Constraining the Earth's lower mantle composition: Insights from mineral physics

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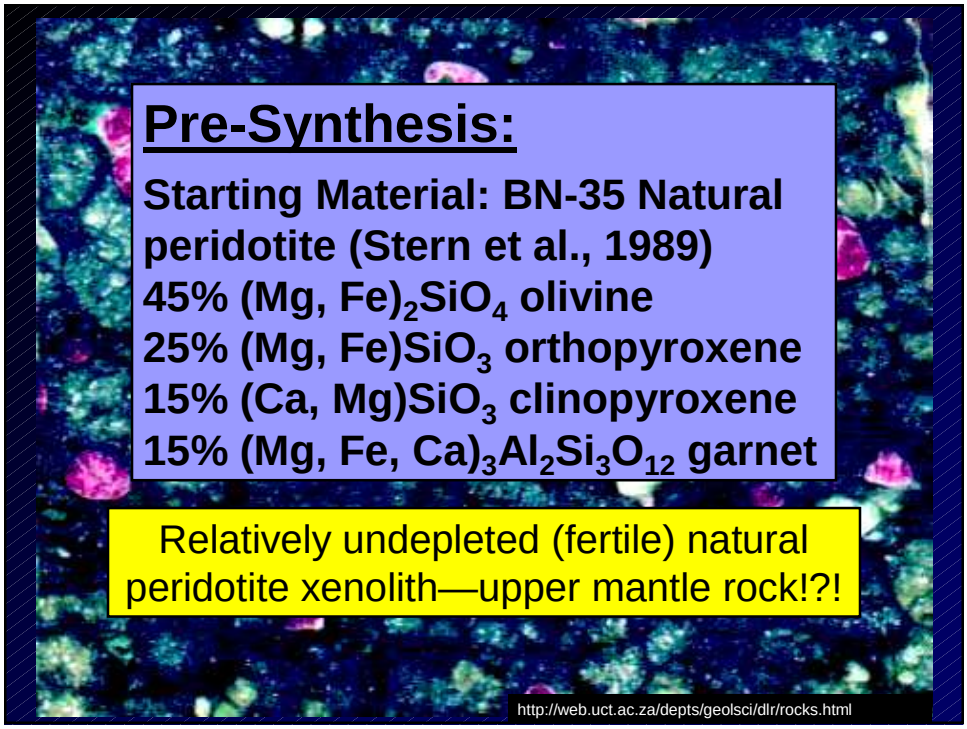


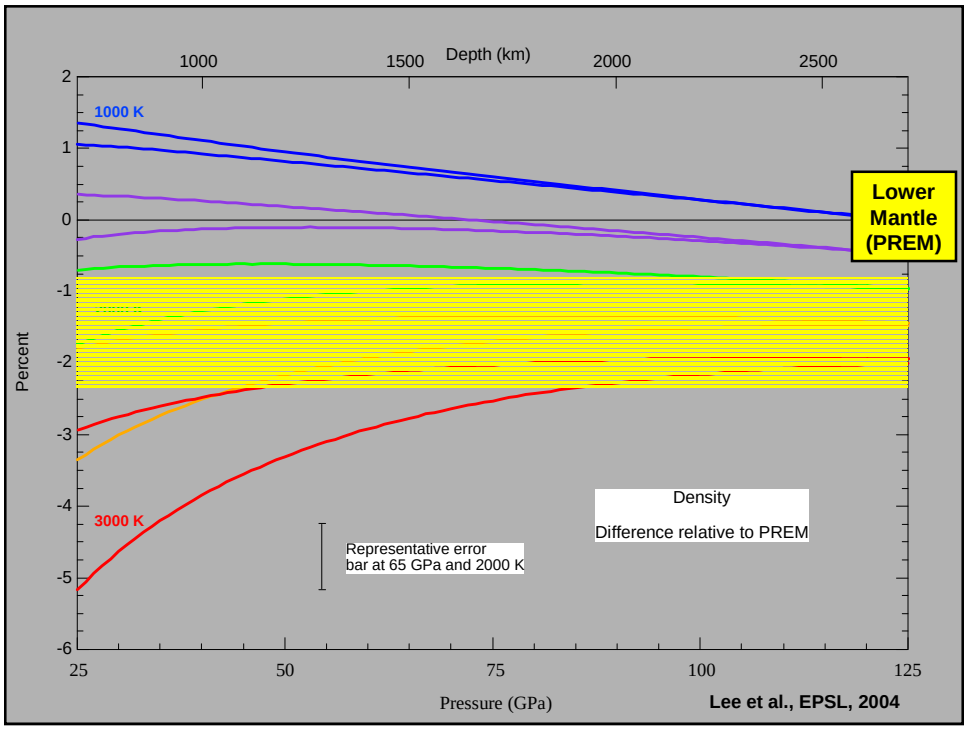
Post-Synthesis

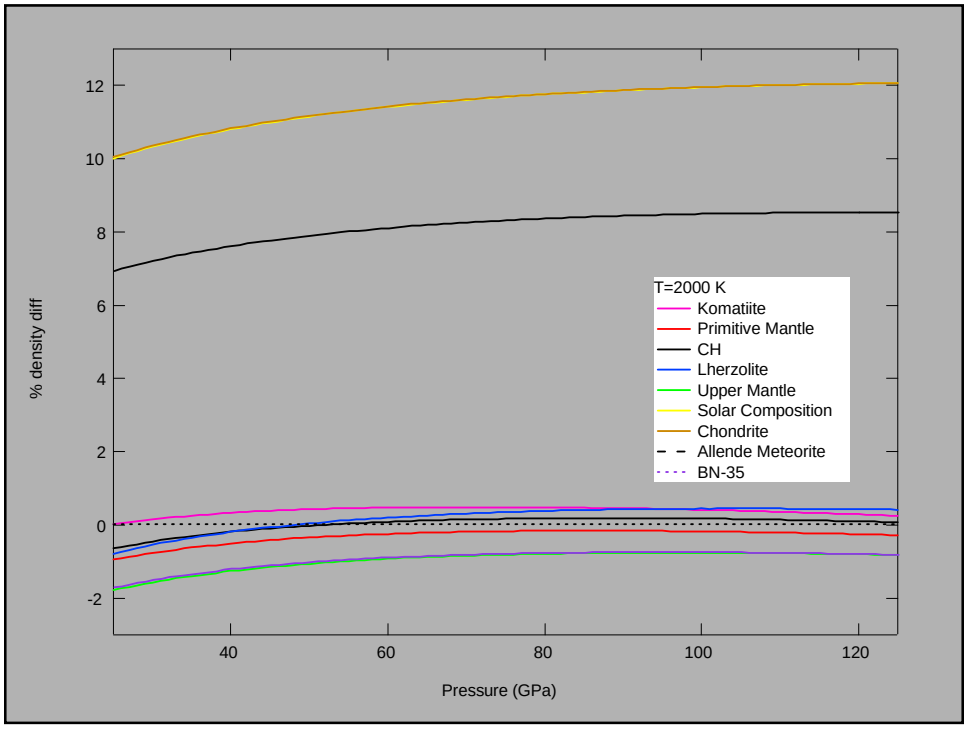
64 (±2) mol% $(Mg_{0.88}, Fe^{2+}_{0.05}, Fe^{3+}_{0.01}, Al_{0.12}, Si_{0.94})O_3$
Orthorhombic Perovskite (opv)

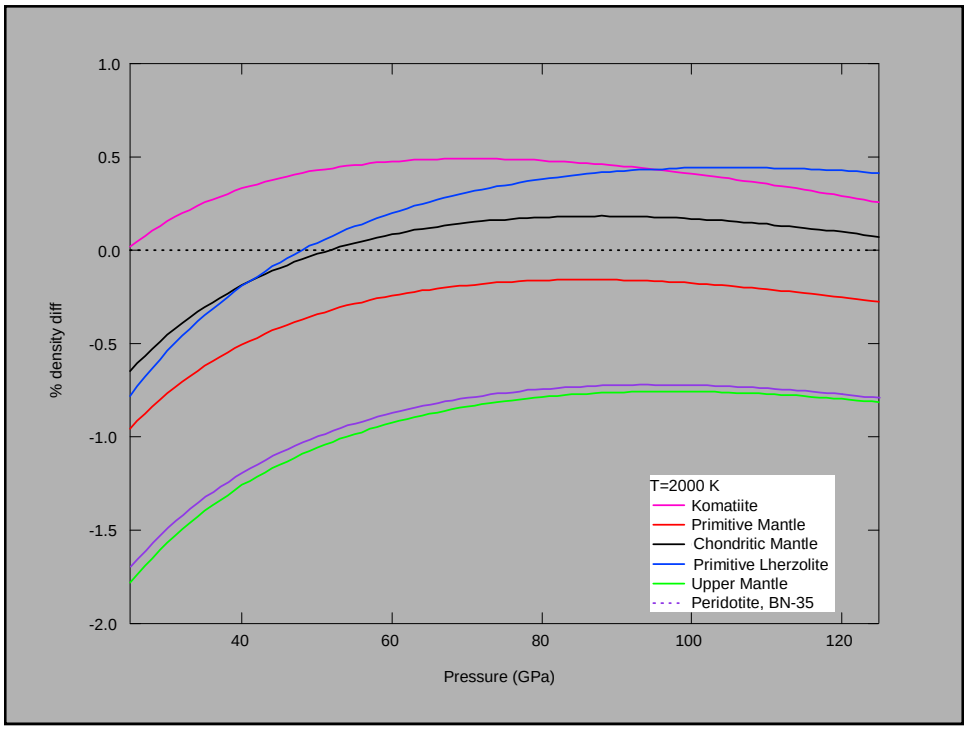
31 (±2) mol% $(Mg_{0.80}, Fe_{0.20})O$
Magnesiowüstite (mw)

5 (±1) mol% $CaSiO_3$
Calcium Perovskite (cpv)

Lee et al., EPSL, 2004




% density diff
Pressure (GPa)
T=2000 K
Komatiite
Primitive Mantle
CH
Lherzolite
Upper Mantle
Solar Composition
Chondrite
Allende Meteorite
BN-35


% density diff
Pressure (GPa)
T=2000 K
Komatiite
Primitive Mantle
Chondritic Mantle
Primitive Lherzolite
Upper Mantle
Peridotite, BN-35

More "primitive" compositions agree with seismically-observed Lower Mantle properties

Test natural pyroxenite mixture, MIX1G*, a good representative of global pyroxenites

* Hirschmann et al., Geology, 2003

Chemical Composition

Cations per 12 Oxygen

	BN35[1]	Pyrolite[2]	MIX1G[3]
Si	3.244 (0.094)	3.251 (0.084)	3.322 (0.003)
Ti	0.010 (0.008)	0.011 (0.011)	0.049 (0.003)
Al	0.423 (0.112)	0.391 (0.073)	1.305 (0.002)
Cr	0.018 (0.002)	0.017 (0.006)	0.006 (0.001)
Fe	0.467 (0.072)	0.474 (0.101)	0.475 (0.004)
Mn	0.008 (0.002)	0.006 (0.002)	0.009 (0.001)
Mg	4.074 (0.128)	4.094 (0.235)	1.810 (0.001)
Ca	0.244 (0.024)	0.239 (0.065)	0.896 (0.003)
Na	0.037 (0.010)	0.056 (0.021)	0.198 (0.016)
Mg/(Mg+Fe)	0.89 (0.02)	0.90 (0.05)	0.793 (0.002)

[1]Stern et al., 1989. 2σ uncertainties determined by independent analysis (O'Neill, 1994).

[2]An average pyrolite from Table 5-2, column 8 of Ringwood, 1975. Uncertainties determined from the standard deviation of columns 1-7.

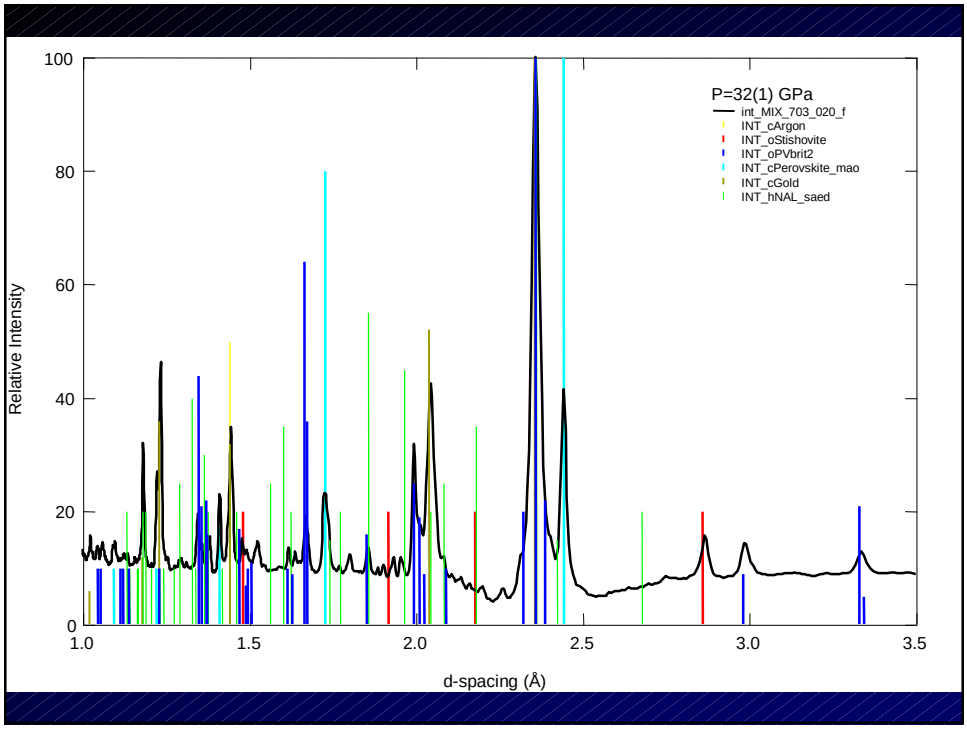
[3]Hirschmann et al., 2003.

Synthesis Prediction

64 mol% $(Mg_{0.40}, Fe_{0.11}, Al_{0.52}, Si_{0.97})O_3$
Orthorhombic Perovskite (opv)

13 mol% $(Mg_{0.80}, Fe_{0.20})O$
Magnesiowüstite (mw)

23 mol% $CaSiO_3$
Calcium Perovskite (cpv)



Synthesis Prediction (w/ XRD constraints)

67 mol% $(Mg_{0.68}, Fe_{0.18}, Al_{0.39}, Si_{0.75})O_3$
Orthorhombic Perovskite (**opv**)

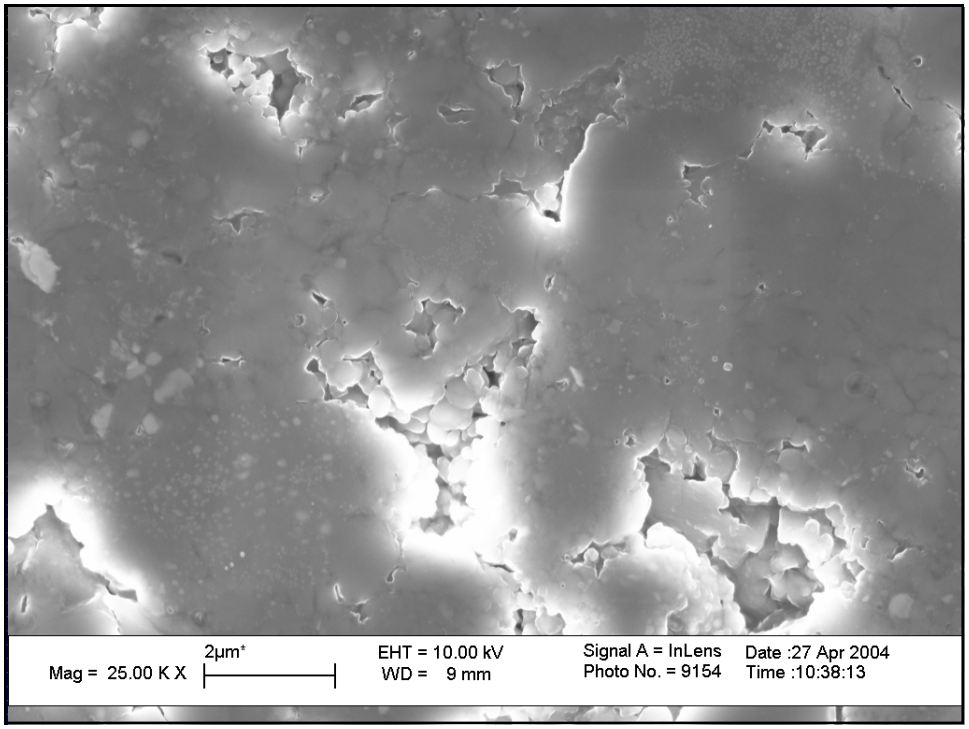
~~0 mol% $(Mg_{0.80}, Fe_{0.20})O$~~
~~Magnesiowüstite (**mw**)~~

22 mol% $CaSiO_3$
Calcium Perovskite (**cpv**)

4 mol% SiO_2
Stishovite (**stv**)

Uncertain by factor of 2-4

7 mol% NAL phase (**nal**)



Average composition: SEM results

60 mol% $(Mg_{0.64}, Fe_{0.15}, Al_{0.43}, Ti_{0.02}, Si_{0.76})O_3$
Orthorhombic Perovskite (**opv**)

23 mol% $CaSiO_3$
Calcium Perovskite (**cpv**)

17 mol% SiO_2
Stishovite (**stv**)

Possible NAL phase not considered...

But composition is not the only thing that matters...

- **Structure: Post-perovskite?**
- **Interaction with core: partitioning, saturation, flux in/out of elements… (K, U, Th, …O, Si, S, C, …H, He, Ar, Xe)**