00E-07	5.00E-07	-	5.00E-07
Melt fraction density change[e]	0.13	0.13	-	-	0.13
Solidus term 1 (K)	923	923	1063	-	923
Solidus term 2 (K Pa^{-1})	-1.20E-07	-1.20E-07	-1.20E-07	-	-1.20E-07
Solidus term 3 (K Pa^{-2})	1.20E-16	1.20E-16	1.20E-16	-	1.20E-16
Liquidus term 1 (K)	1423	1423	1563	-	1423
Liquidus term 2 (K Pa^{-1})	-1.20E-07	-1.20E-07	-1.20E-07	-	-1.20E-07
Liquidus term 3 (K Pa^{-2})	1.60E-16	1.60E-16	1.60E-16	-	1.60E-16
Friction coefficient	0.44	0.44	0.44	0.44	0.44
Softened friction coefficient	0.088	0.088	0.088	0.088	0.088
Cohesion (MPa)	15	15	15	15	1.5
Softened cohesion (MPa)	3	3	3	3	0.3
Pre-exponential factor (MPa^{-n} s^{-1})	5.00E-06	5.00E-06	5.05E-22	70000	5.00E-06
Stress exponent (n)	3	3	4.7	3	3
Activation energy (kJ mol^{-1})	190	190	485	520	190
Activation volume (m^3 mol^{-1})	0	0	0	0	0
Water fugacity	0	0	0	0	0
Water fugacity exponent[f]	0	0	0	0	0
Melt viscous softening factor	1.00E-03	1.00E-03			1.00E-03
Softening melt fraction interval	0.2-0.3	0.2-0.3			0.2-0.3

Additional parameters:
Model Size: 360 km length (241 nodes, constant spacing) - 120 km thick (81 nodes, constant spacing) i.e. 15 km air-like material, 70 km crust, 35 km upper mantle. The marker density is uniform (60 per grid cell).

A weak prismatic region dipping 45 °C simulates a detachment in the upper crust
Basal heat flow is set at 0.015 W.m^{-2}
Velocities tested: 1.8 cm.y^{-1} (fast) or 0.18 cm.y^{-1} (slow) and Isostasy is activated
Prograde amphibolite to garnet-pyroxene rock phase change set at 1050 K
Retrograde garnet-pyroxene rock to amphibolite phase change set at 1050 K and 10-^{14} s^{-1} strain rate
Moho temperature at the start of the model is 883 °C
Solidus and liquidus are defined by a polynomial function of pressure (P):
$T_s = a_0 + a_1 \times P + a_2 \times P^2$, $T_l = b_0 + b_1 \times P + b_2 \times P^2$
The density of the continental crust changes according to T and P:
$\rho = \rho_0 * (1 + (\beta * \Delta P) - (\alpha * \Delta T))$
Note that the presence of melt has an impact on density.
The maximum melt fraction is 30%.

References:
a Parameters were derived from Brace and Kohlstedt (1980)
b Parameters were derived from Mackwell et al (1998)
c Parameters were derived from Brace and Kohlstedt (1980)
d Parameters were derived from Hasterok and Chapman (2011)
e Melt and other parameters were derived from Rey and Muller (2010)
f A zero value denotes that this effect on the viscous flow law is incorporated into the pre-exponential factor

5   Figure DR1: Slow modeling results (0.18 cm.y^{-1} extension speed) at an average strain rate of

6   3e-16 s^{-1} and 25 % extension. Colors are the same as in Fig. 2. Conditions for a, b and c

7   models are the same as in Fig. 3.

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9   Figure DR2: Fast modeling results (1.8 cm.y^{-1} extension speed) at an average strain rate of

10   3e-15 s^{-1} and 25 % extension. Colors are the same as in Fig 3. Variations of model shown on

11   Figure 3b but a. only the prograde phase change is allowed. Retrogression does not occur,

12   and the crust, including the garnet-pyroxene layer, thins homogeneously. b. The strain rate

13   threshold for retrogression has been set to 10^{-13} s^{-1}. Retrogression does not occur, and the

14   crust, including the garnet-pyroxene layer, thins homogeneously. c. The strain rate threshold

15   for retrogression has been set to 10^{-15} s^{-1}, large portions of retrogressed and partially molten

16   crust are exhumed in the center of the model whereas the garnet-pyroxene layer is preserved

17   locally but strongly thinned.

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19   REFERENCES CITED:

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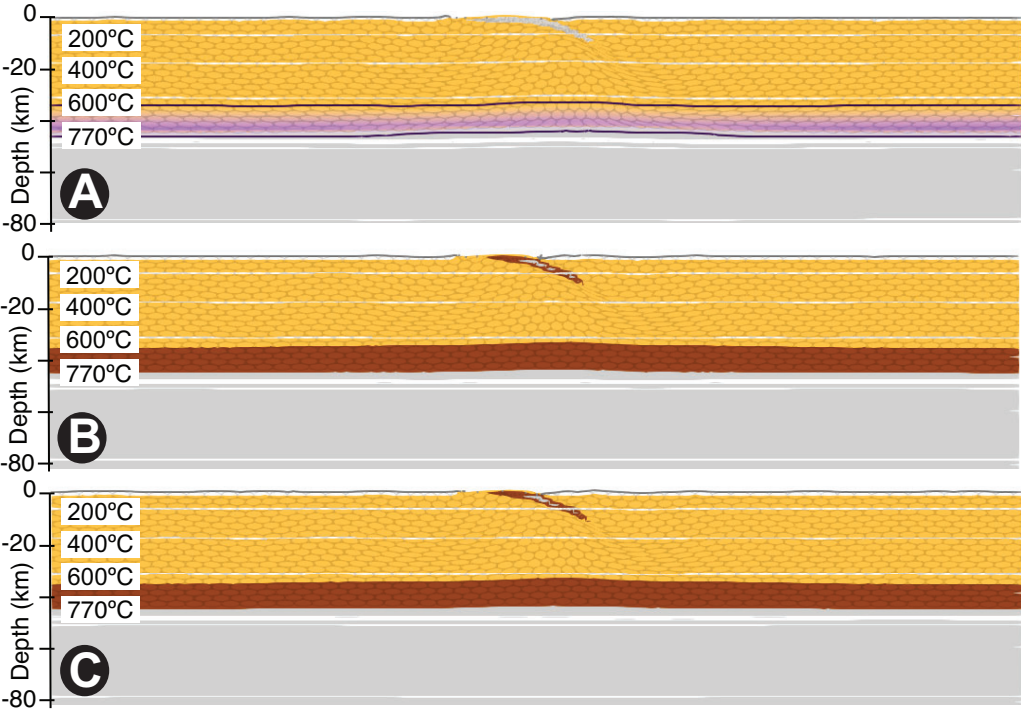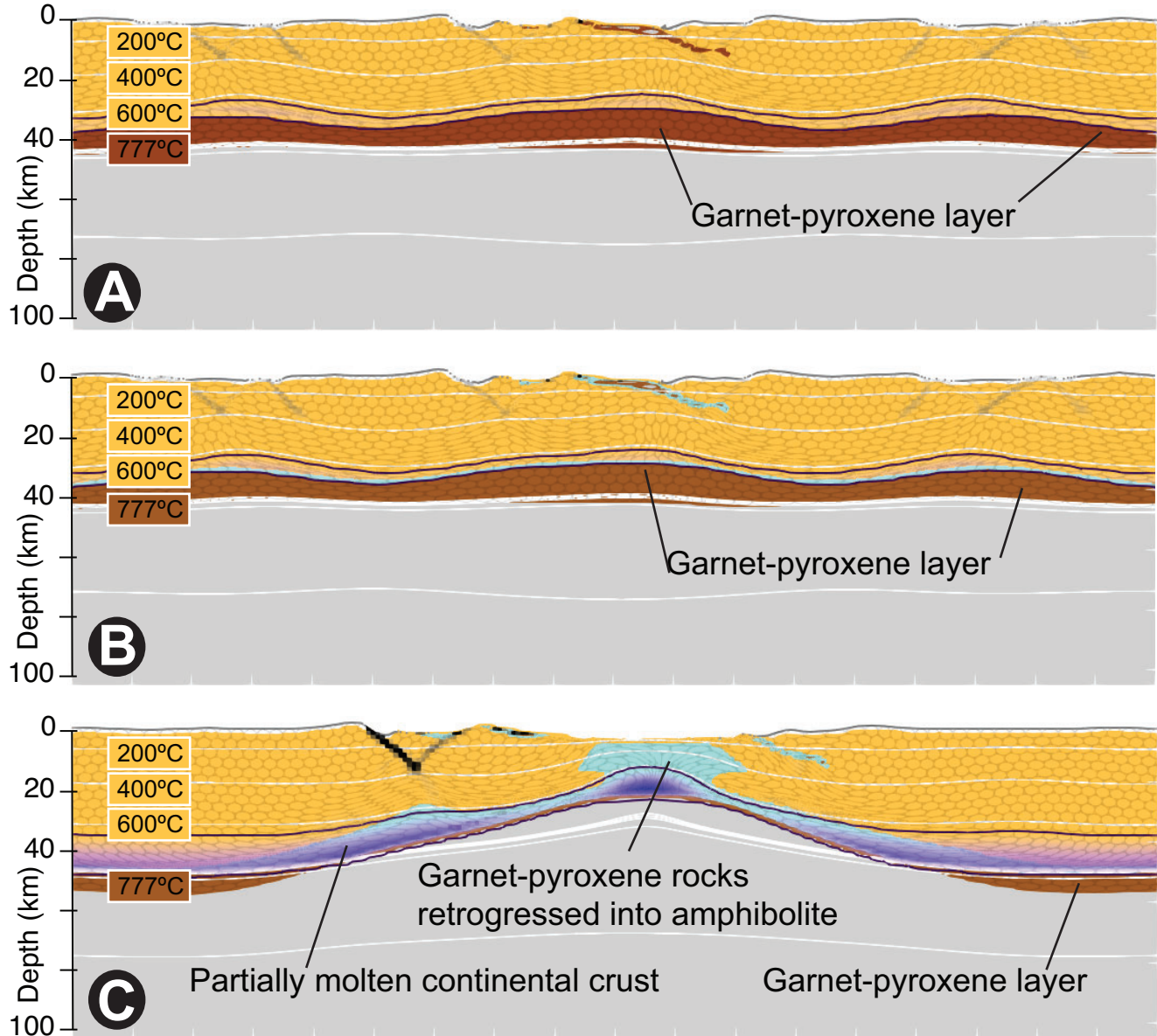28   buoyancy of the mantle wedge. Nat. Geosci. 3 (4), 257–261.

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Fig. DR1

Fig. DR2