A Journey Toward the Center of the Earth

Iron/Light-Element Alloys at Extreme Conditions and Their Implications for the Earth's Core

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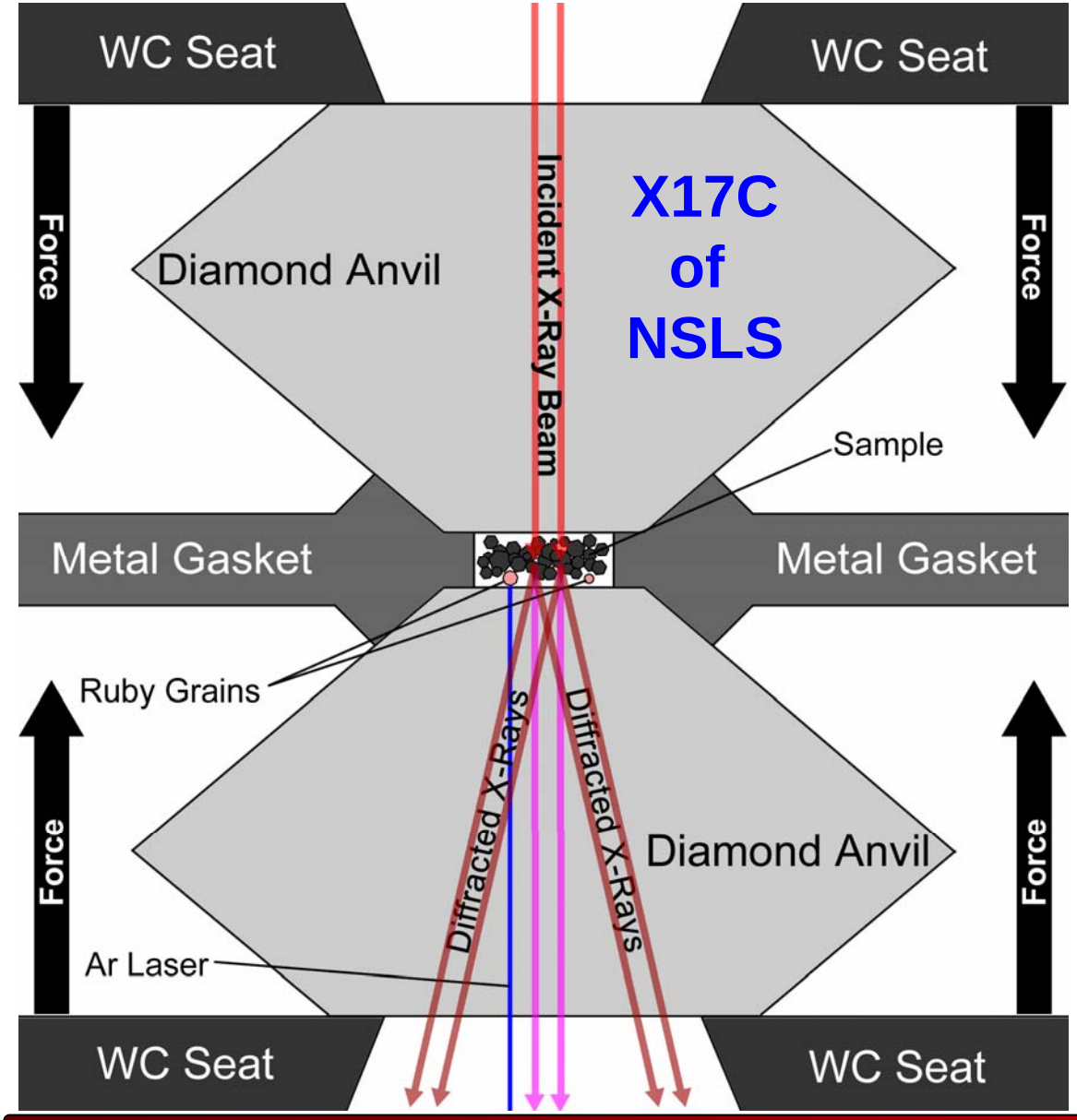
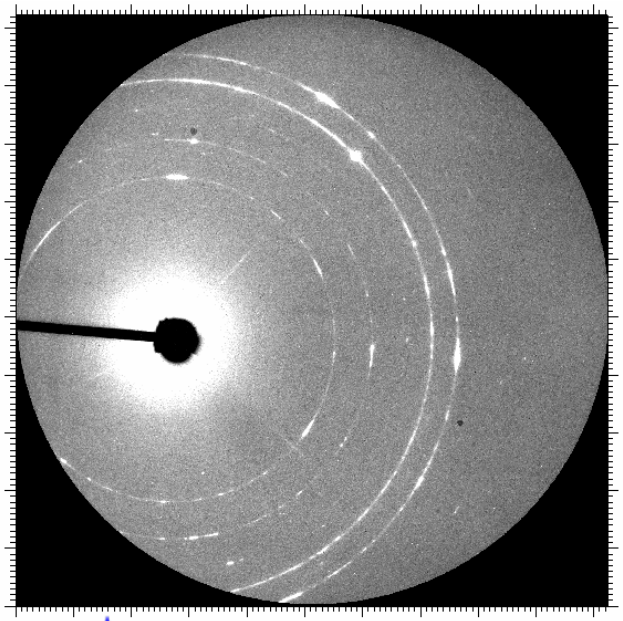
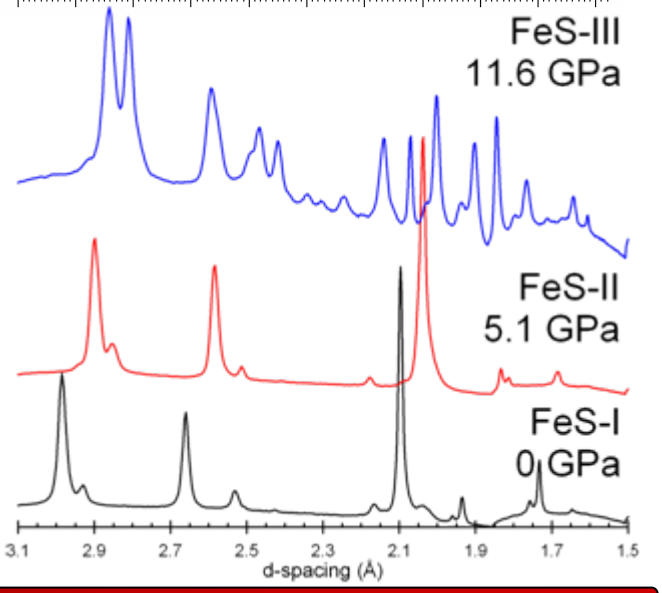
Introduction

- Velocity and density profiles of the Earth's deep interior indicate that the core must contain some amount of light element(s).
- Experiments conducted to determine behavior and physical properties of iron minerals under extreme conditions of P and T
- Synchrotron XRD in Diamond Anvil Cell
- Synchrotron X-rays and Ultrasonic Interferometry in Multi-Anvil Apparatus
- Materials studied: Fe_3P, FeS_2, FeS, ε-FeSi

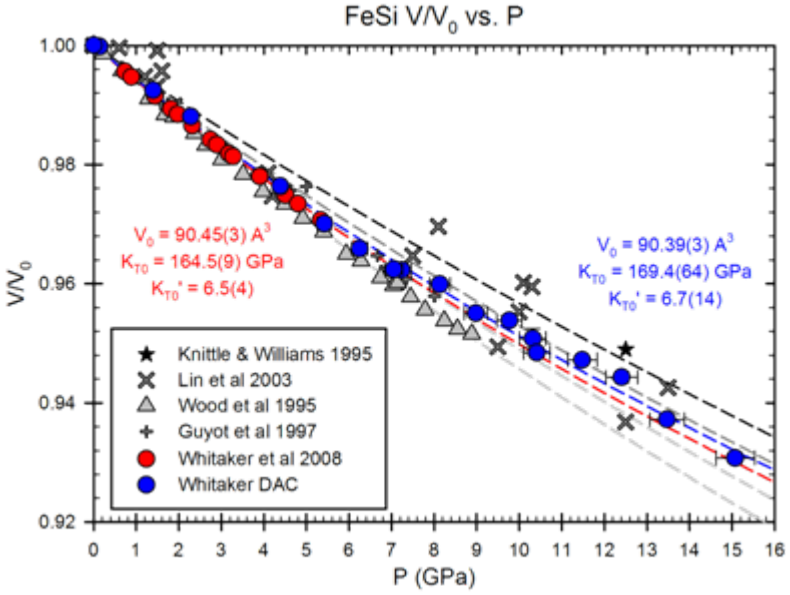
Diamond Anvil Cell Experiment

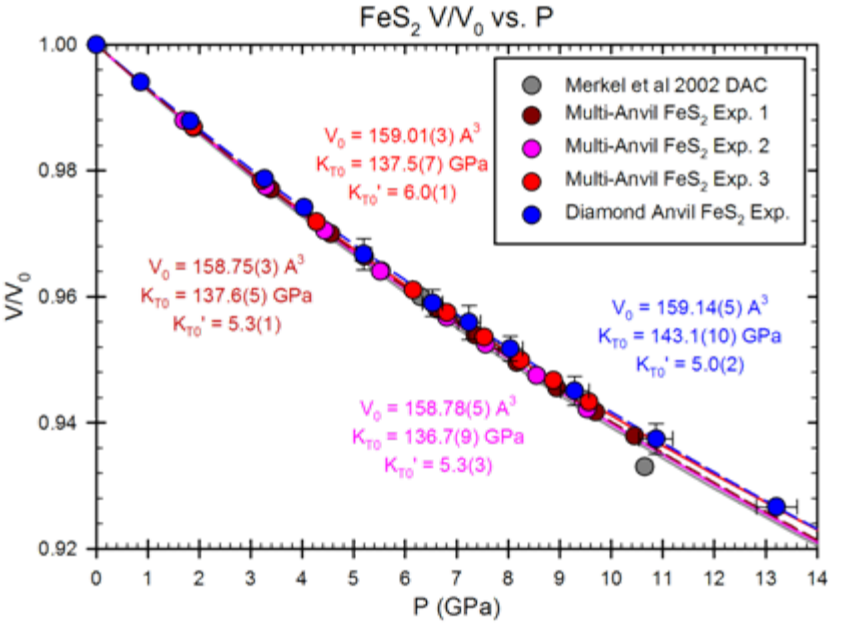


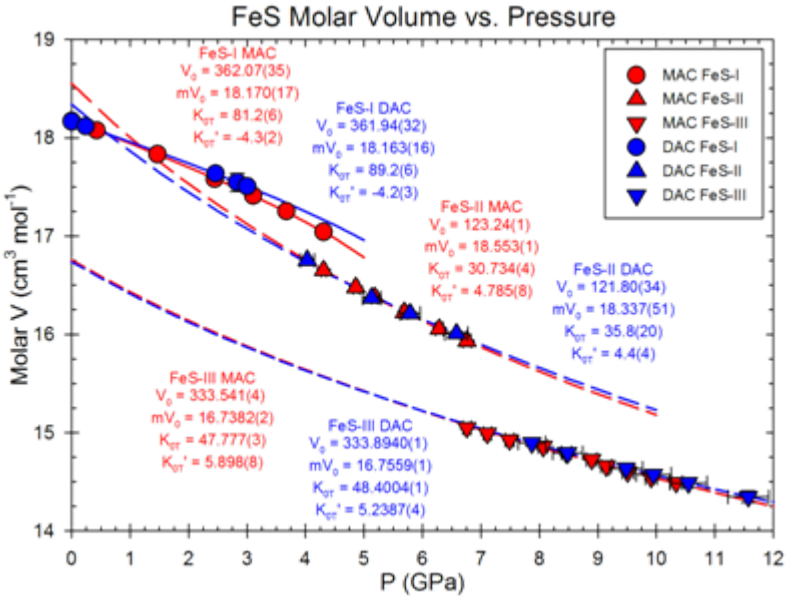


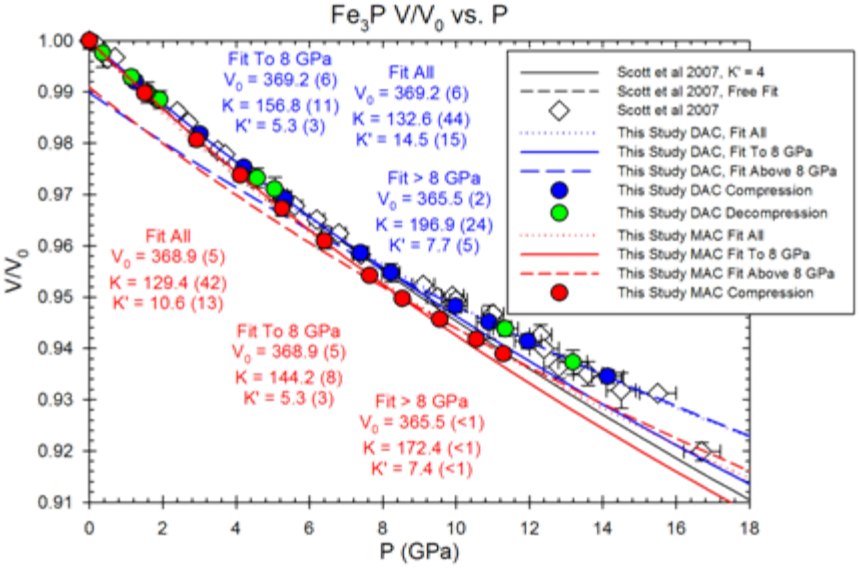


Diamond Anvil Cell Results



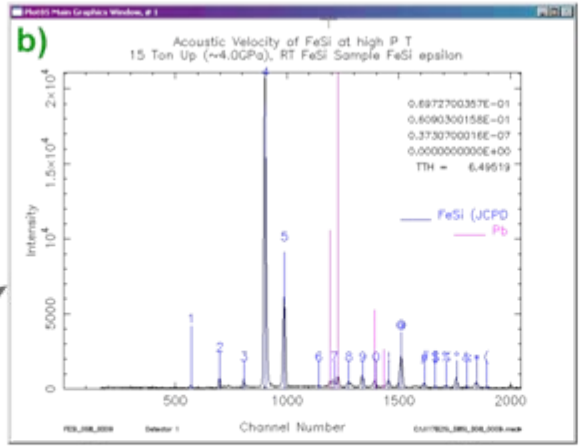


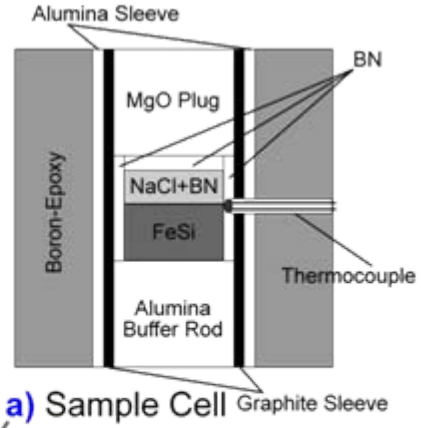




Ultrasonic & X-Ray Experiment

X17B2 of NSLS





a) Sample Cell

SSD/CCD

Anvil

Slits

2θ

X-Ray

c)

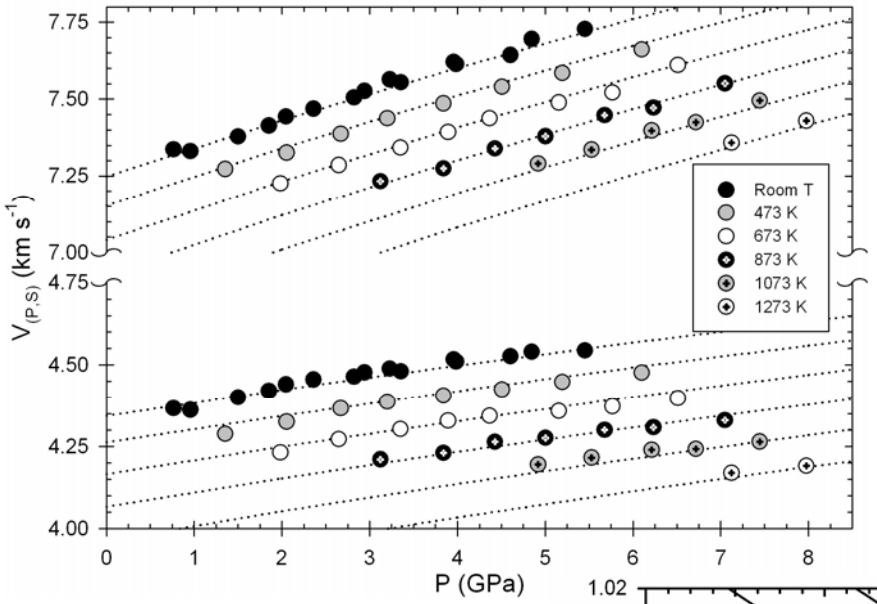
CCD Camera

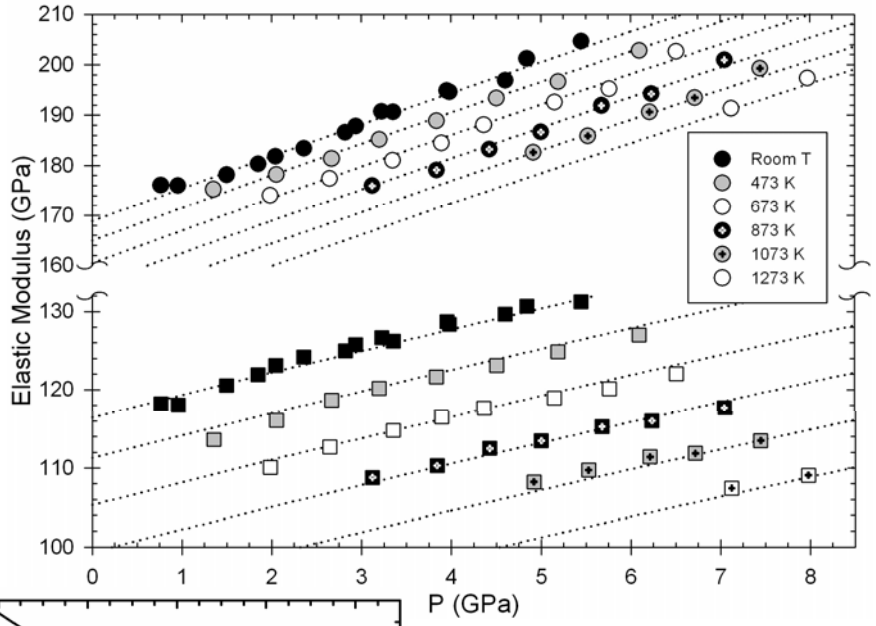
Transducer

Ultrasonic Control

d)

ε-FeSi Results





V_0 = 90.45(3) Å^3

K_{S0} = 168.9(7) GPa

K_{S0}' = 6.6(2)

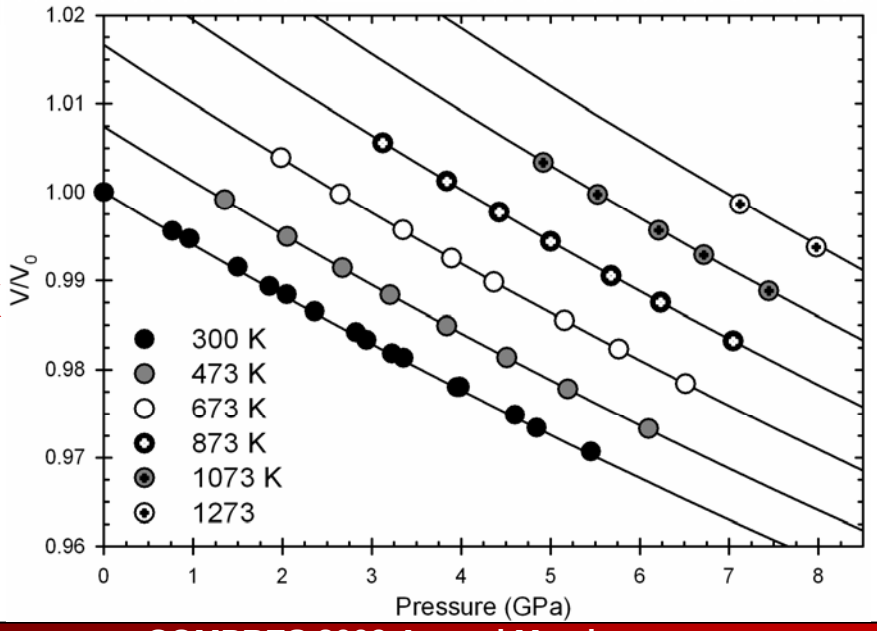
$\partial K_{S0}/\partial T$ = -0.023(1) GPa/K

G_0 = 116.5(3) GPa

G_0' = 2.9(1)

$\partial G_0/\partial T$ = -0.030(1) GPa/K

Whitaker et al., Am. Min., July 2009



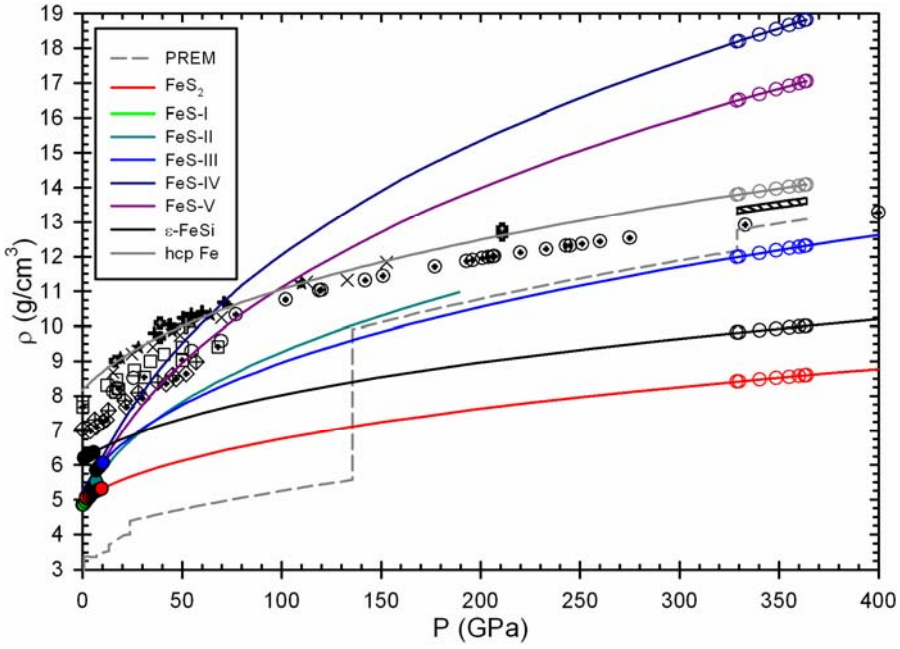
See poster for results on troilite (FeS) and pyrite (FeS_2).

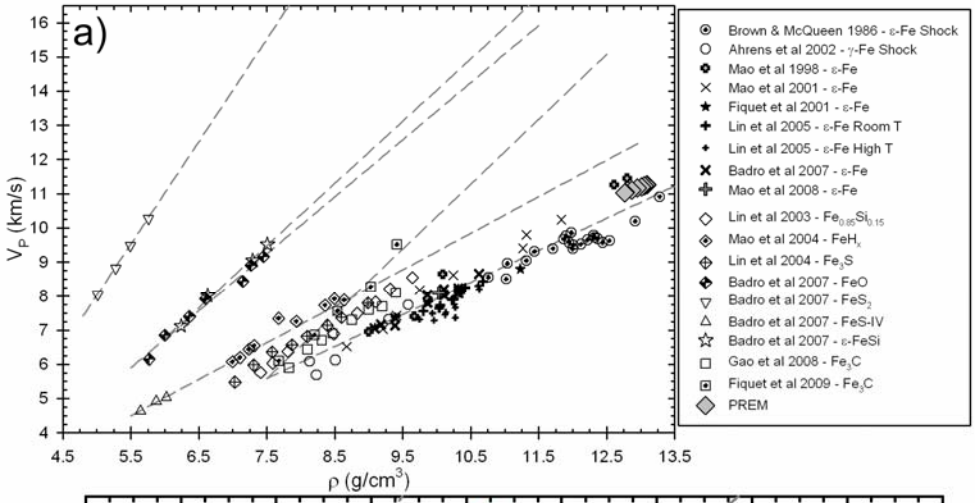
Table of Results

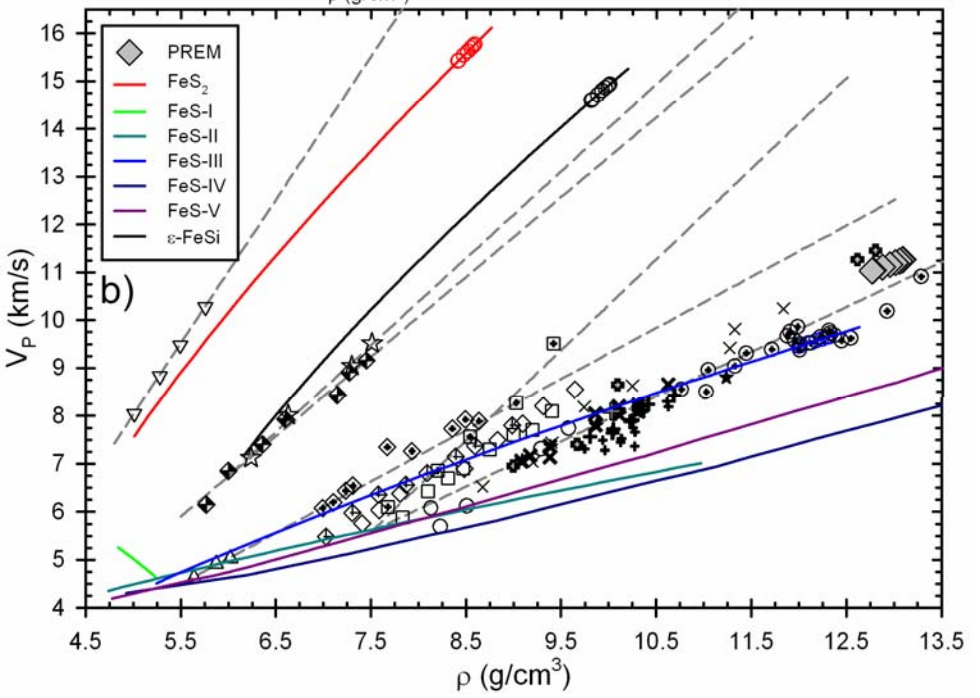
Material	Method	P (GPa)	V_0 (Å^3)	K_0 (GPa)	K_0'	$\partial K_0/\partial T$ (GPa K^{-1})	G_0 (GPa)	G_0'	$\partial G_0/\partial T$ (GPa K^{-1})
Fe_3P[b]	MAC P-V	8 (300 K)	368.9(5)	153.3(9)	5.3(2)	-	-	-	-
Fe_3P[b]	DAC P-V	8 (300K)	369.2(6)	156.8(11)	5.3(3)	-	-	-	-
FeS_2[a]	Ultrasonics & X-ray	10 (300 K)	159.01(3)	138.9(7)	6.0(1)	-	112.3(3)	3.0(<1)	-
FeS_2[b]	MAC P-V	10 (300 K)	159.01(3)	137.51(1)	6.01(1)	-	-	-	-
FeS_2[b]	DAC P-V	13.2 (300 K)	159.14(5)	143.1(10)	5.0(2)	-	-	-	-
FeS-I[a]	Ultrasonics w/ P-V	4.3 (300 K)	362.07(35)	83.2	-4.3	-	39.6(4)	1.1(2)	-
FeS-I[b]	MAC P-V	4.3 (300 K)	362.07(35)	81.2(6)	-4.3(2)	-	-	-	-
FeS-I[b]	DAC P-V	3 (300 K)	361.94(32)	89.2(6)	-4.2(3)	-	-	-	-
FeS-II[a]	Ultrasonics w/ P-V	4.3-6.8 (300 K)	123.24(1)	32.13	4.78	-	44.5(3)	1.1(2)	-
FeS-II[b]	MAC P-V	4.3-6.8 (300 K)	123.24(1)	30.73(1)	4.78(1)	-	-	-	-
FeS-II[b]	DAC P-V	4-6.6 (300 K)	121.80(34)	35.8(20)	4.4(4)	-	-	-	-
FeS-III[a]	Ultrasonics w/ P-V	6.8-10.4 (300 K)	333.541(4)	51.553	5.239	-	43.9(3)	1.3(2)	-
FeS-III[b]	MAC P-V	6.8-10.4 (300 K)	333.541(4)	48.402(1)	5.239(1)	-	-	-	-
FeS-III[b]	DAC P-V	7.9-11.6 (300 K)	333.8940(1)	47.777(3)	5.898(9)	-	-	-	-
FeS-IV[a]	Ultrasonics w/ P-V-T	1-7 (300-673 K)	237.11(4)	39.96	1.772	-0.0090	40.8(3)	1.82(1)	-0.0259(8)
FeS-IV[b]	MAC P-V-T	1-7 (300-673 K)	237.11(4)	37.08(9)	1.800(5)	-0.0172(2)	-	-	-
FeS-V[a]	Ultrasonics w/ P-V-T	2.7-7.8 (673-1073 K)	61.061(3)	35.09	2.412	-0.0023	38.1(2)	2.13(2)	-0.0199(9)
FeS-V[b]	MAC P-V-T	2.7-7.8 (673-1073 K)	61.061(3)	33.42(8)	2.372(6)	-0.0075(2)	-	-	-
ε-FeSi[a]	Ultrasonics & X-ray	8 (300-1273 K)	90.45(3)	168.9(7)	6.6(2)	-0.023(1)	116.5(3)	2.9(1)	-0.030(1)
ε-FeSi[b]	MAC P-V-T	8 (300-1273 K)	90.45(3)	164.6(1)	6.5(1)	-0.039(1)	-	-	-
ε-FeSi[b]	DAC P-V	15 (300 K)	90.40(3)	169.4(64)	6.7(14)	-	-	-	-

[a]Adiabatic values; [b]Isothermal values

Comparison to Inner Core



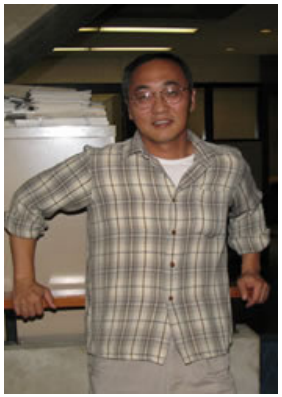




Results and Implications

- Excellent agreement between MAC and DAC
- First data on shear modulus and its first pressure and temperature derivatives for ε-FeSi, FeS_2, and FeS-I, II, III, IV, and V
- Extrapolation of data to core pressures allows for comparison to inner core
- Two-component mixing model generated to assess eligibility and amount of elements in the inner core
- ***Come to the poster to see the results!***

Acknowledgements



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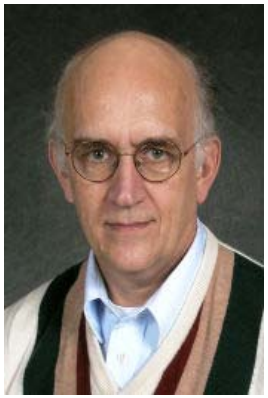

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