Metal-silicate experiments in the laser-heated diamond anvil cell

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BGI group meeting
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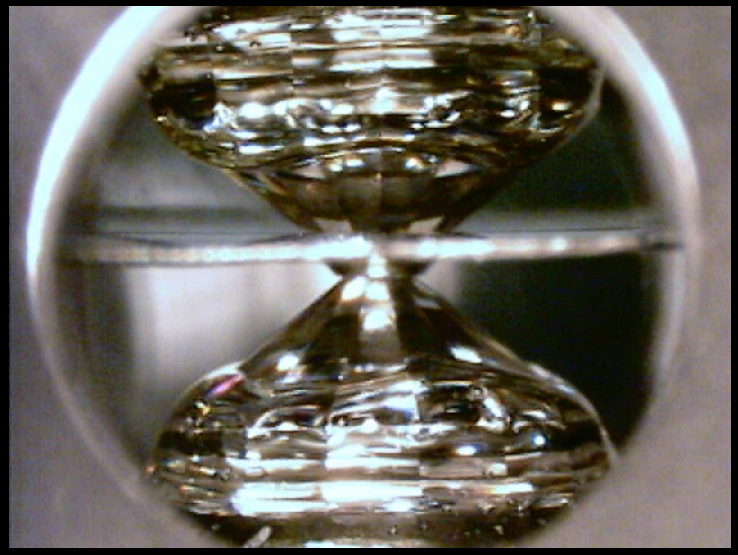
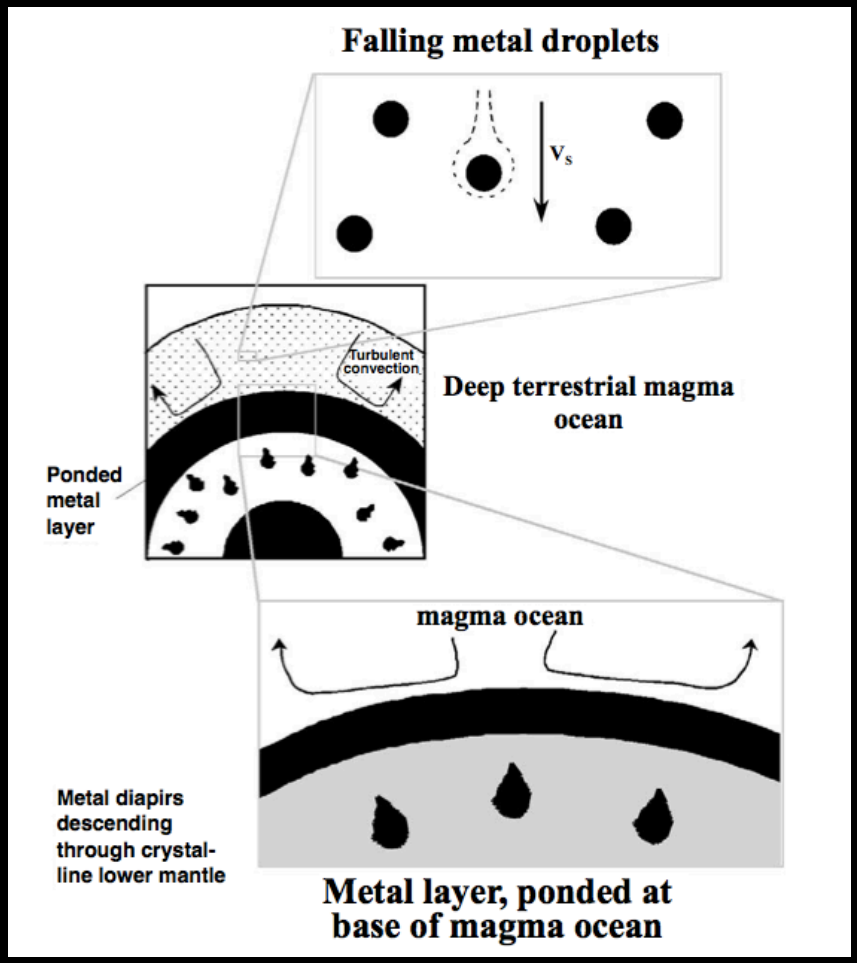


Introduction

Possible picture of core formation:



Rubie et al. (2003)

Introduction

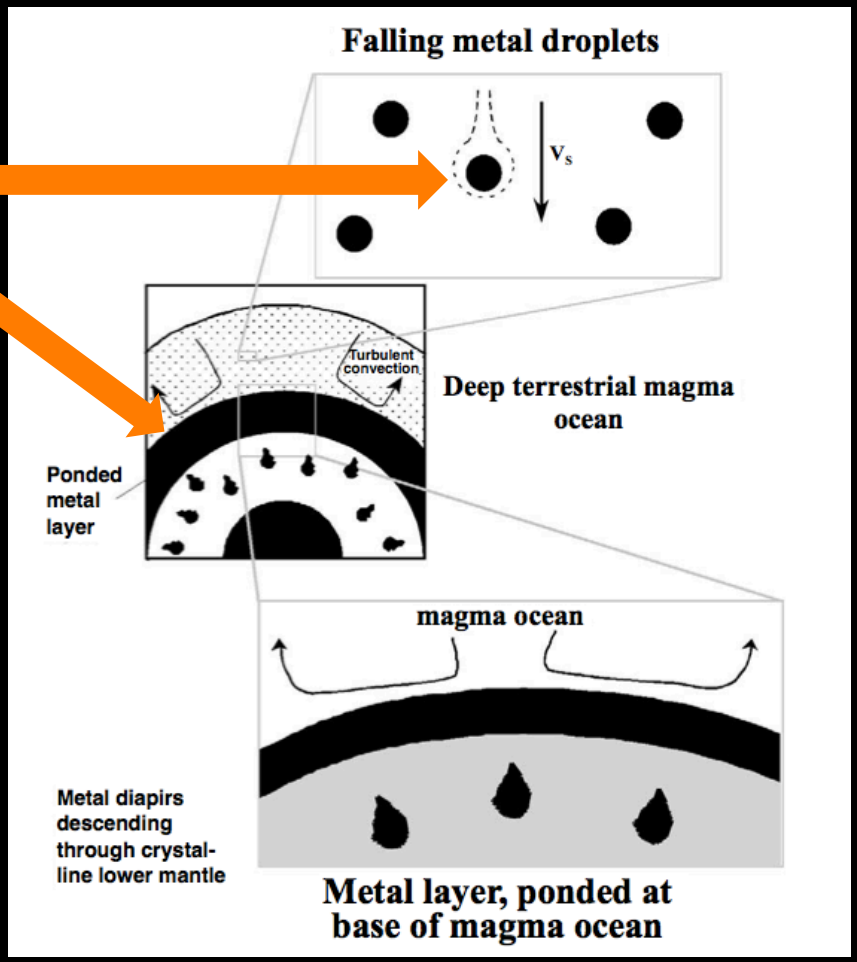
What are the chemical reactions between metal and silicate?

Method: High *P-T* experiments, FIB recovery, TEM chemical analysis

Under what *P-T-f*O_2 conditions (or range of conditions) did the core last equilibrate with the mantle?

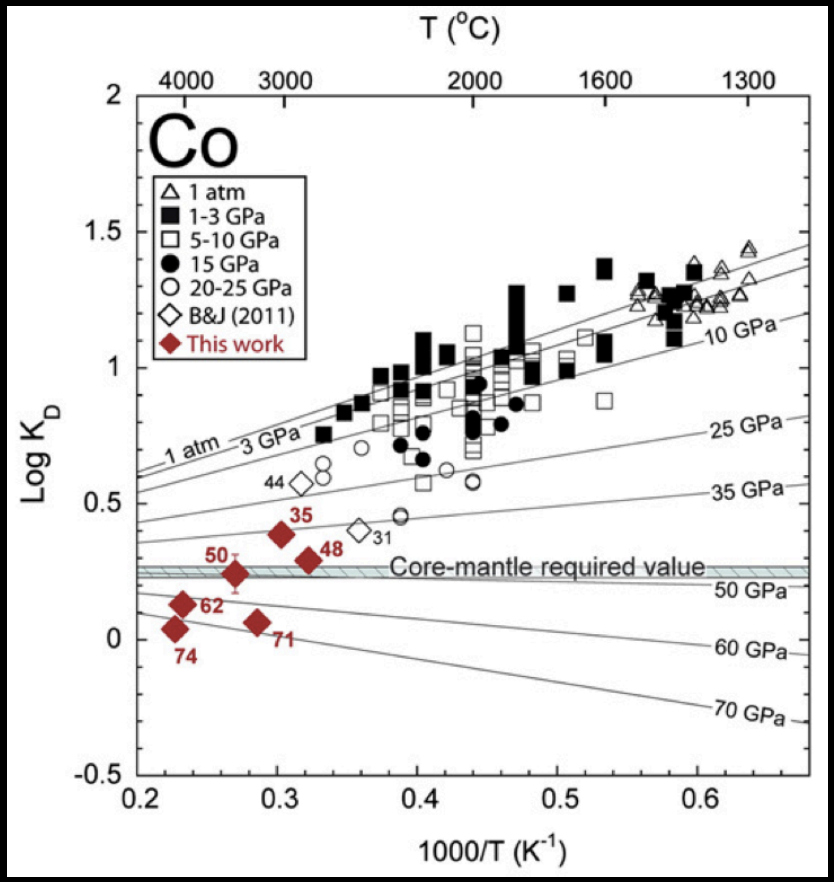
What is the composition of the Earth's core?

Possible picture of core formation:



Rubie et al. (2003)

Previous work

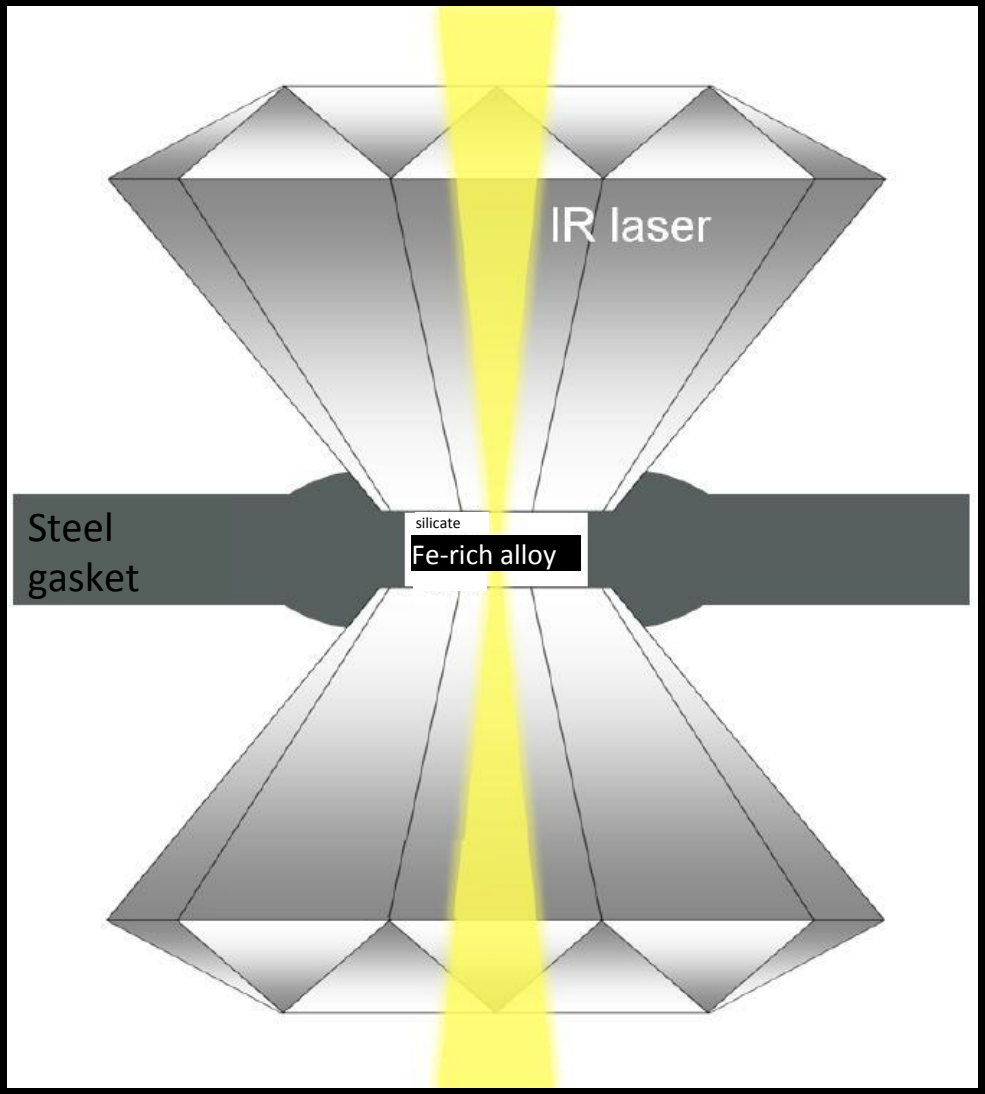


Siebert et al. (2012)

Many partitioning experiments at lower pressures, very few at higher pressures

$$K_D = D_M / D_{Fe}^{n/2}$$
$$= (X_{M,met}/X_{M,sil}) / (X_{Fe,met}/X_{Fe,sil})^{n/2}$$

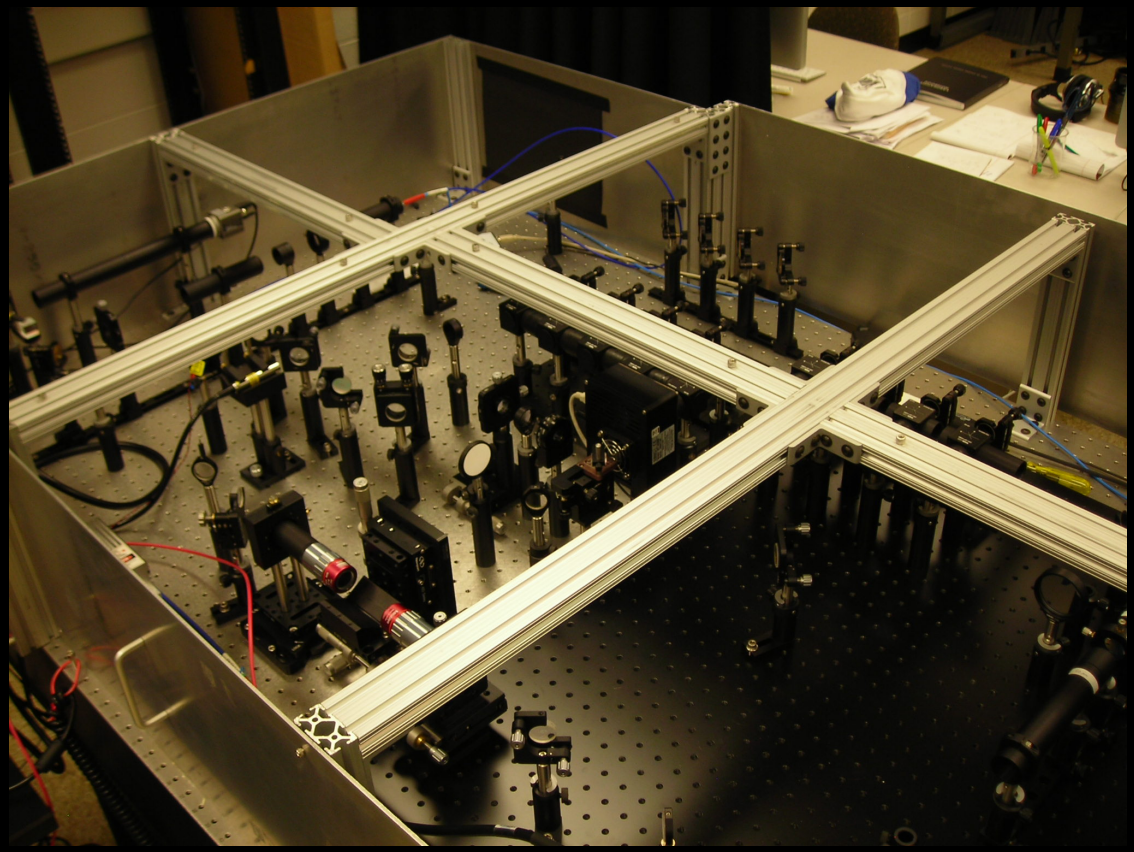
Diamond anvil cell experiments



Pressures of 39-77 GPa and over 4400 K

Metal contains Fe, Ni, Co, V, ± Si

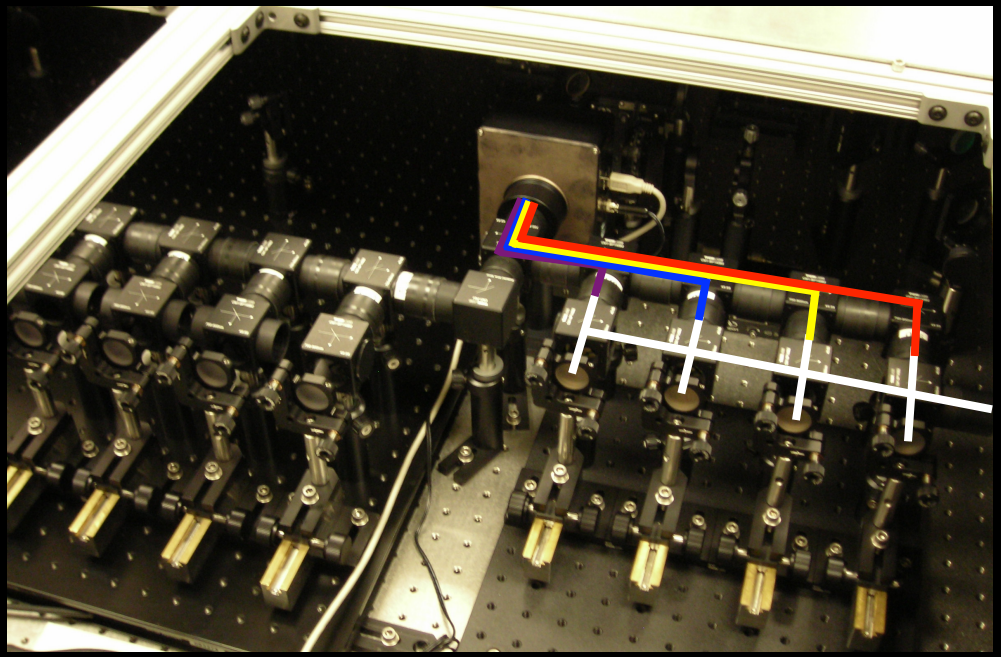
Experiments in our lab



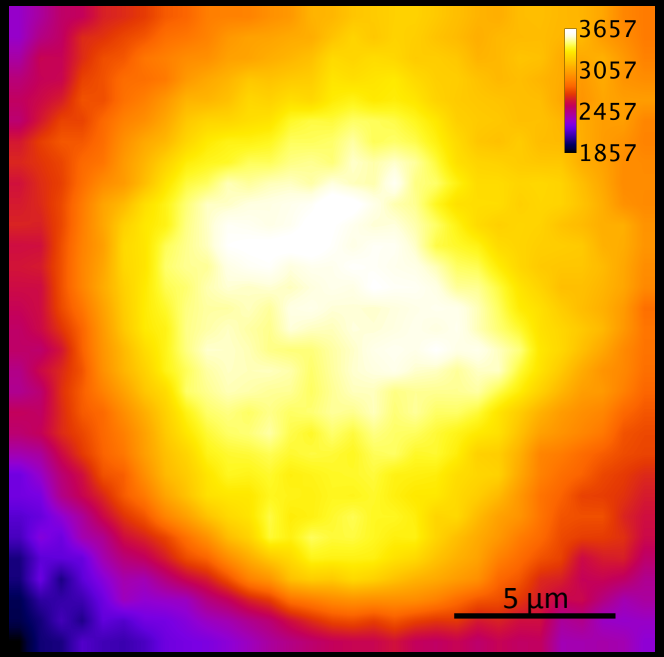
- Double-sided laser-heating (λ=1.064 μm)
- Spectrometers measure temperatures from cental 5 μm in real time
- Camera captures images of laser-heated spot

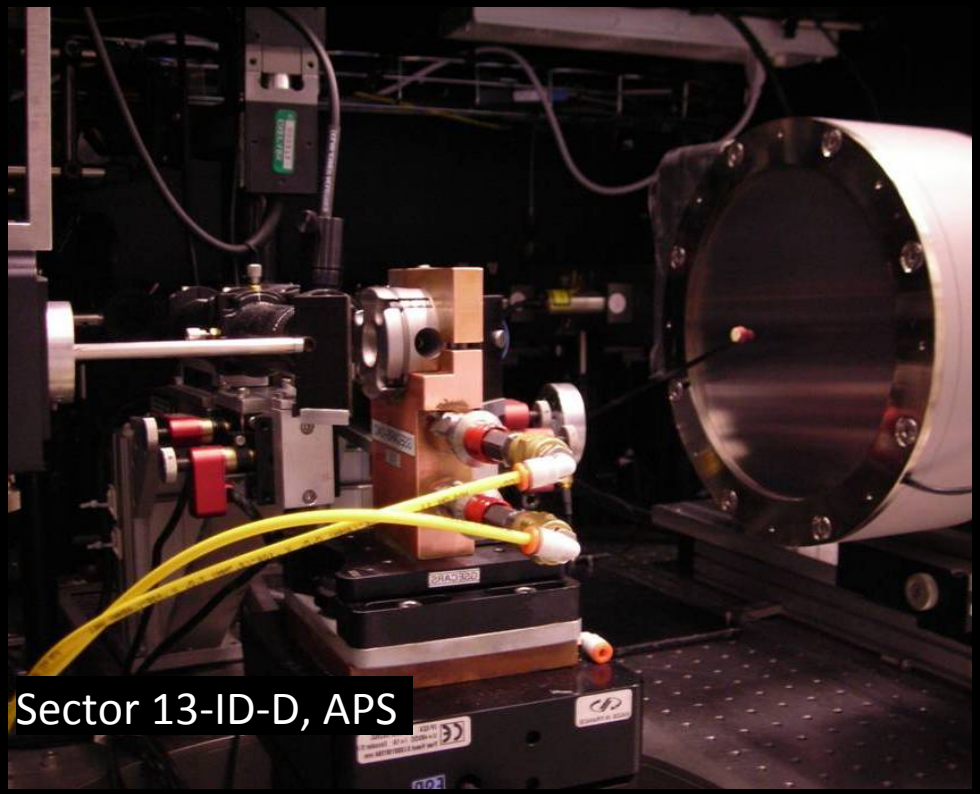
4-color temperature imaging system

670 nm 750 nm 800 nm 850 nm

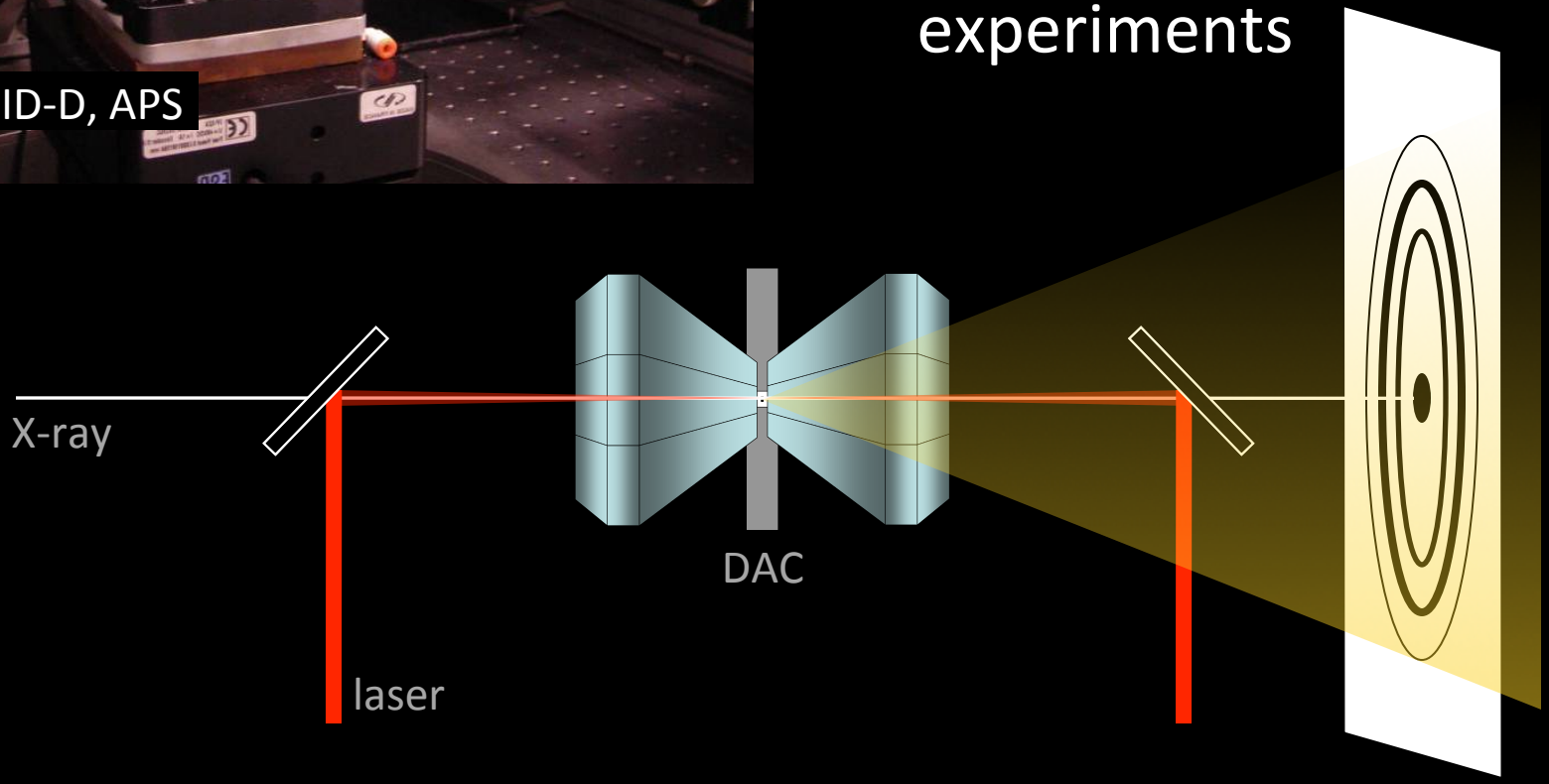


39 GPa

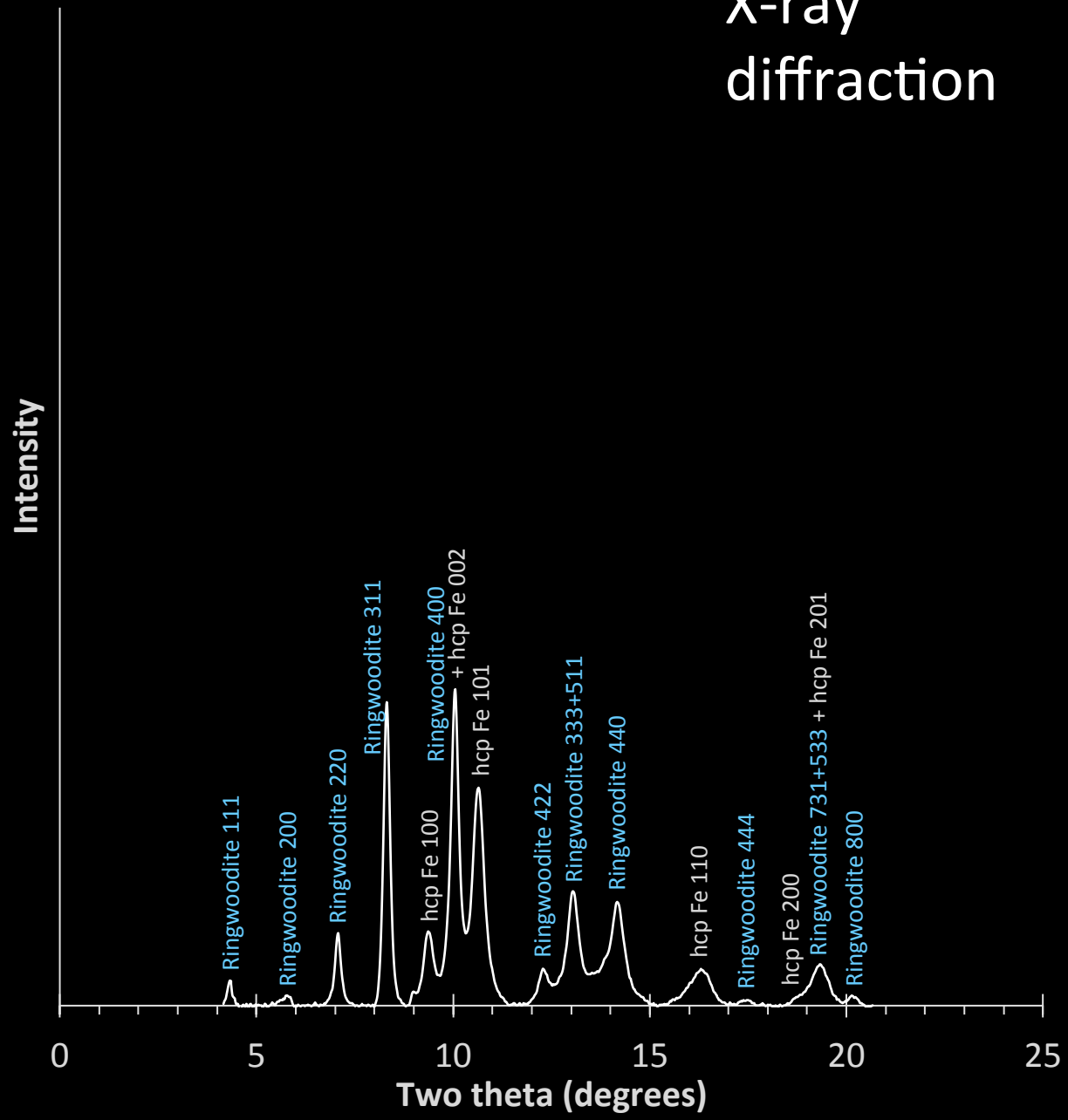




Synchrotron X-ray diffraction experiments



X-ray diffraction

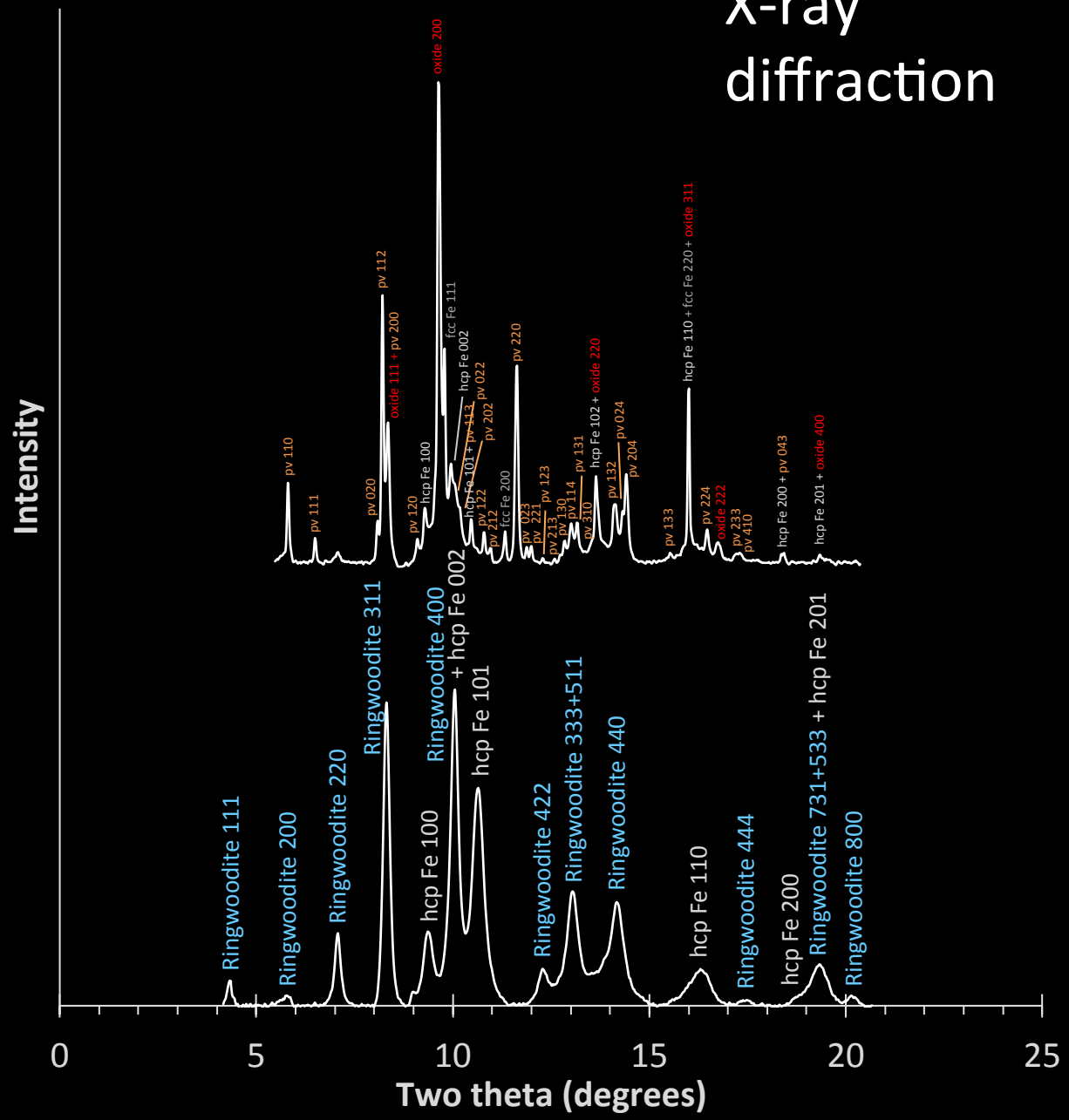


Before heating
65 ± 5 GPa, 300 K

hcp Fe-alloy:
a = 2.361 ± 0.002 Å
c = 3.789 ± 0.004 Å

Ringwoodite:
a = 7.654 ± 0.006 Å

X-ray diffraction



At high temperature
72 ± 6 GPa, 3120 ± 160 K

hcp Fe-alloy:
a = 2.390 ± 0.004 Å
c = 3.856 ± 0.006 Å

fcc Fe-alloy:
a = 3.393 ± 0.004 Å

Oxide (ferropericlase):
a = 3.979 ± 0.001 Å

Silicate perovskite:
a = 4.577 ± 0.003 Å
c = 4.746 ± 0.003 Å
c = 6.595 ± 0.005 Å

Before heating
65 ± 5 GPa, 300 K

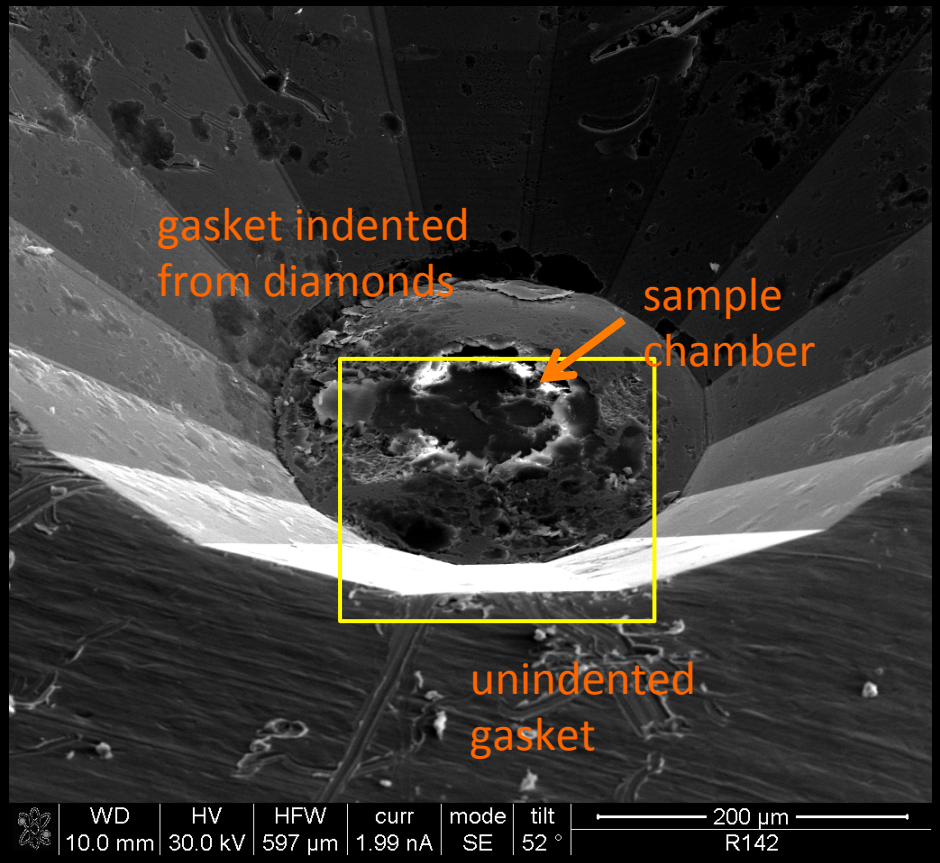
hcp Fe-alloy:
a = 2.361 ± 0.002 Å
c = 3.789 ± 0.004 Å

Ringwoodite:
a = 7.654 ± 0.006 Å

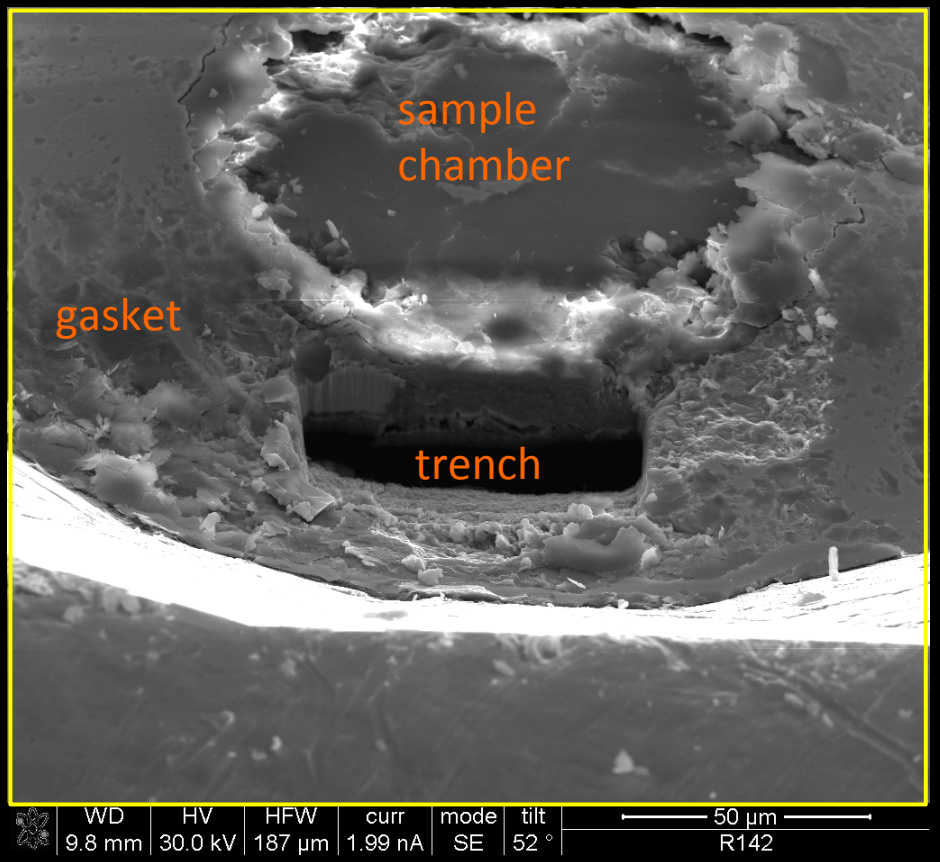
FIB at Jena

Sectioned and recovered two high pressure samples last week, began one more

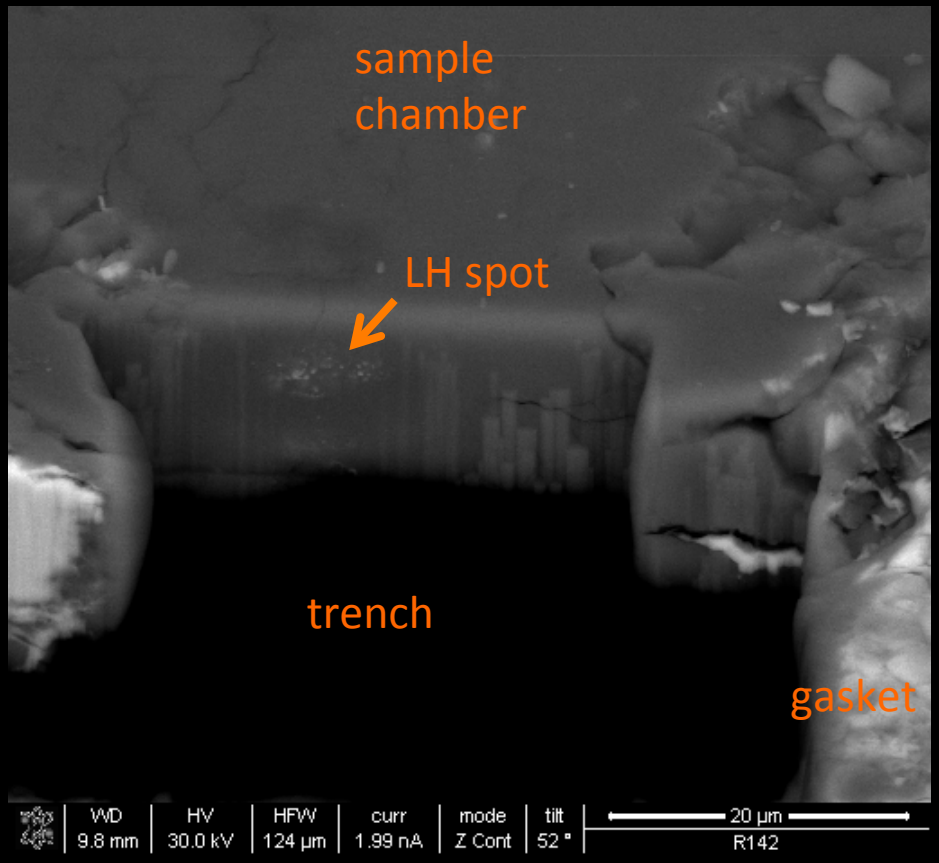
Initial view of the sample



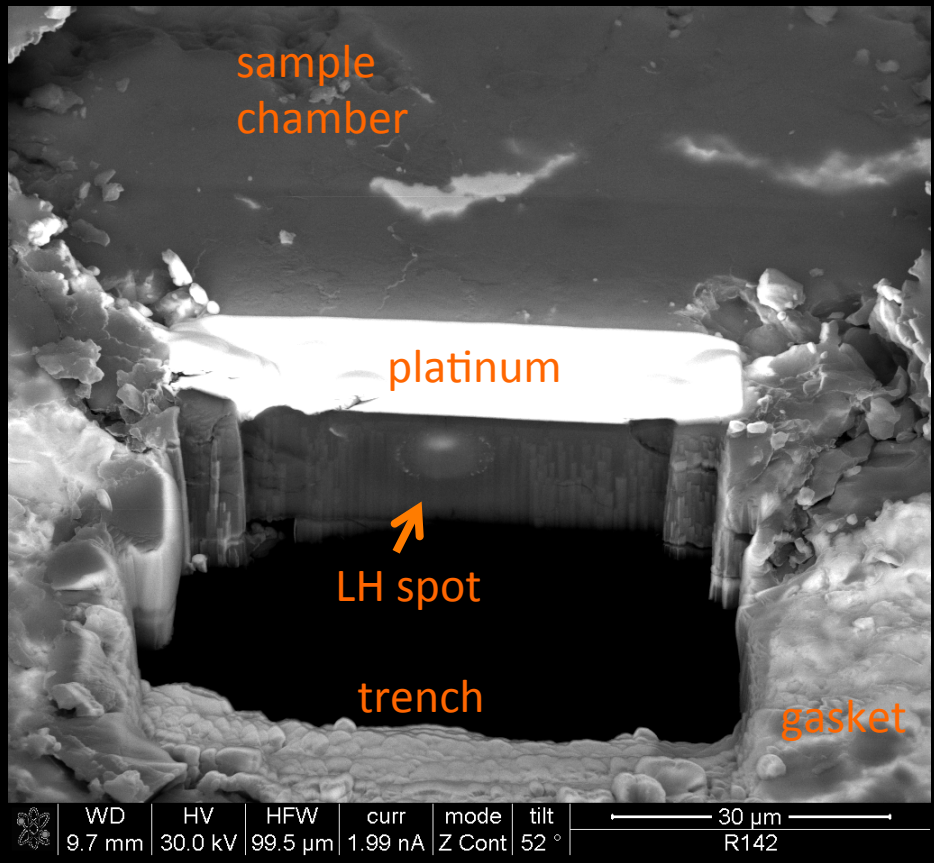
Milling a trench on first side



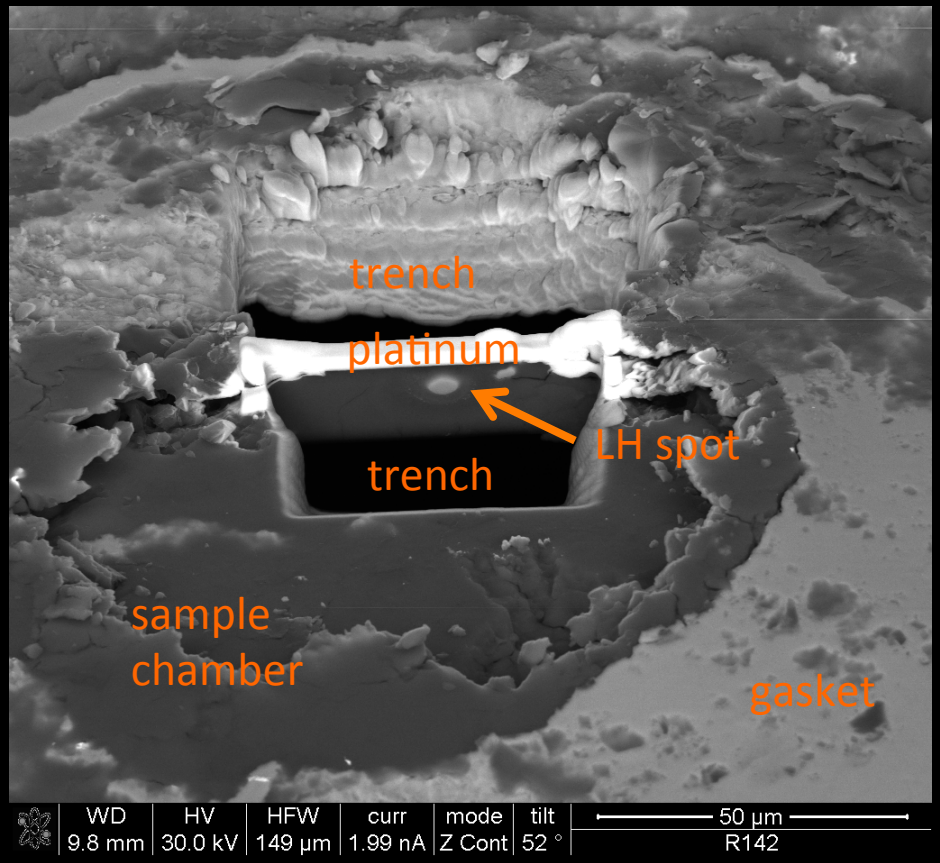
Beginning to expose the LH spot



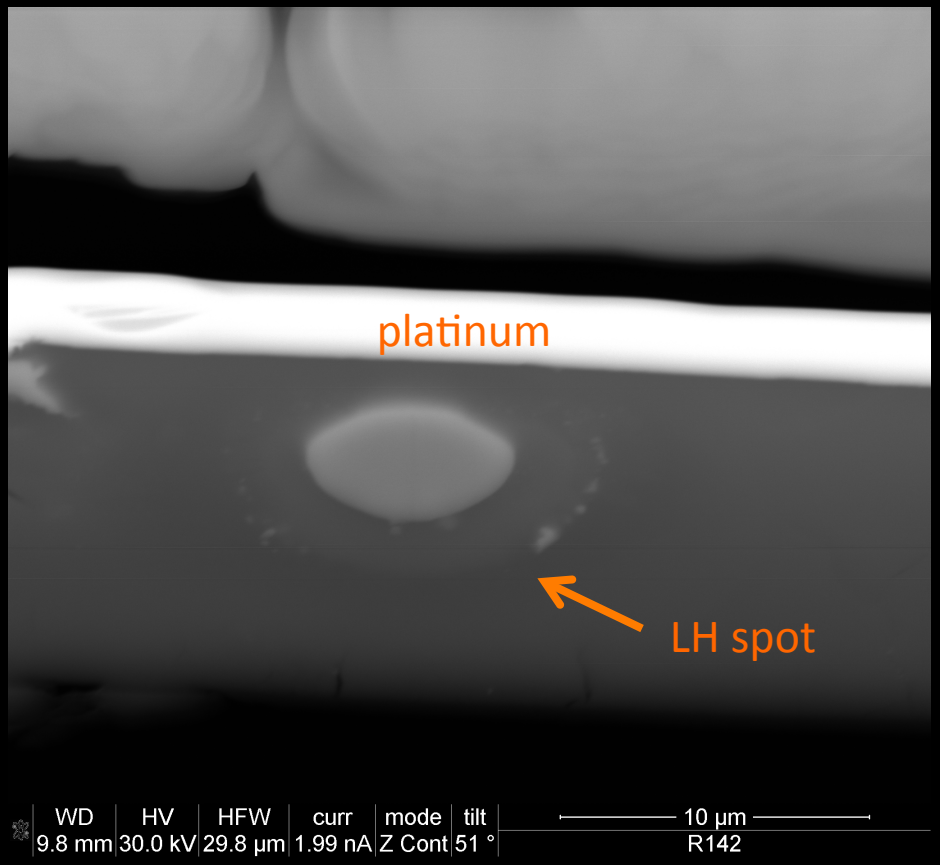
Deposited Pt and polished



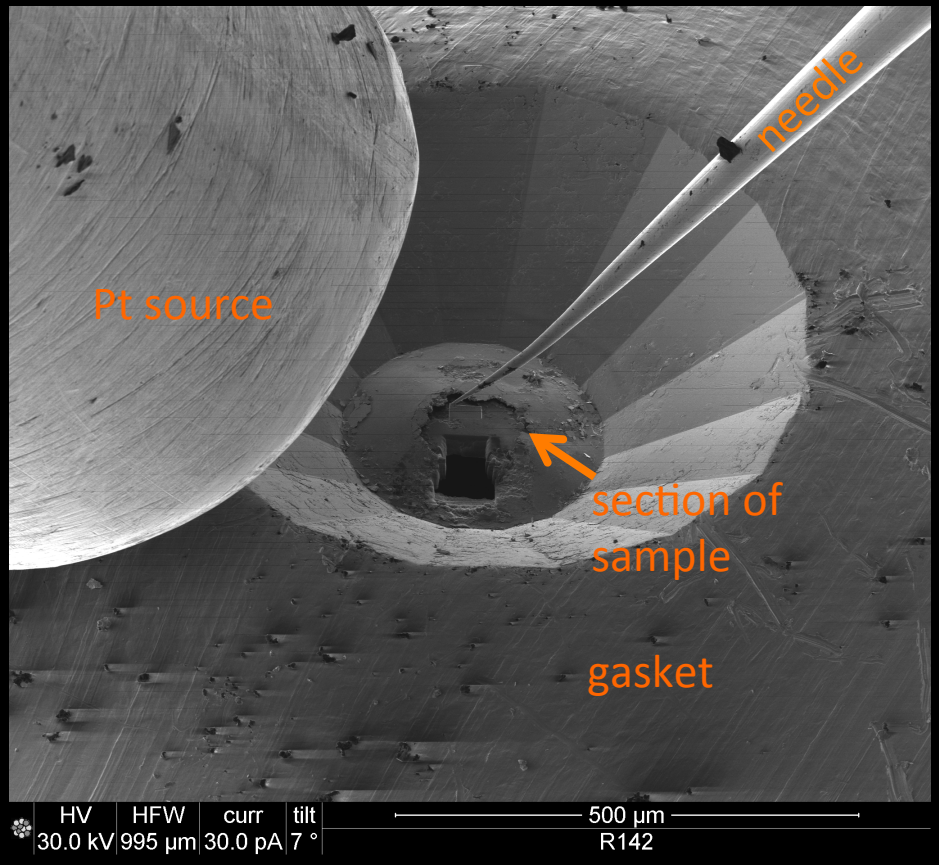
Milling a trench on the other side



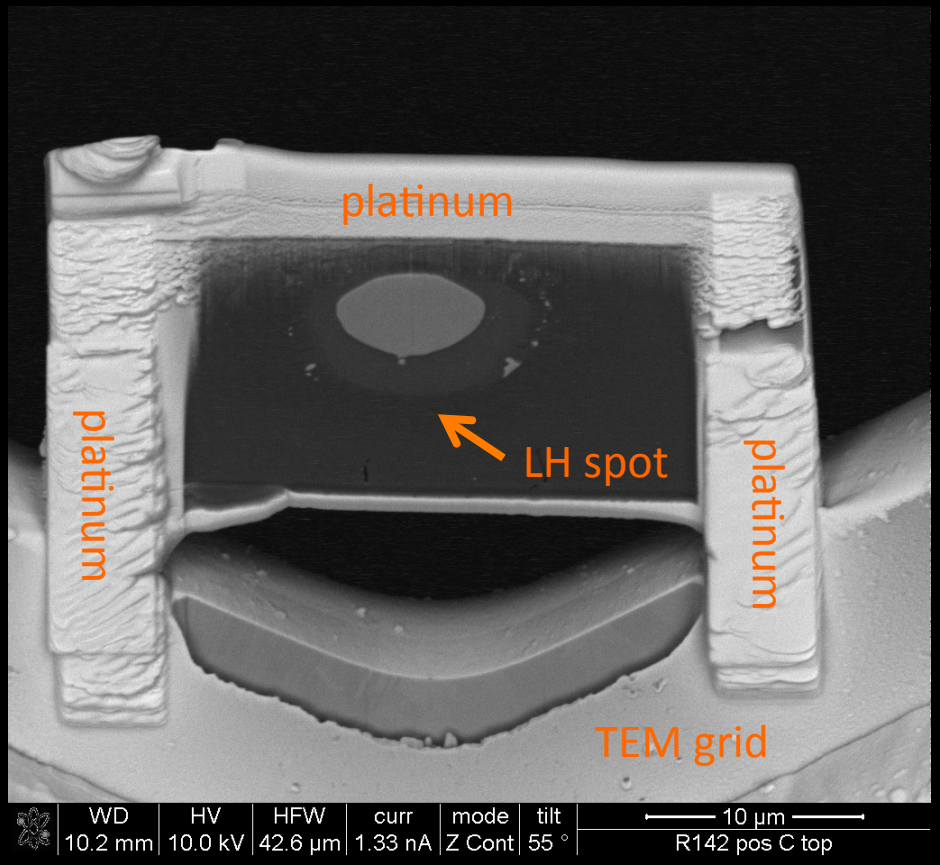
Thin sample from both sides to expose center of LH spot



Milled out sides, attached to needle, and lifted out

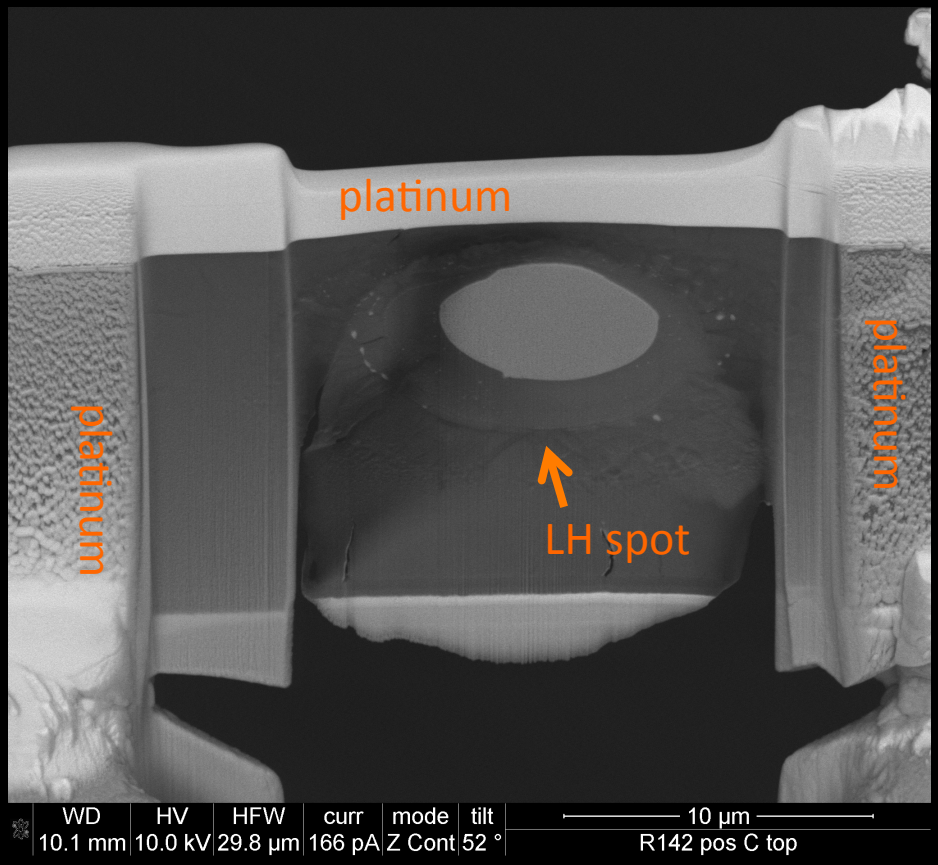


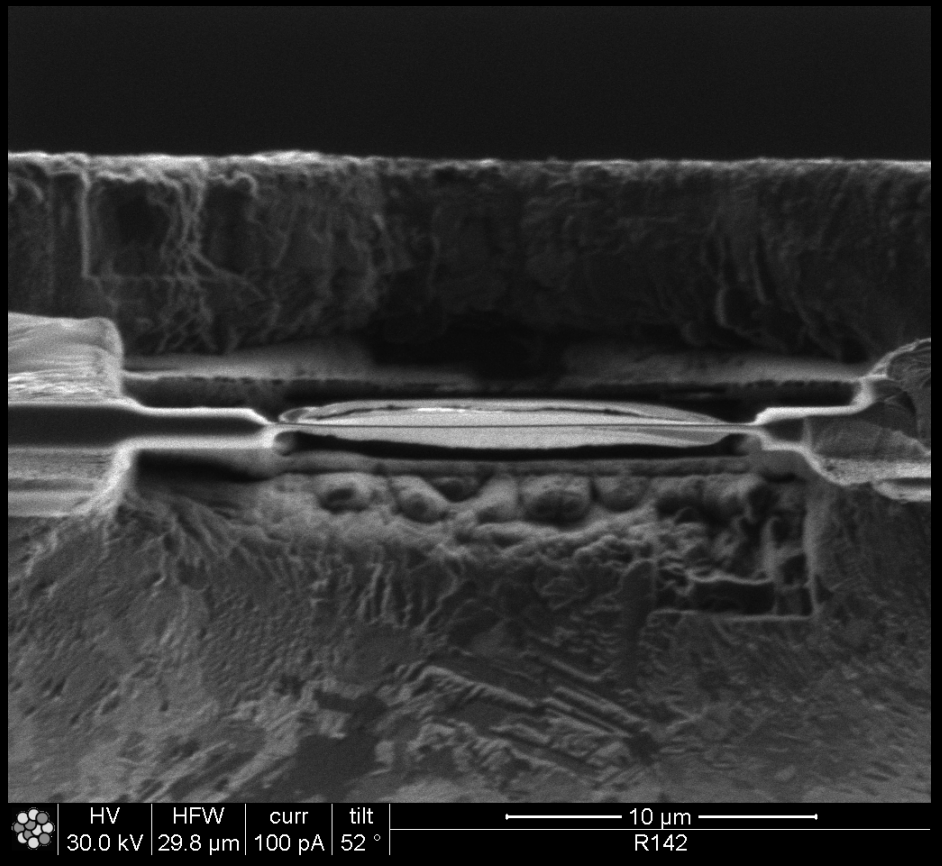
Fixed to a TEM grid and removed needle



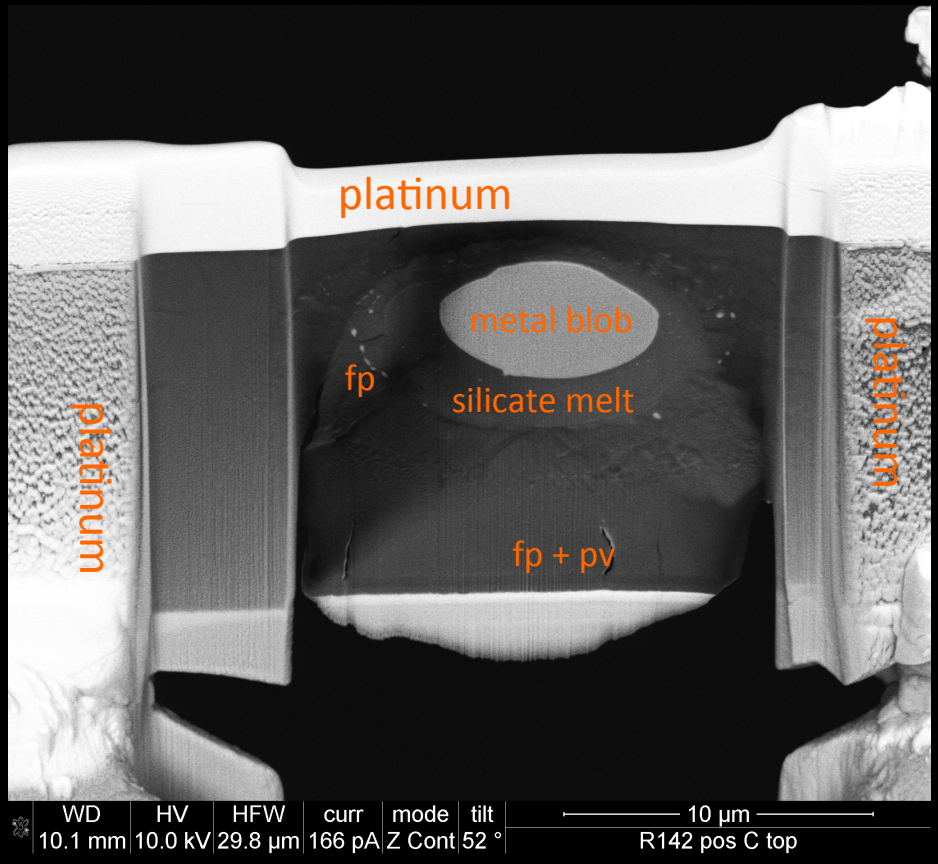
Thinned to ~100 nm

View from above

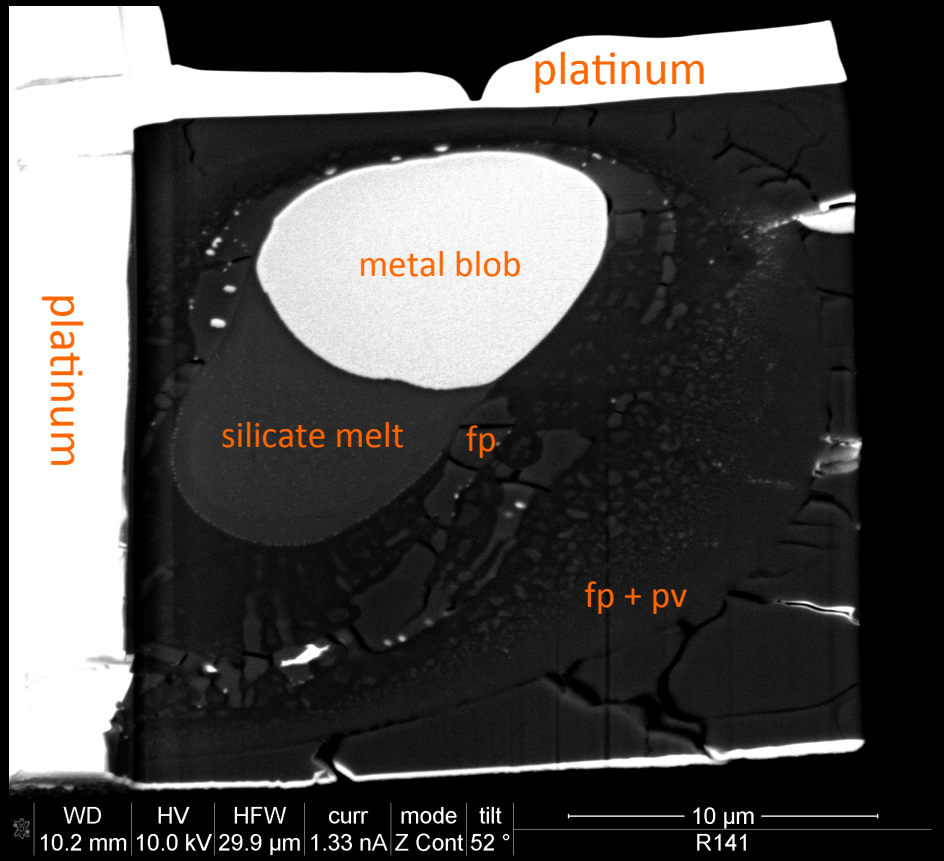




39 GPa, 3690 K

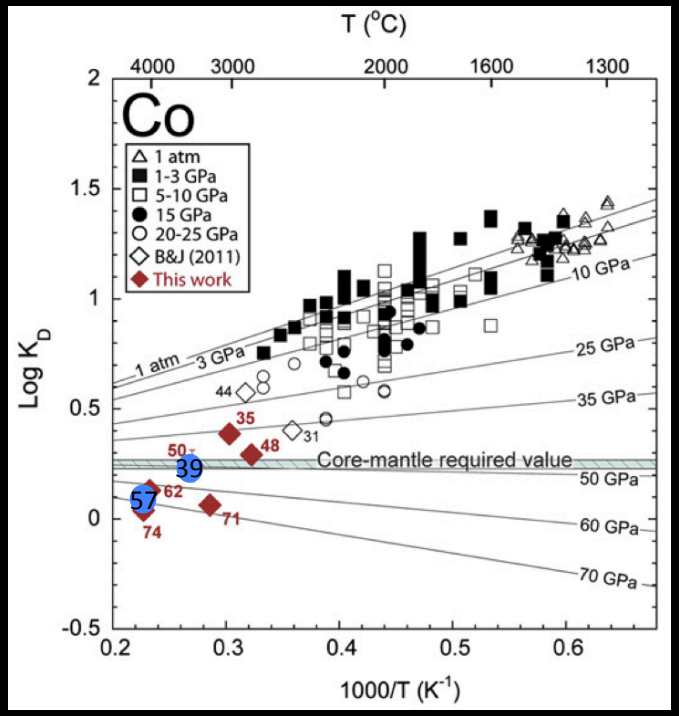


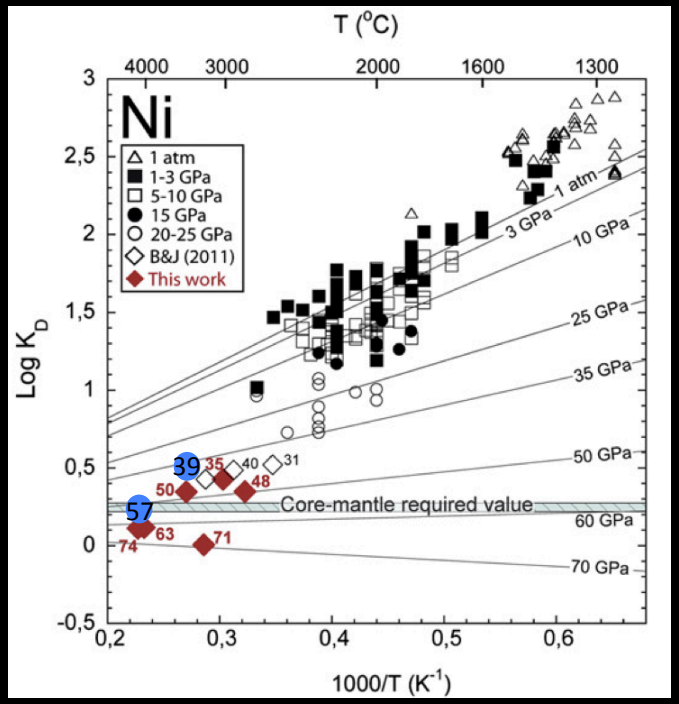
57 GPa, 4360 K

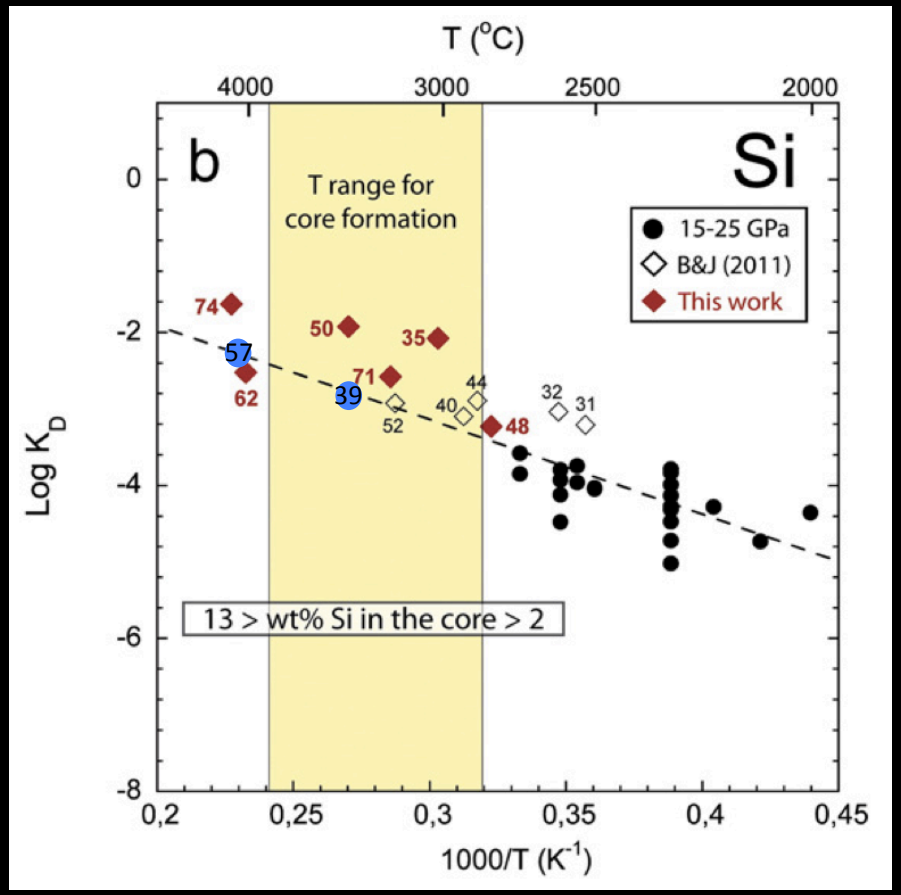


Exchange coefficients

Comparison to results from Siebert et al. (EPSL, 2012)







Conclusions: Progress so far

- Seven high *P-T* experiments run
- Two samples sectioned and recovered by FIB
- TEM analysis on these two samples
  - K_D values for Co, Ni, Si

Acknowledgements:
- Dave Rubie, Dan Frost, Catherine McCammon, Antje Vogel, Nobuyoshi Miyakima (BGI)
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