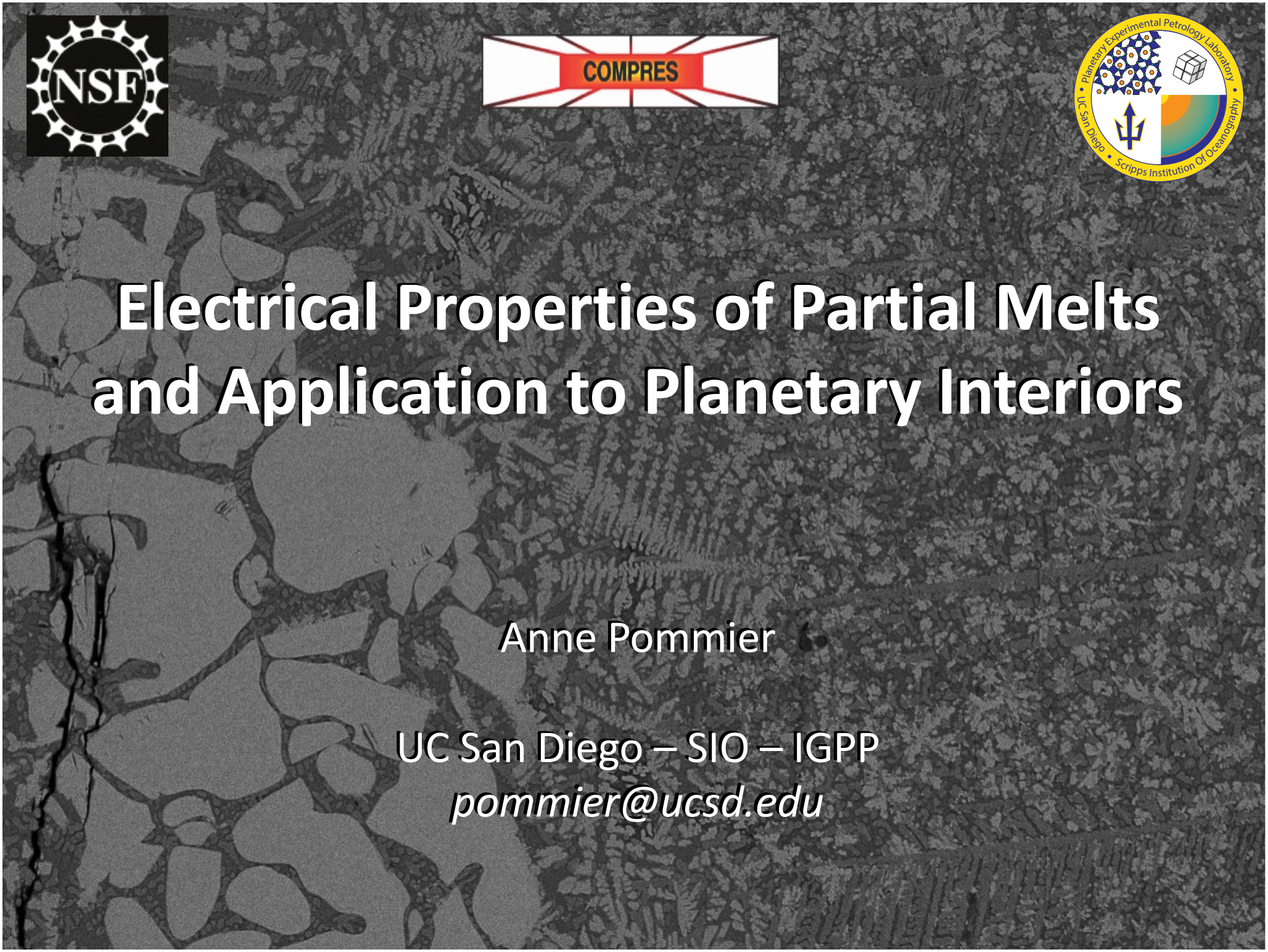

Electrical Properties of Partial Melts and Application to Planetary Interiors

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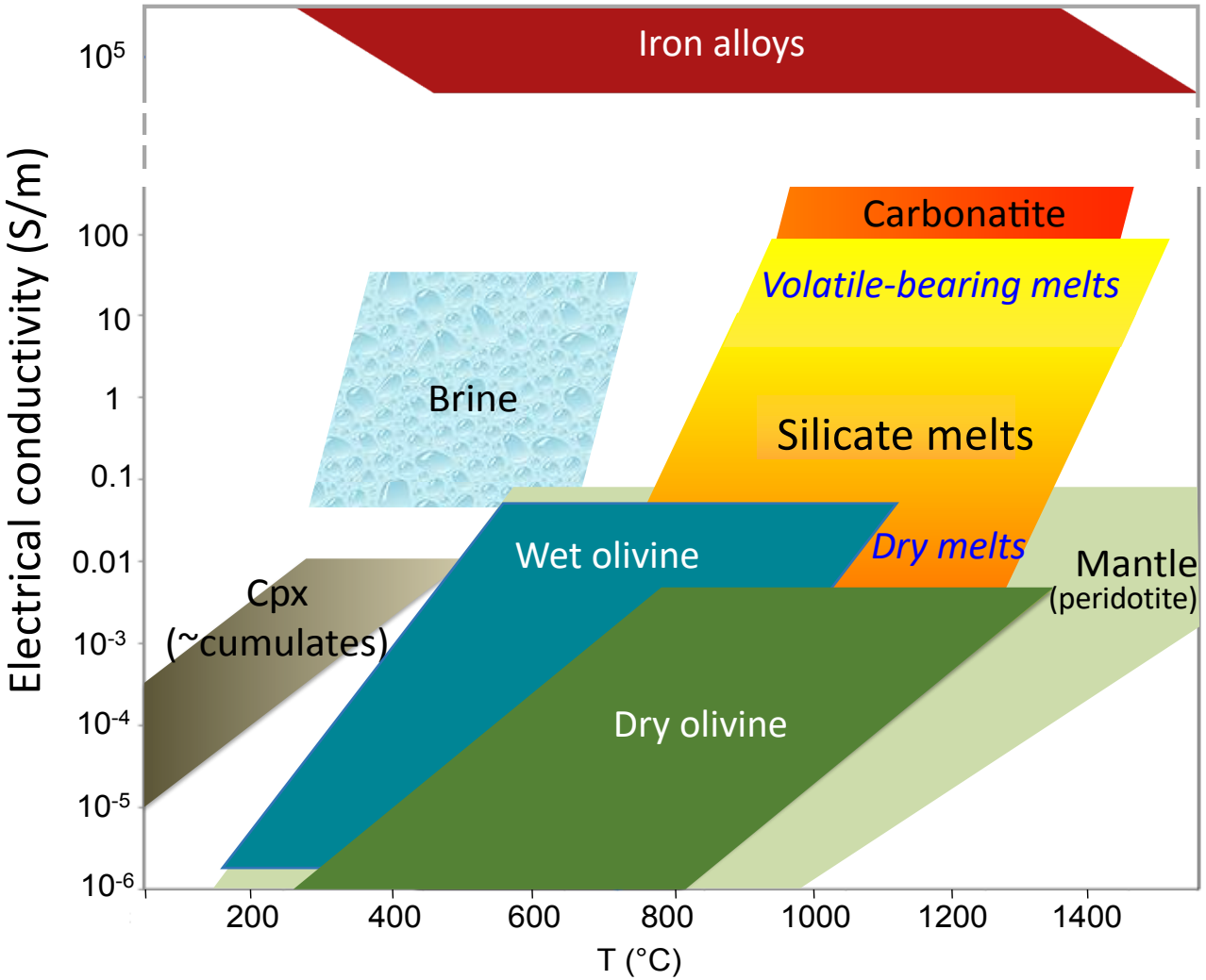
Electrical conductivity of geomaterials

Transport property sensitive to temperature, chemistry (volatiles, fluids, iron content, oxygen fugacity), deformation

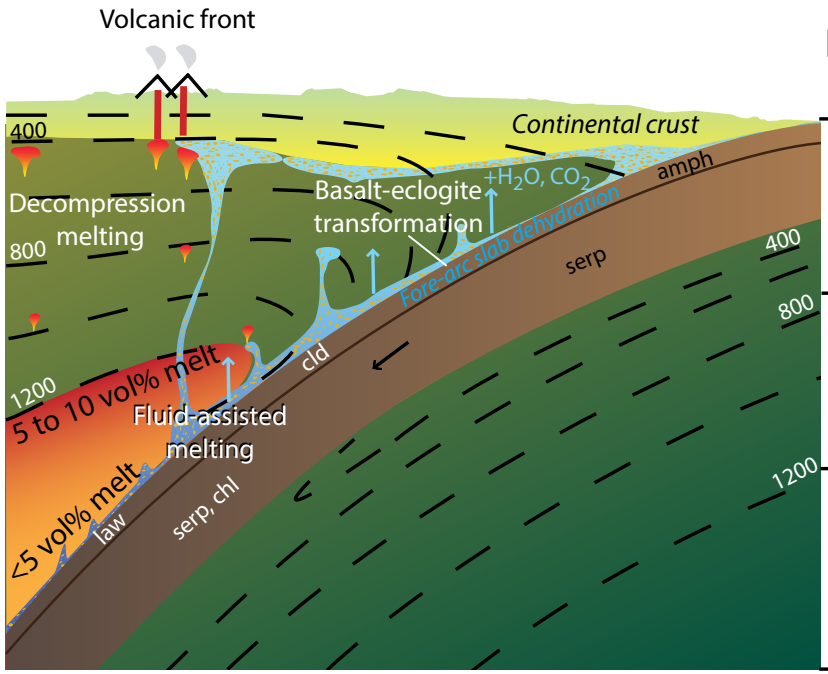


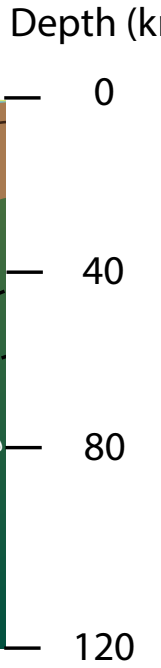
Combined with petrological constraints, laboratory-based models interpret field data in terms of melt fraction, mantle or core temperature, fluid migration

Imaging fluids with electrical measurements

Example of the Earth

Petrological view

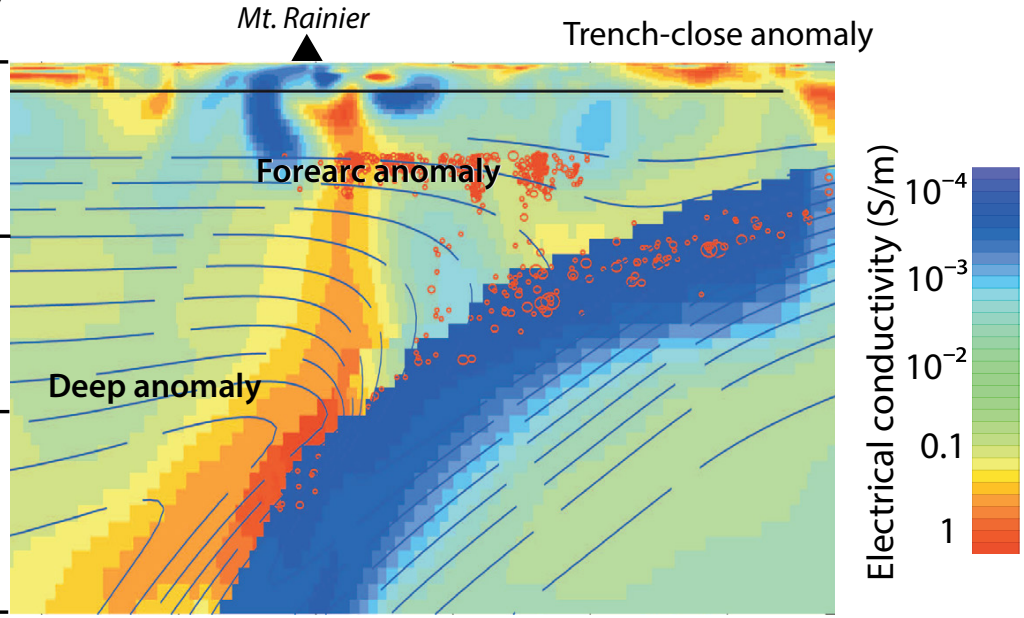




After Poli and Schmidt, 1998; Grove et al., 2009; Timm et al., 2014

Geophysical (EM) view

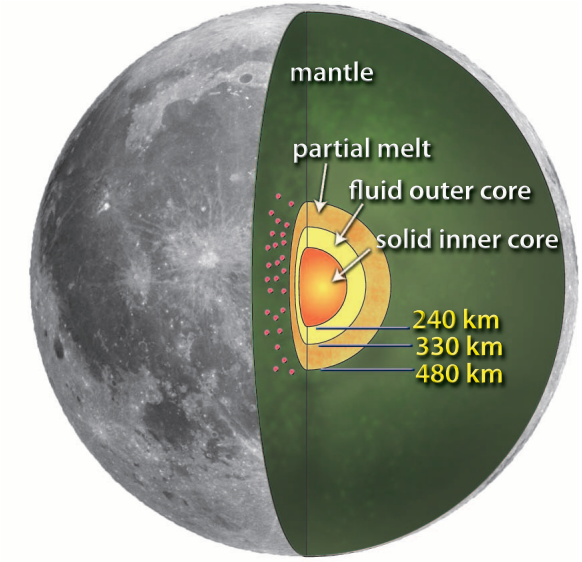
(example of the Cascades)



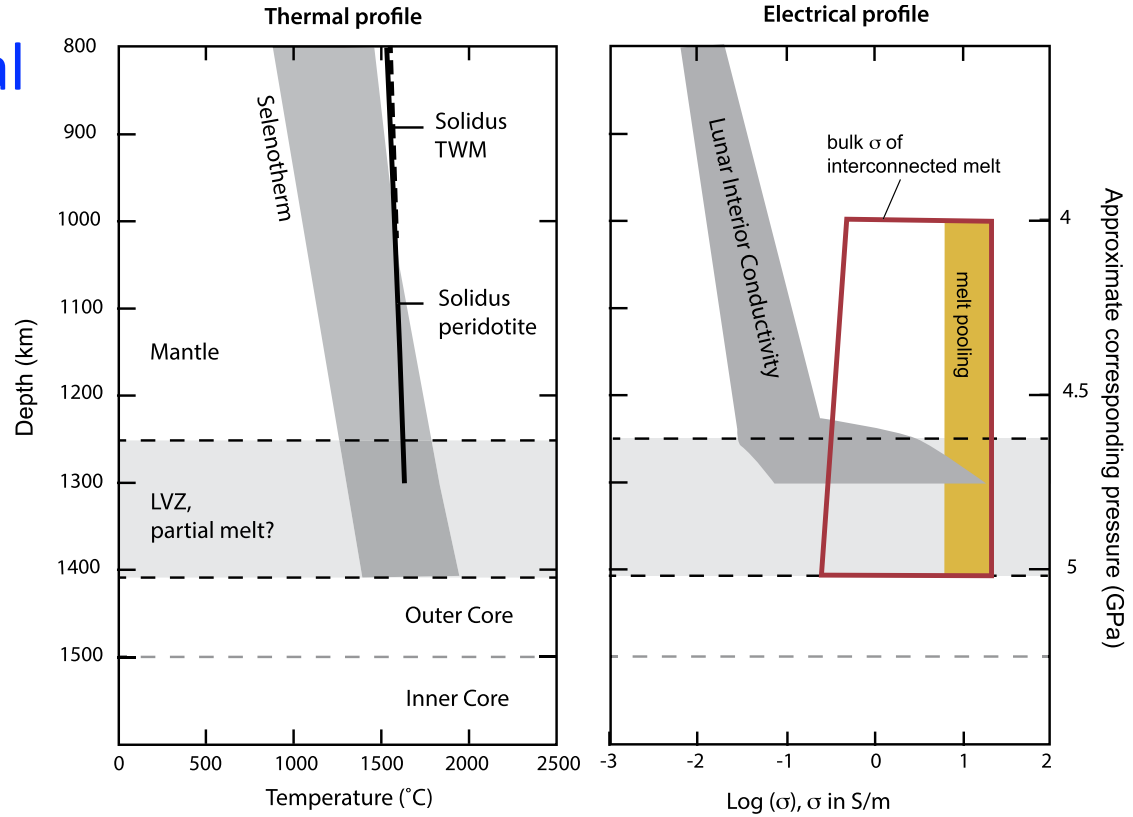
After McGary et al., 2014

Lab experiments show that high conductivity anomalies are consistent w/ melting at mantle wedge and expected zones of fluid accumulation (slab dehydration)

Probing the Moon with electrical measurements

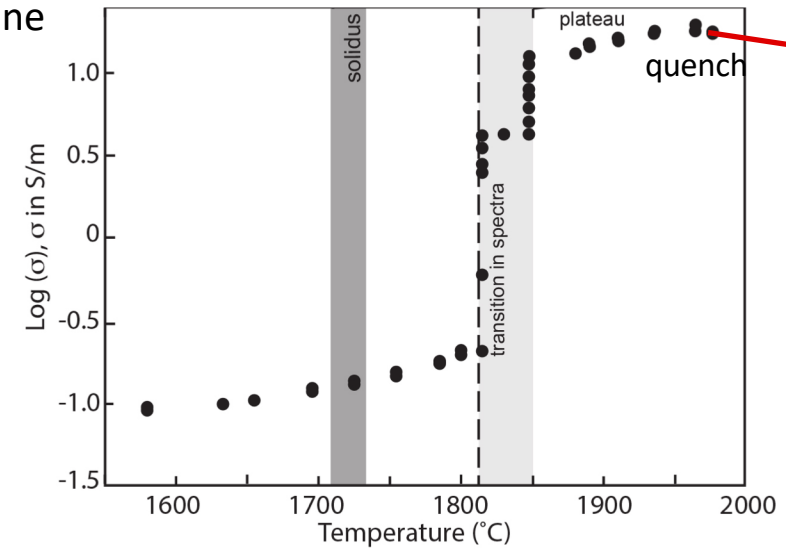


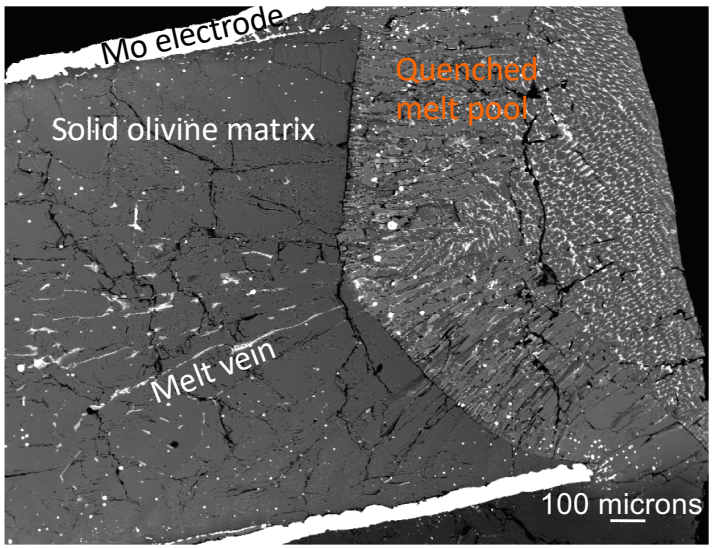
Weber et al., 2011



Pommier et al., 2015a

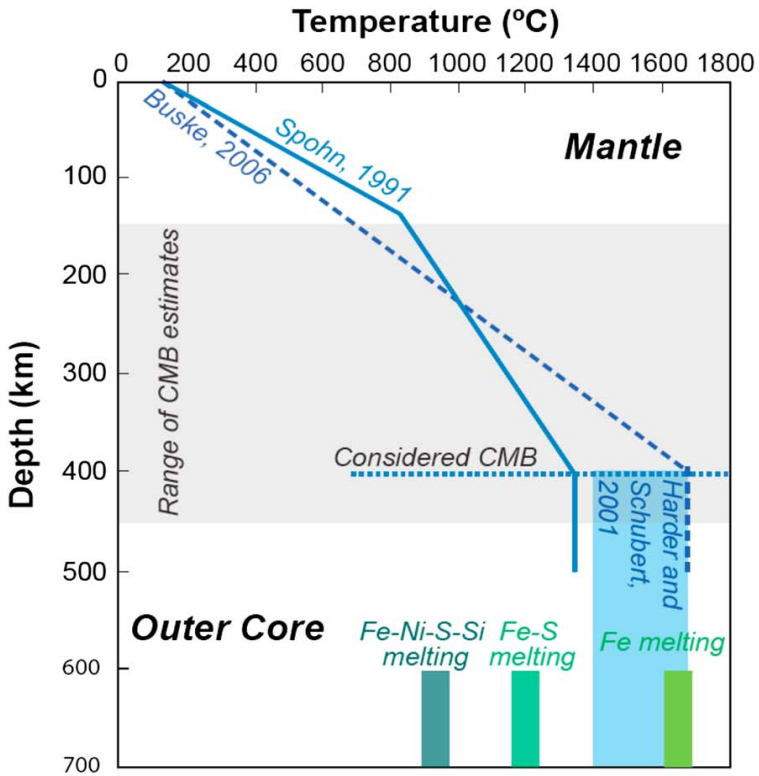
Polycrystalline olivine Fo_{77}
P = 6 GPa

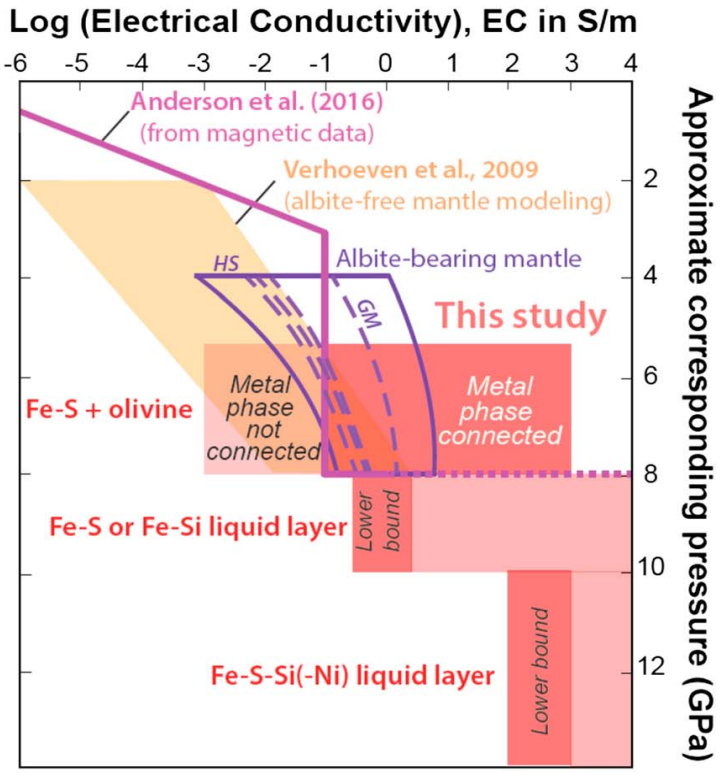




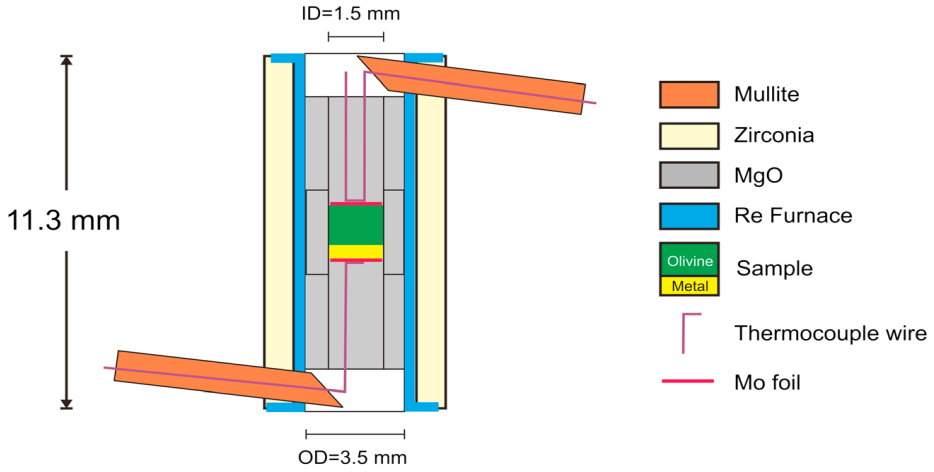
Solidus from Katsura and Ito, 1989 and Ohtani et al., 1998

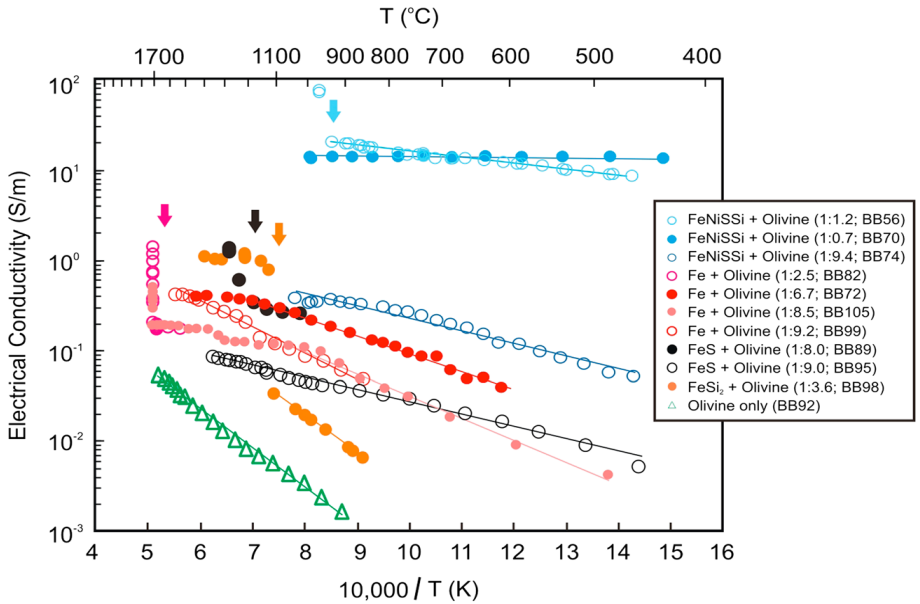
Probing Mercury with electrical measurements





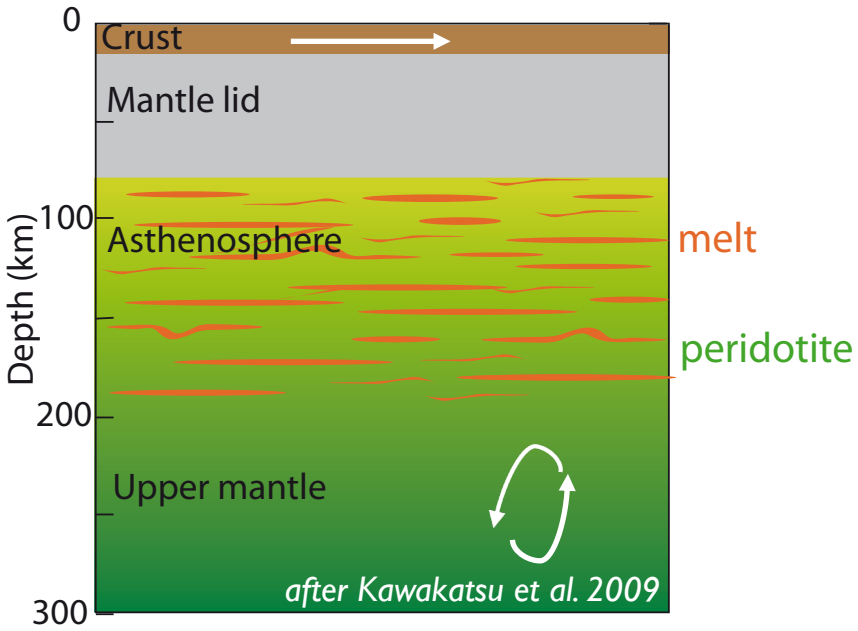
Zhang and Pommier, 2017





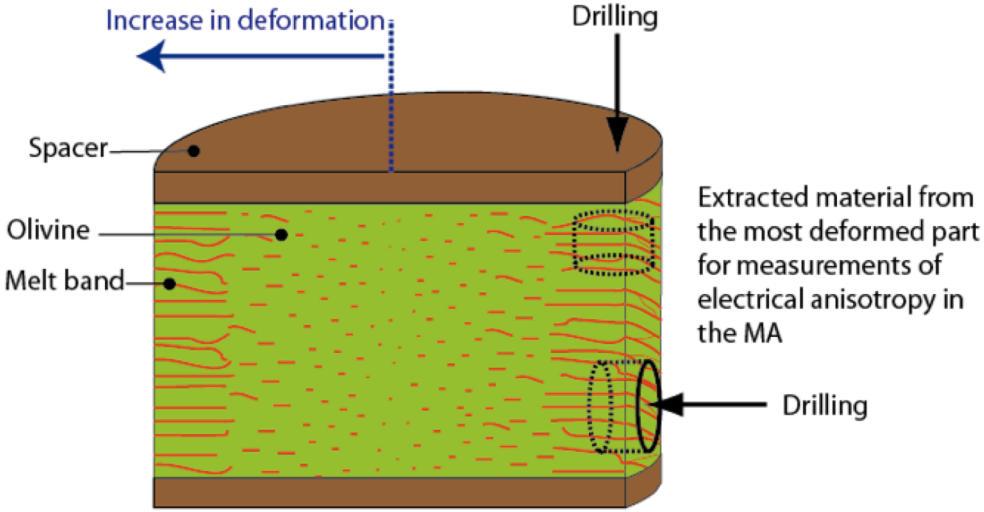
The effect of deformation on conductivity

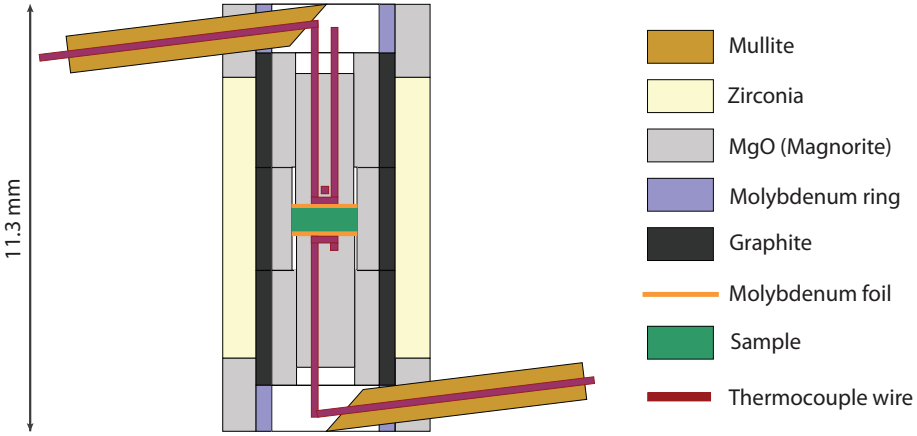
Field



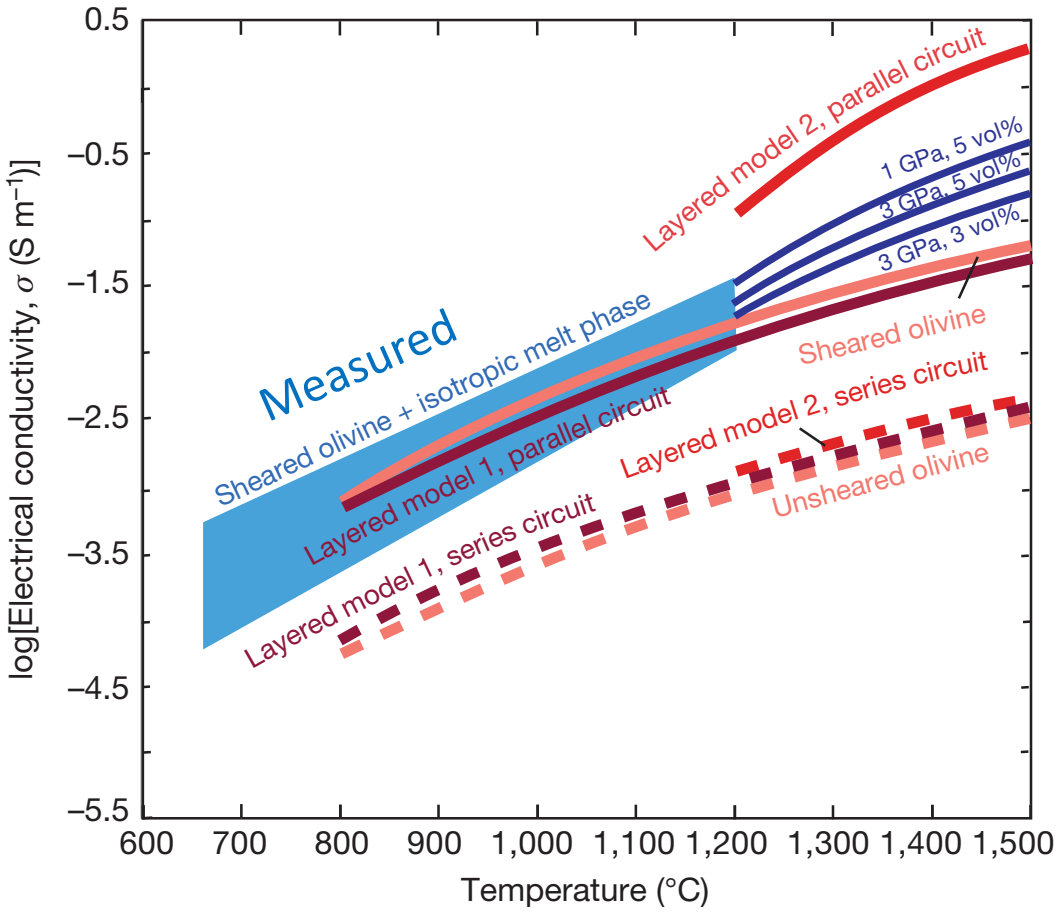
- Synthesis of sheared olivine materials in a Paterson press (UMN) at 1200-1250°C and 300 MPa
- Considered compositions: Fo_{90} + 5 vol.% MORB, Fo_{90} + 2 vol.% $NaKCO_3$ melt, polycrystalline Fo_{90}
- Shear strain from 1 to 9

Laboratory





Electrical results of melt-bearing sheared samples



To model higher anisotropy structures, we developed layered electrical models based on experimental results

Layered model 1 considers layers of sheared olivine alternating with layers of sheared Fo_{90} + 5 vol% MORB

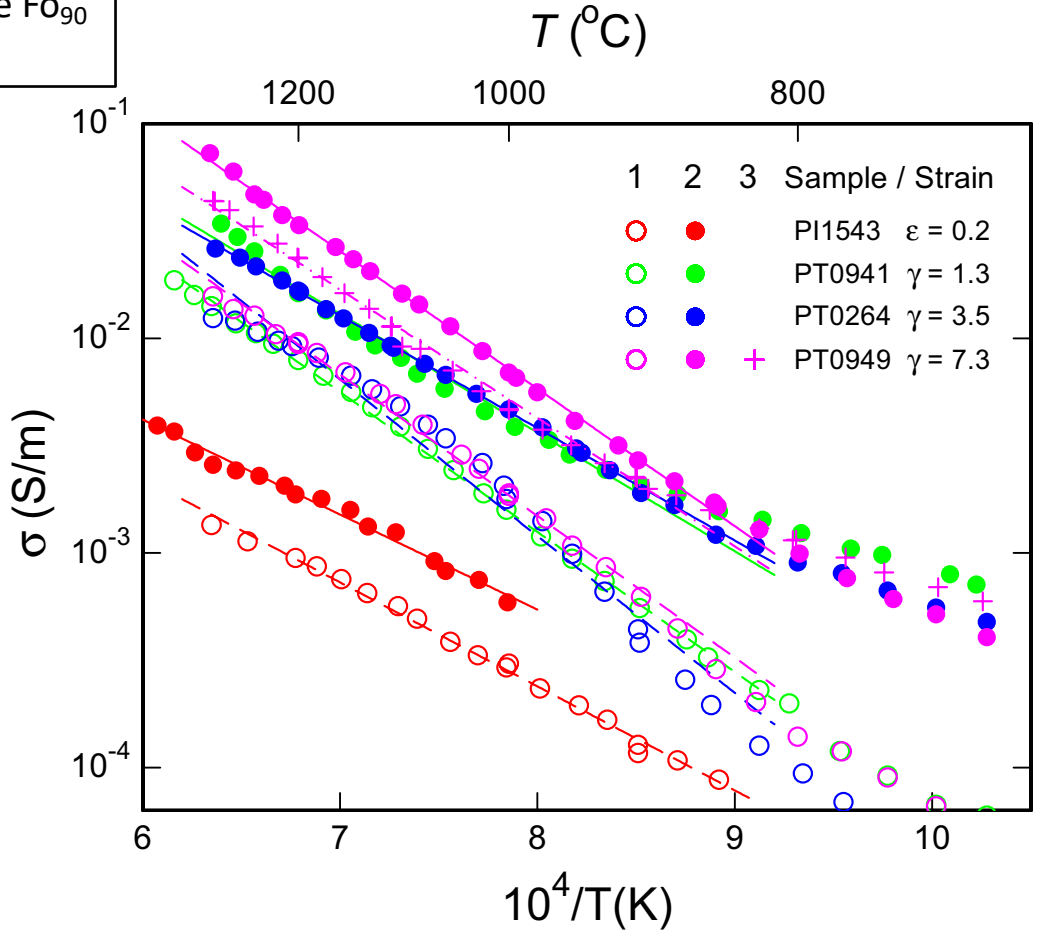
Layered model 2 considers layers of sheared Fo_{90} alternating with layers of 100% basalt

Pommier et al., 2015b

Effect of shear on polycrystalline olivine conductivity

Probing the effect of volatiles and fluids on the conductivity of sheared mantle rocks involves understanding the effect of shear on the conductivity of "dry" materials

"Dry" polycrystalline Fo_{90} at 3 GPa



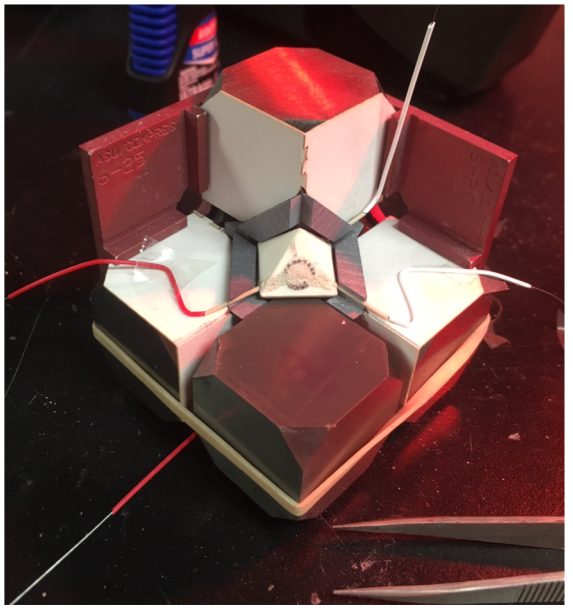
- Conductivity depends on the orientation, with highest conductivities measured in the direction of deformation
- Electrical anisotropy is high at low T
- Melt is not requested to have electrical anisotropy (in contrast with results by Zhang et al., 2014)

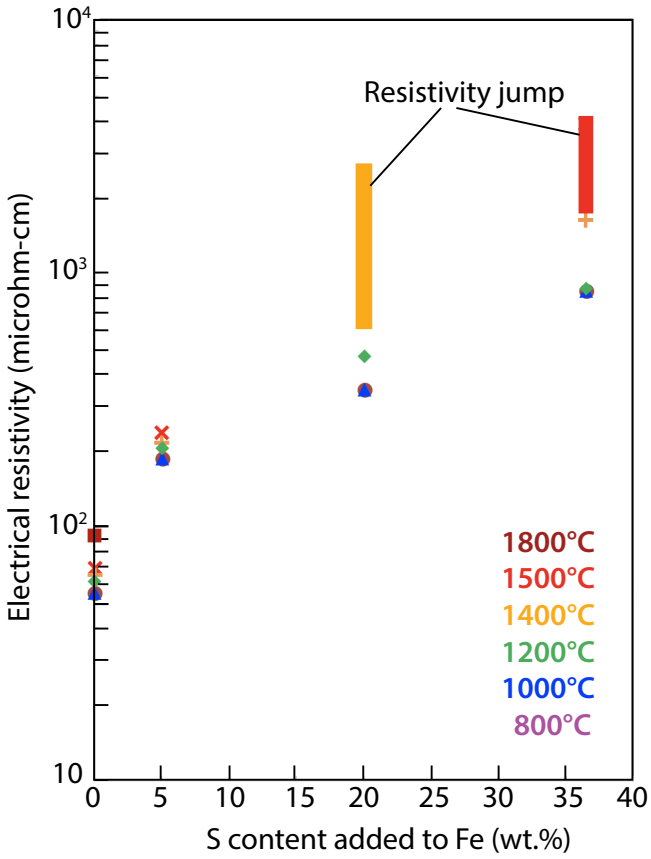
Pommier et al., 2018a

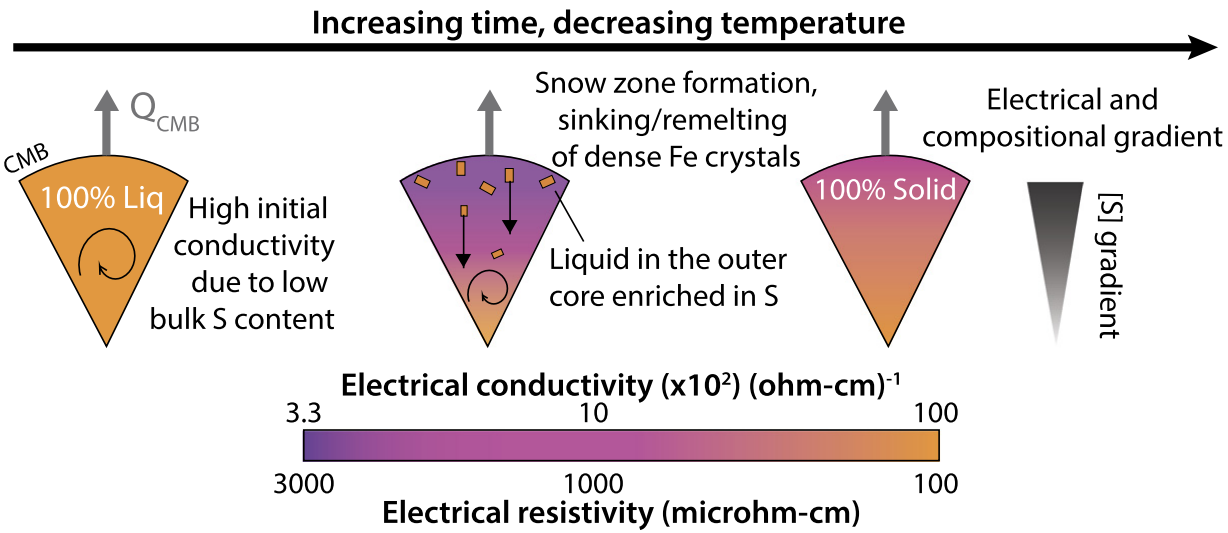
Electrical conductivity and core cooling

Poster today!
(application to Ganymede's core)

- 4-electrode experiments on iron alloys (Fe-S, Fe-Si, Fe-S-Si, Fe-S-O systems)
- Pressure up to 10 GPa



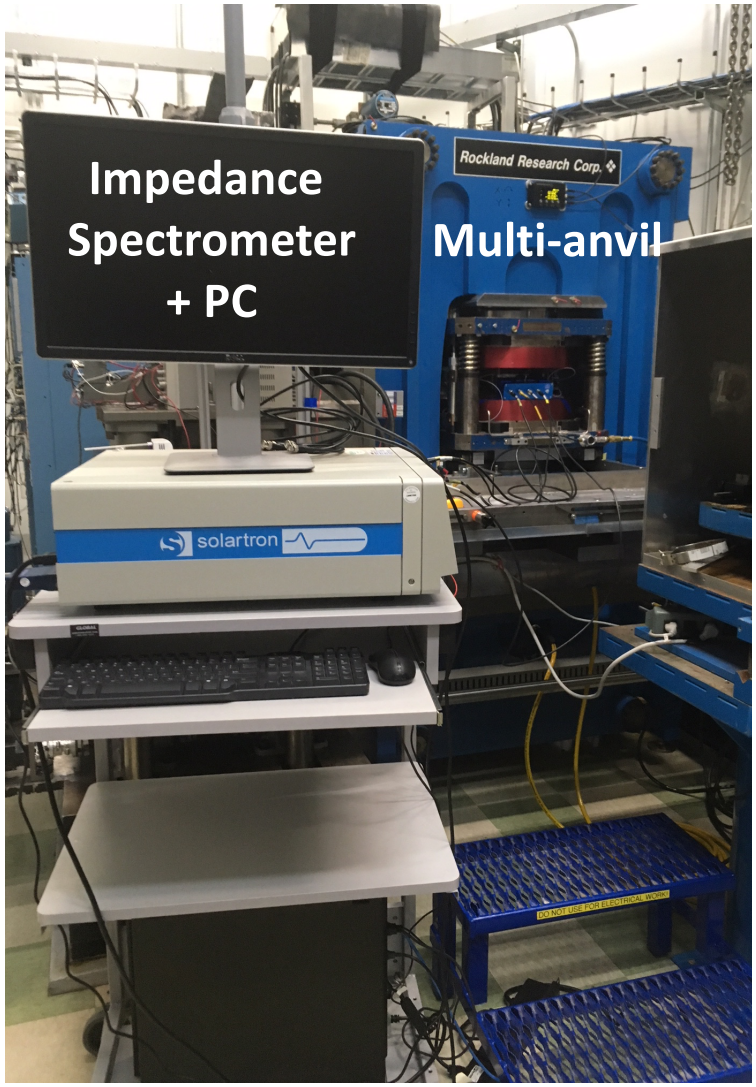




Pommier, 2018

Ongoing development : Electrical + viscosity measurements at APS-GSECARS 13-ID-D

Collaboration with Yanbin Wang (APS) and Kurt Leinenweber (ASU)



- First successful test on olivine (Fo_{90})
- Development of a viscosity-conductivity cell for simultaneous measurements of transport and structural properties in melts
- Impedance spectrometer will be made available to any interested GSECARS users

Concluding remarks

- Electrical conductivity is a relevant tool to probe planetary interiors
- It is sensitive to (even small) changes in temperature, chemistry, fluid phase interconnectivity, and also deformation (grain boundary paths)
- Chemistry has a key role in crystallization processes during planetary cooling and influences the heat flow (insulating vs. conductive properties) as well as the magnetic field
- Many unknowns remain, such as the effect of chemistry on the cooling rate and heat flow and hence the generation of a magnetic field, …

Thank you for your attention