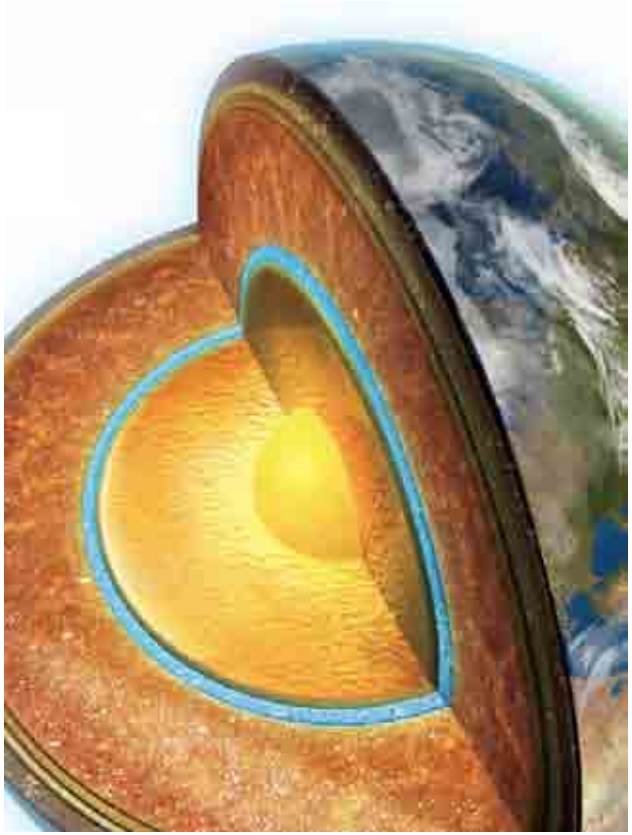
Density Deficit and Light Element Composition of Core



Existing Constraints
Implications for Earth Power Budget
Atmosphere neutrino Constraint

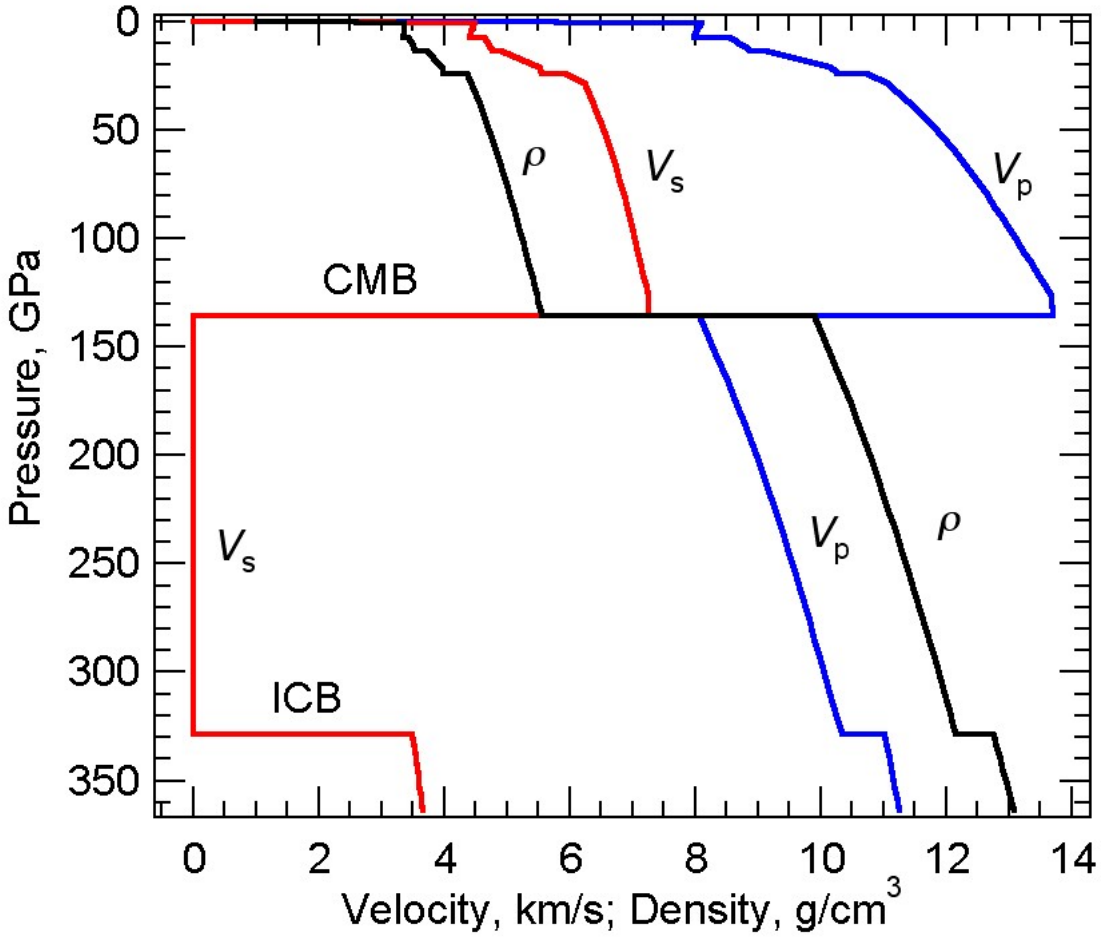
Jie (Jackie) Li
Earth & Environmental Sciences
University of Michigan

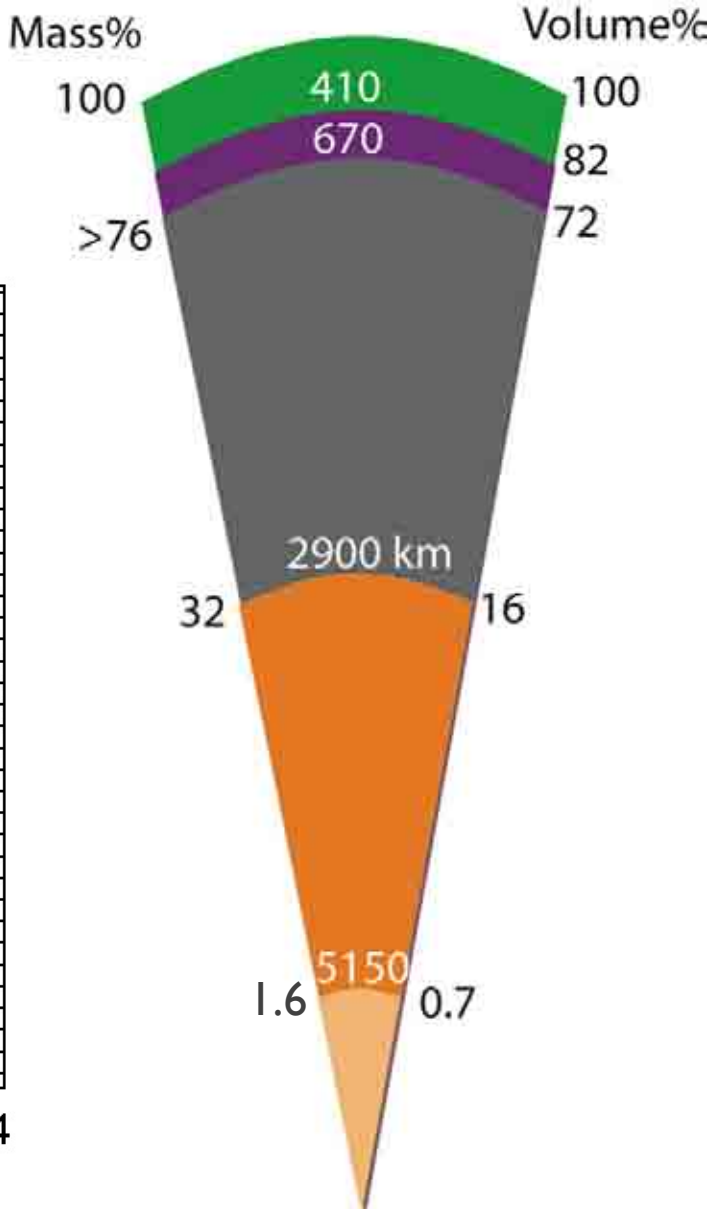
Geoneutrio Working Group, KITP, Santa Barbara, July 1st

Earth's Core from Seismic Observations

PREM: Preliminary Reference Earth Model

Dziewonski and Anderson 1981



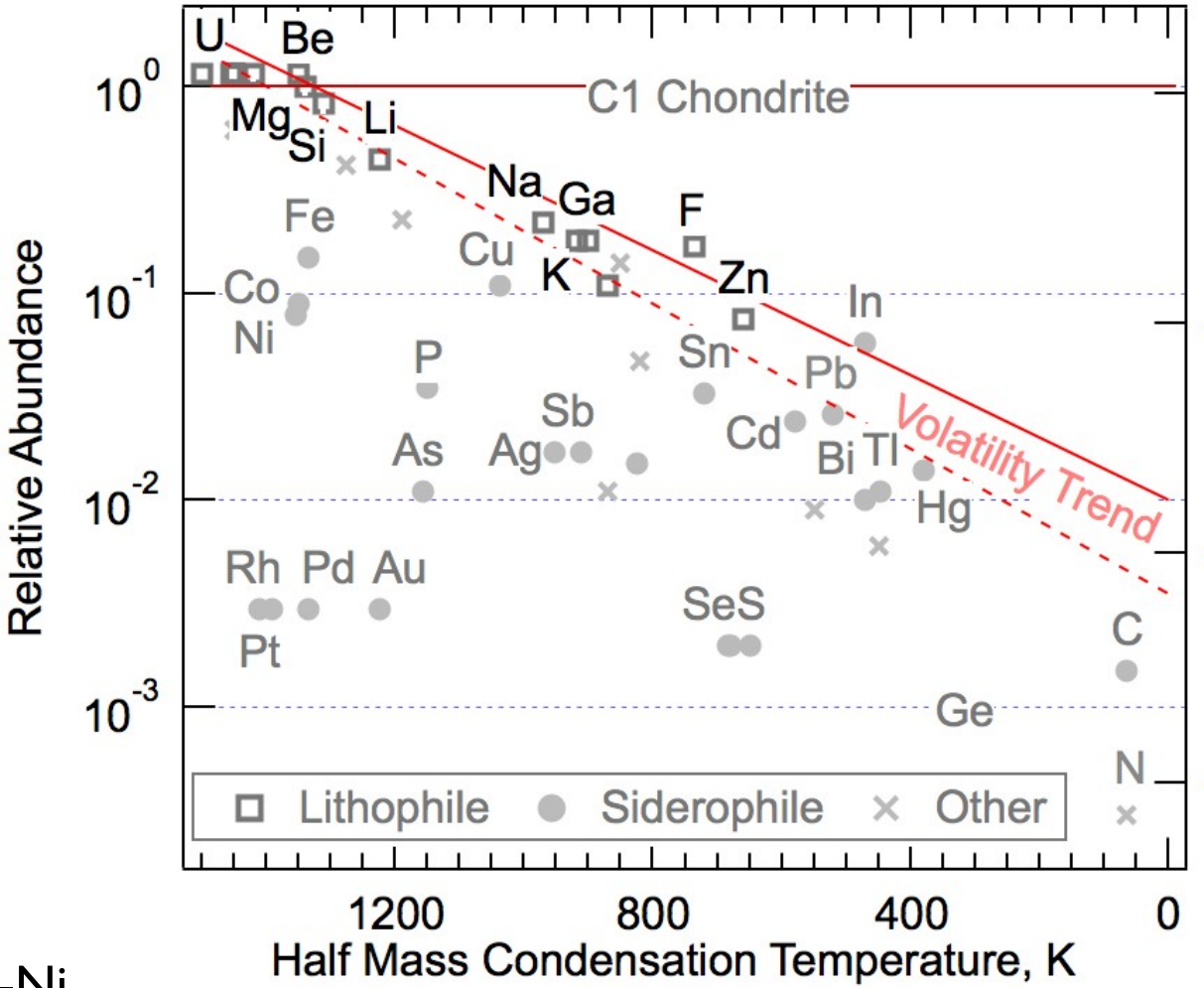


Geo-Cosmochem. Provide Candidate Comp.

Chondrites

Mantle xenolith

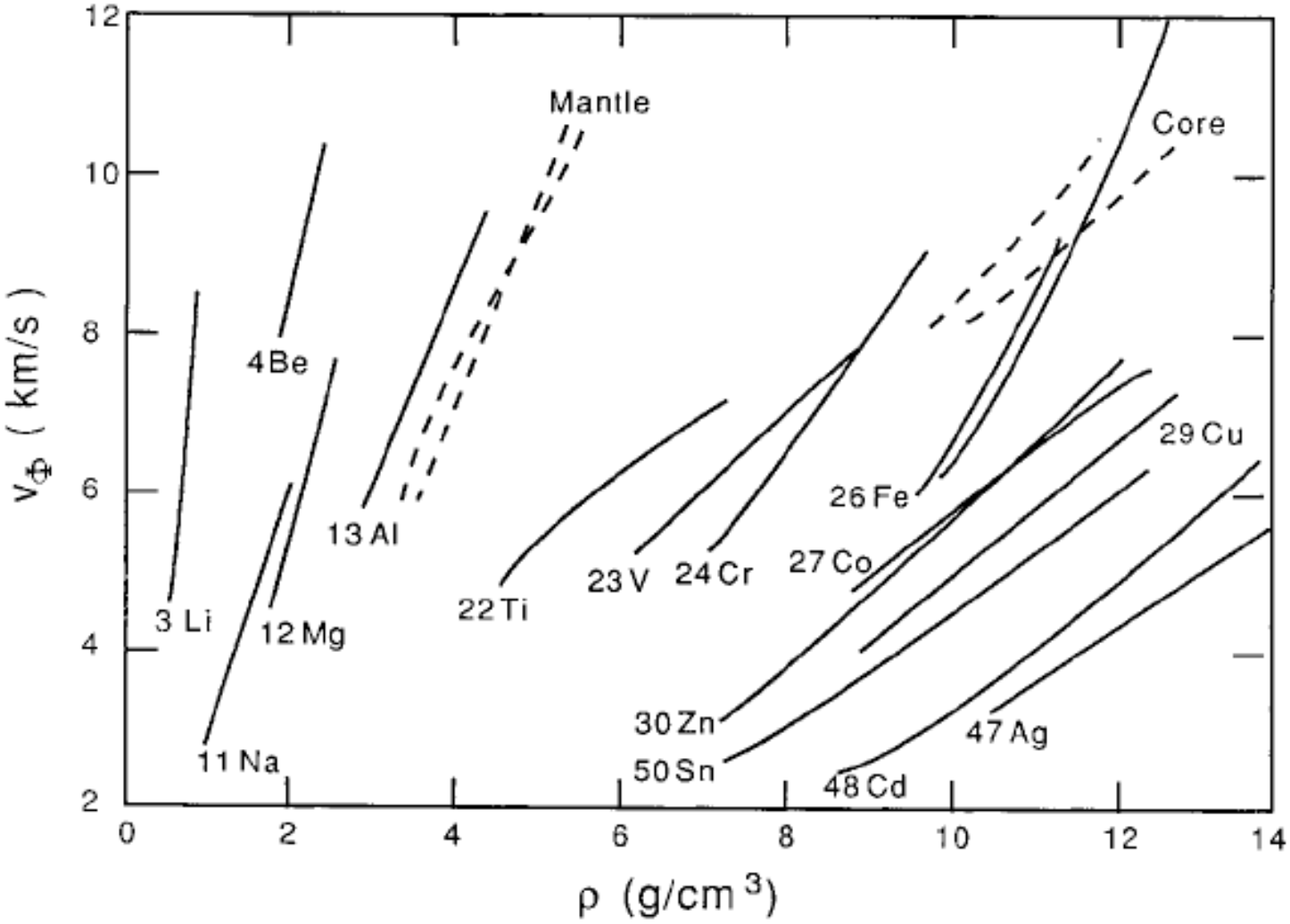
Taenite & Kamacite. Fe-Ni Widmanstätten Pattern



modified after McDonough & Sun 1995 Chem. Geol.

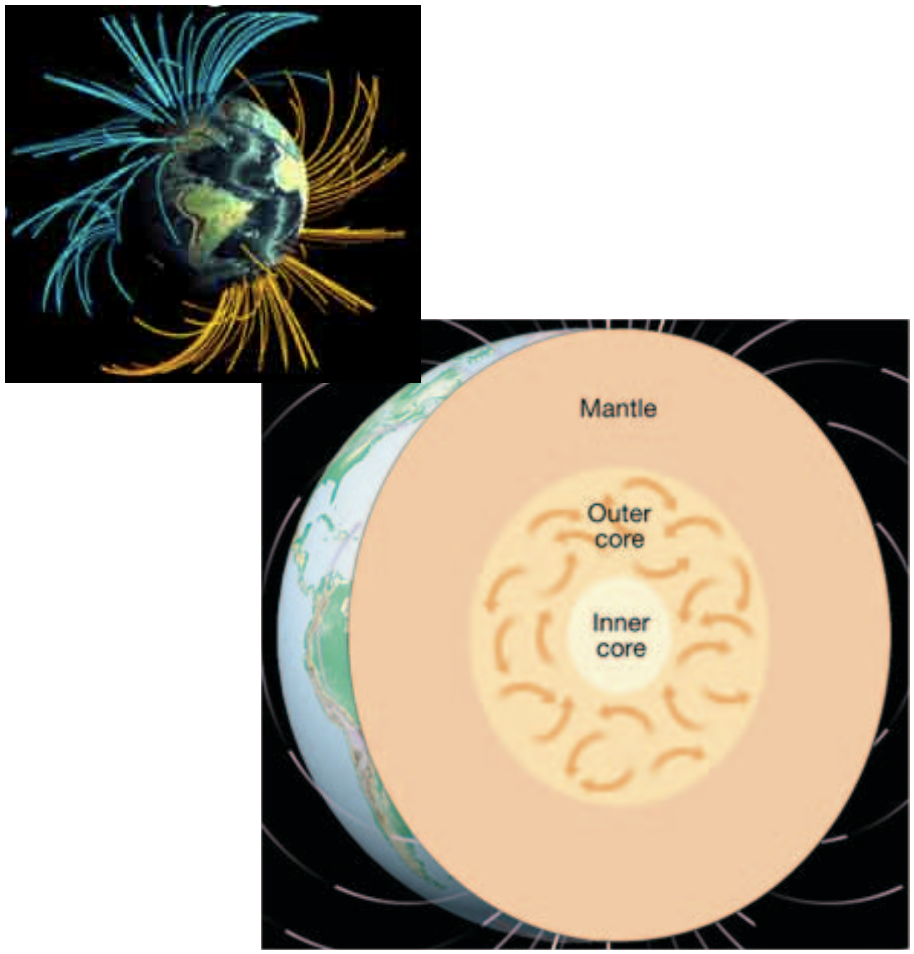
GERM: Geochemical Earth Reference Model

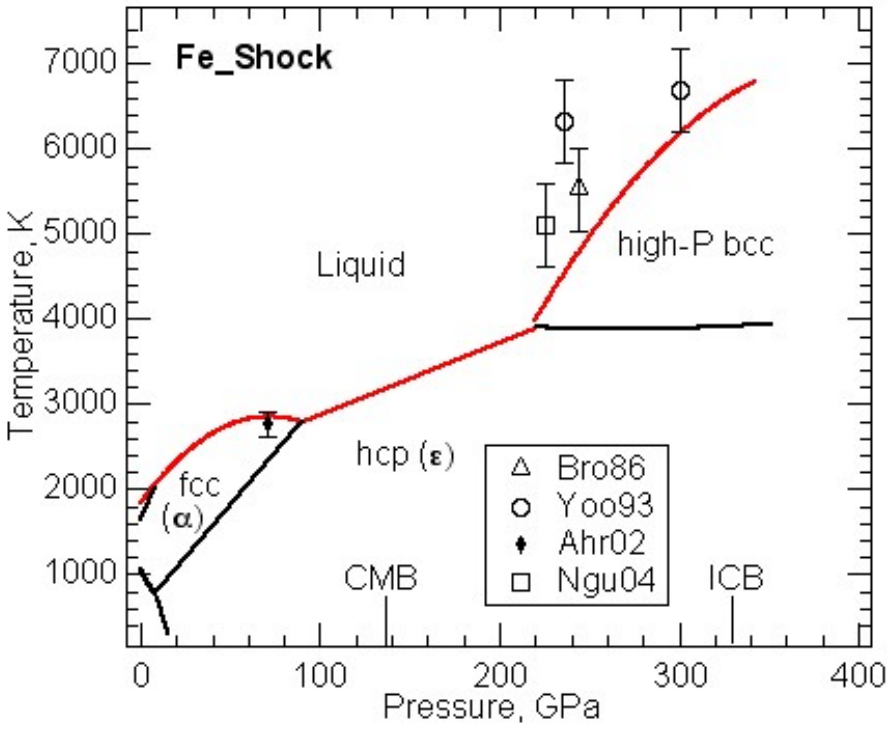
Mineral Physics
Establishes Major Element Composition



Birch 1952

Geodynamo Supports Fe-Ni Core





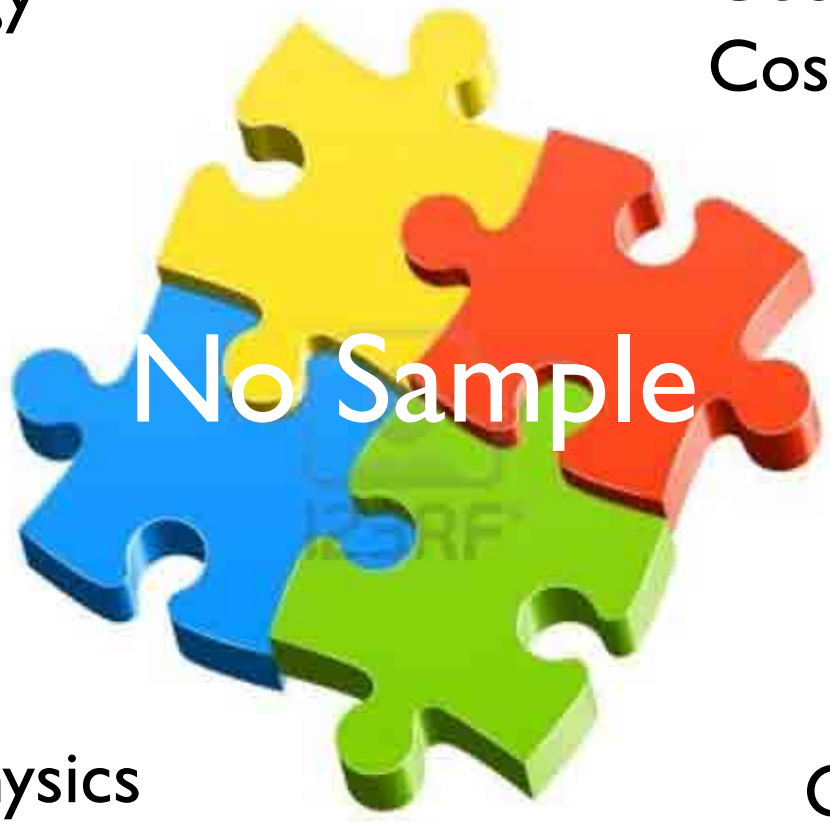
Convecting Fluid
Electrically conducting

Li and Fei 2014 TGC

Earth's Core Consists of Fe-Ni Alloy

Seismology

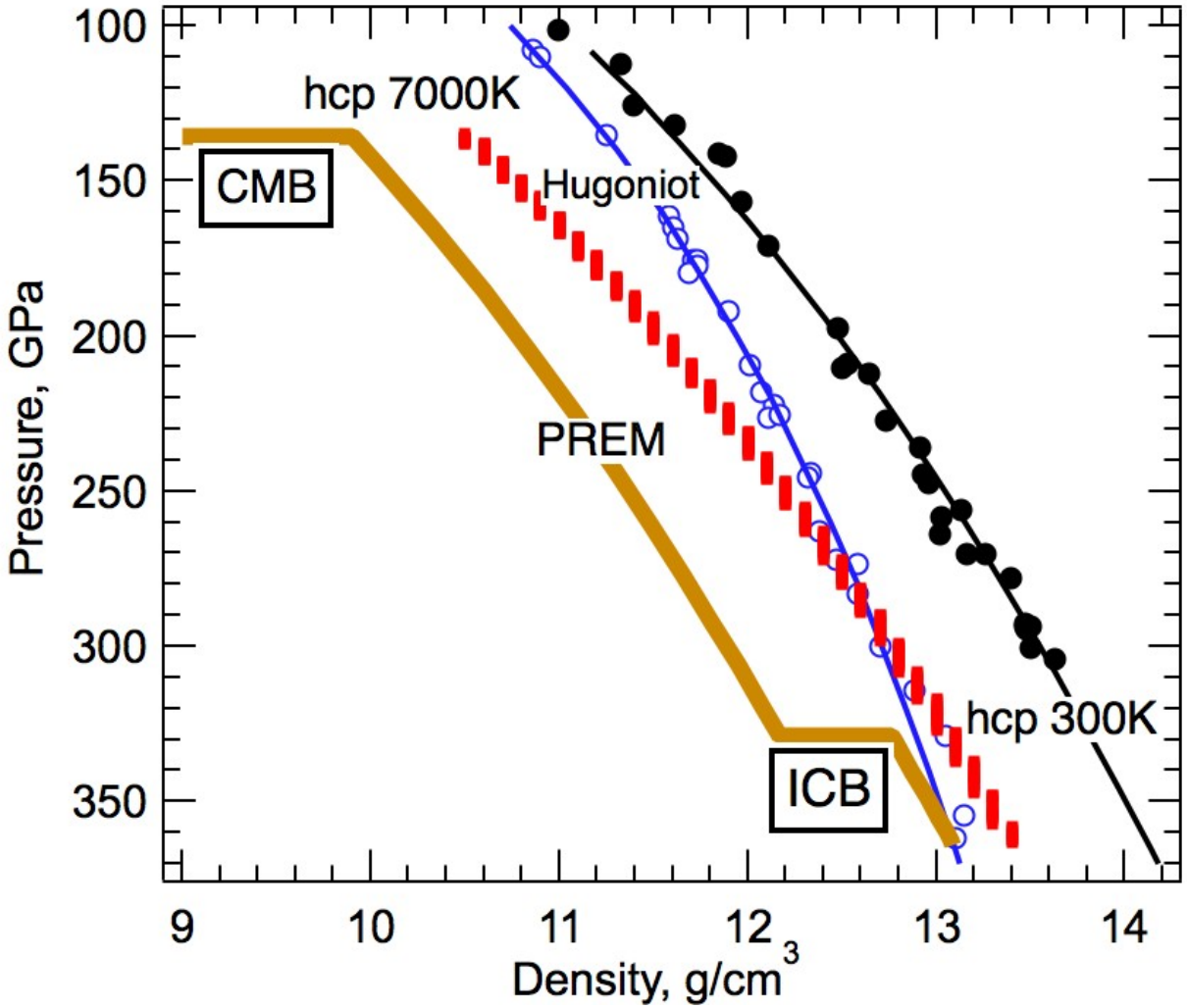
Geochemistry
Cosmochemistry



Mineral Physics

Geodynamics

Density Deficit in Earth's Core



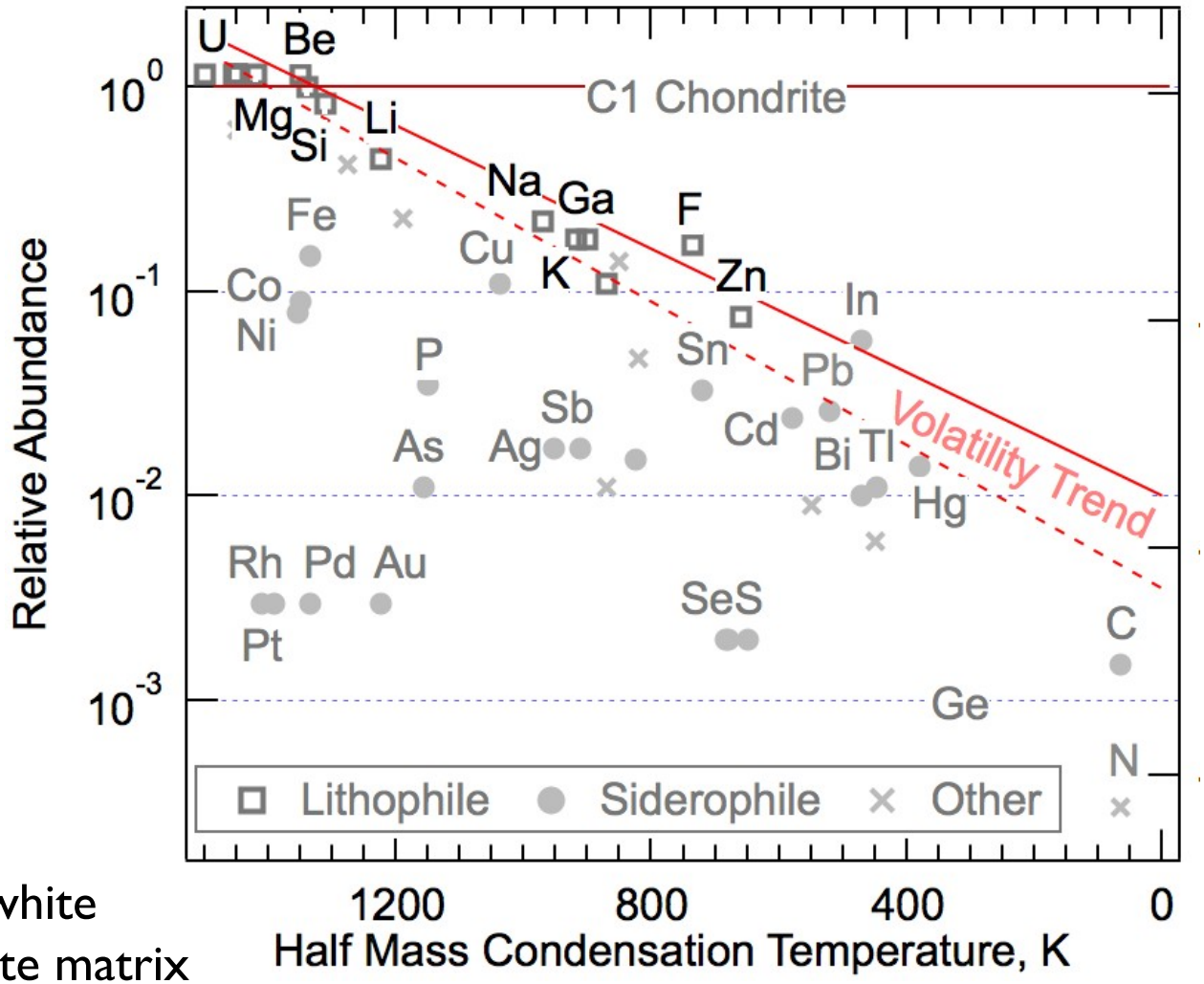
Mineral Physics + Seismo

Li and Fei 2014 TGC

Constraints from Geo-Cosmochem

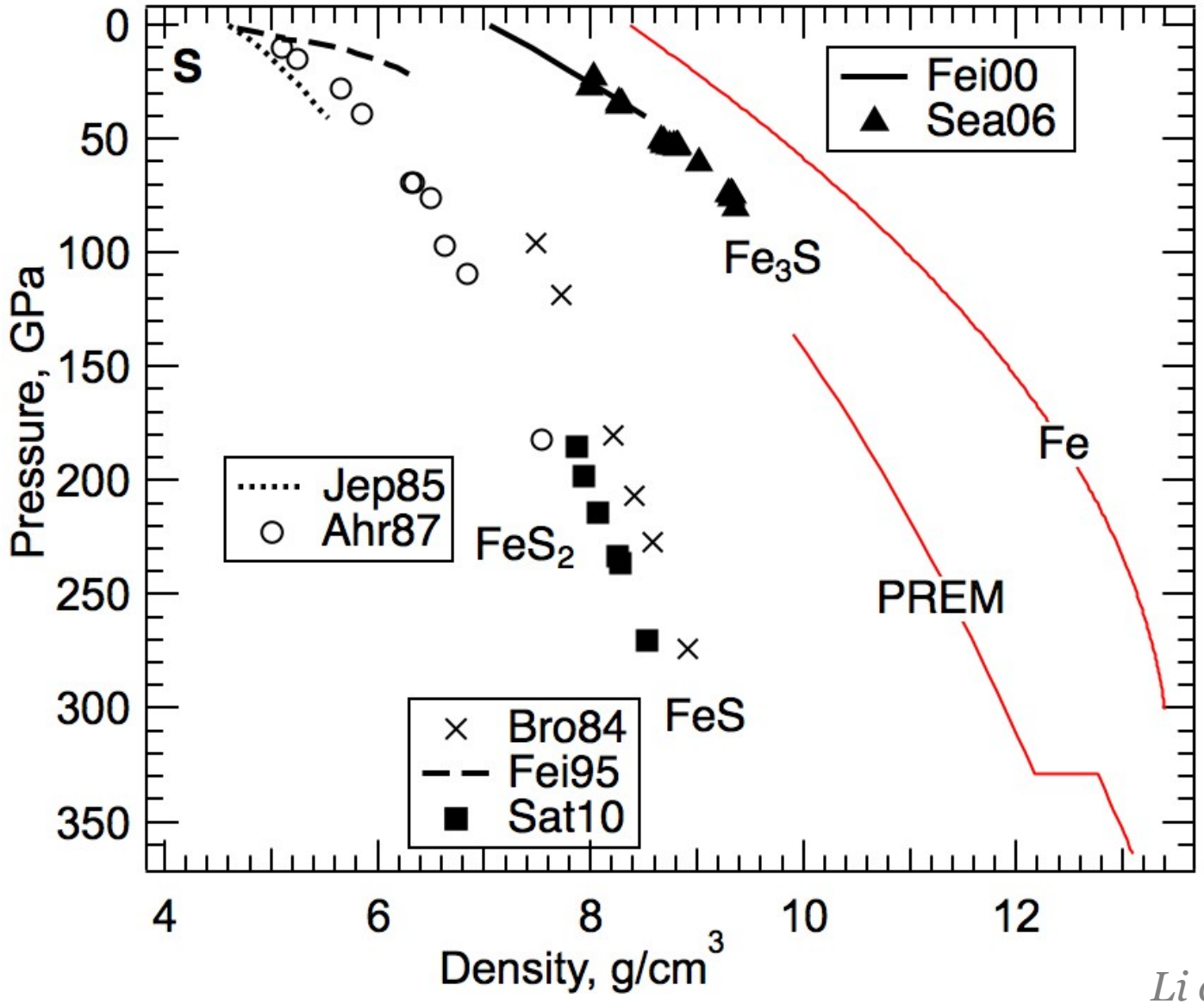
cohenite $(Fe,Ni)_3C$

troilite, FeS, brown
cohenite. $(Fe,Ni)_3C$, white
in taenite and kamacite matrix



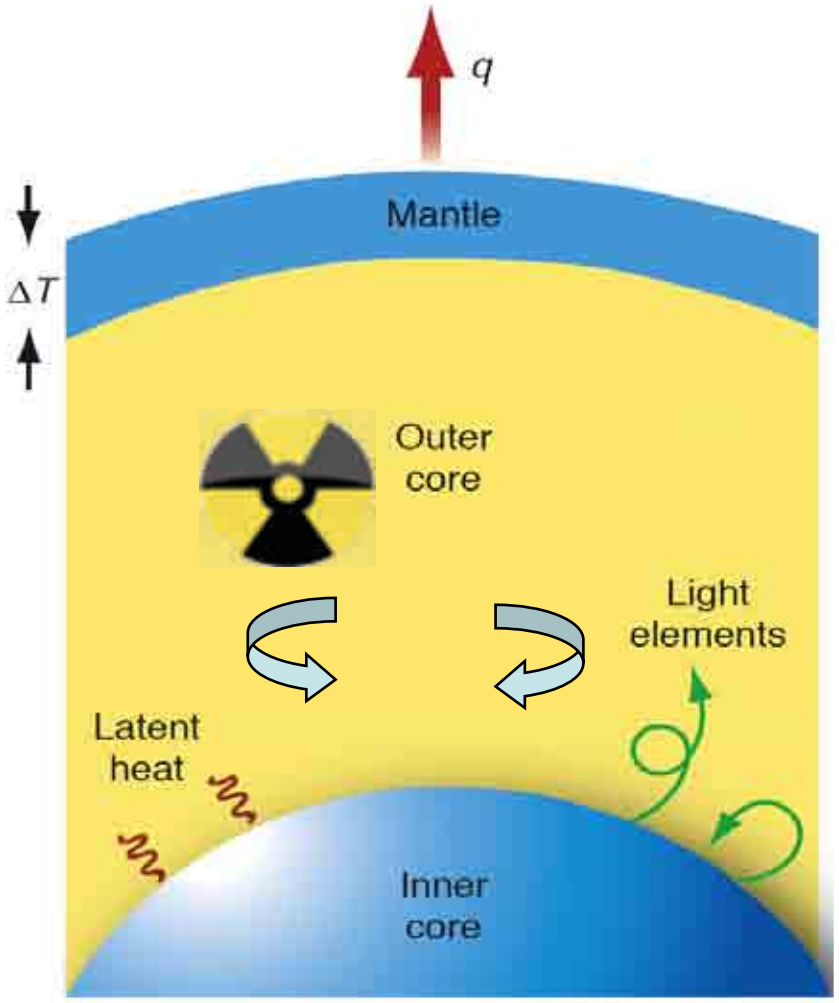
modified after McDonough & Sun 1995 Chem. Geol.

Constraints from Mineral Physics

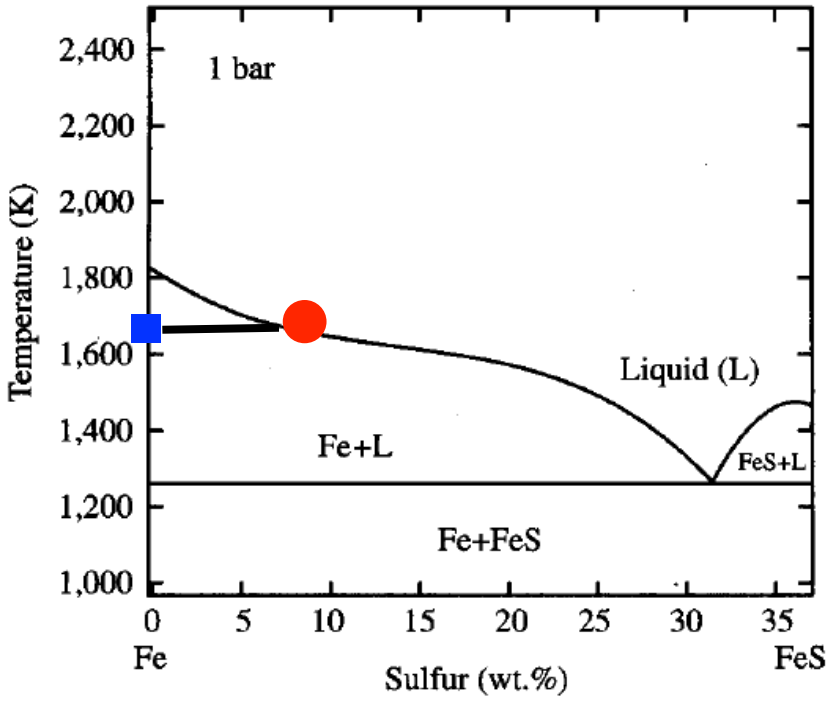


Li and Fei 2014 TGC

Dynamo Power from Chemical Convection



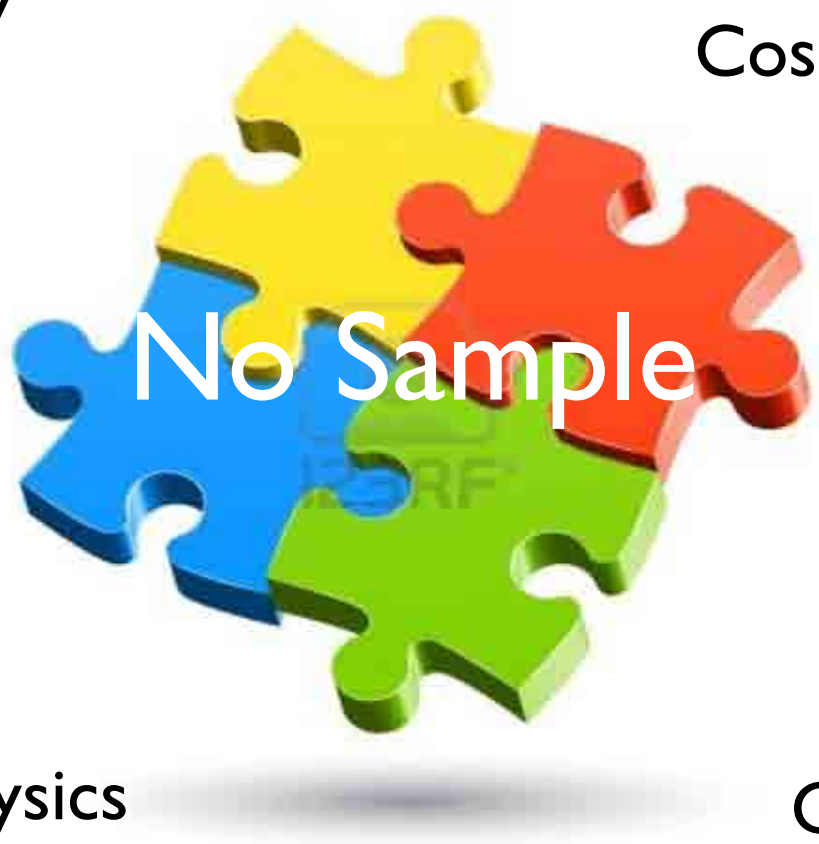
after Buffett 2003 Science



Light Element Comp. of Earth's Core
H, C, O, S, Si

Seismology

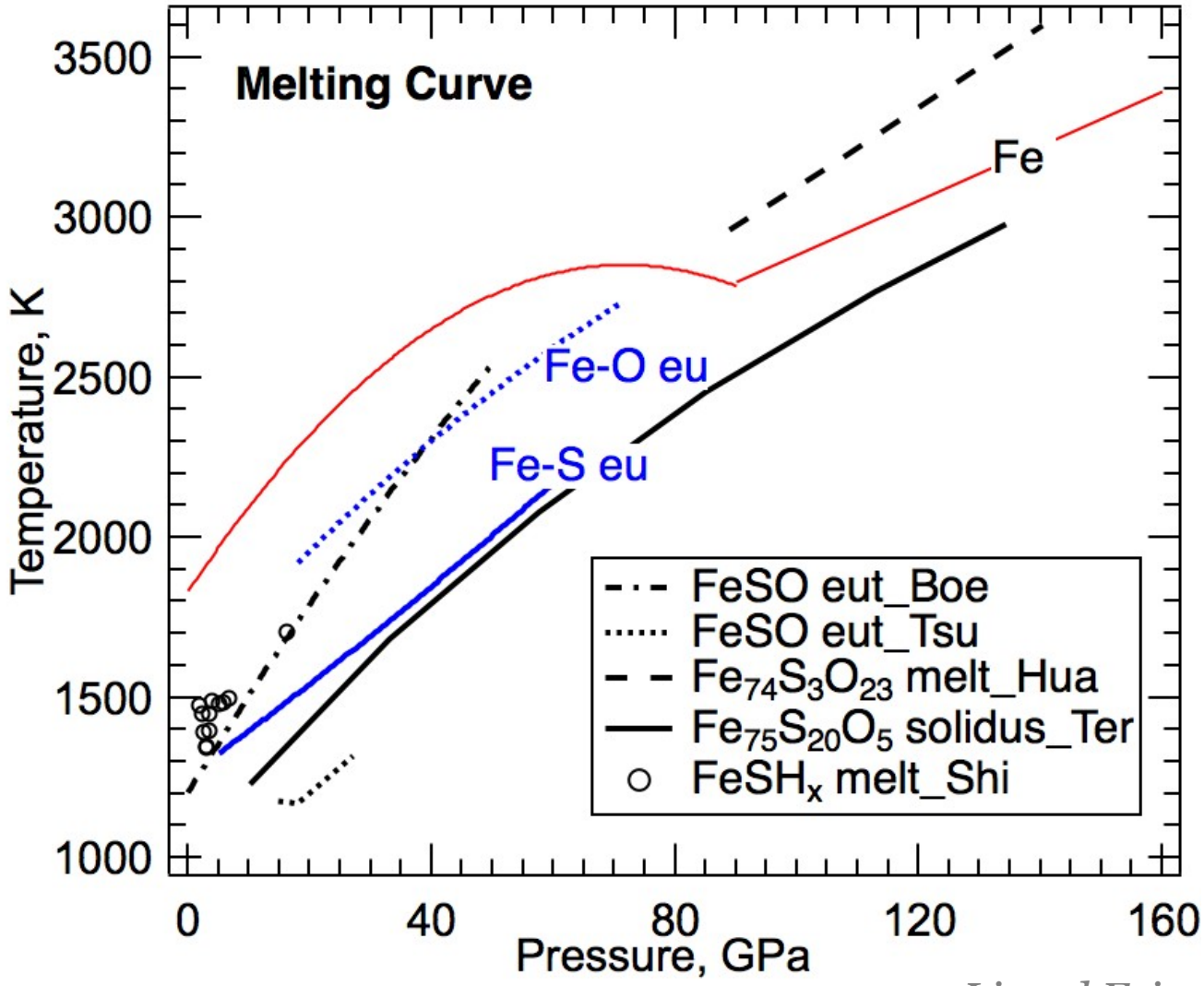
Geochemistry
Cosmochemistry



Mineral Physics

Geodynamics

Thermal Power and Melting Temp.



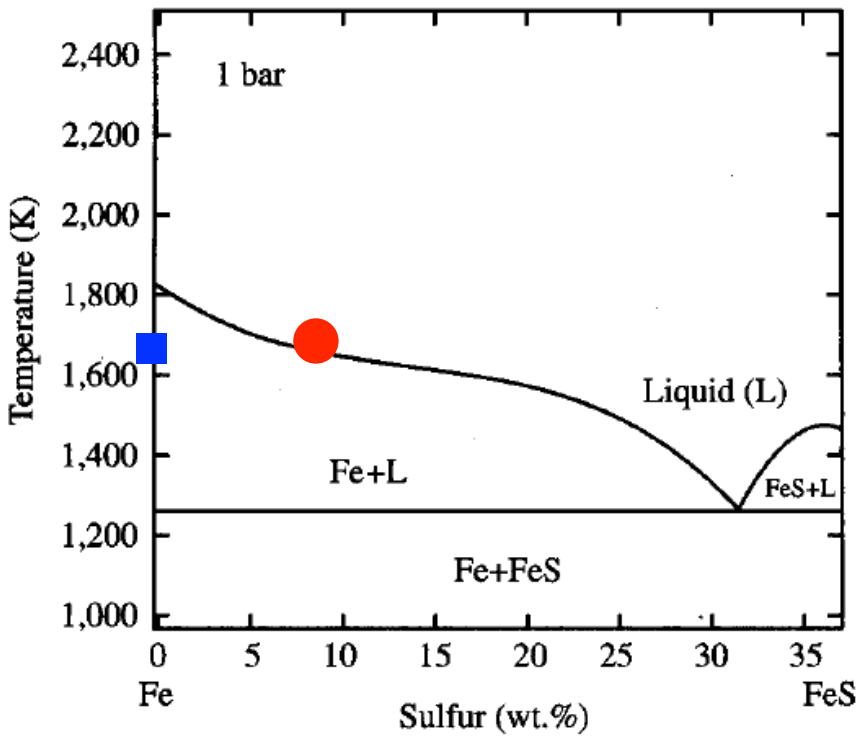
Primordial heat
Latent heat

Fourier's Law

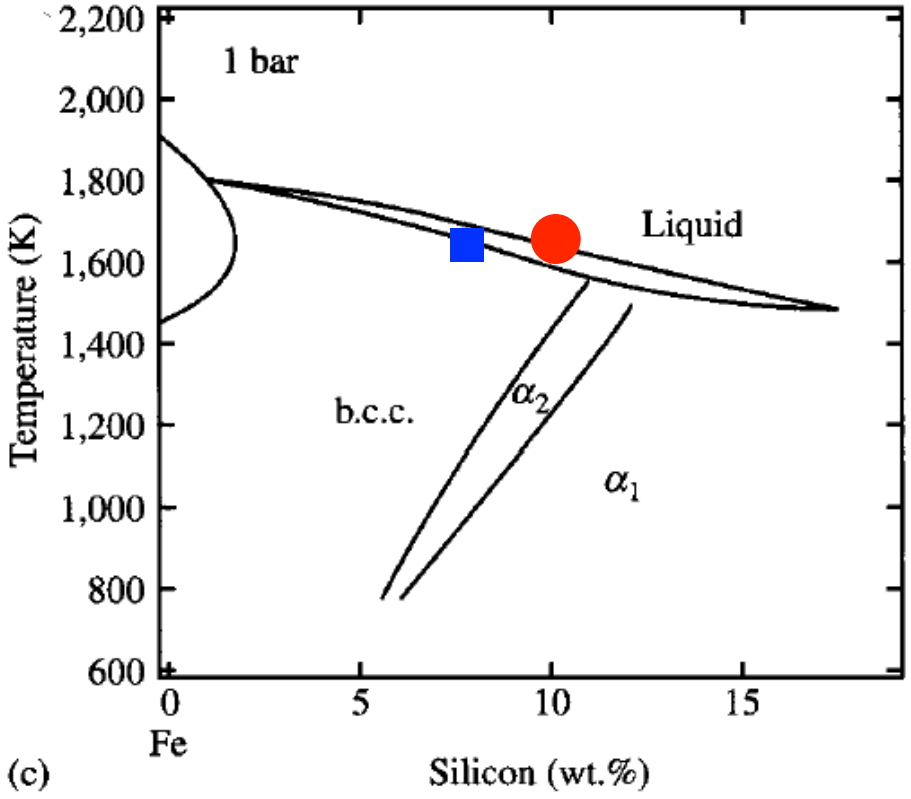
$$\vec{q} = -k\nabla T$$

Li and Fei 2014 TGC

Chemical Power & Melting Interval



Large amount

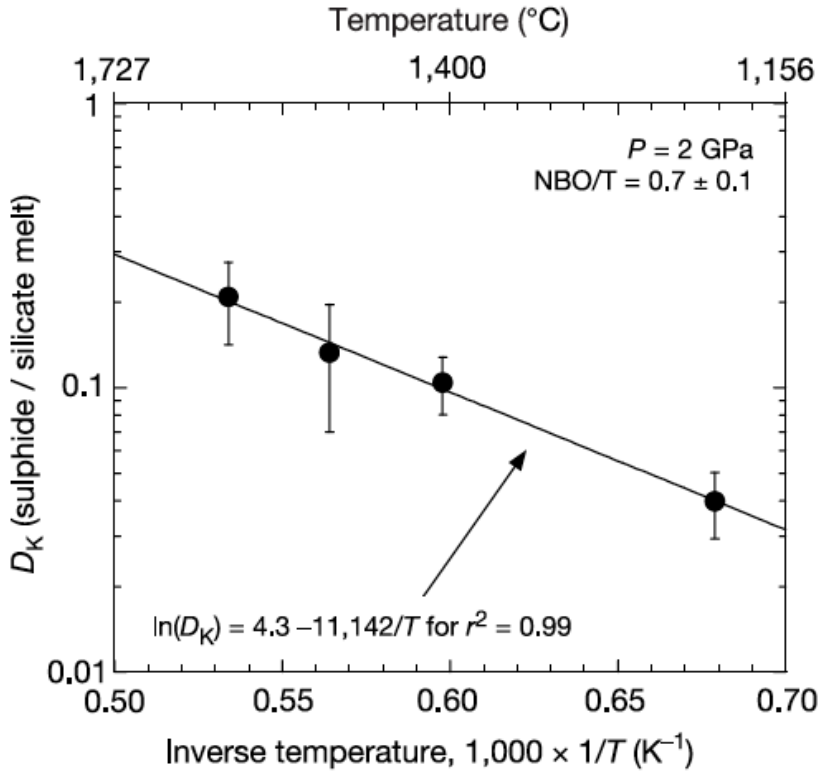


Small amount

Radiogenic Power: K, U, Th

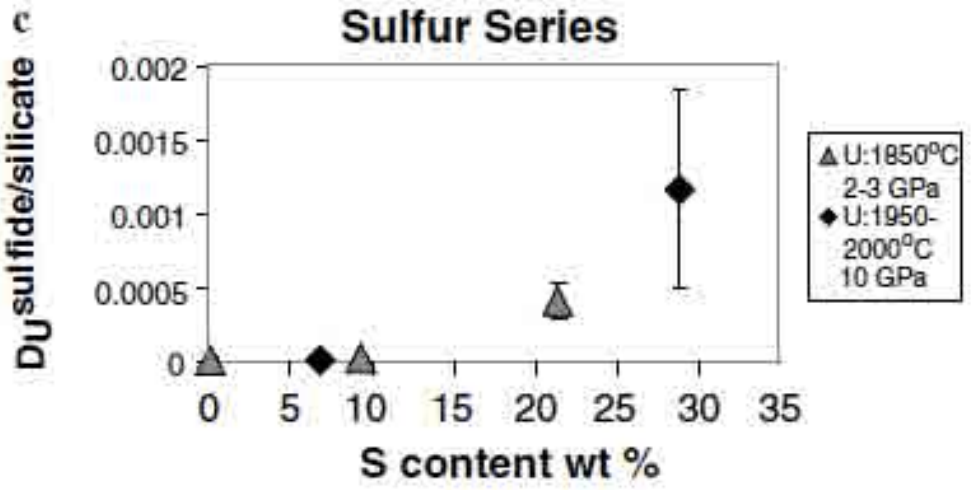
Sulfur enhances K and U solubility in alloy

K 60-130 ppm, 0.4-0.8 TW



Murthy et al. 2003 Nature
Hirao et al. 2006 GRL 35 ppm

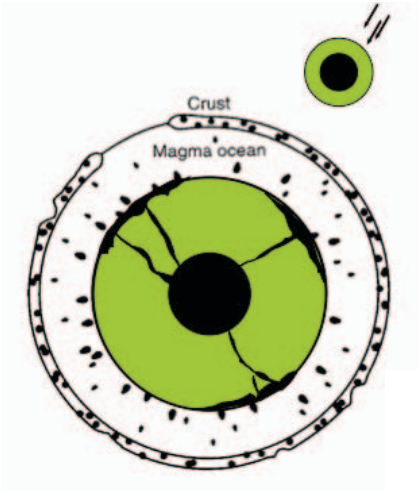
U negligible



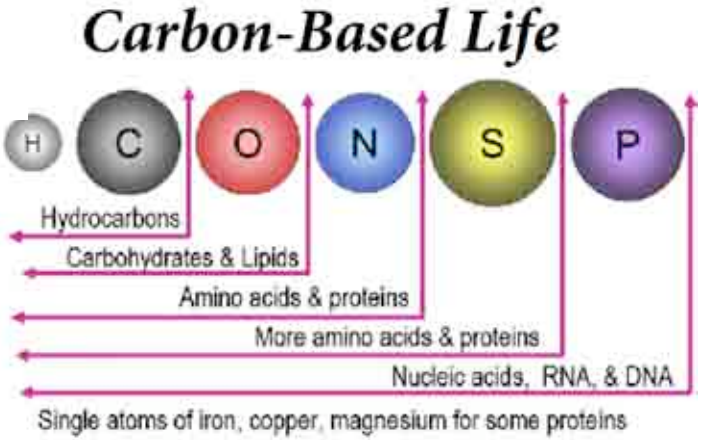
Wheeler et al. 2006 GCA

Light Element Comp. Also Important for

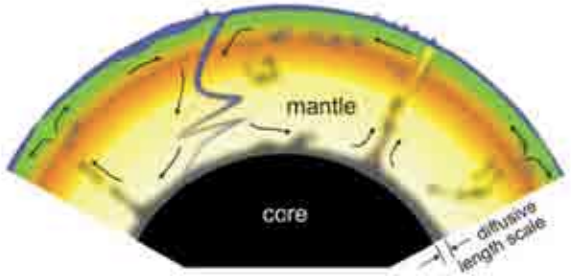
Accretion history
and volatile budget



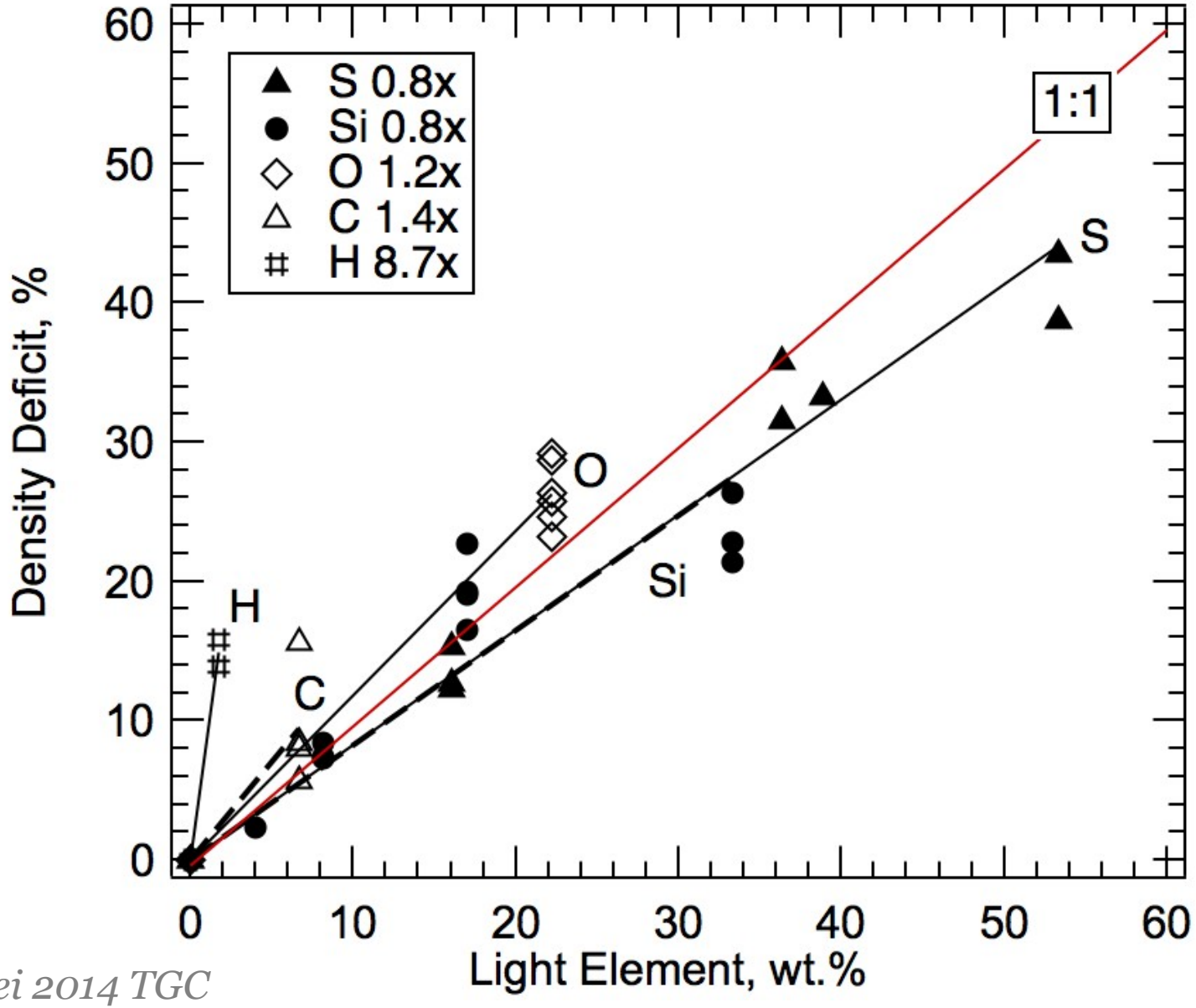
Origin of life
and long-term habitability



Climate and Dynamics:
Deep volatile cycles

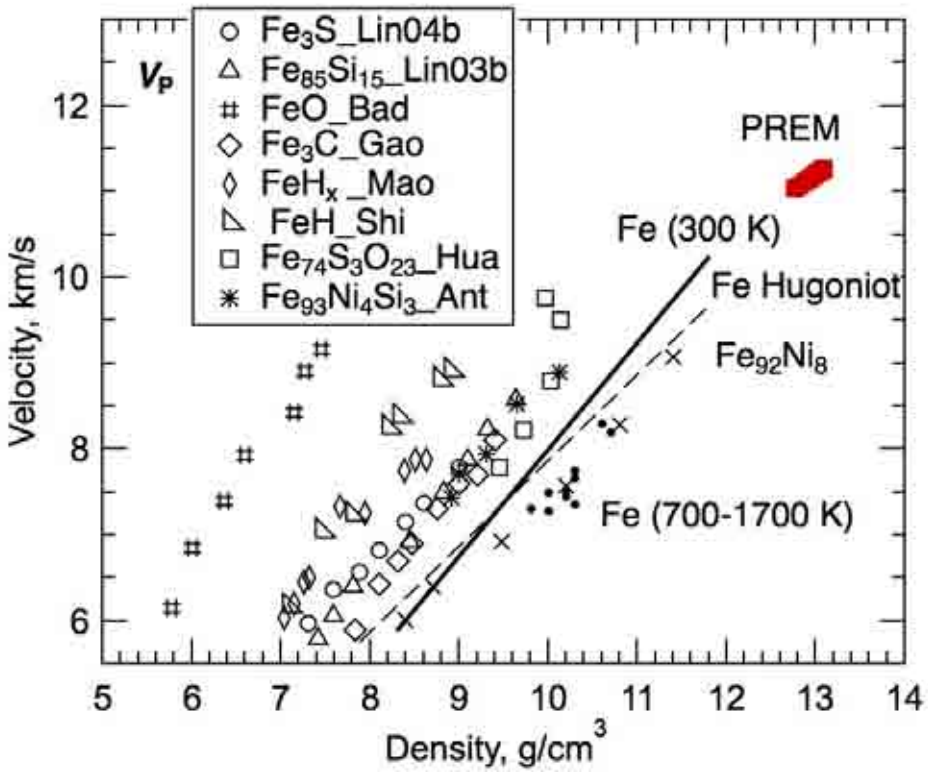


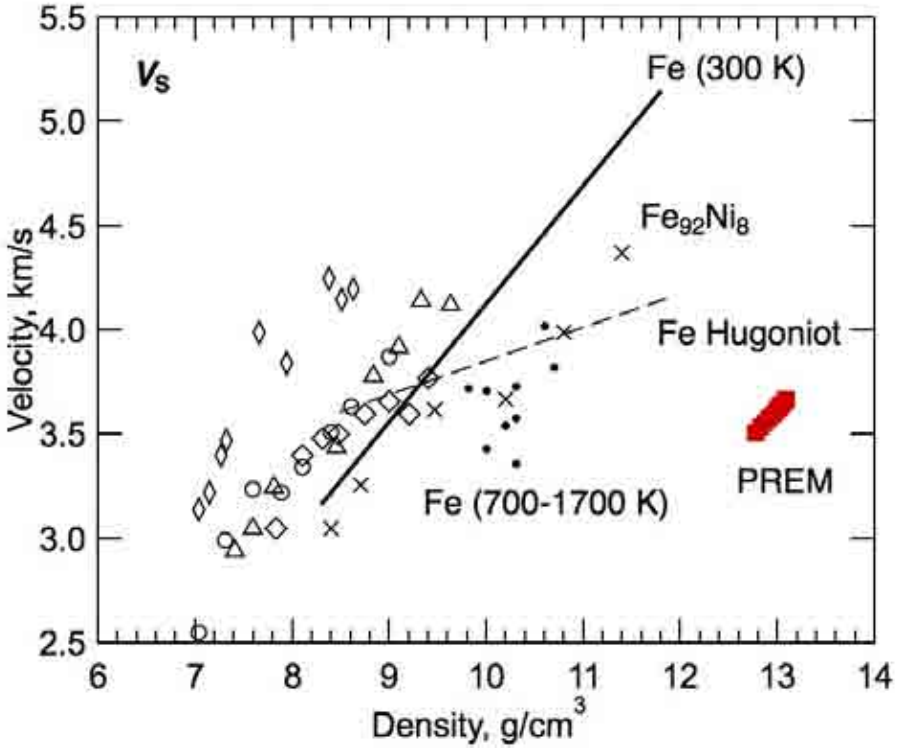
Constraints from Reproducing Density Deficit



Li and Fei 2014 TGC

More Constraints from MP Single Phase





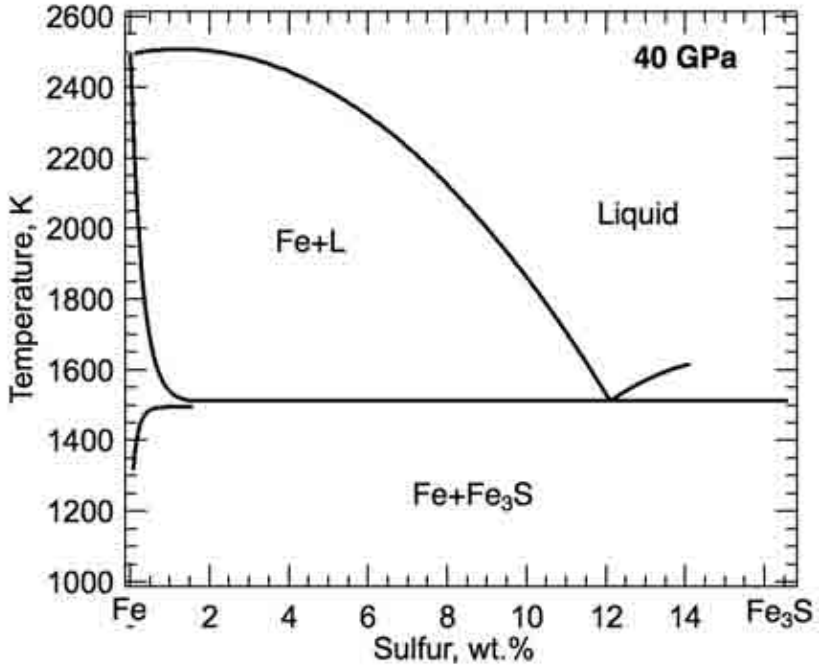
Li and Fei 2014 TGC

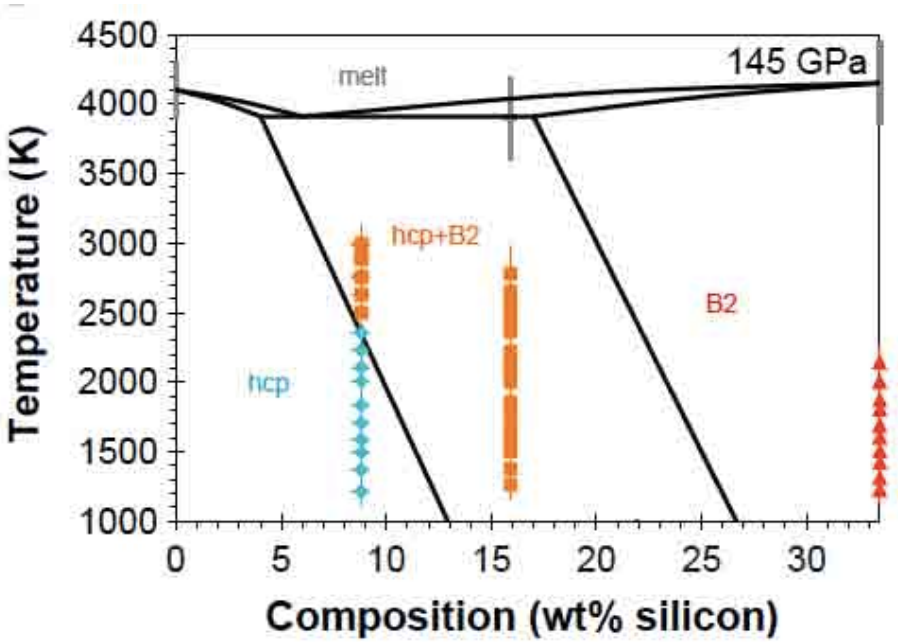
Expand P & T

Match ρ and V

Match gradients

More Constraints from MP Binary Systems



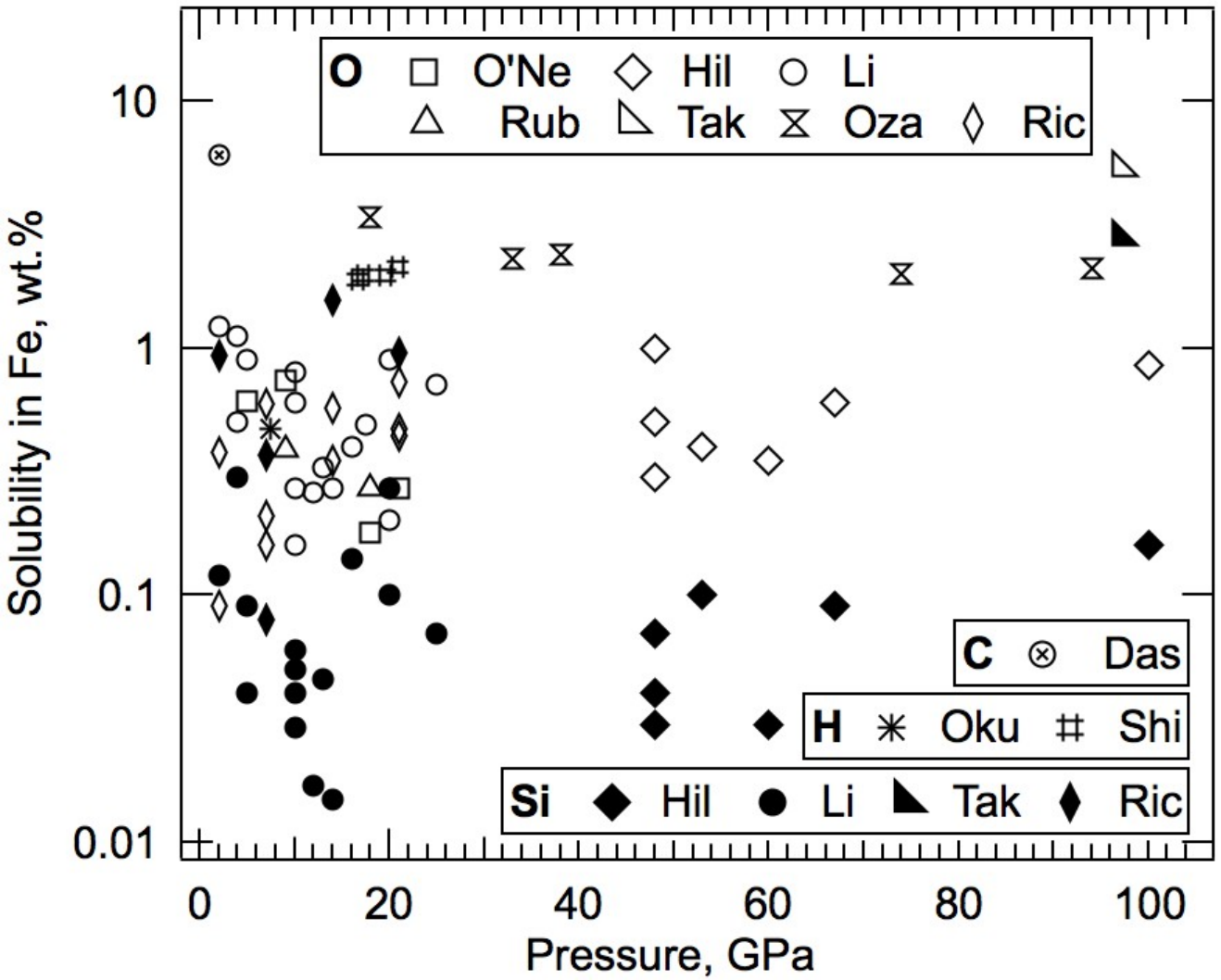


	Solid	Liquid
Sulfur/Silicon	8.5±2.5	10±2.5
Oxygen	0.2±0.1	8.0±2.5

Alfè et al. 2002 EPSL
Fischer et al. 2013 EPSL
Li and Fei 2014 TGC

Ternary, quaternary, ...

Geo-Cosmo Chem Constraints: Solubility in Fe



P

T

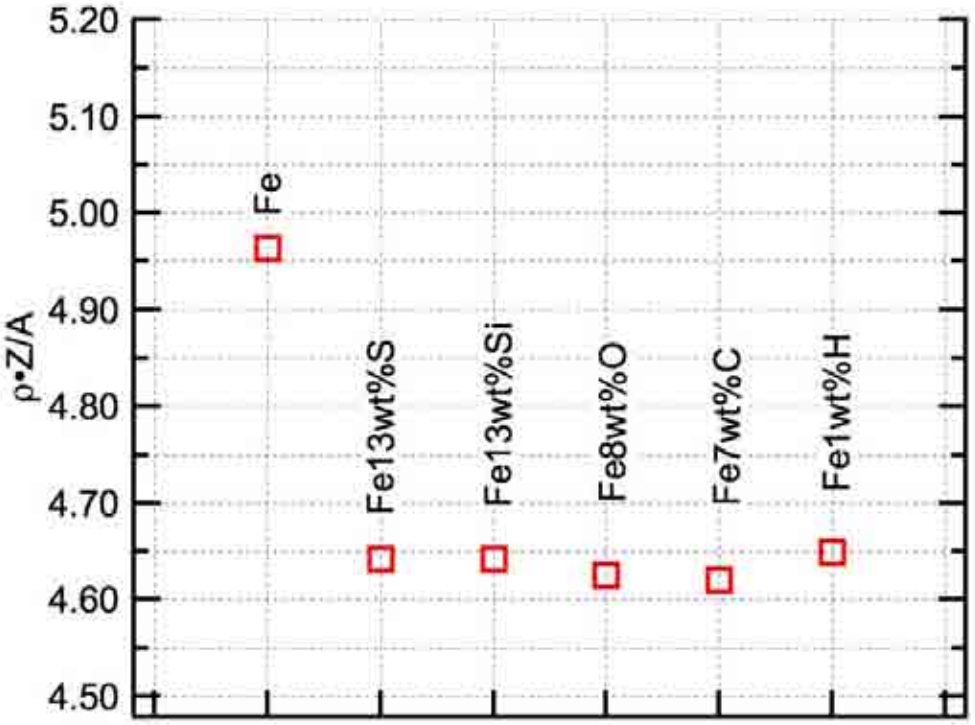
fO_2

Multiple elements

Li and Fei 2014 TGC

Core Composition from Atmosphere Neutrino

Neutrino oscillation depends on electron density, which scales with mass density (ρ) • atomic number (Z) / mass number (A)



Assume the mass density of iron-alloys at CMB is 9.9 g/cc and that of pure iron is 8% higher

Dye, Li, Enomoto

Light Element Composition of Earth's Core

Seismology

Geochemistry
Cosmochemistry

Mineral Physics

Geodynamics