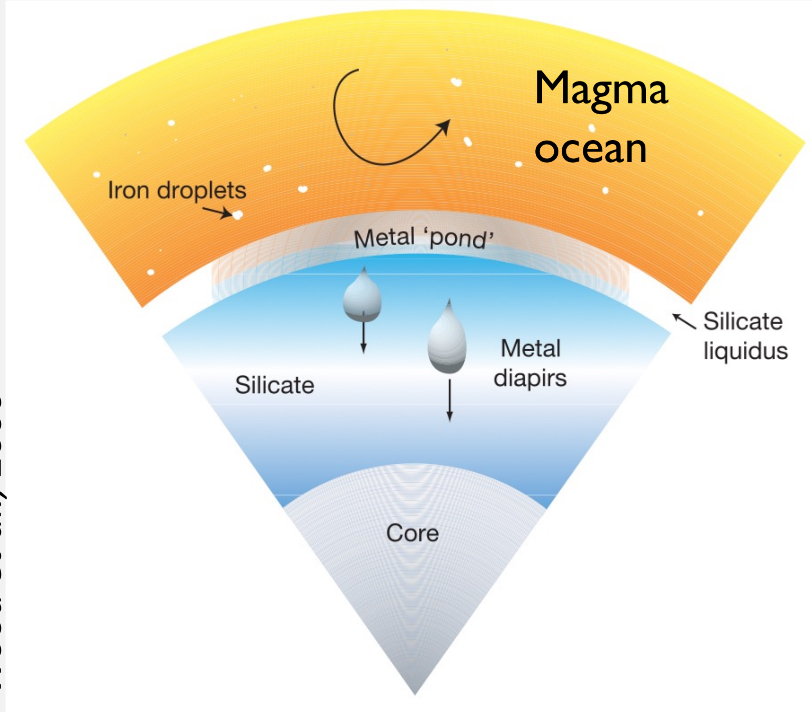
Chemical Analysis of Trace Elements at the Nanoscale in Samples Recovered From Laser-Heated Diamond Anvil Cell Experiments

Ingrid Blanchard

S. Petitgirard, V. Laurenz, N. Miyajima, M. Wilke, D. C. Rubie, S. S. Lobanov, L. Hennet, W. Morgenroth, R. Tucoulou, V. Bonino, X. Zhao, I. Franchi

FRAMEWORK: DIFFERENTIATION OF THE EARTH

4.5 Gyrs ago: Most important fractionation event during Earth history



Wood et al., 2006

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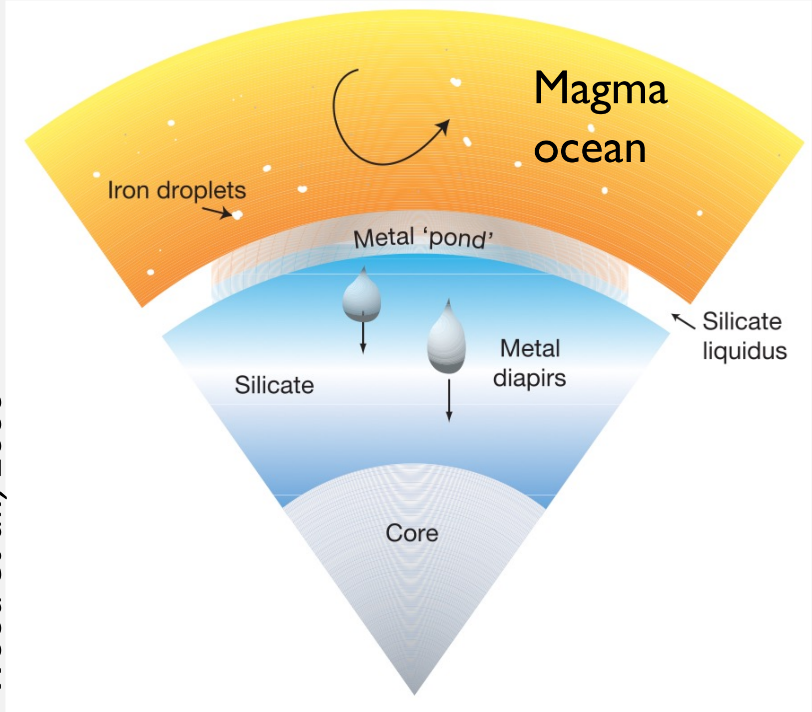

Wood et al., 2006

$$D_M = \frac{X_M^{core}}{X_{\mathrm{MO}_{n/2}}^{mantle}}$$

$$D_M = f(P, T, X_i, fO_2)$$

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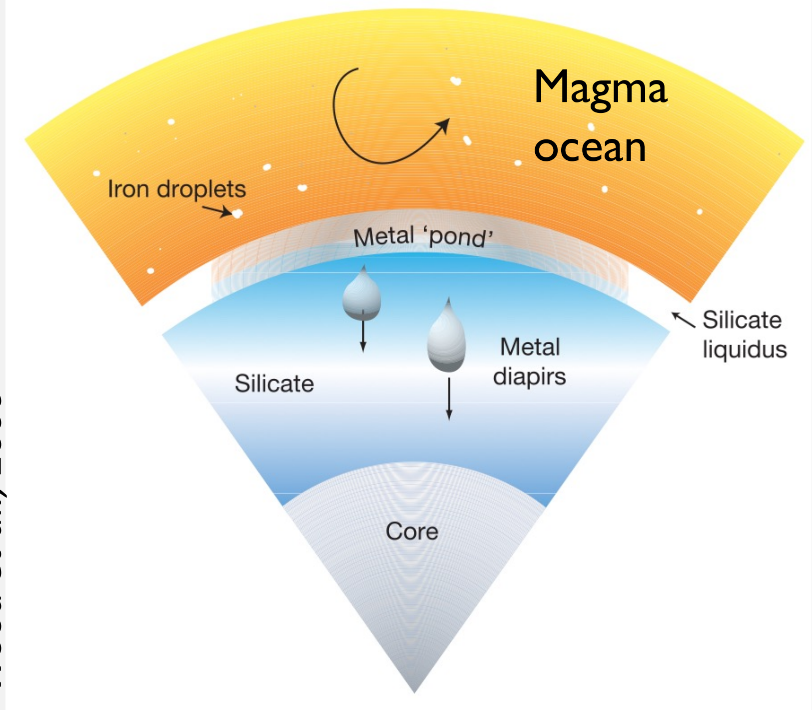


Wood et al., 2006

$$D_M = \frac{X_M^{core}}{X_{MO_{n/2}}^{mantle}}$$

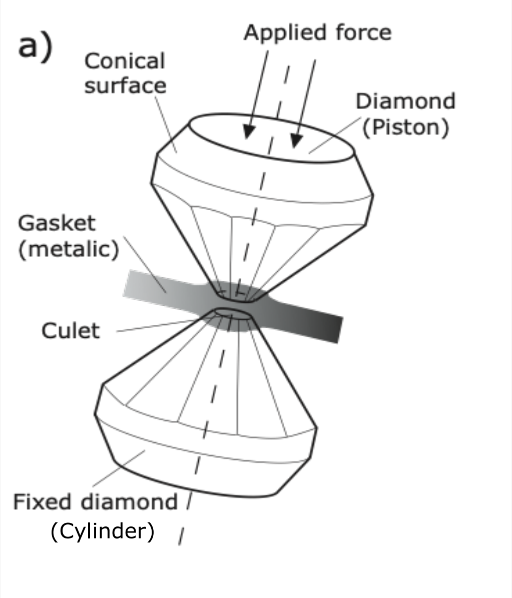
$$D_M = f(P, T, X_i, fO_2)$$

Chemical composition of mantle and core inherited from this episode

High pressure-temperature conditions

Elements of interest: siderophile elements diluted in silicate

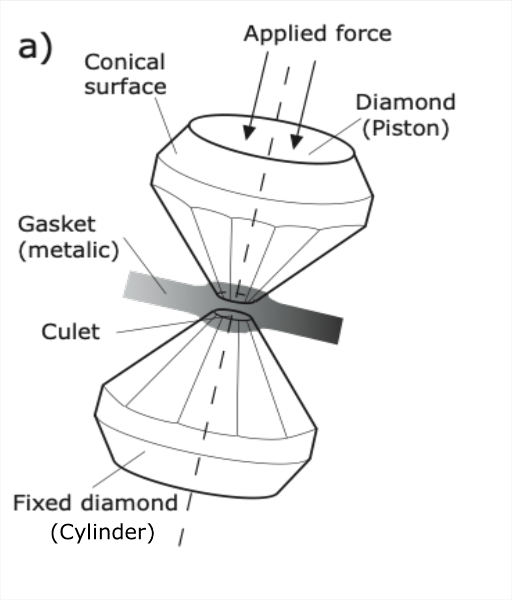
HIGH P–T EXPERIMENTS

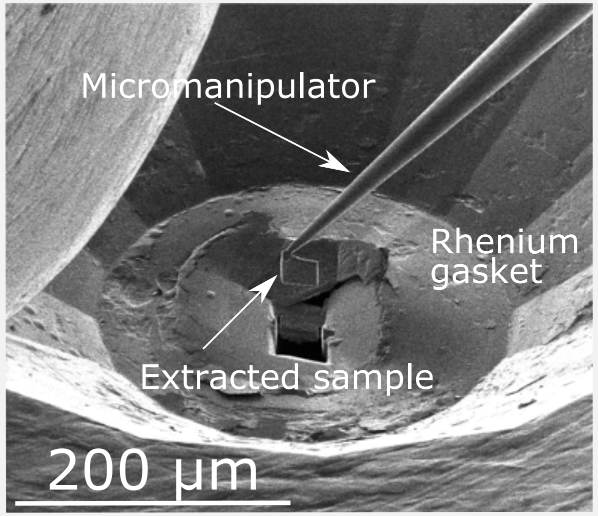


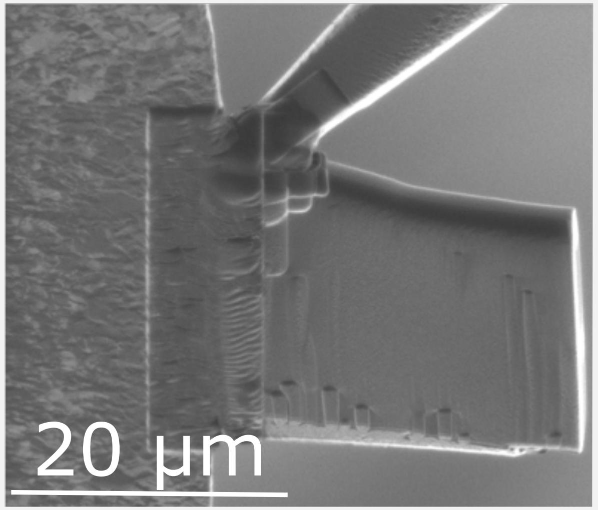
P > 40 GPa

T > 3000 K

HIGH P–T EXPERIMENTS







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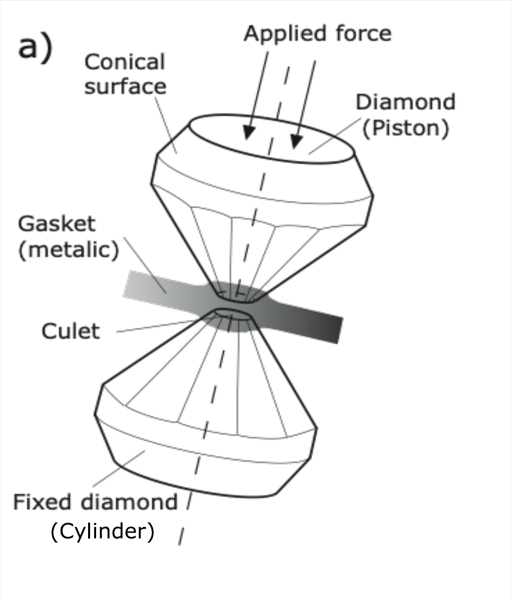

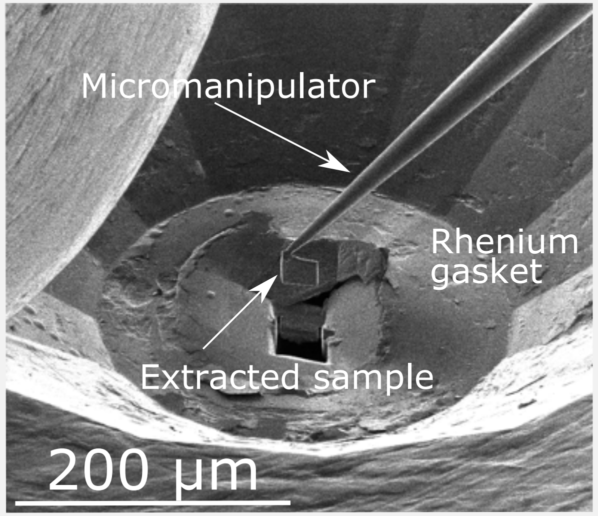

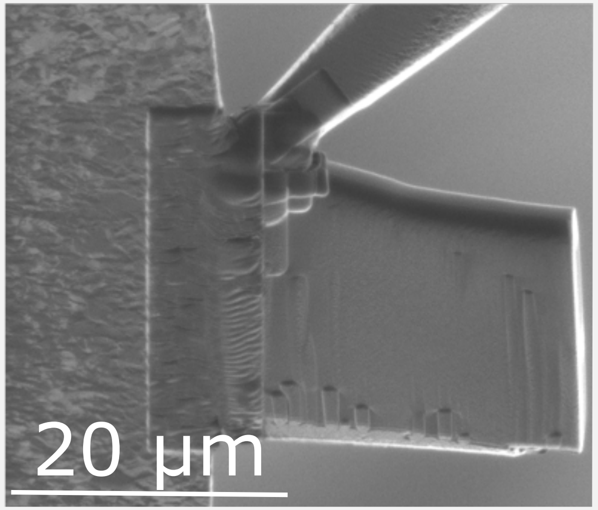

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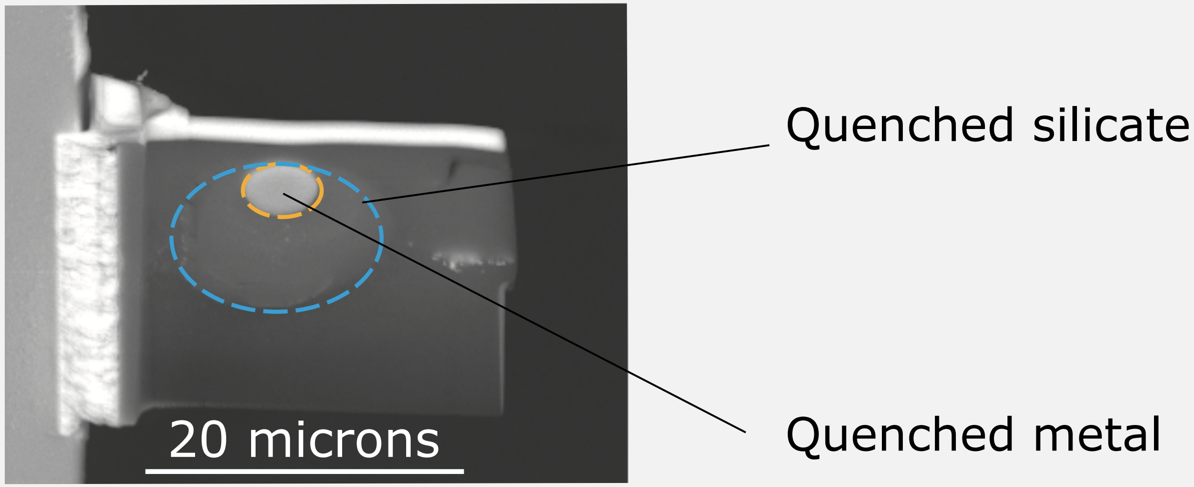
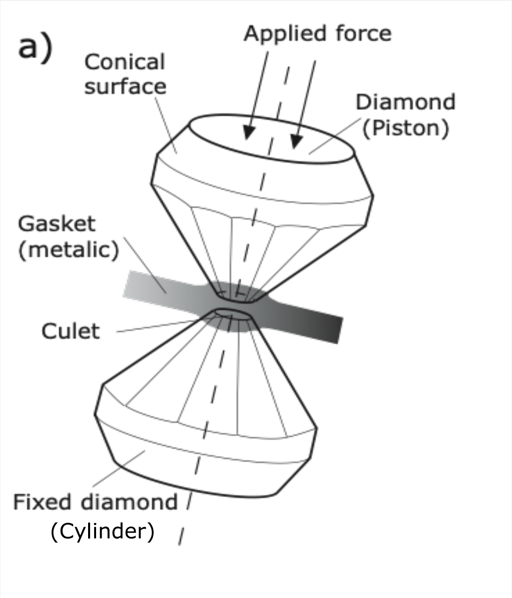
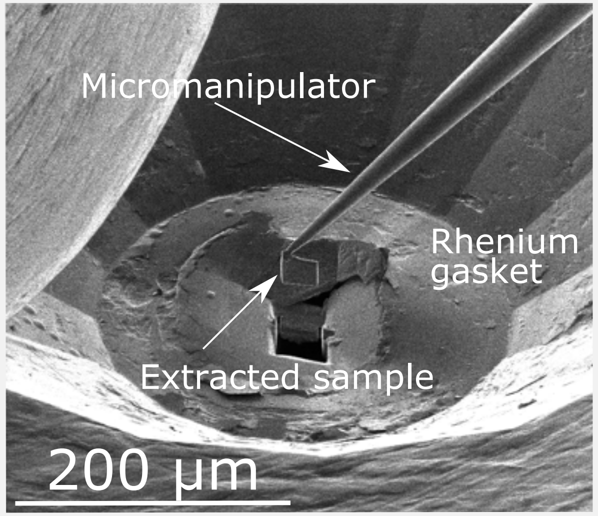
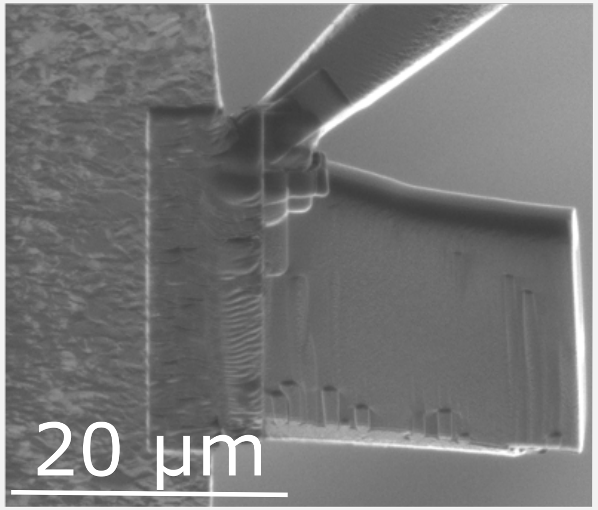


3 microns thickness

HIGH P–T EXPERIMENTS







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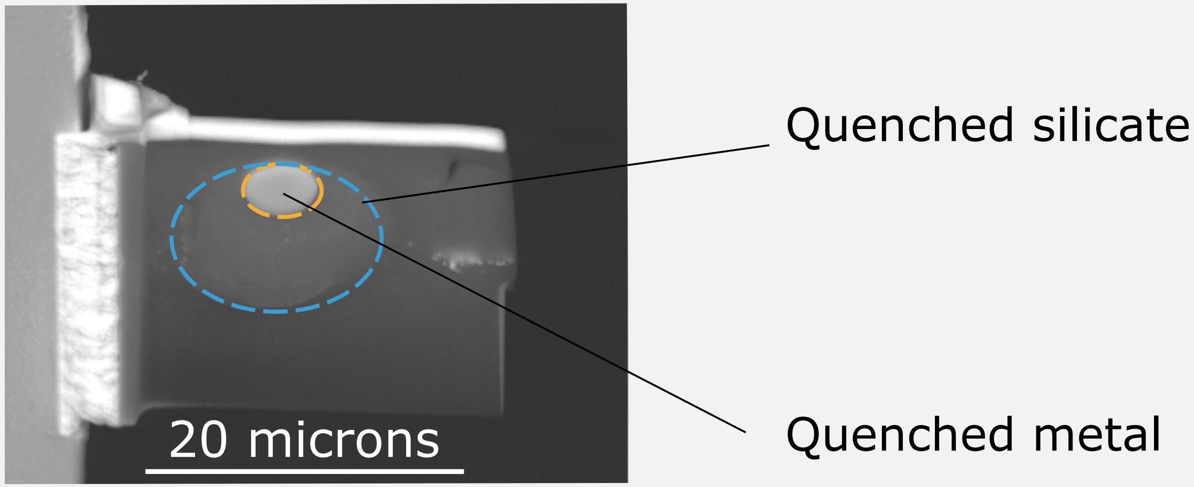


3 microns thickness

Very small run products: impossible to use traditionnal methods to analyse trace elements

ANALYTICAL TECHNIQUES

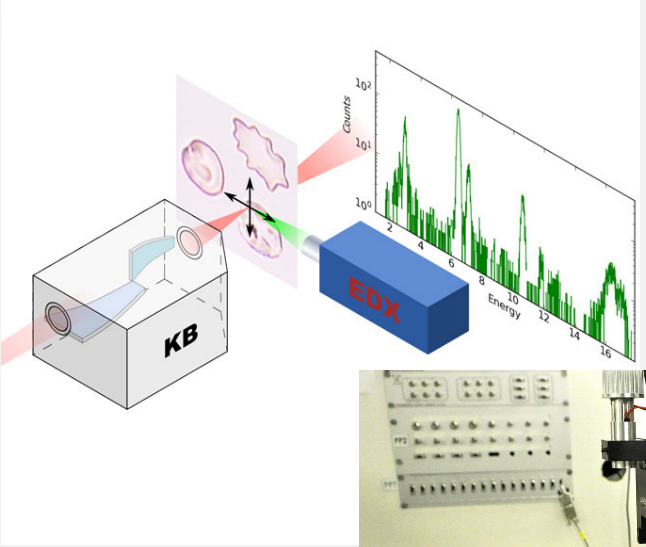
NANO-XRF

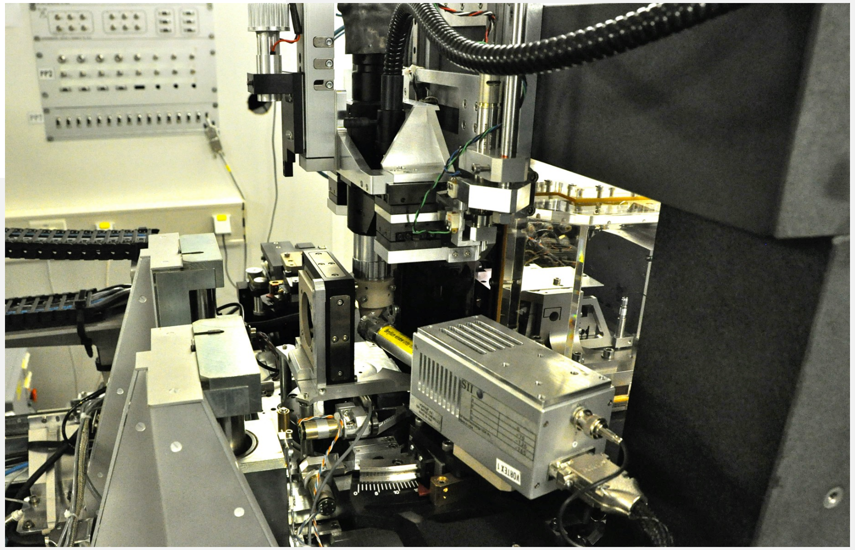
NANOSIMS

ANALYTICAL TECHNIQUES

NANO-XRF

60 x 60 nm beam
Monochromatic mode and high brilliance
High sensitivity for heavy elements
Non destructive





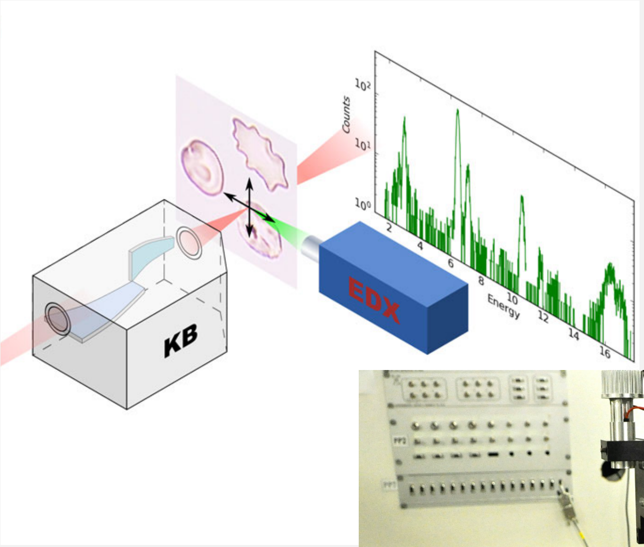
ESRF

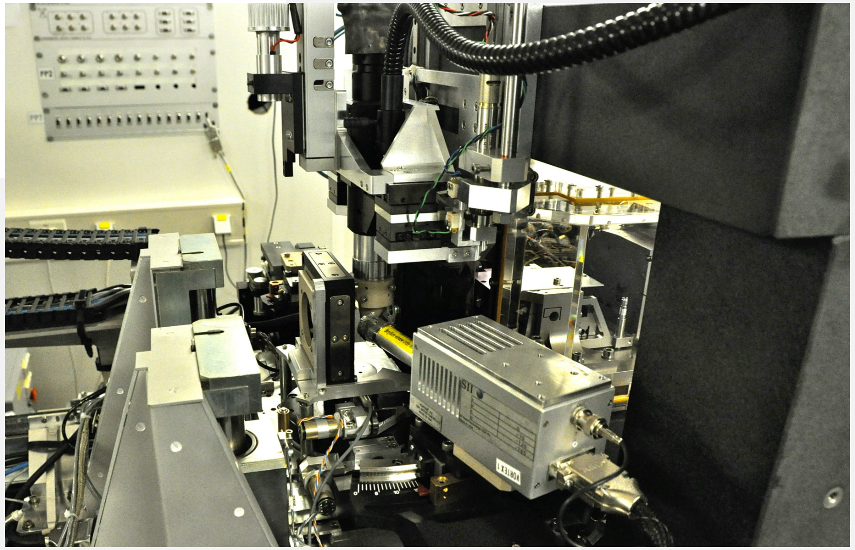
NANOSIMS

ANALYTICAL TECHNIQUES

NANO-XRF

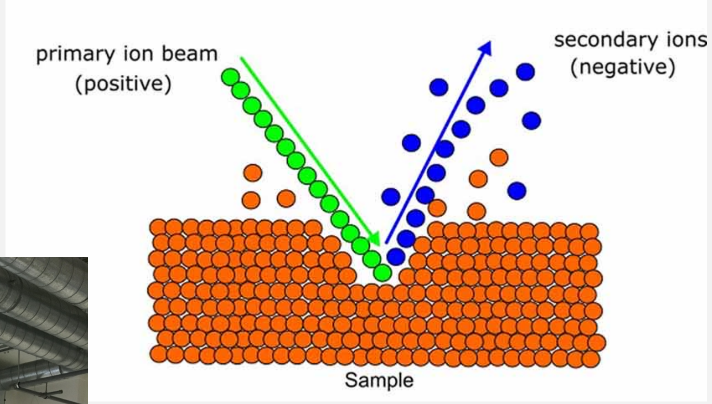
60 x 60 nm beam
Monochromatic mode and high brilliance
High sensitivity for heavy elements
Non destructive

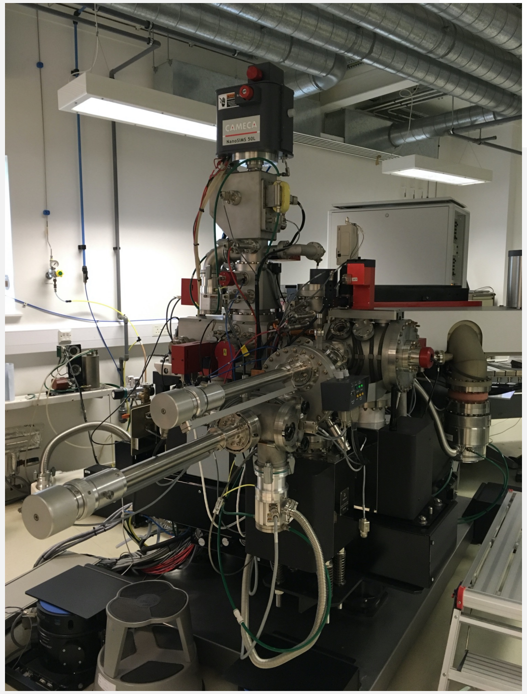




NANOSIMS

Spatial resolution : 300 nm
Highly focused beam of O^-
Destructive



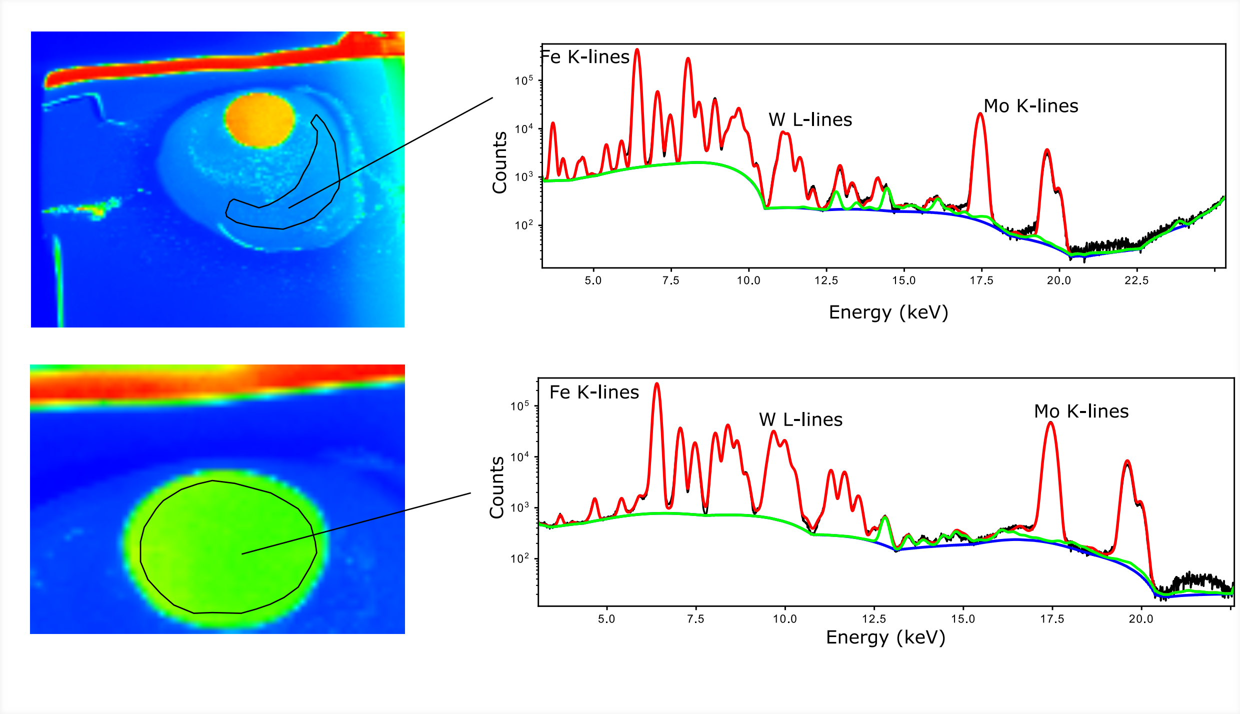


Bonnin and Rizzoli, 2020

ANALYTICAL TECHNIQUES

NANO-XRF

- Mo/Fe and W/Fe for the metal
- Mo/Si and W/Si for the silicate



NANOSIMS

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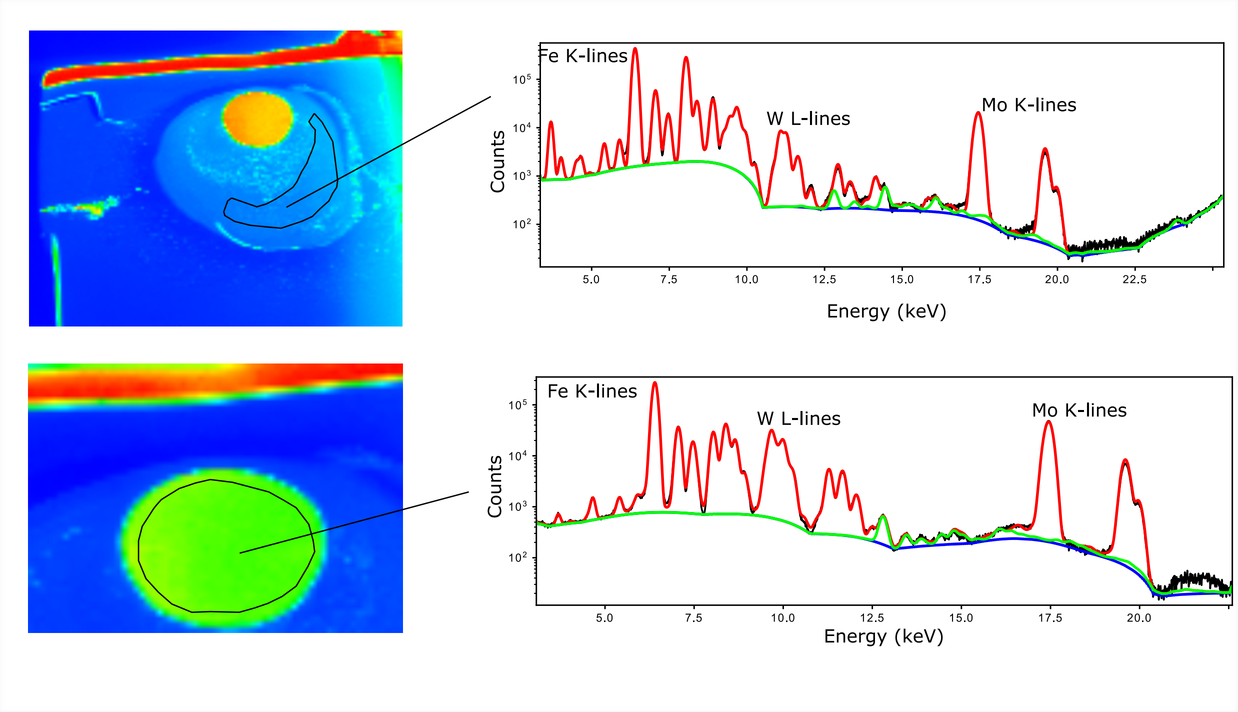
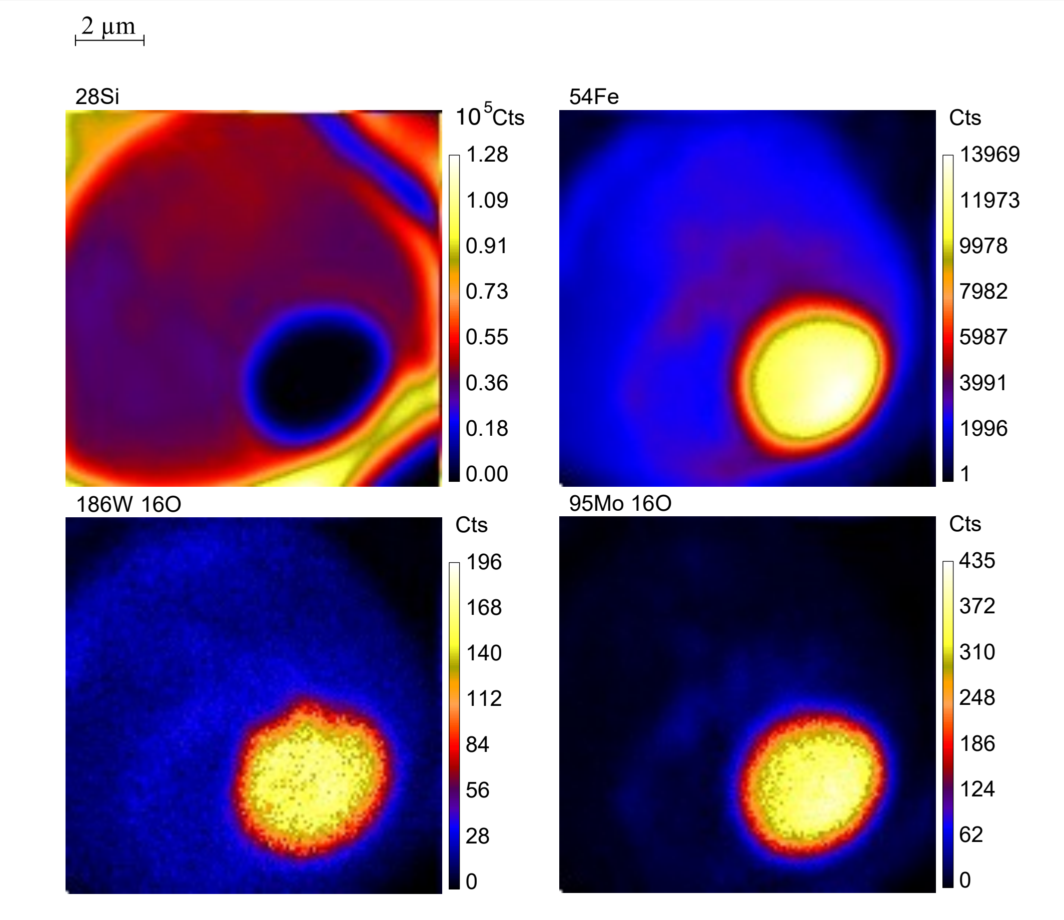


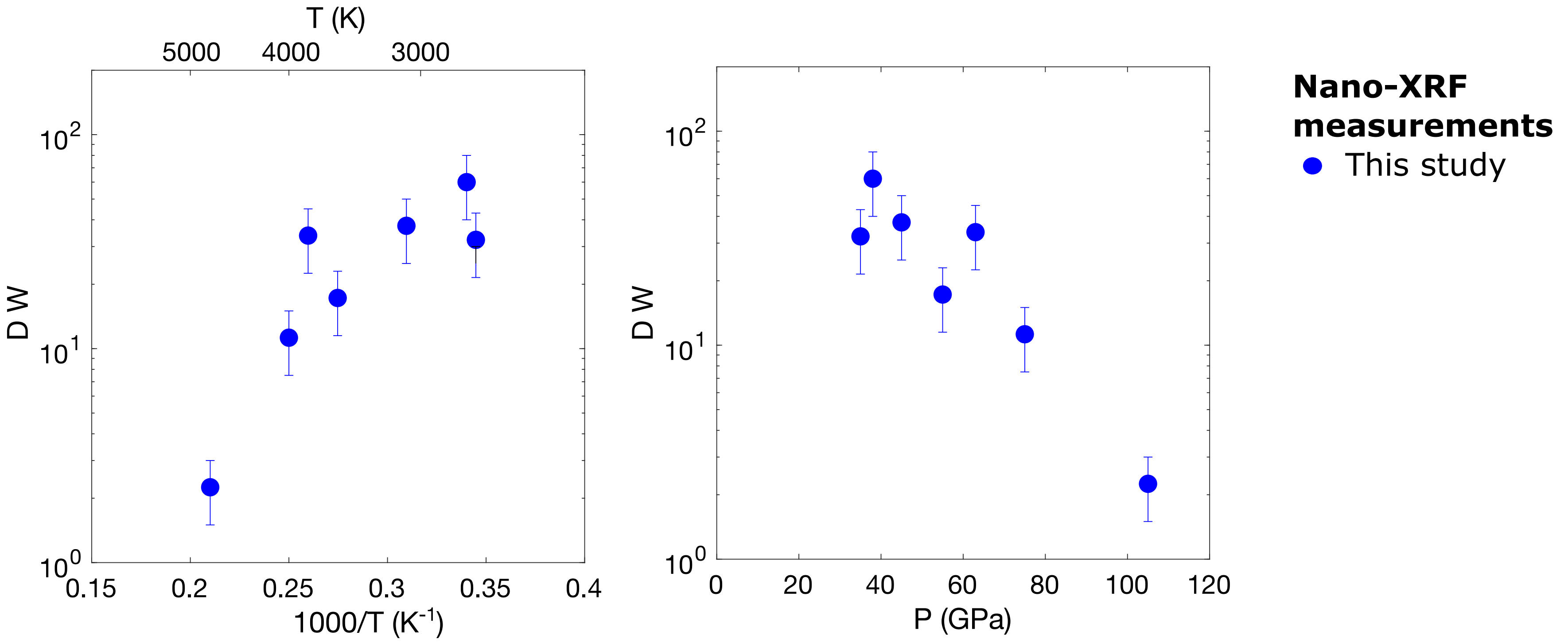
NANOSIMS

$^{95}Mo/^{54}Fe$ and $^{186}W/^{54}Fe$ for the metallic part
$^{95}Mo/^{30}Si$ and $^{186}W/^{30}Si$ for the silicate part



RESULTS FOR MODERATELY SIDEROPHILE ELEMENTS

$$D_M = \frac{X_M^{core}}{X_{\mathrm{MO}_{n/2}}^{mantle}}$$



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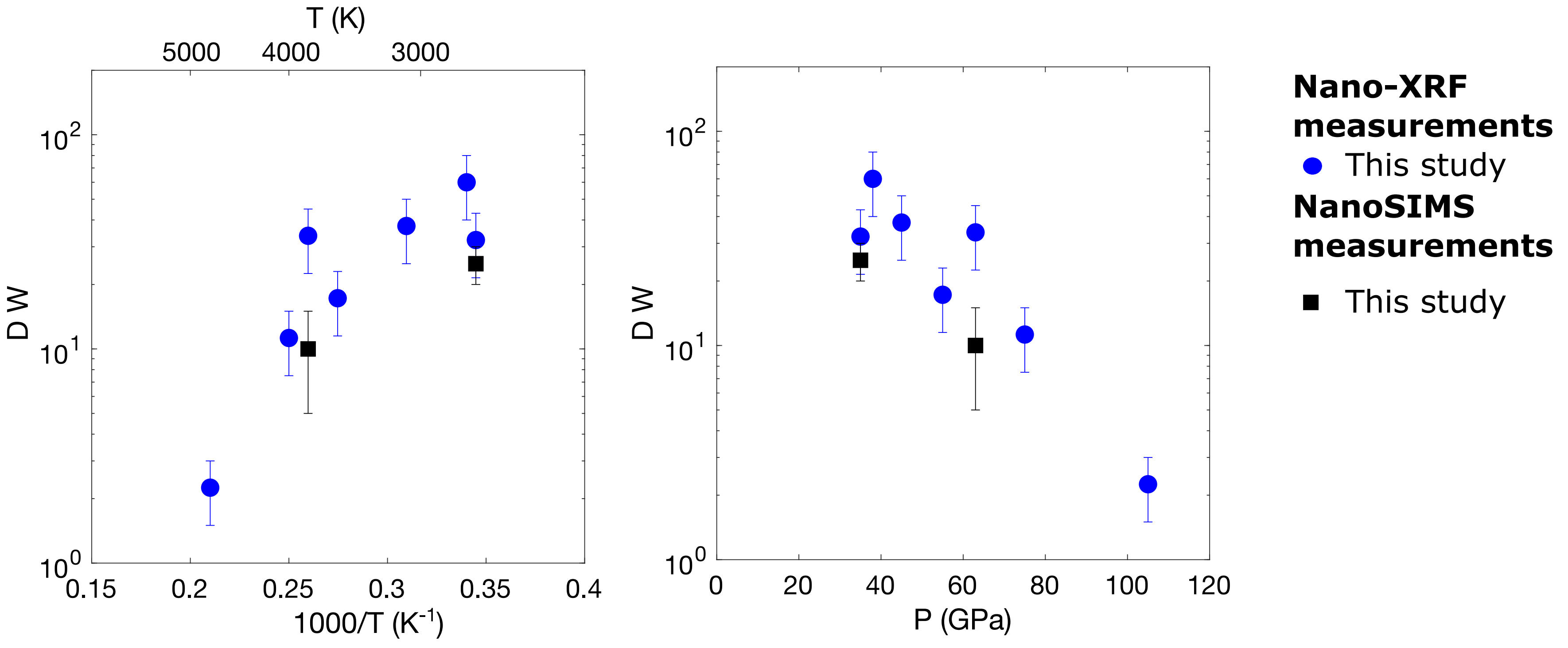

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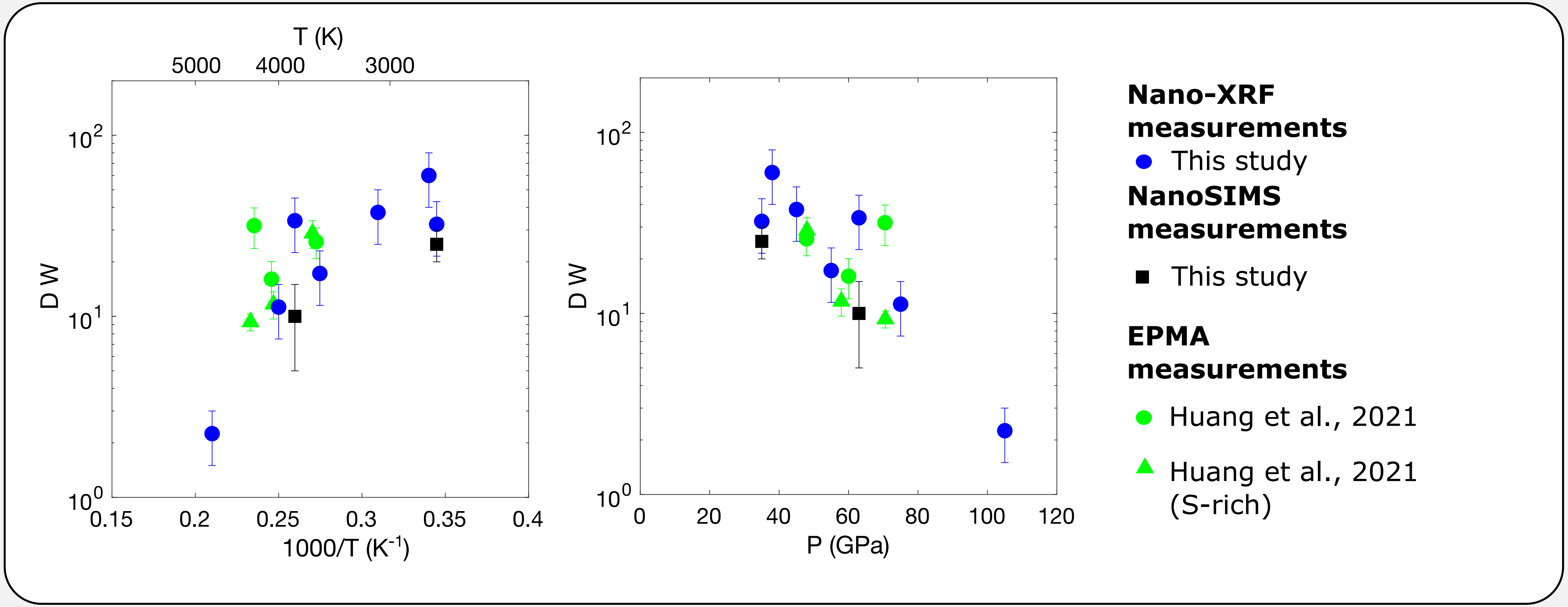

Excellent agreement between our data obtained by nano-XRF, NanoSIMS and literature's data obtained using conventional EPMA measurements.

CONCLUSIONS

- First tests to analyse MSEs in silicate melts using nano-XRF at the synchrotron and NanoSIMS.
- Study on bulk and FIB lamella standards showing the importance of geometry for nano-XRF
- High elemental sensitivity (down to few ppm)
- High spatial resolution (~ 100 nm)
- Promising technique to better constrain the behavior of HSEs during core formation, solid-solid and solid-liquid trace element

Blanchard et al., (2022b) Chemical Analysis of Trace Elements at the Nanoscale in Samples Recovered from Laser-Heated Diamond Anvil Cell Experiments

Physics and Chemistry of Minerals (special issue : *Experimental & Analytical techniques at extreme and ambient conditions*)