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SUPPLEMENTARY INFORMATION

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Constraints from material properties on the dynamics and evolution of Earth's core

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This document contains four tables. Supplementary Table 1 is a more complete version of Table 1 in the main text that gives values for depth-varying quantities at the inner core boundary (ICB) as well as the core-mantle boundary (CMB) and provides error estimates where available. Supplementary Tables 2–4 list polynomial coefficients for depth-dependent properties listed in Table 1. Diffusion coefficients for Oxygen and Silicon, D_O and D_{Si} (m^2 s^{-1}), thermal conductivity k (W m^{-1} K^{-1}), density ρ (kg m^{-3}), electrical conductivity σ (S m^{-1}), adiabatic temperature $T_{\rm a}$ (K), viscosity ν (mPa s), melting temperature $T_{\rm m}$ (K), and thermal expansion coefficient α_T (K^{-1}) are presented up to third order in pressure P.

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Symbol	Definition	Units	100%Fe		82%Fe-8%O-10%Si		79%Fe-13%O-8%Si		81%Fe-17%O-2%Si	
$\Delta\rho$	ICB density jump	gm cc^{-1}	0.24 [1]		0.6 [2]		0.8 [3]		1.0 [3]	
c_O^S	O concentration (solid)		–		0.0002 [4]		0.0004 [4]		0.0006 [5]	
c_{Si}^S	Si concentration (solid)		–		0.0554 [4]		0.0430 [4]		0.0096 [5]	
c_O^L	O conc (liquid)		–		0.0256 [4]		0.0428 [4]		0.0559 [5]	
c_{Si}^L	Si conc (liquid)		–		0.0560 [4]		0.0461 [4]		0.0115 [5]	
C_p	Specific heat	J kg^{-1} K^{-1}	715 [6] — 800 [7]		–		–		–	
γ	Grüneisen parameter		1.4 [8] — 1.5 [1,6]		–		–		–	
ΔS	Entropy of Melting (r_i)	k_B	1.05 (0.05) [1]		–		–		–	
L	Latent heat (r_i)	MJ kg^{-1}	0.75 (0.1)		–		–		–	
T_m	Melting point (r_i)	K	6350 (300) [1,9]		5900 (300)		5580 (300)		5320 (300)	
			r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o
α_T	Thermal expansivity	K^{-1} × 10^{-5}	1.0 [6,10]	1.7 [6,10]	-	-	-	-	-	-
T_a	Temperature	K	6350 (300)[1,9]	4735 (300) [1]	5900 (300)	4290 (300)	5580 (300)	4105 (300)	5330 (300)	3910 (300)
$\frac{\partial T_a}{\partial P}$		K GPa^{-1}	6.96	10.9	6.25	9.75	6.01	9.41	5.81	9.07
$\frac{dT_m}{dP}$		K GPa^{-1}	9.01	12.9	9.01	12.9	9.01	12.9	9.01	12.9
$\frac{\partial T_a}{\partial r}$		K km^{-1}	-0.39	-1.15	-0.35	-1.03	-0.34	-1.00	-0.33	-0.96
$\frac{dT_m}{dr}$		K km^{-1}	-0.48	-1.39	-0.48	-1.39	-0.48	-1.39	-0.48	-1.39
C_r	$dr_i/dt = C_r dT_o/dt$	m K^{-1}	-14.96		-10.39		-9.50		-8.75	
C_c	$dc_X^L/dt = C_c C_r dT_o/dt$	10^{-9}	-3.16		-3.16		-5.28		-6.90	
			r_i	r_o	r_i	r_o	r_i	r_o	r_i	r_o
σ	Electrical conductivity	S m^{-1} ×10^6	1.56 (1) [11], 1.6 [12] 2.32 [13,a]	1.36 (1) [11], 1.4 [12] 1.86 [13,b]	1.27 (1) [11]	1.12 (1) [11]	1.24 (1) [11]	1.11 (1) [11]	1.33 (1) [11]	1.18 (1) [11]
k	Thermal conductivity	W m^{-1}K^{-1}	246 [11], 230 [12] 281 [13]	159 (1) [11], 150 [12] 170 [13]	160 (1) [11]	107 (1) [11]	148 (1) [11]	99 (1) [11]	150 (1) [11]	101 (1) [11]
D_O	O Diffusivity [11]	m^{2}s^{-1} × 10^{-8}	-	-	0.98 (0.06)	1.31 (0.05)	0.92 (0.03)	1.30 (0.07)	-	-
D_{Si}	Si Diffusivity [11]	m^{2}s^{-1} × 10^{-8}	-	-	0.41 (0.02)	0.52 (0.02)	0.38 (0.01)	0.46 (0.02)	-	-
ν	Viscosity [11]	mPa s	11.9 (9)	6.9 (4)	11.7 (10)	6.8 (6)	13.1 (9)	6.7 (8)	-	-
α_O^D	Barodiffusion coeff (O)	kg m^{-3} s ×10^{-12}	–		0.72		0.97		1.11	
α_{Si}^D	Barodiffusion coeff (Si)	kg m^{-3} s ×10^{-12}	–		1.19		1.10		40.6	
					O			Si		
α_c	Chemical expansivity [14,15]		–		1.1			0.87		
$(\partial\mu/\partial c)_{P,T}$		×10^{10} ev/atom	–		1.02			1.40		

Table 1: **Core material properties for pure iron and three Fe-O-Si mixtures**. Models are named after the mass concentrations of mixtures of Fe, O, and Si corresponding to the given density jump. Quantities in the first section define the core chemistry model used in this review. Numbers in the second section determine the core temperature properties given in the third section. The core temperature is assumed to follow an adiabat, denoted T_a, which intersects the melting temperature T_m of the mixture at the inner core boundary (ICB). $C_r = [T_\mathrm{i}/T_\mathrm{o}][\rho(r_\mathrm{i})g(r_\mathrm{i})(\frac{\mathrm{d}T_\mathrm{m}}{\mathrm{d}P} - \frac{\partial T_\mathrm{a}}{\partial P})]^{-1}$ specifies the inner core growth rate for a given cooling rate; $C_c = 4\pi r_\mathrm{i}^2 \rho(r_\mathrm{i}) \left(c_X^l - c_X^s\right)/M_\mathrm{oc}$, together with C_r, determines the rate of change of light elements in the outer core. $T_\mathrm{i} = T_\mathrm{a}(r_\mathrm{i})$ and $T_\mathrm{o} = T_\mathrm{a}(r_\mathrm{o})$ are respectively the temperatures at the ICB (radius r_i) and CMB (radius $r_\mathrm{o} = 3480$ km), $M_\mathrm{oc} = 1.85 \times 10^{24}$ kg is the mass of the outer core and k_B is Boltzmann's constant. All values given at the ICB radius pertain to the present-day. All values are accompanied by a reference unless they are derived quantities. Where a range is given, numbers highlighted in red are used in the core models in section 3. ^{a}: This value was derived at a presumed ICB temperature of 4971 K; ^{b}: This value was derived at a presumed CMB temperature of 3750 K. μ is the chemical potential.

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Quantity	1	P	P^2	P^3
D_O	3.15284×10^{-9}	1.58911×10^{-10}	-7.79726×10^{-13}	1.08753×10^{-15}
D_{Si}	9.67659×10^{-9}	-5.52376×10^{-11}	1.92294×10^{-13}	-2.31242×10^{-16}
k	69.541	0.24992	0.000289419	-6.57978×10^{-7}
ρ	7597.11	21.3527	-0.0314965	2.64104×10^{-5}
σ	844513	3295.58	-11.59	0.0166341
T_a	2941.37	10.8331	-0.00743569	-2.07225×10^{-8}
ν	20.4292	-0.229596	0.00119676	-1.76303×10^{-6}
T_m	1698.55	27.3351	-0.0664736	7.94628×10^{-5}
α_T	3.09159×10^{-5}	-1.58122×10^{-7}	4.47468×10^{-10}	-4.87145×10^{-13}

Table 2: Coefficients for polynomial fits to depth-dependent core properties obtained from *ab initio* calculations[11]. $\Delta\rho = 0.6$ gm cc^{-1}.

Quantity	1	P	P^2	P^3
D_O	8.13315×10^{-9}	1.01693×10^{-10}	-6.27438×10^{-13}	9.96886×10^{-16}
D_{Si}	5.41447×10^{-9}	-2.77825×10^{-12}	-3.44781×10^{-14}	8.53179×10^{-17}
k	49.5315	0.435578	-0.000563041	4.67761×10^{-7}
ρ	7580.08	20.8655	-0.0306676	2.59429×10^{-5}
σ	1.05182×10^{6}	-126.985	5.1831	-0.00919998
T_a	2733.82	12.2139	-0.0162101	1.42997×10^{-5}
ν	4.04062	0.0188676	-2.88082×10^{-6}	9.16488×10^{-8}
T_m	1498.55	27.3351	-0.0664736	7.94628×10^{-5}

Table 3: Coefficients for polynomial fits to depth-dependent core properties obtained from *ab initio* calculations[11]. $\Delta\rho = 0.8$ gm cc^{-1}.

Quantity	1	P	P^2	P^3
k	44.5507	0.539047	-0.0011221	1.39095×10^{-6}
σ	0.895385	0.00327394	-1.07115×10^{-5}	1.45871×10^{-8}
T_a	2594.91	11.6949	-0.0131957	8.20578×10^{-6}
T_m	1298.55	27.3351	-0.0664736	7.94628×10^{-5}

Table 4: Coefficients for polynomial fits to depth-dependent core properties obtained from *ab initio* calculations[5]. $\Delta\rho = 1.0$ gm cc^{-1}.

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