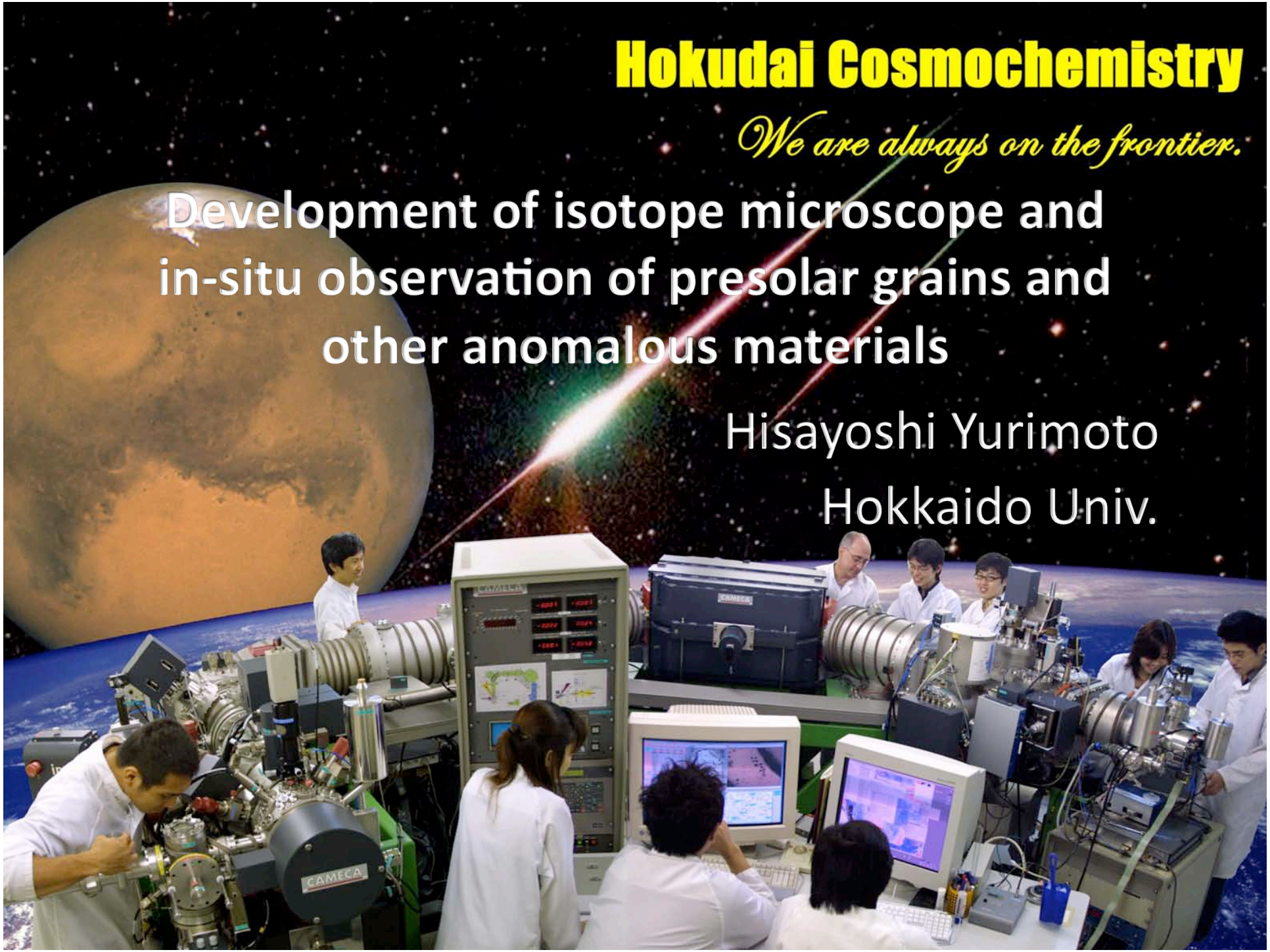
Hokudai Cosmochemistry

We are always on the frontier.

Development of isotope microscope and in-situ observation of presolar grains and other anomalous materials

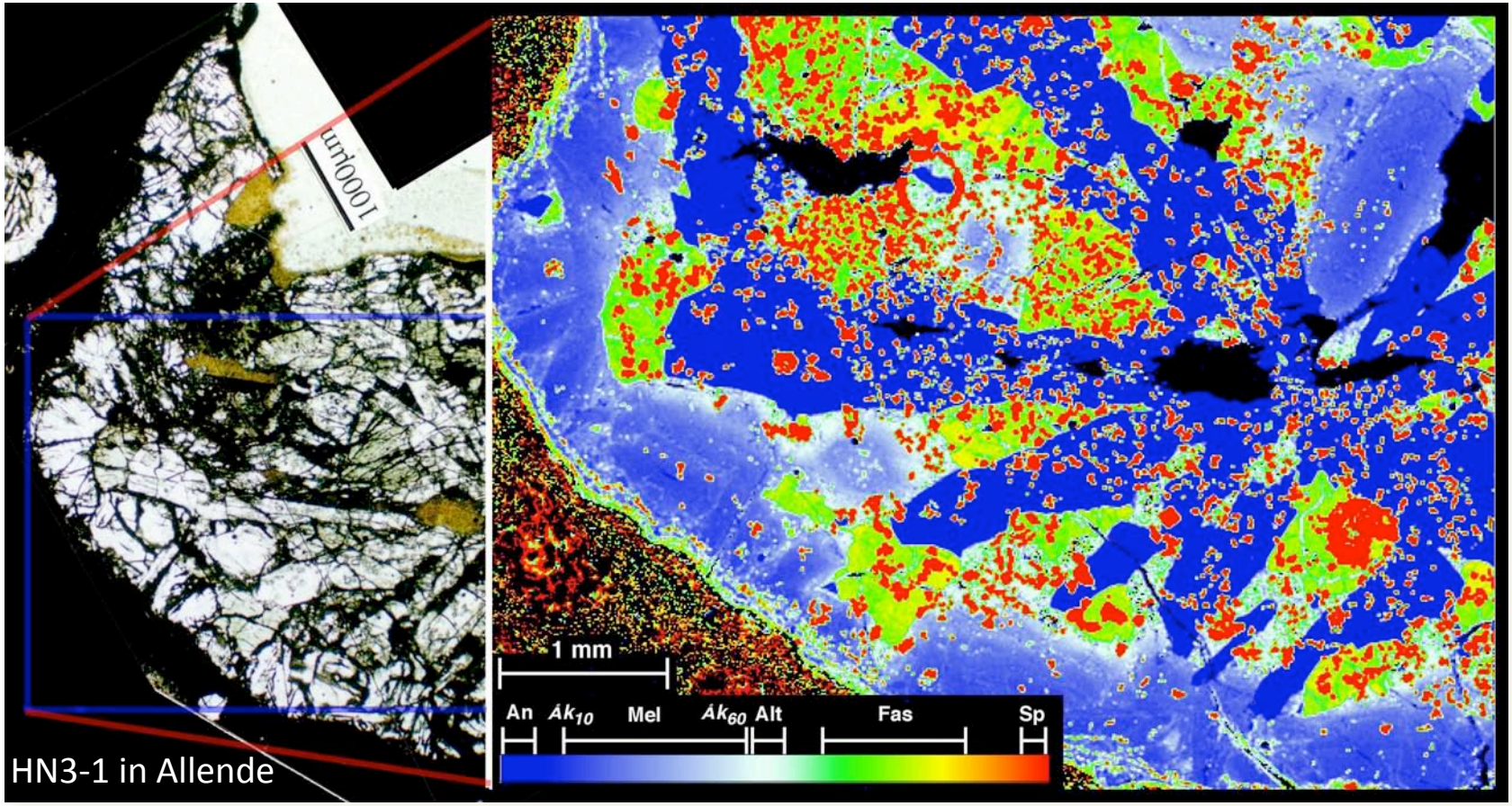
Hisayoshi Yurimoto
Hokkaido Univ.



Outline

- Paradox between chemical and isotope petrography of CAIs
- Point to Line SIMS analysis
- Development of isotope microscope
- Advancement of Isotopography
- Astrophysical dynamic setting for CAI formation
- Surprises
  - Presolar grains
  - Cosmic symplectite (COS)
- Development of isotope nanoscope

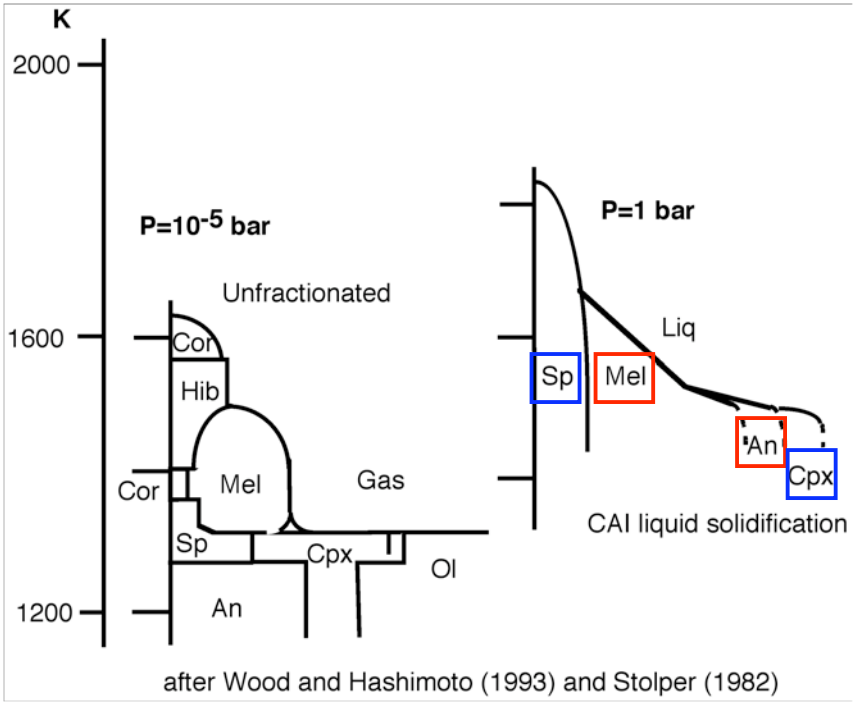
Petrography of Coarse-grained CAIs



- Crystallized from a liquid droplet
  - Mineral assemblage
  - Chemical petrography of minerals

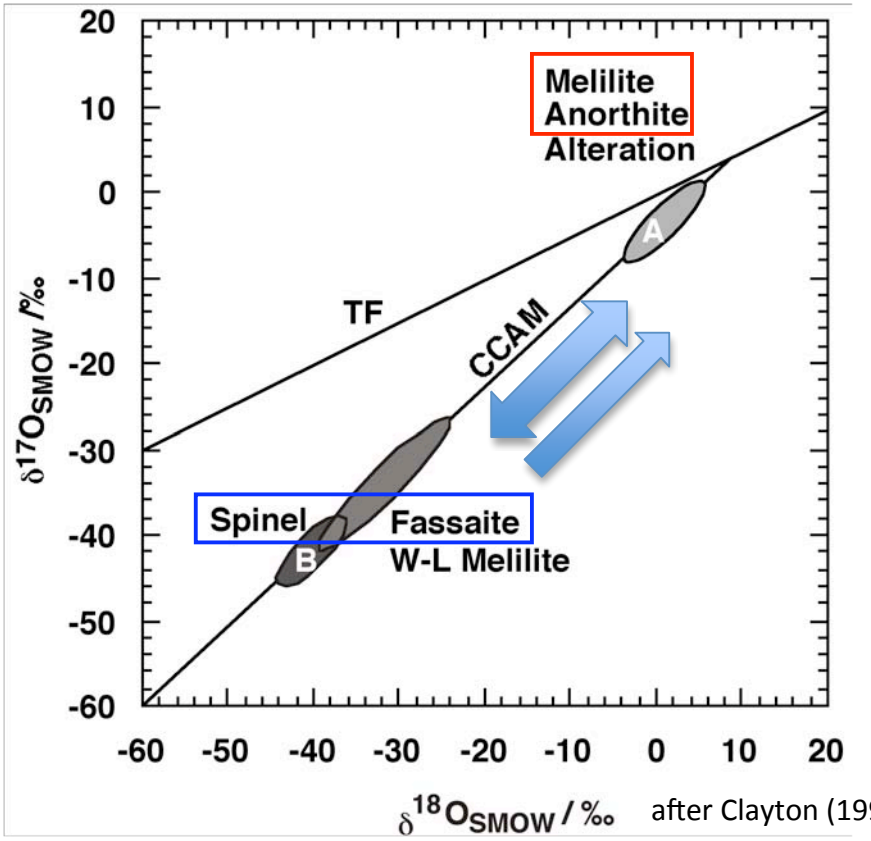
Coarse-grained CAIs

Crystallization sequence



after Wood and Hashimoto (1993) and Stolper (1982)

Isotope distribution



after Clayton (1993)

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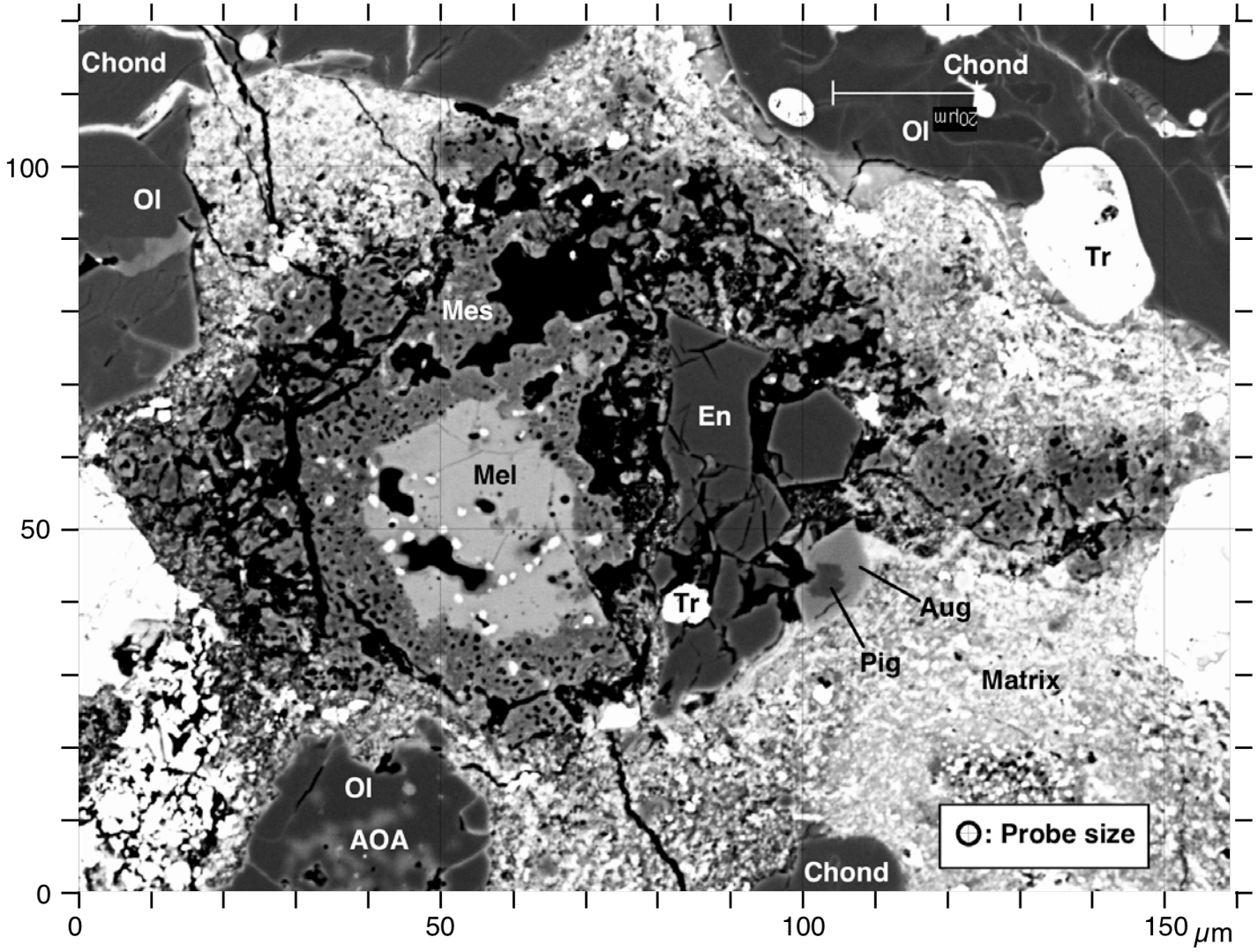
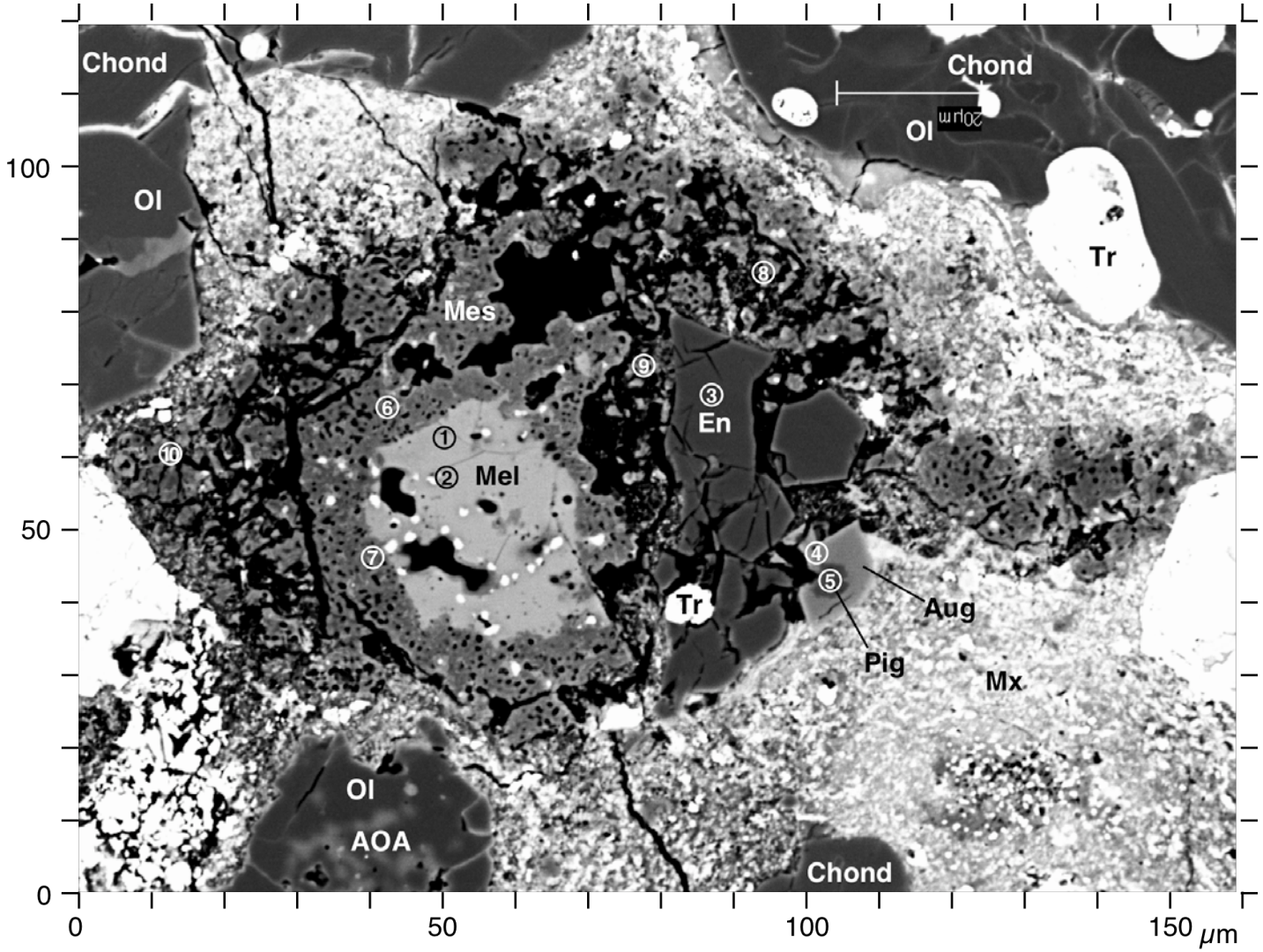
Point to Line analysis 1



A5 in Y-81020 (Nature, 2003)

Point to Line analysis 1



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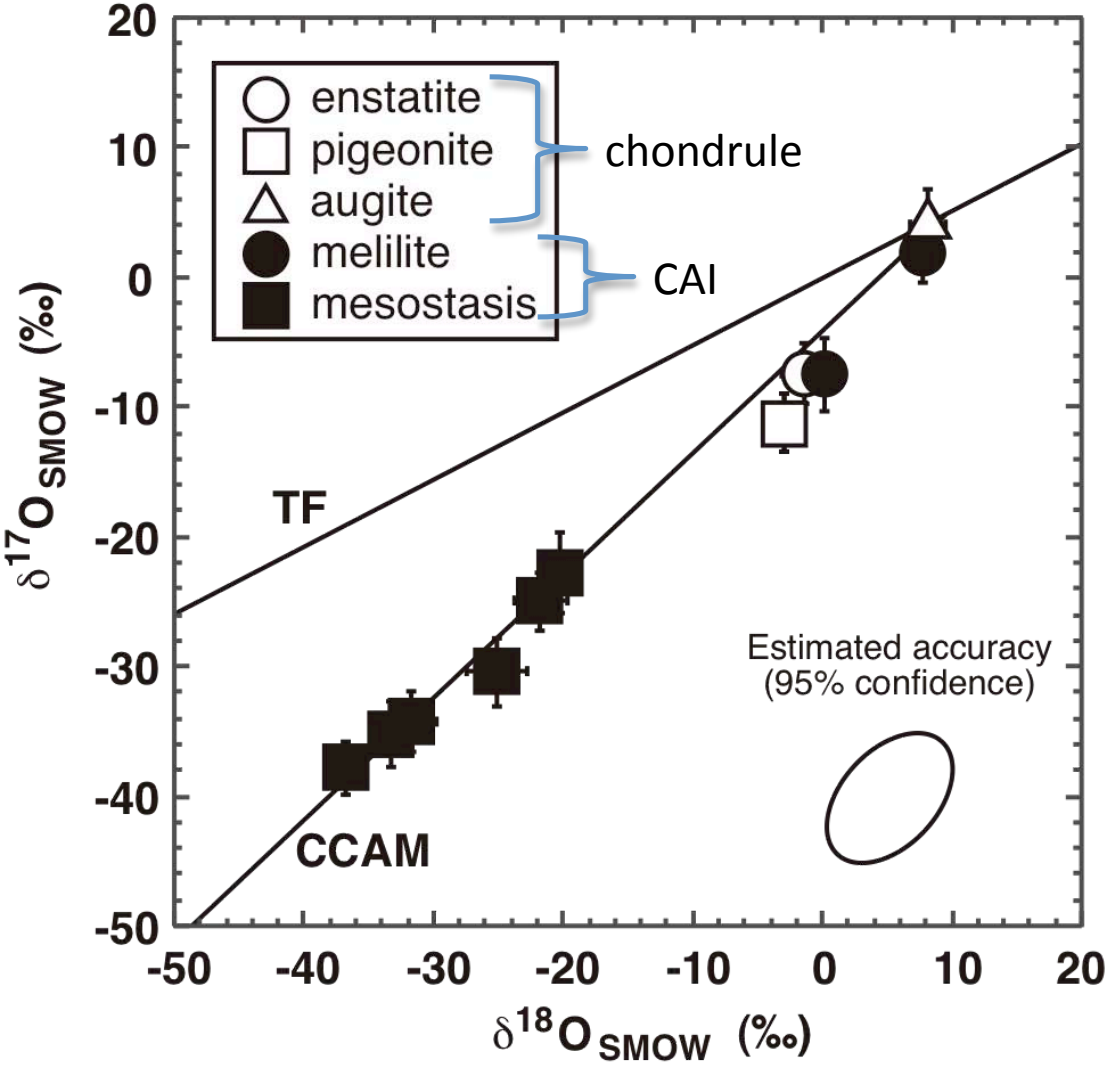

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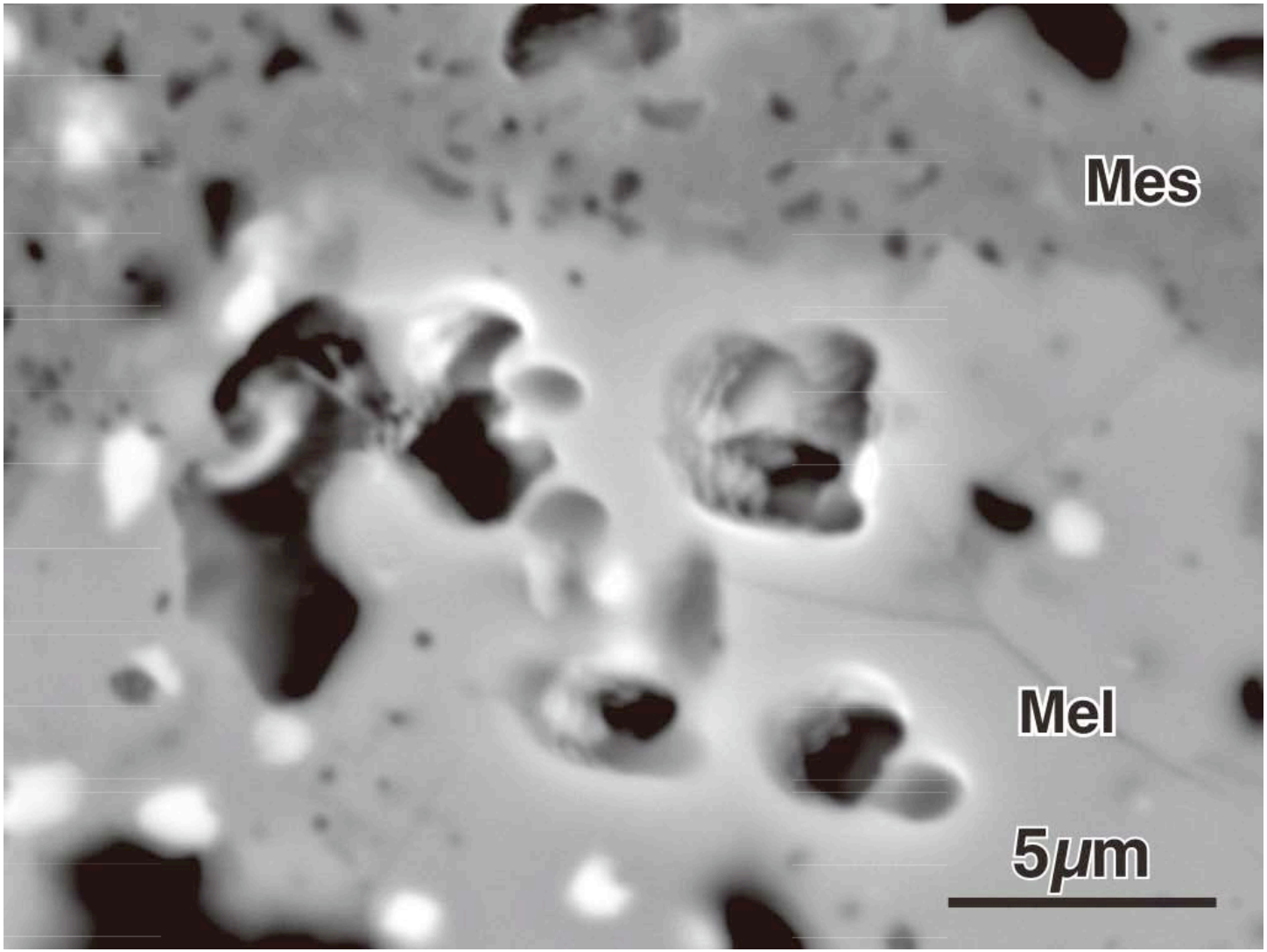

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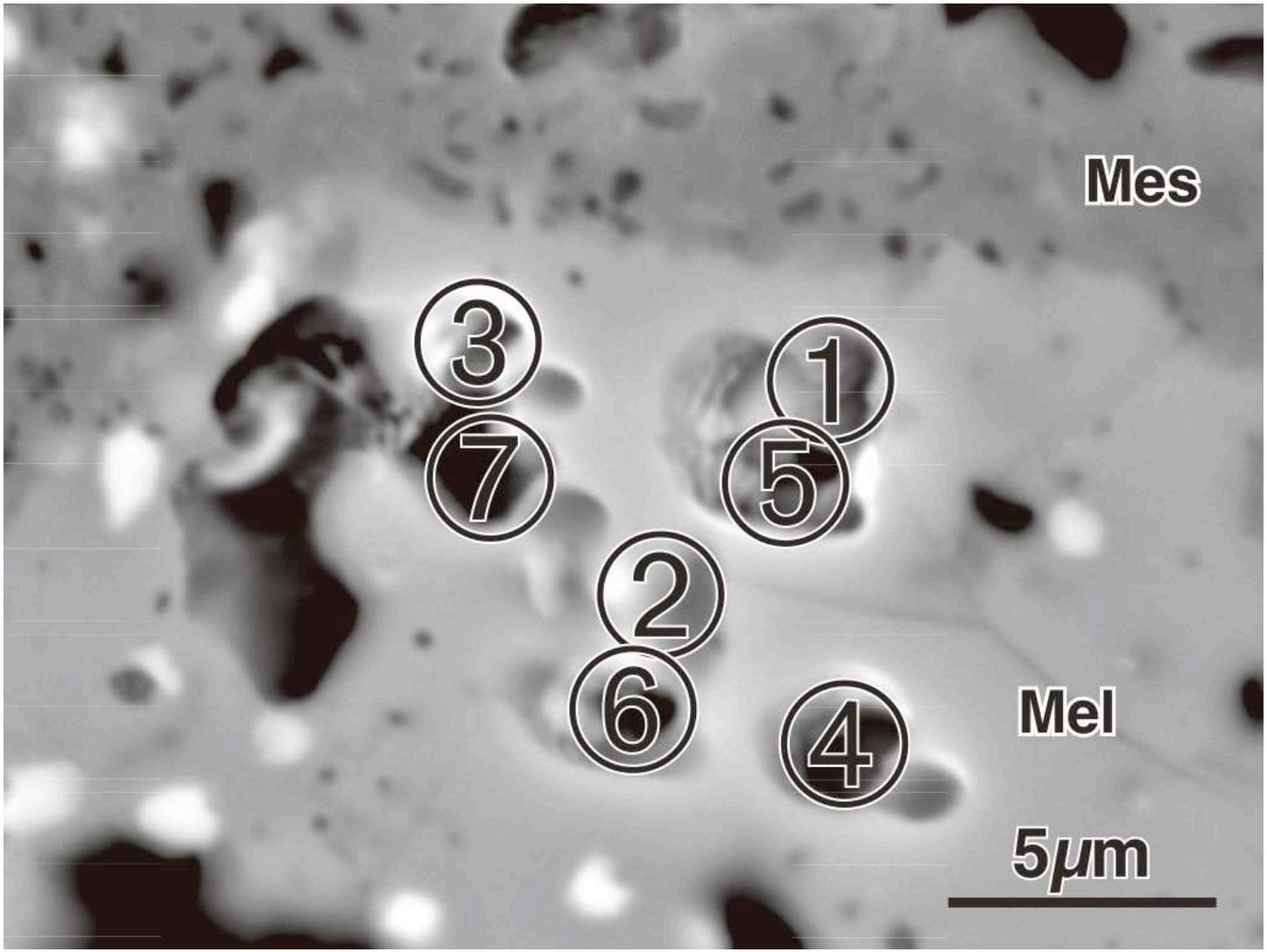

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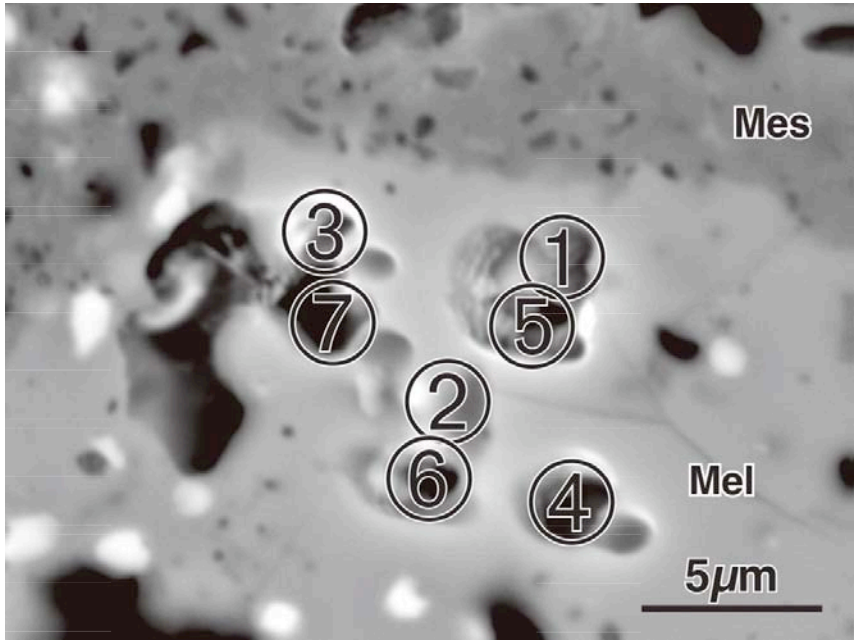

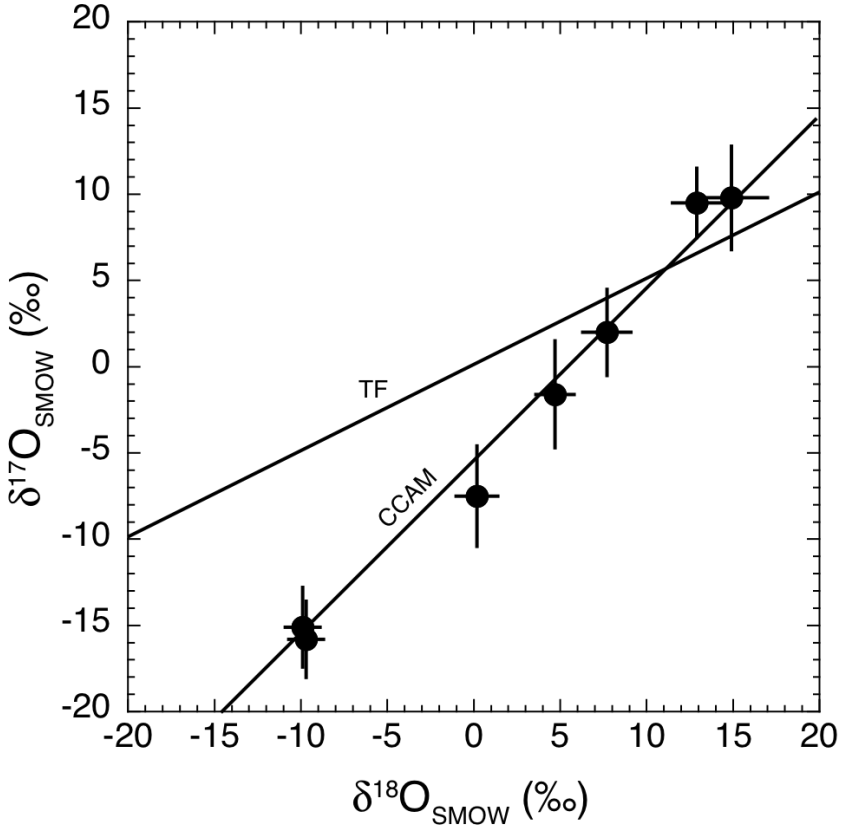

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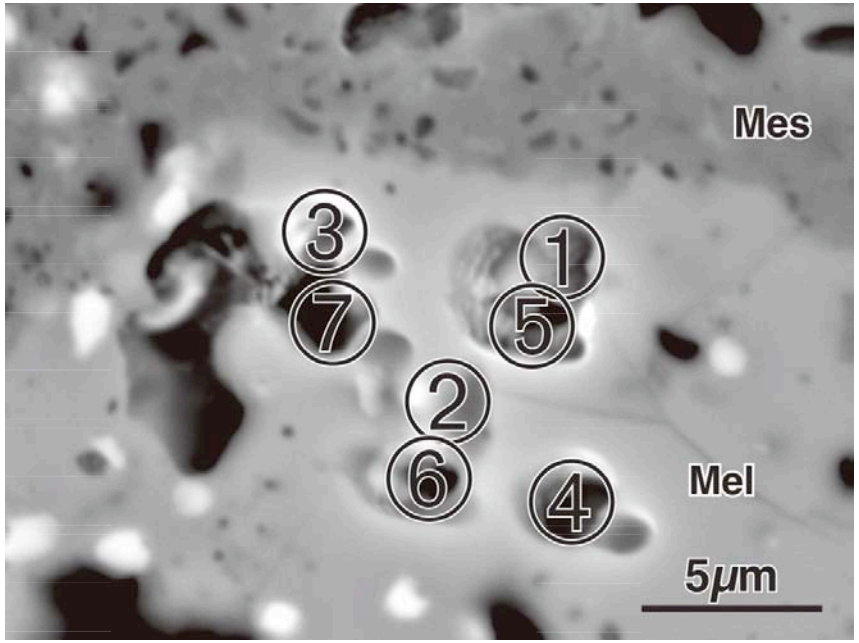
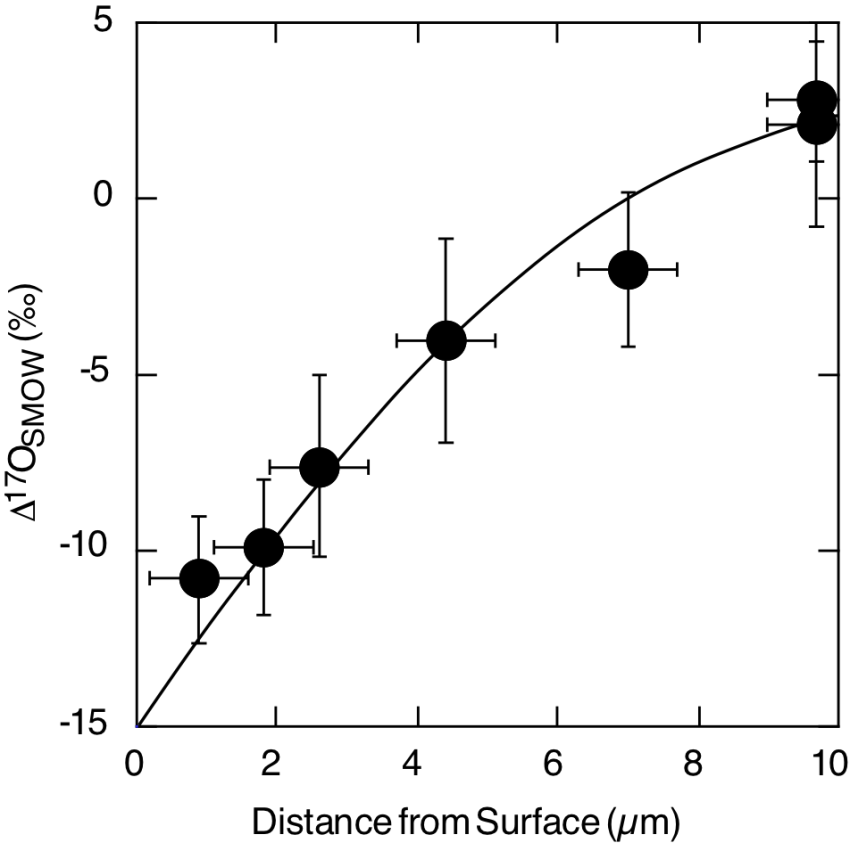
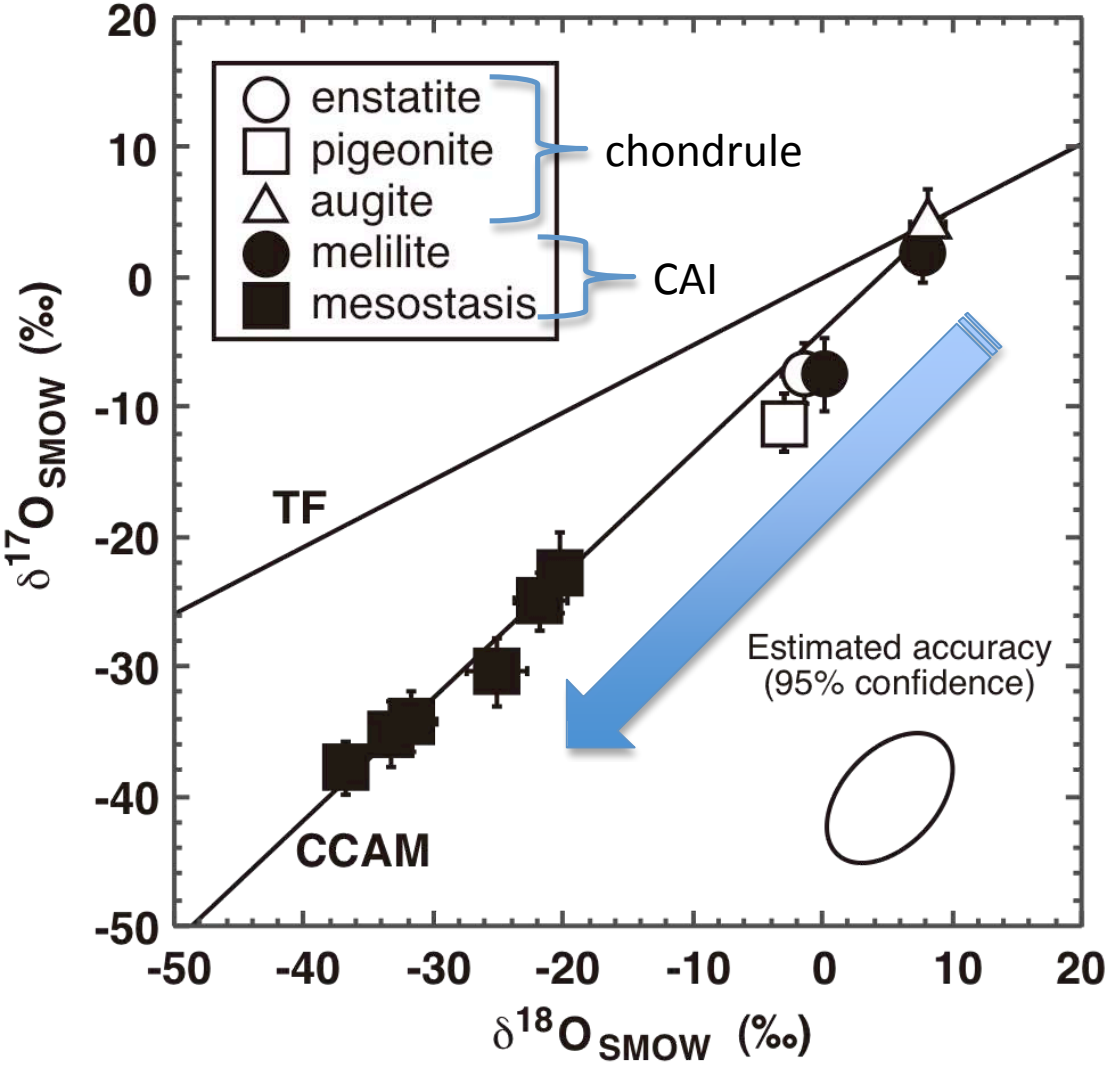




Diffusion profile : limited to ~10 µm
Cooling rate: 50-200 °C/hour from 1600 °C

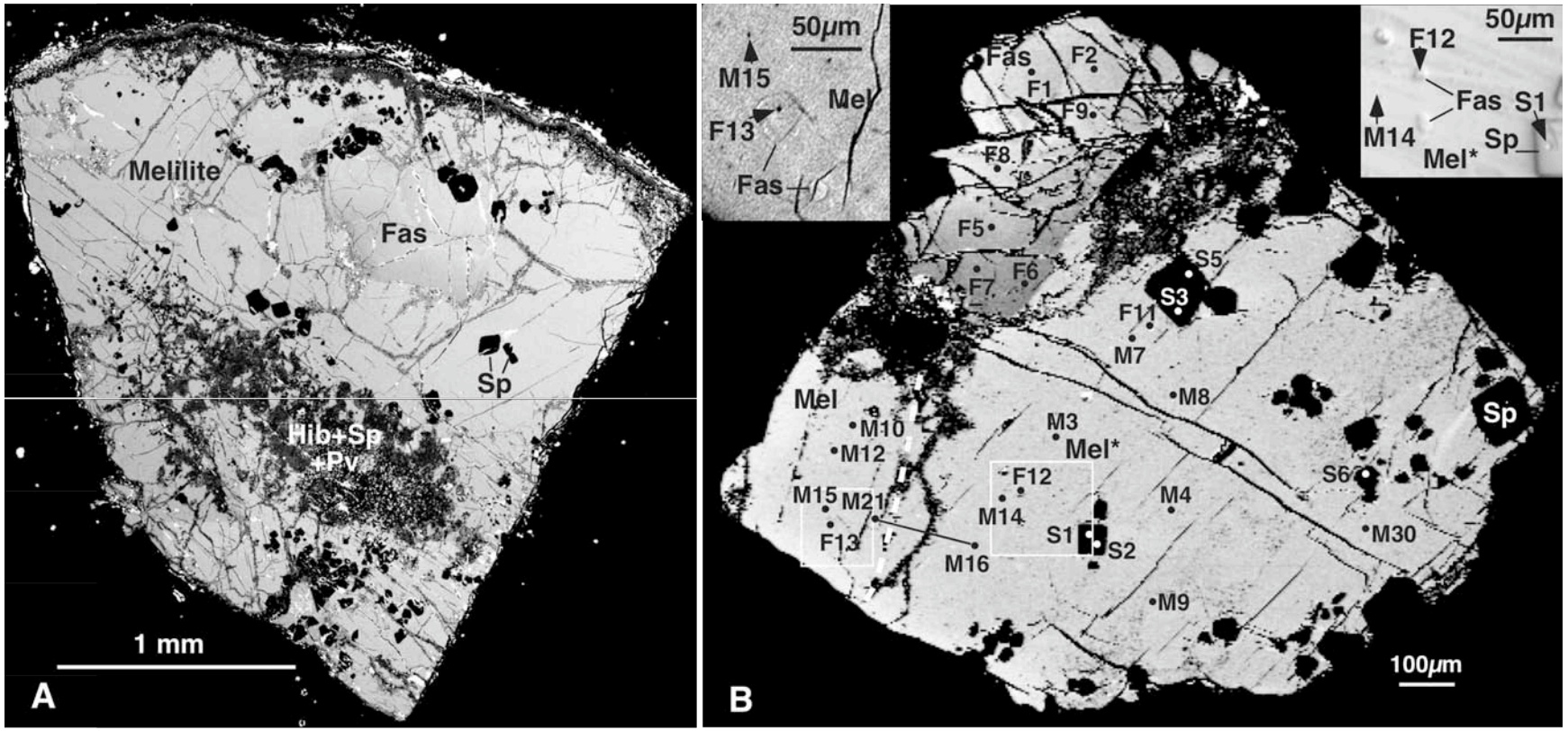
A5 in Y-81020 (Nature, 2003)

Point to Line analysis 1



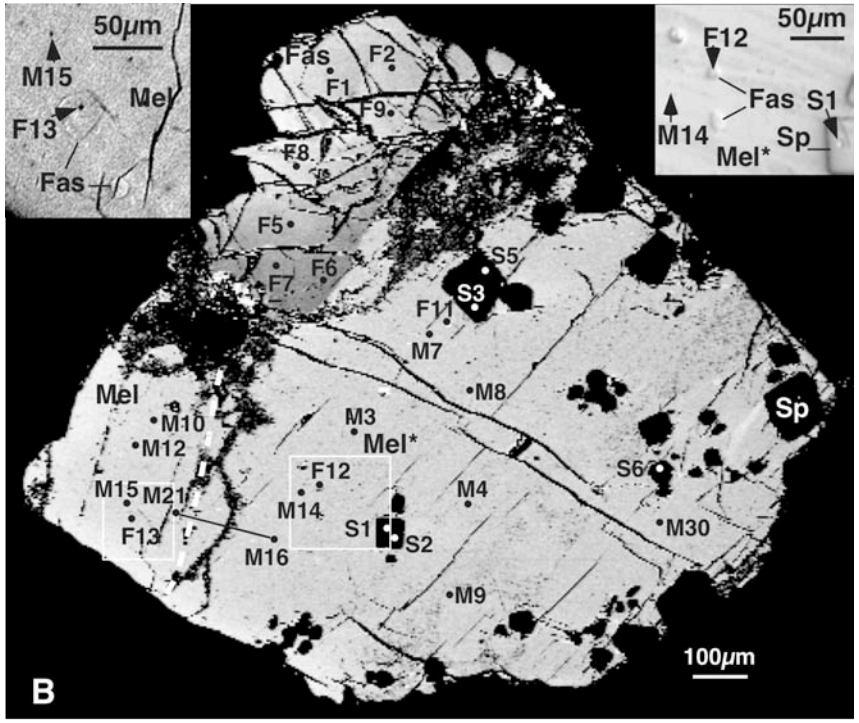
A5 in Y-81020 (Nature, 2003)

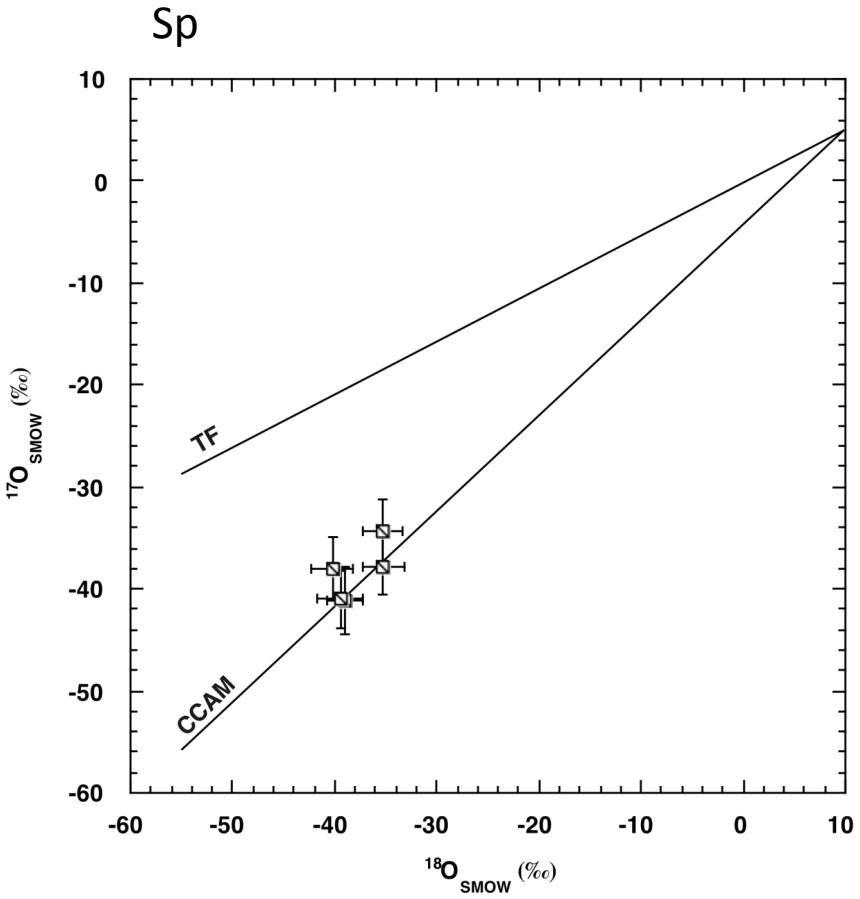
Point to Line analysis 2



7R-19-1 in Allende (Science, 1998)

Point to Line analysis 2





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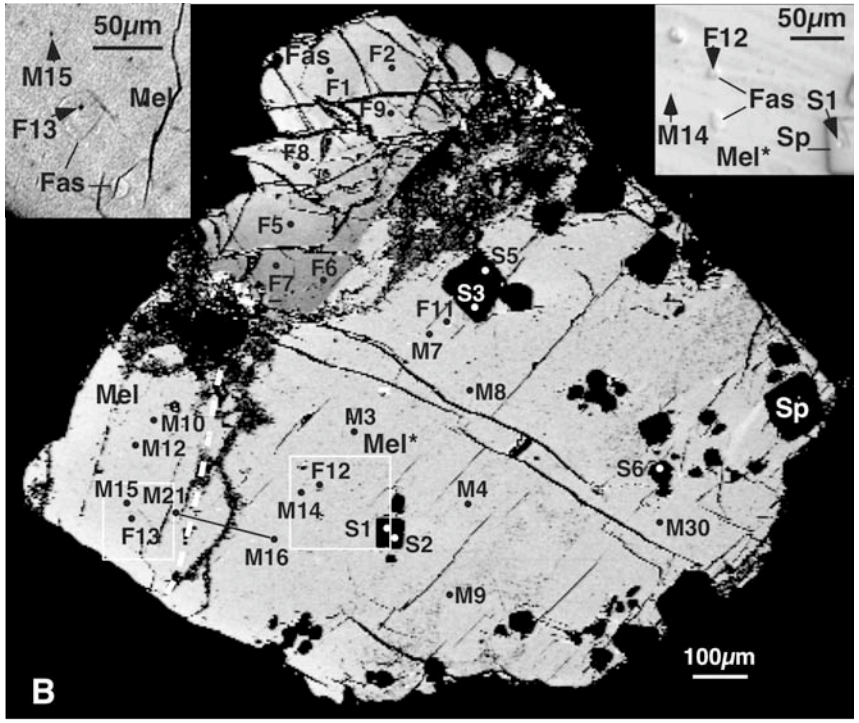

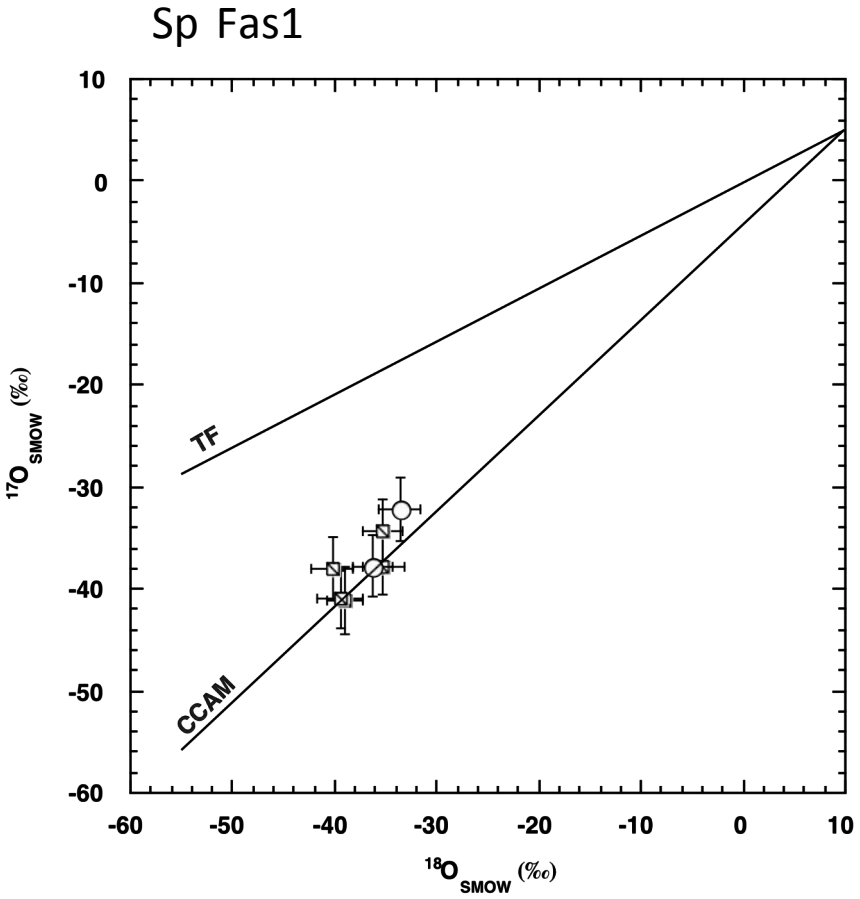

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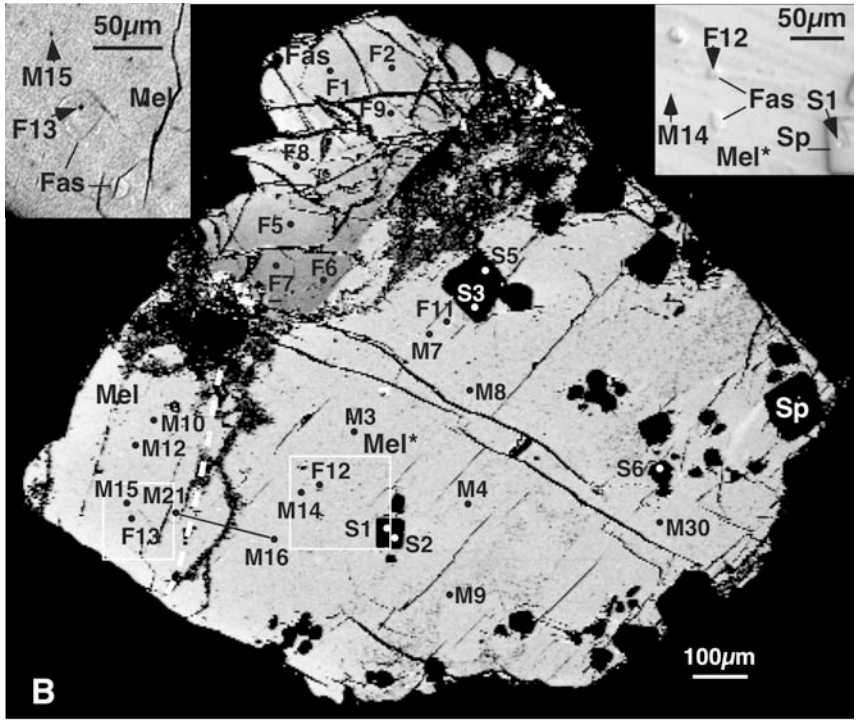
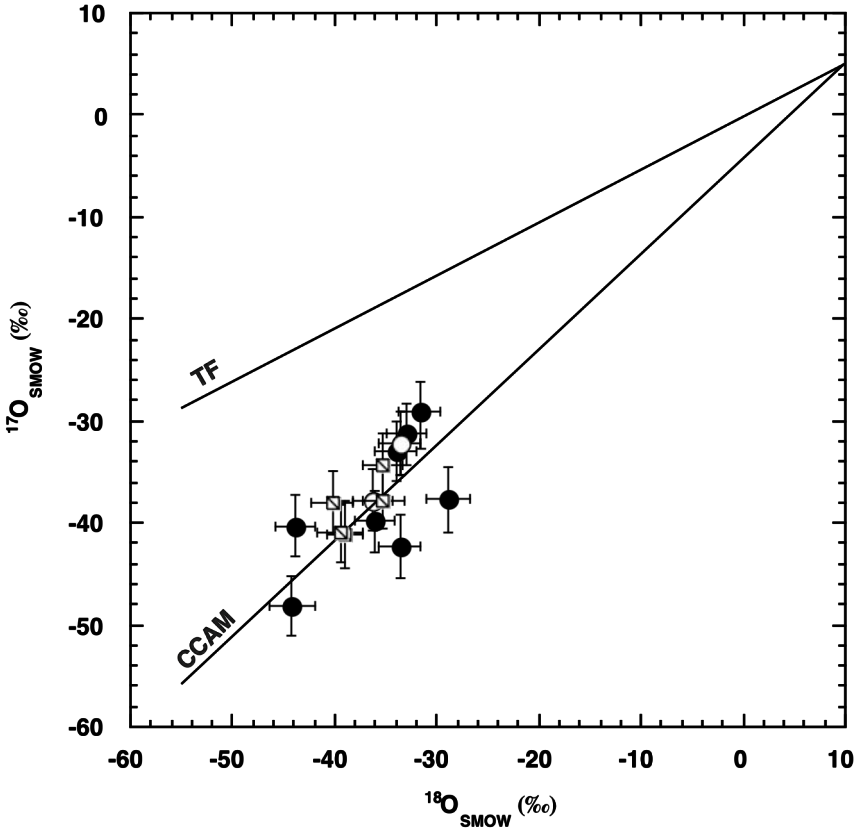


←Mel1→
Sp Fas1



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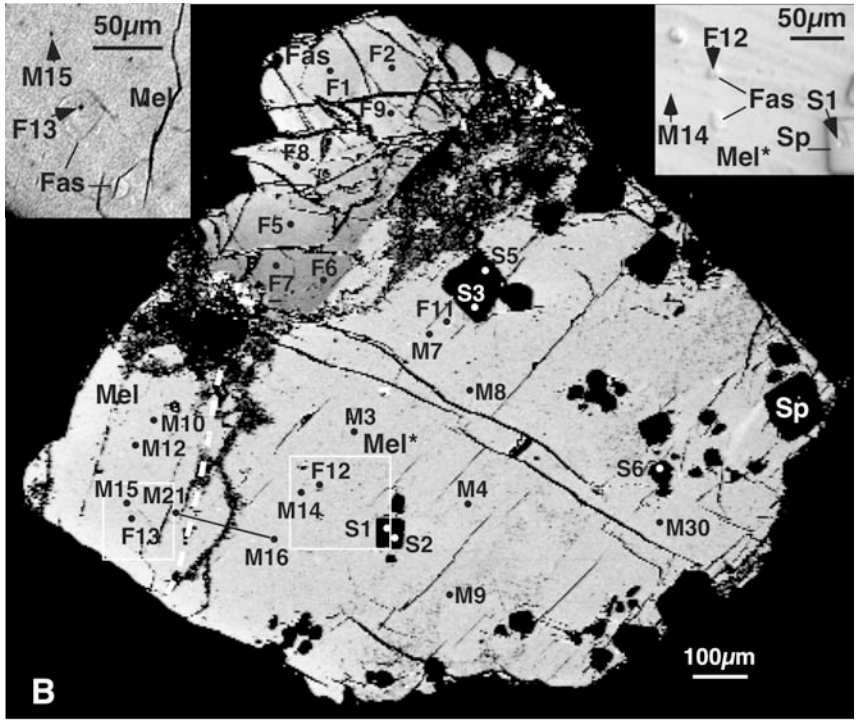

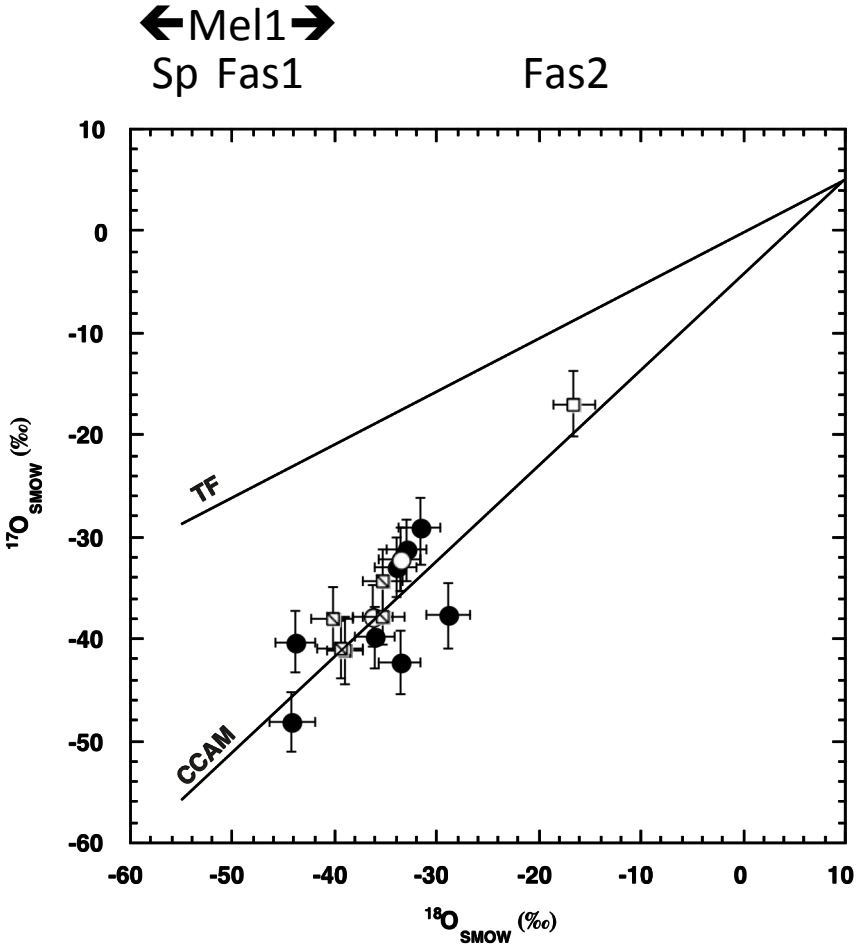

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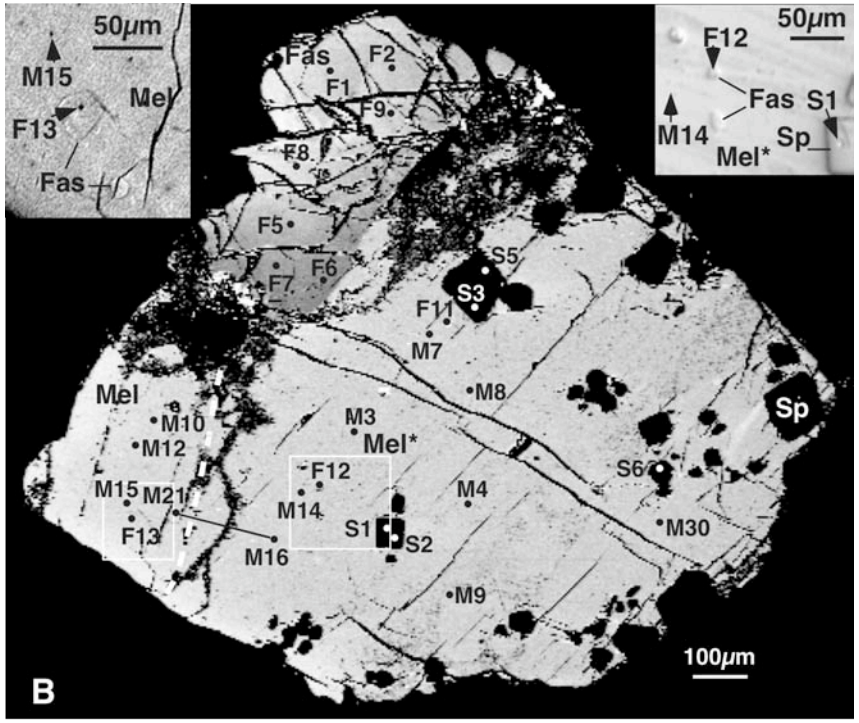

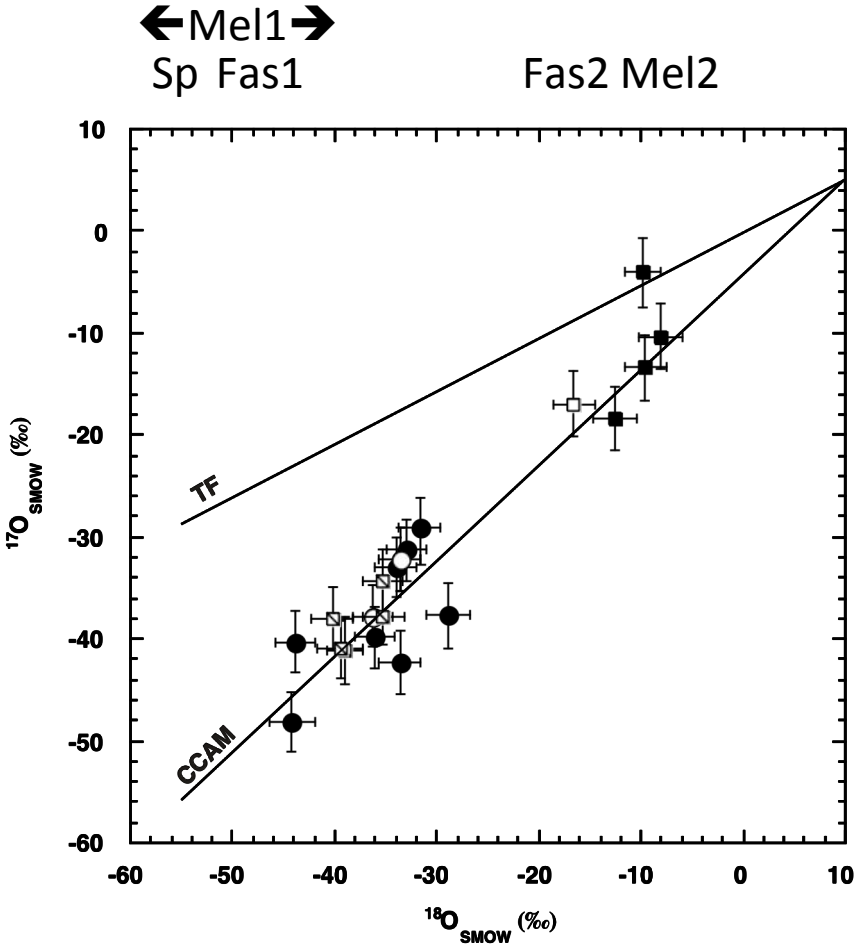

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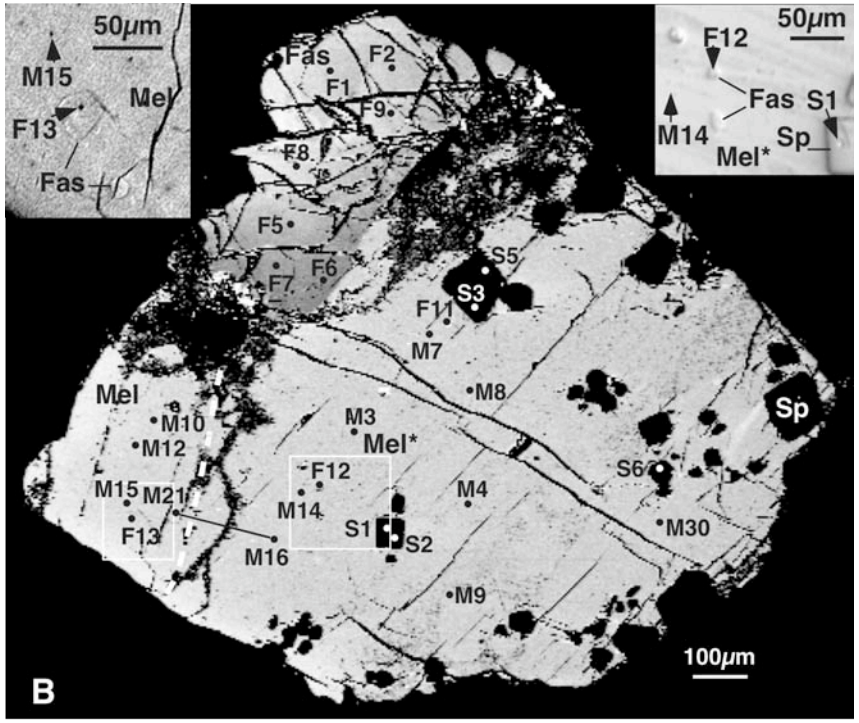
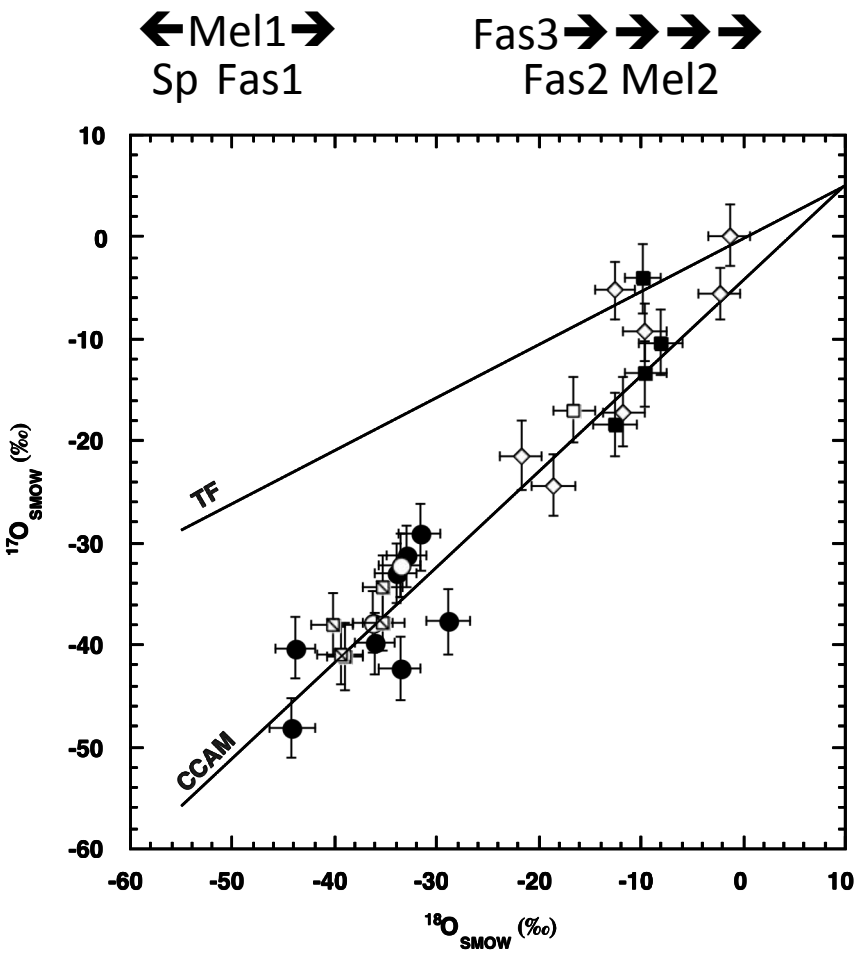
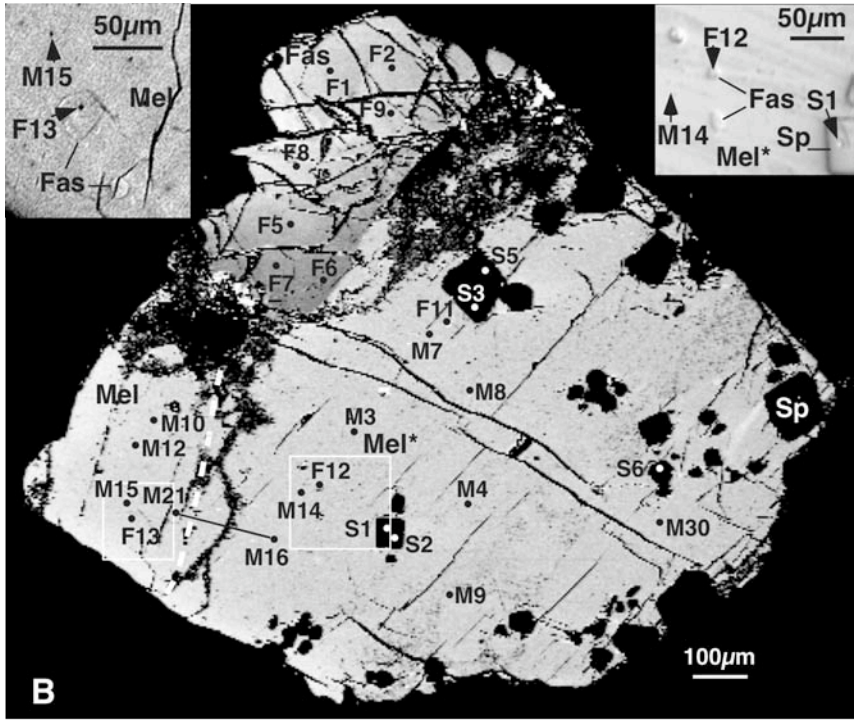


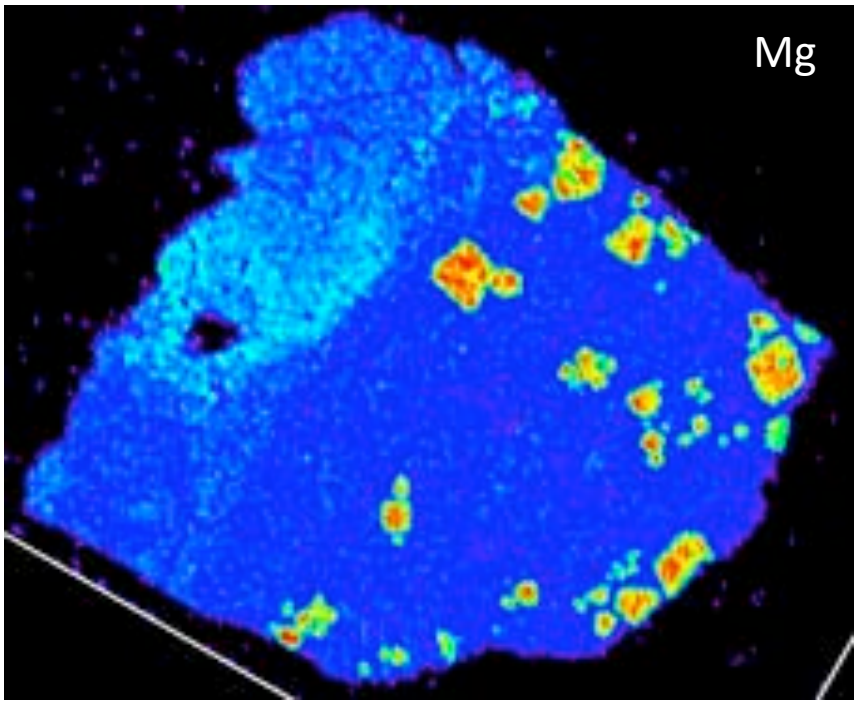


7R-19-1 in Allende (Science, 1998)

Point to Line analysis 2

←Mel1→ Fas3→→→→
Sp Fas1 Fas2 Mel2





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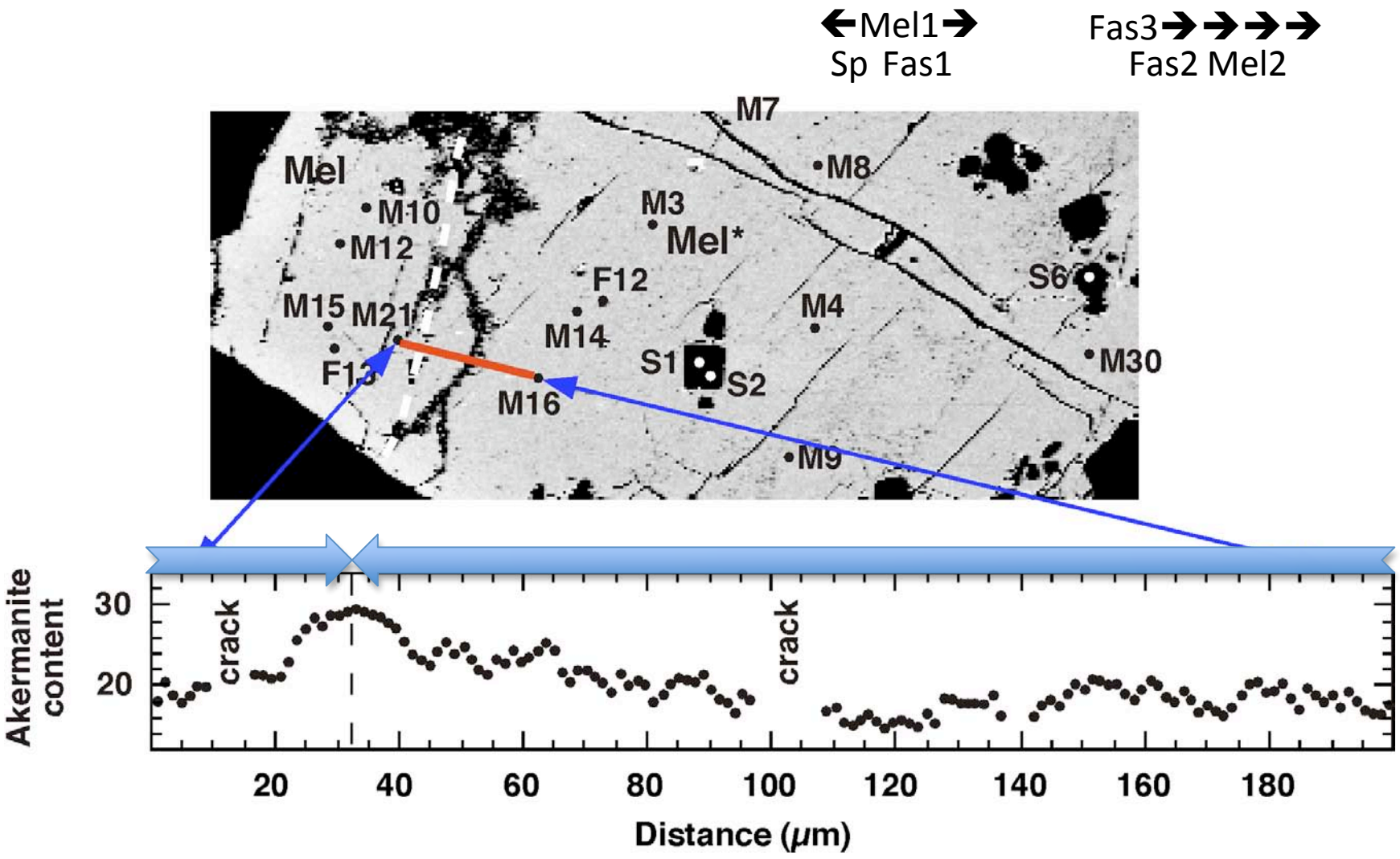

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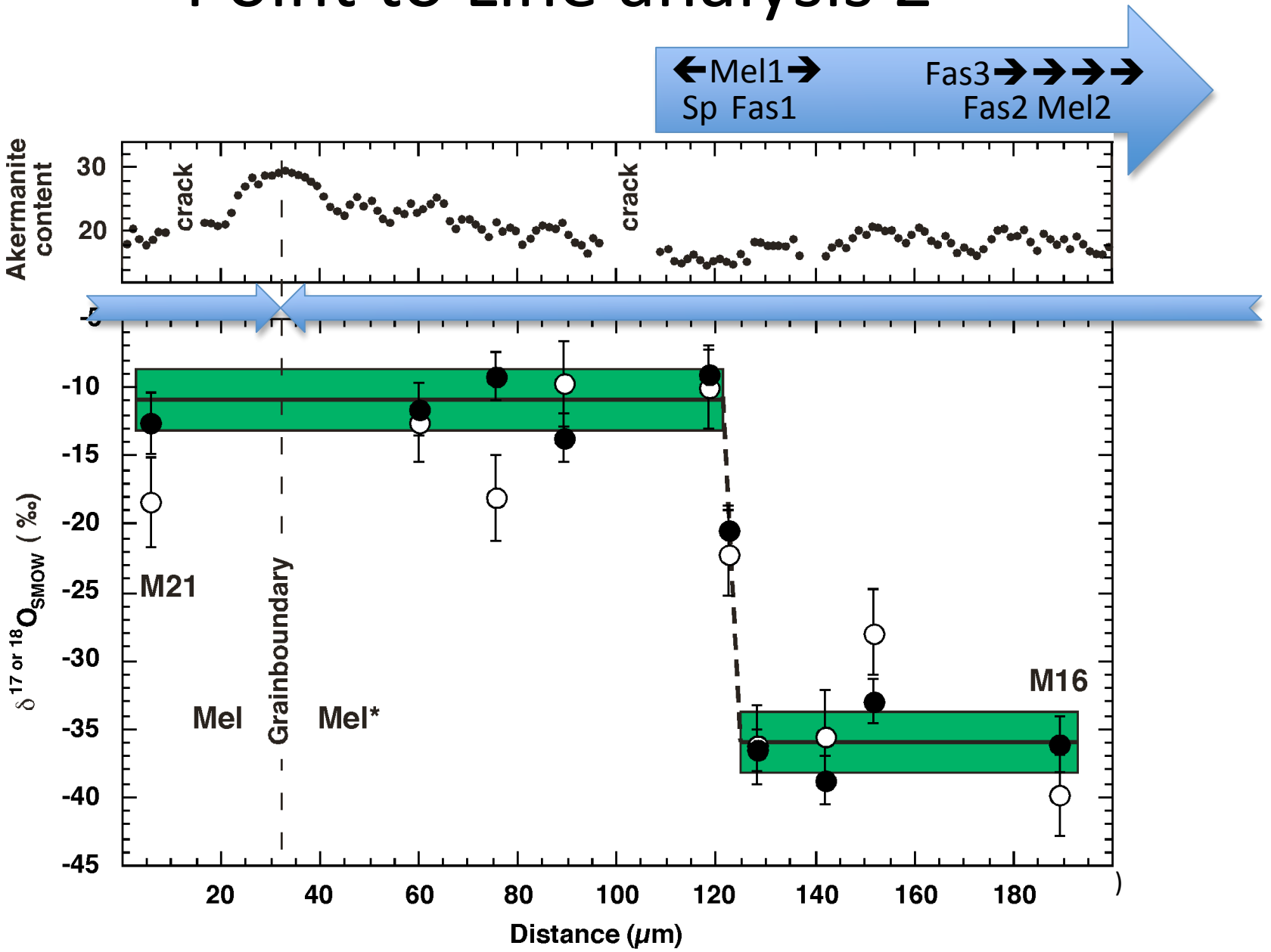

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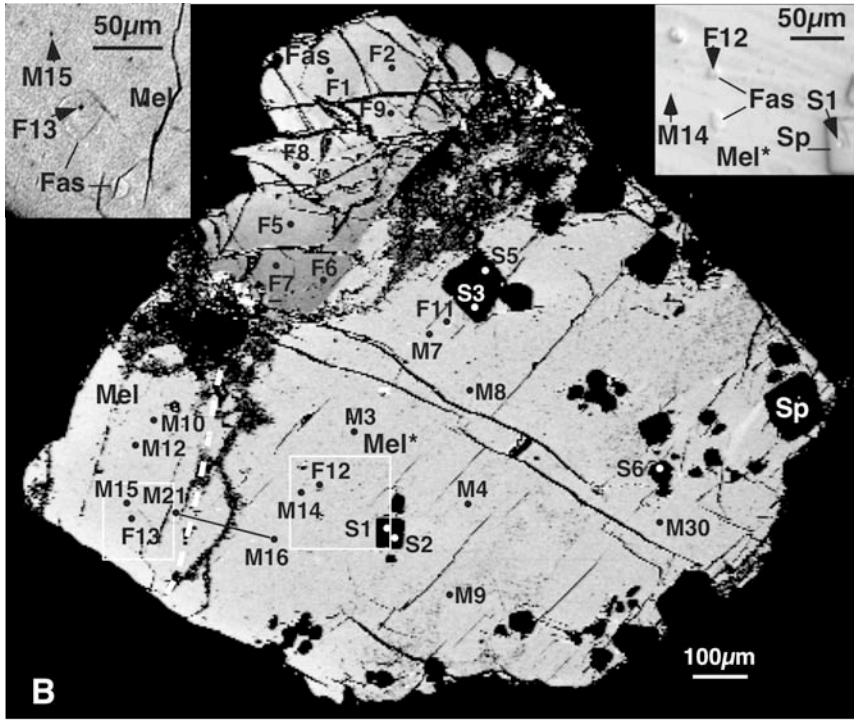

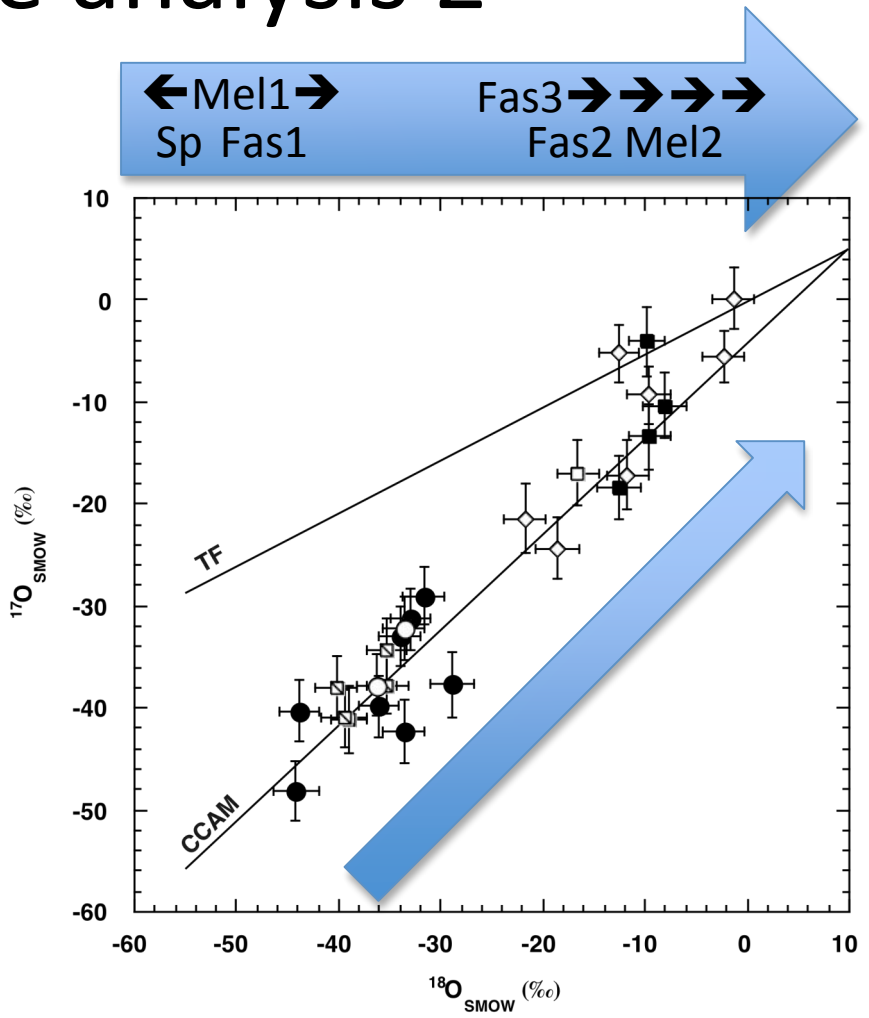

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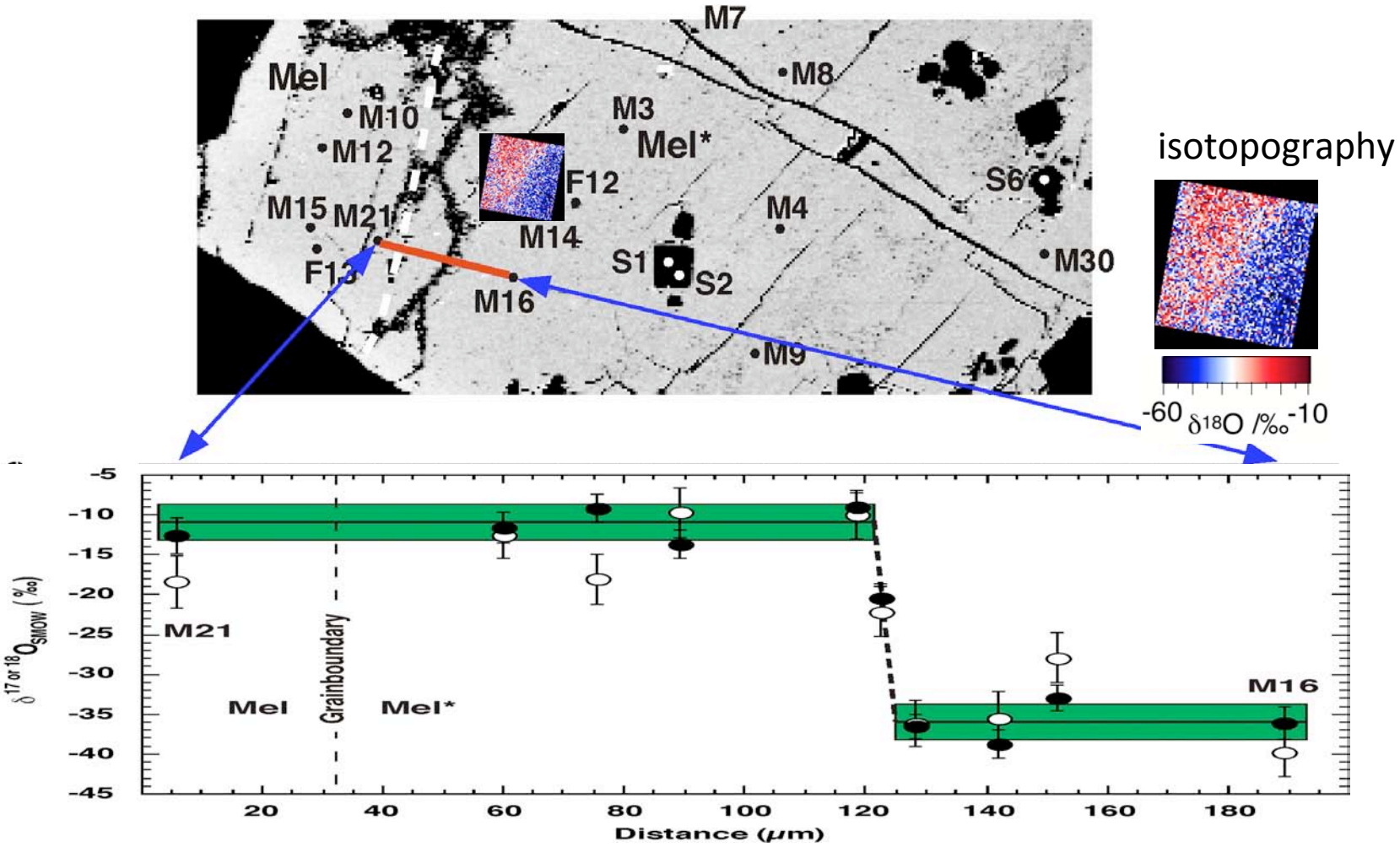
Development of Isotope Microscope



Outline

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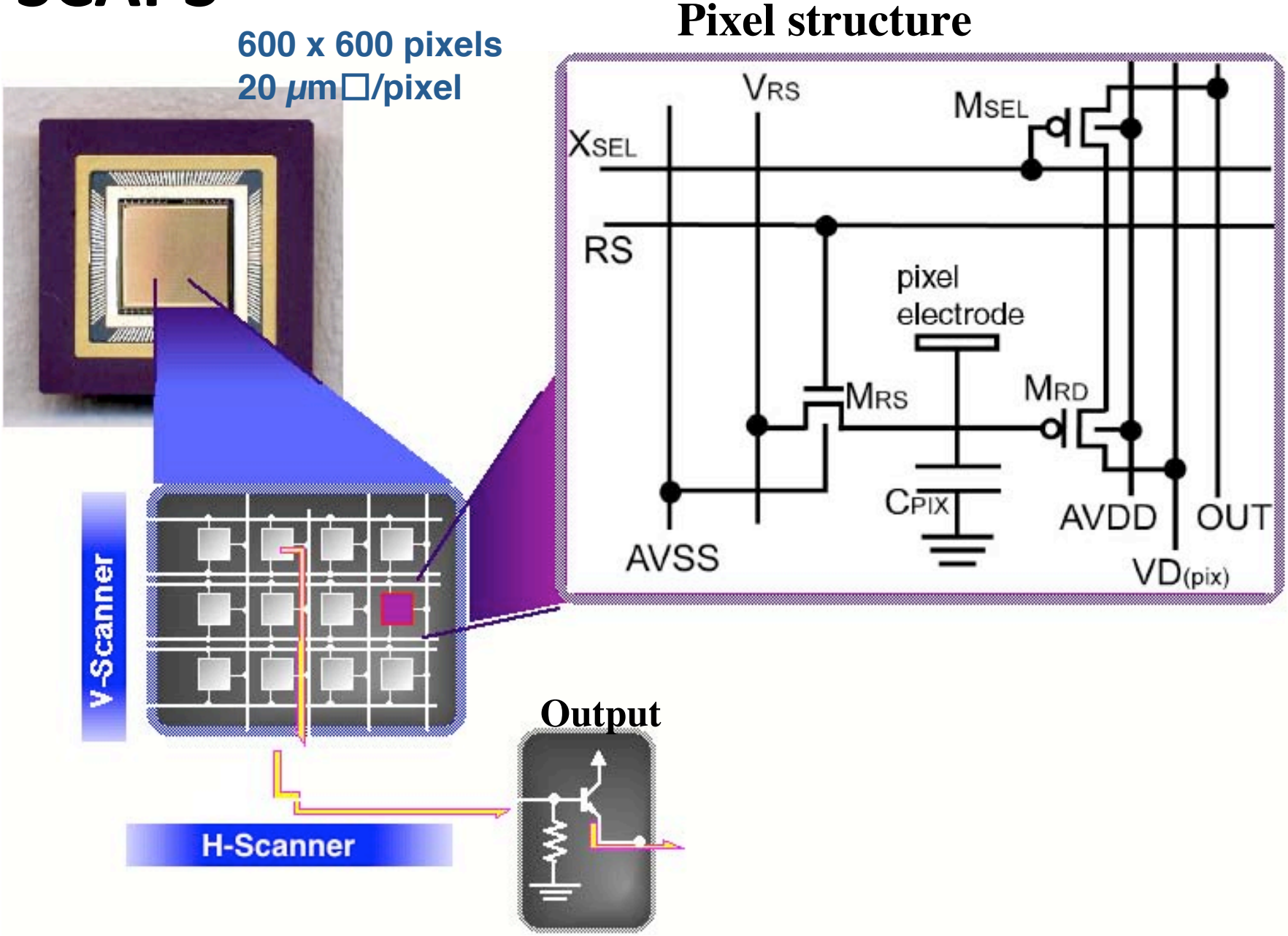
Development of Isotope Microscope

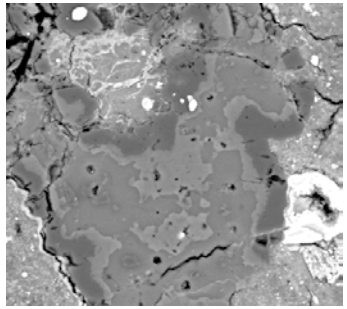
SCAPS

600 x 600 pixels
20 μm□/pixel



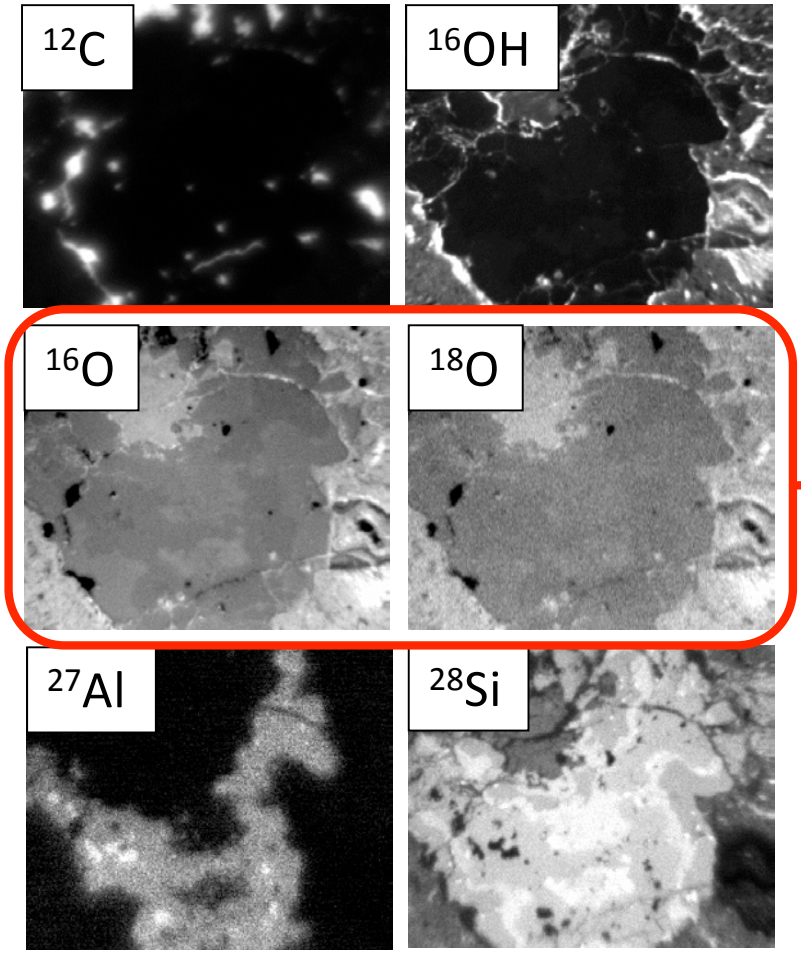
Development of Isotope Microscope

BSE

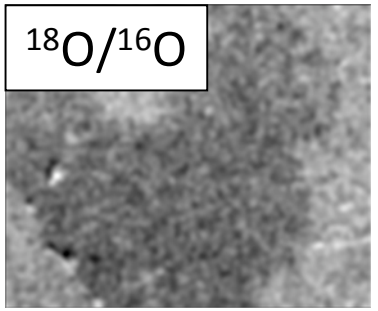


10µm

Refractory incl. in Acfer 094

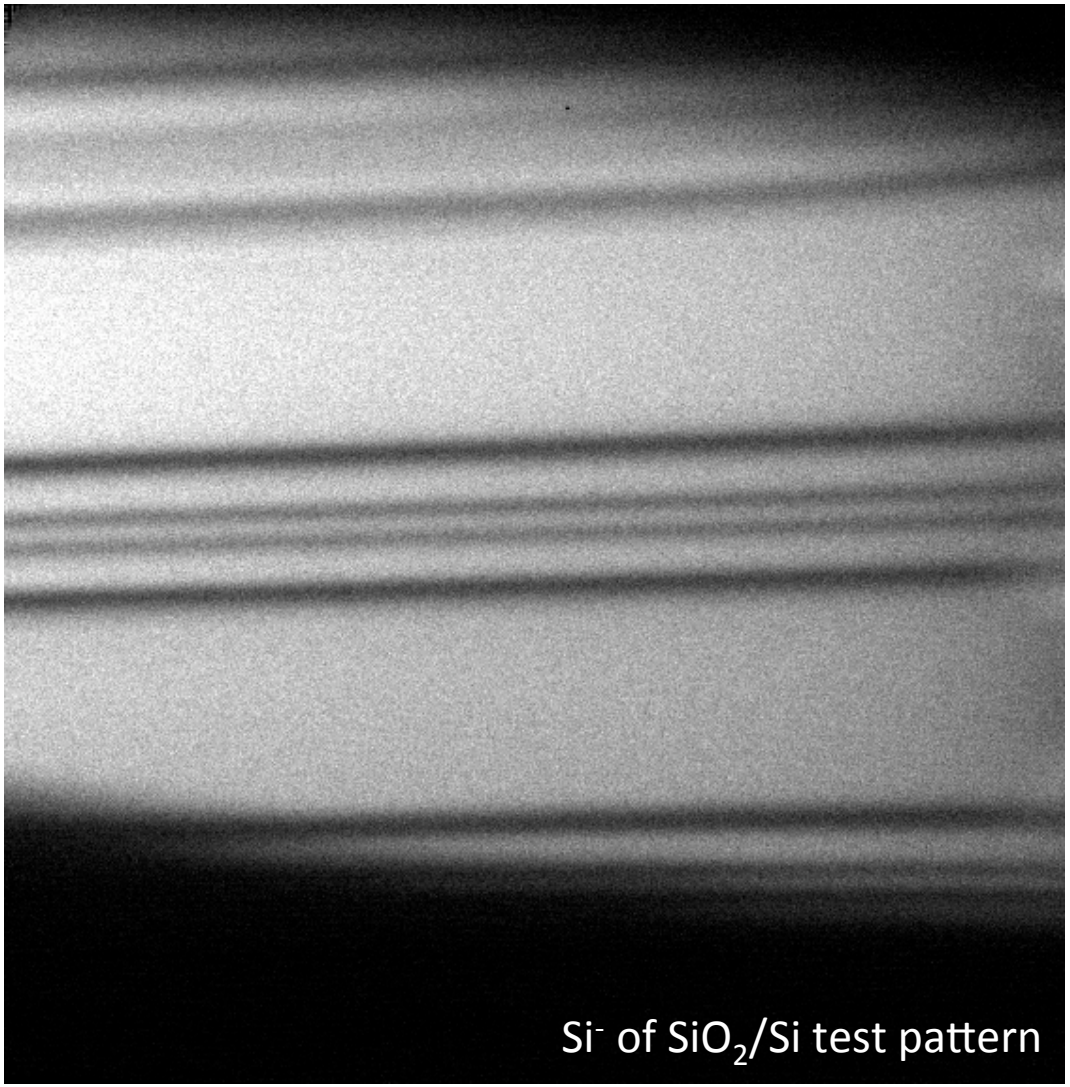


isotopography



This refractory incl. is homogeneously enriched in ^{16}O (Δ = ~50‰).

Development of Isotope Microscope



300 nm width

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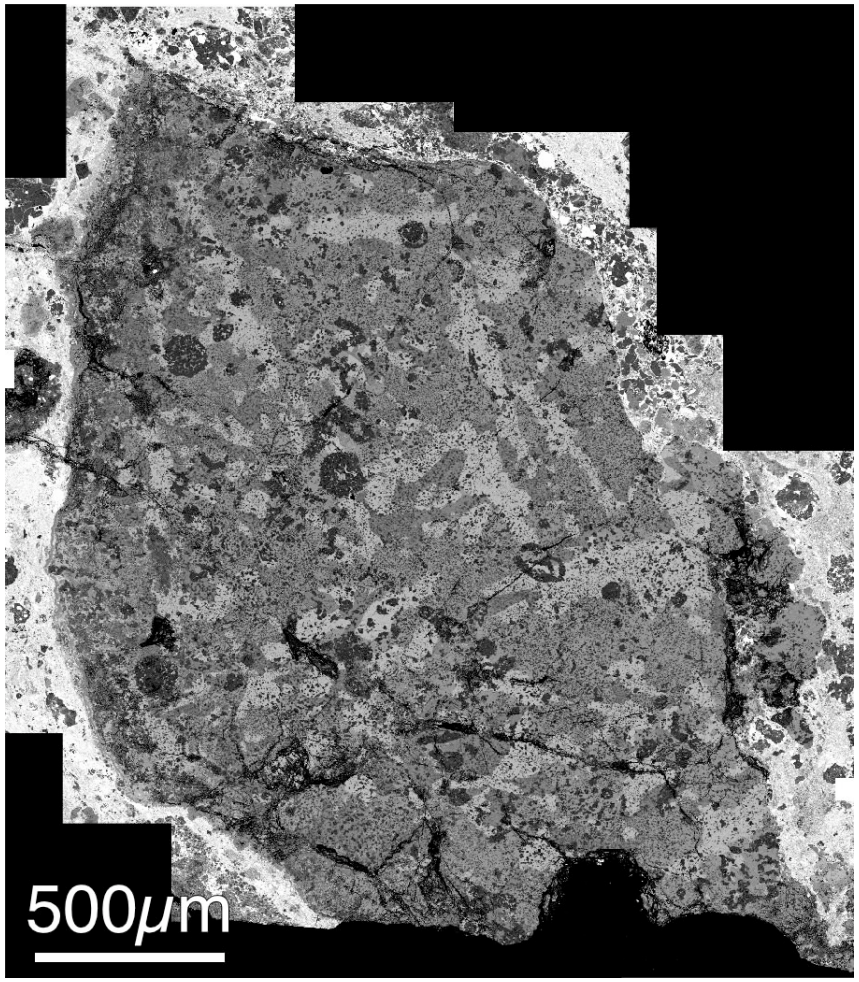
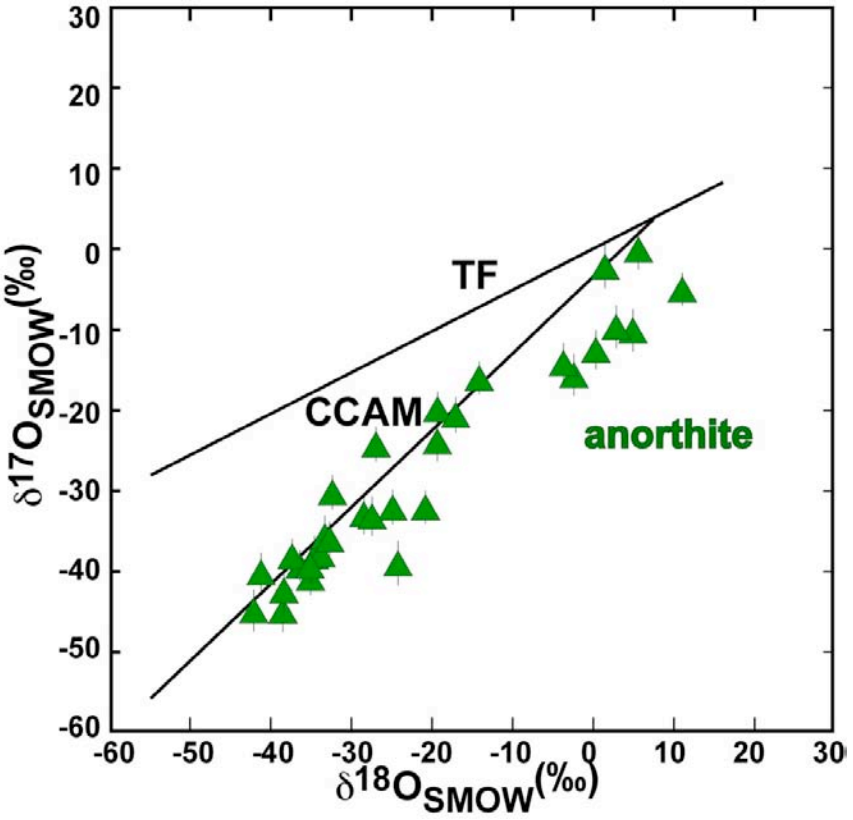
Isotopography of oxygen

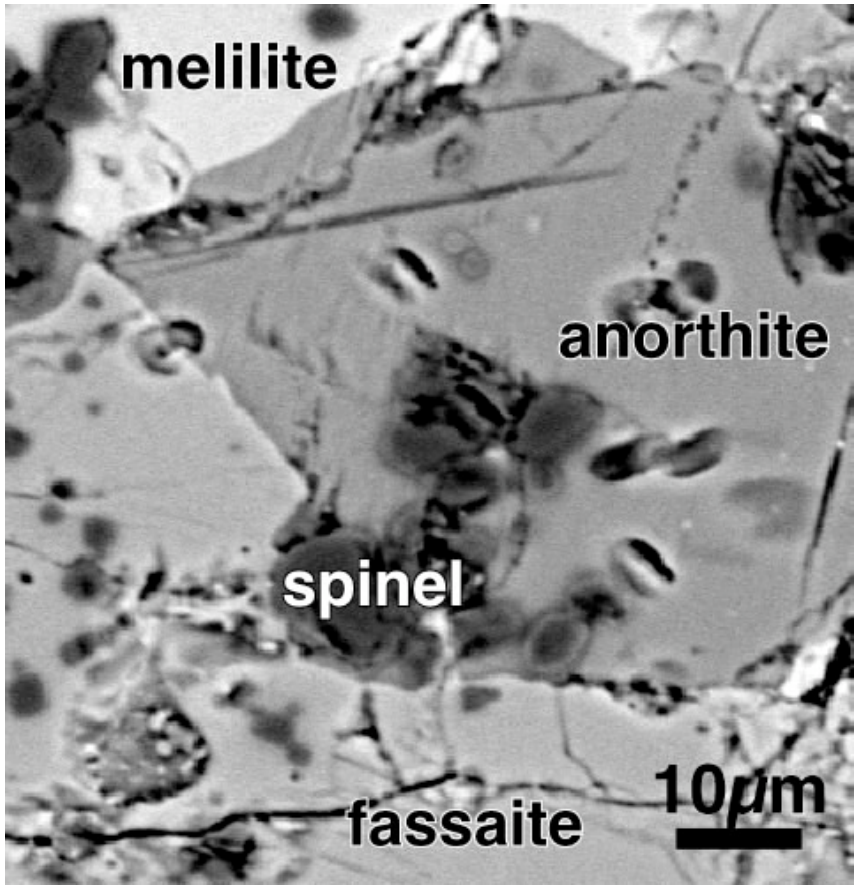


TTV1-01 in Vigarano (GCA, 2005)



Continuous O isotopic distribution

Isotopography of oxygen



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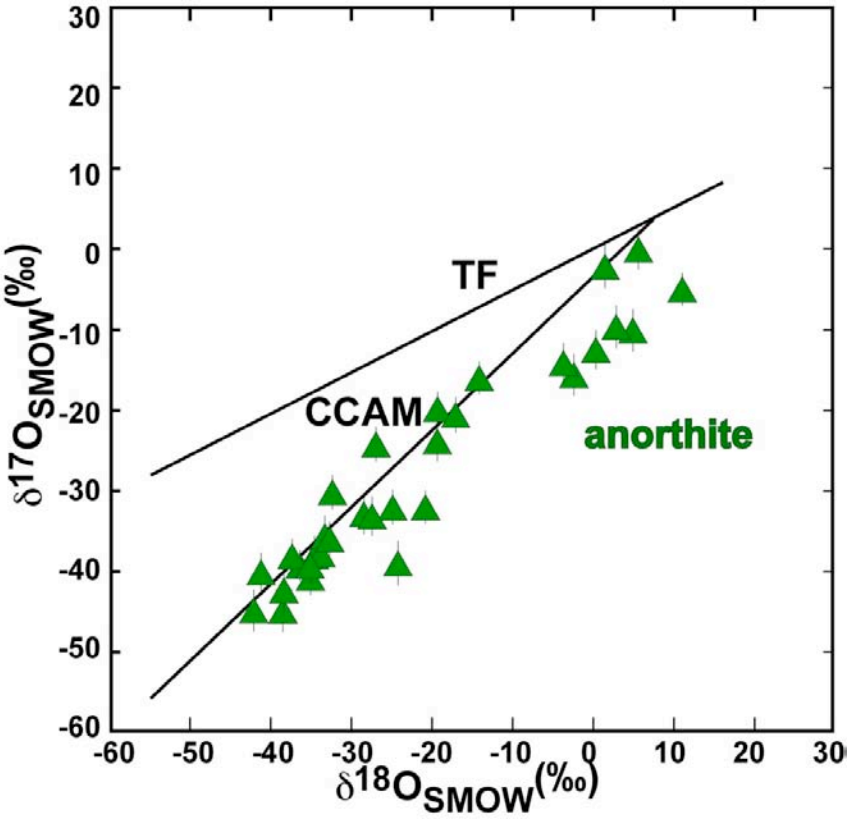

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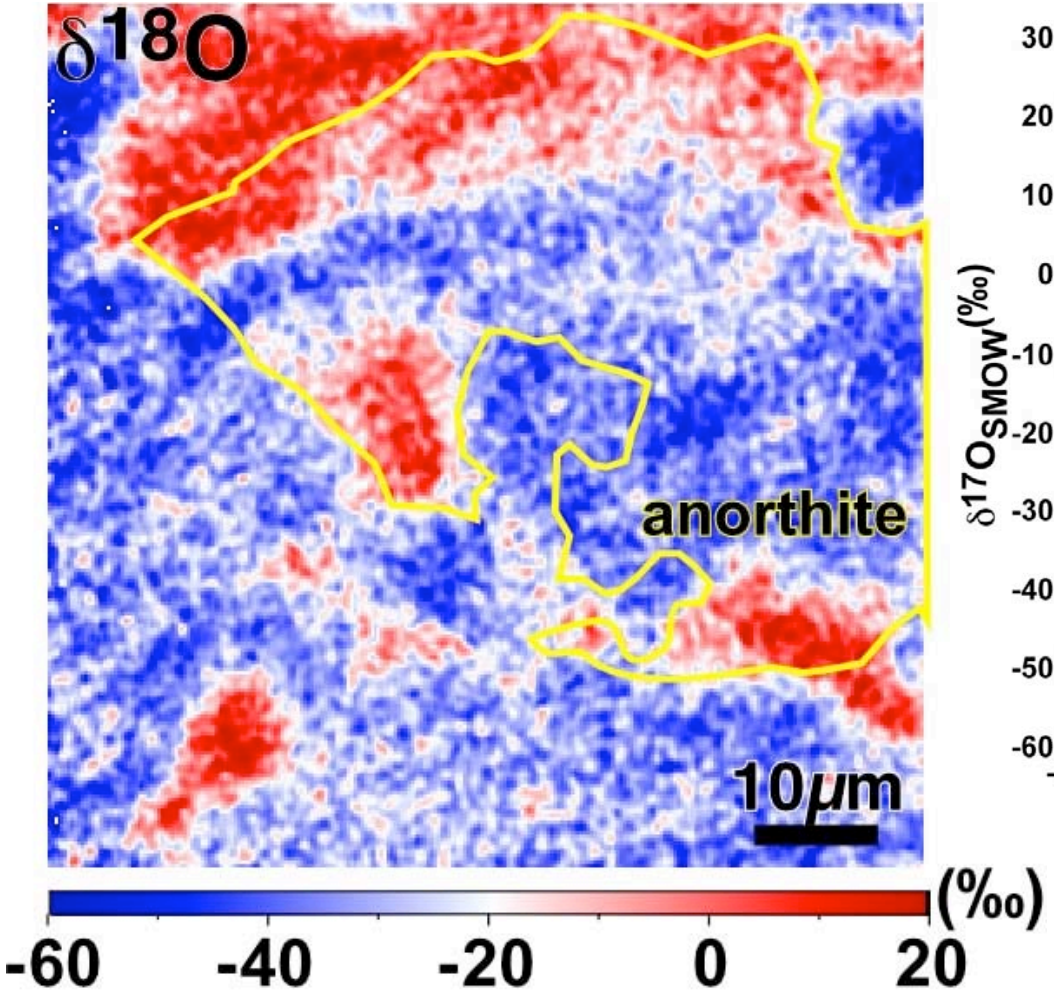
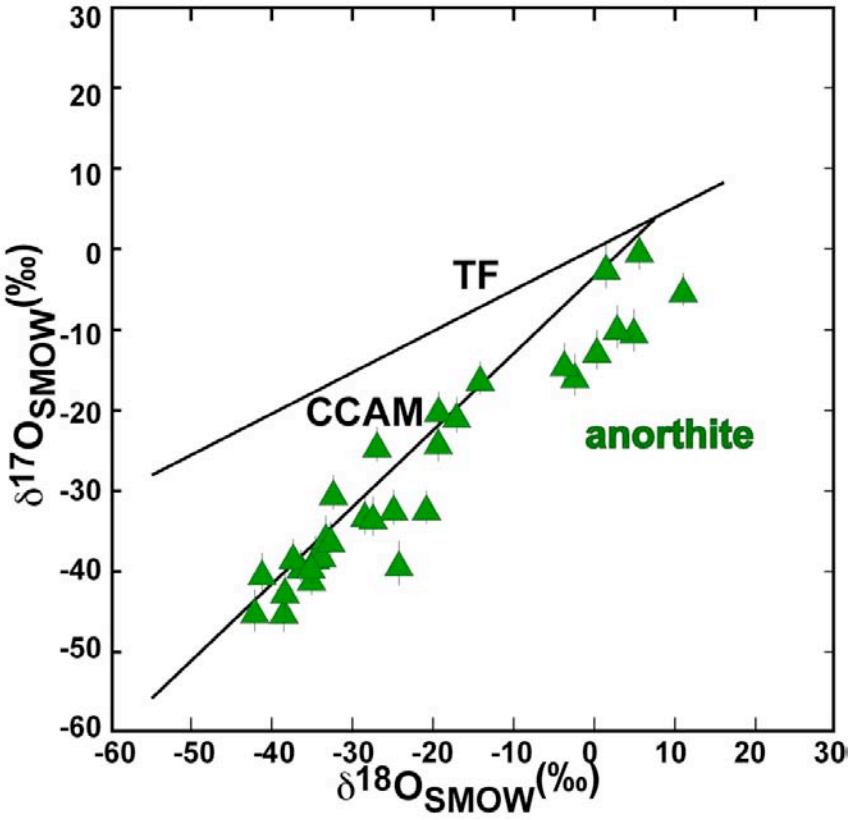
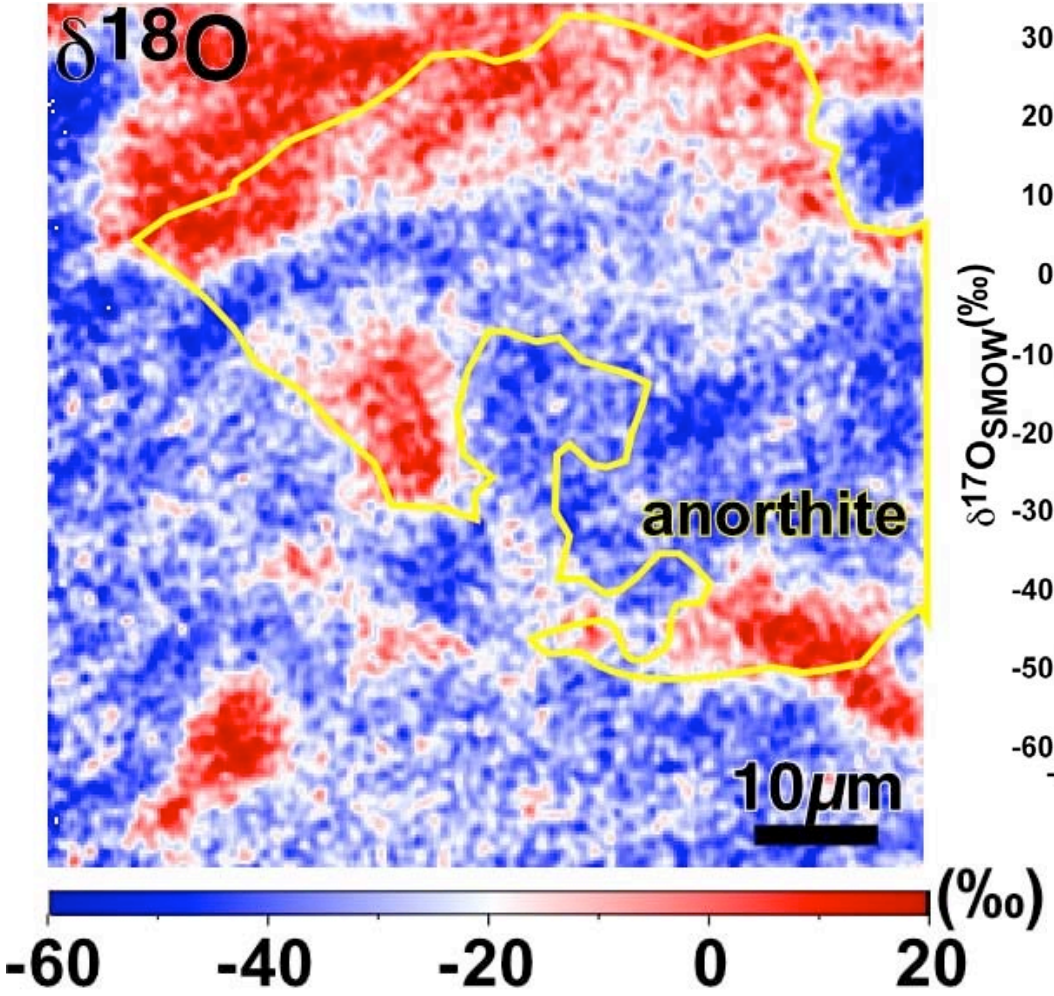
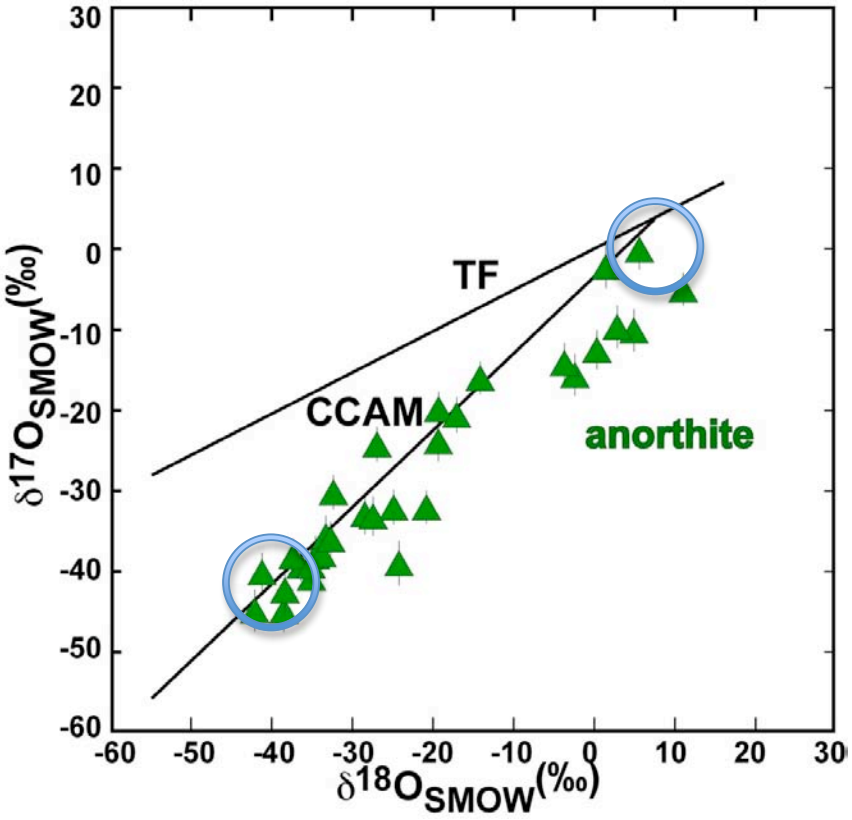




~~Continuous O isotopic distribution~~

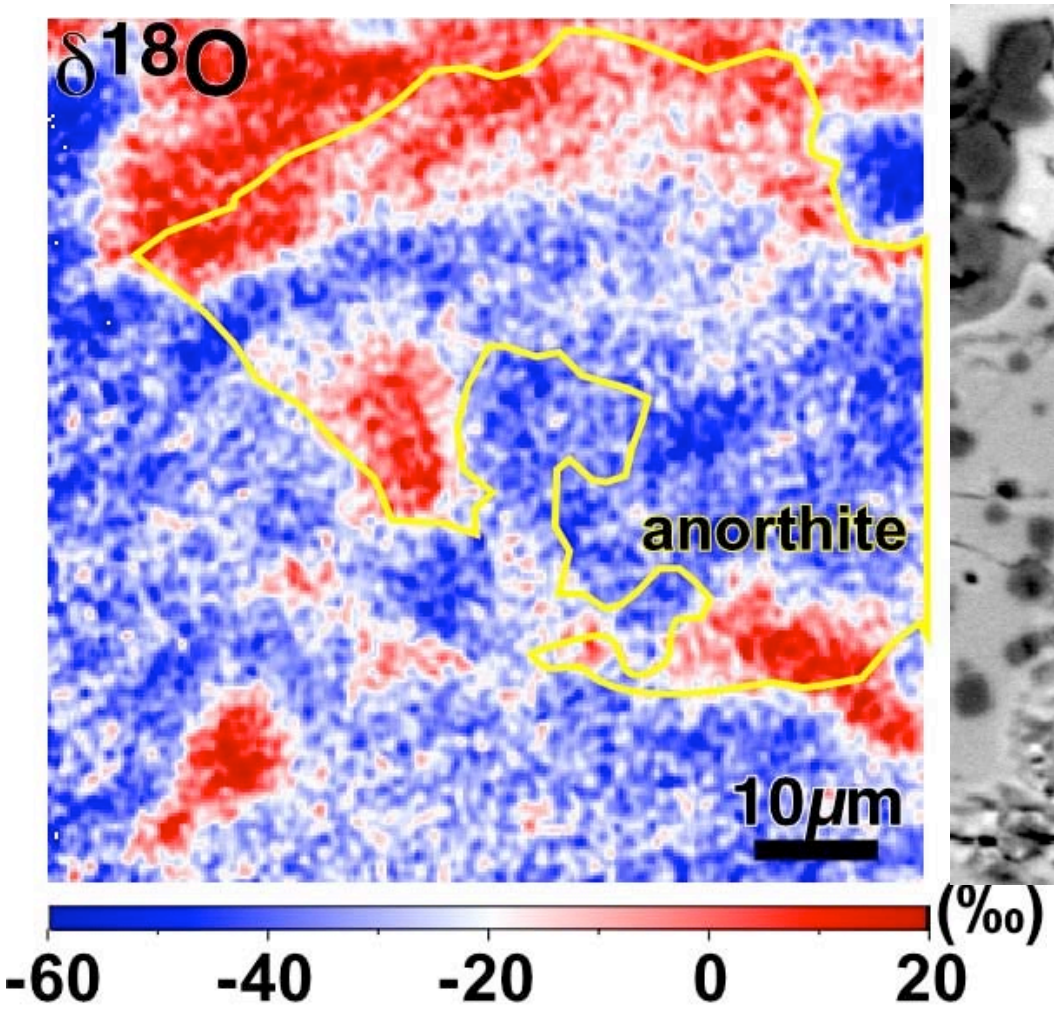
Isotopography of oxygen

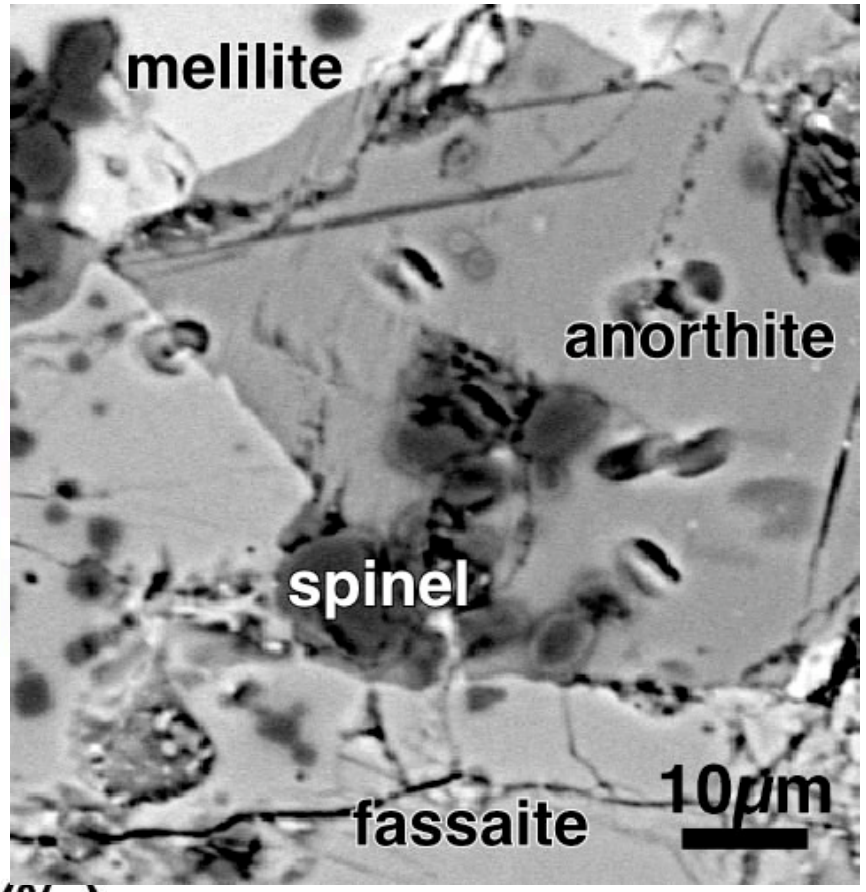




Bimodal O isotopic distribution

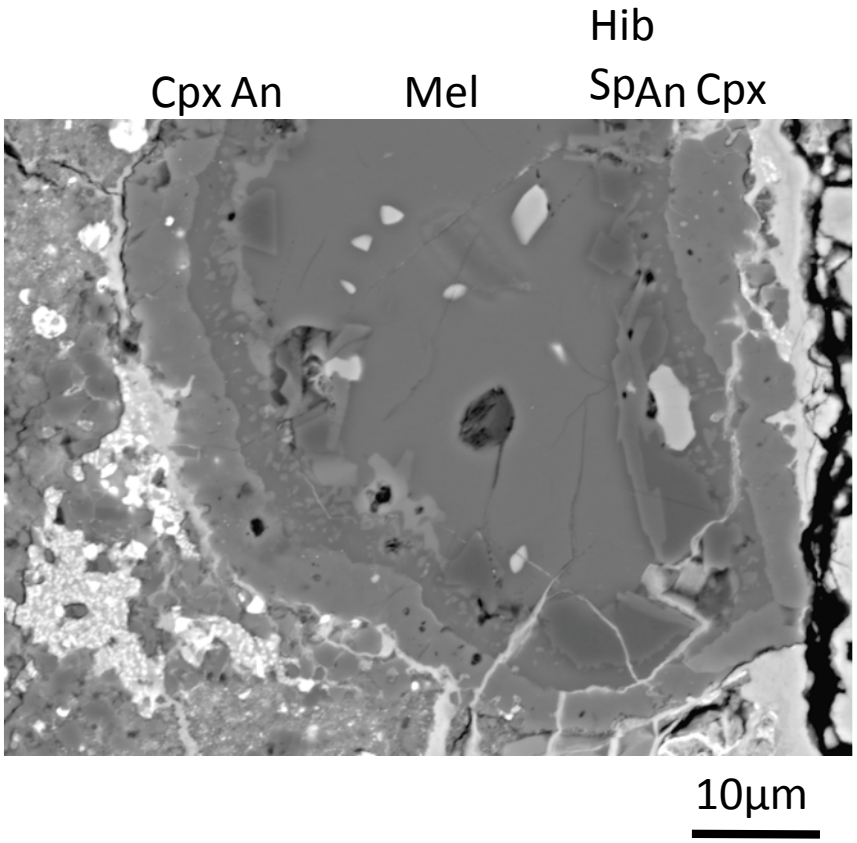
Isotopography of oxygen



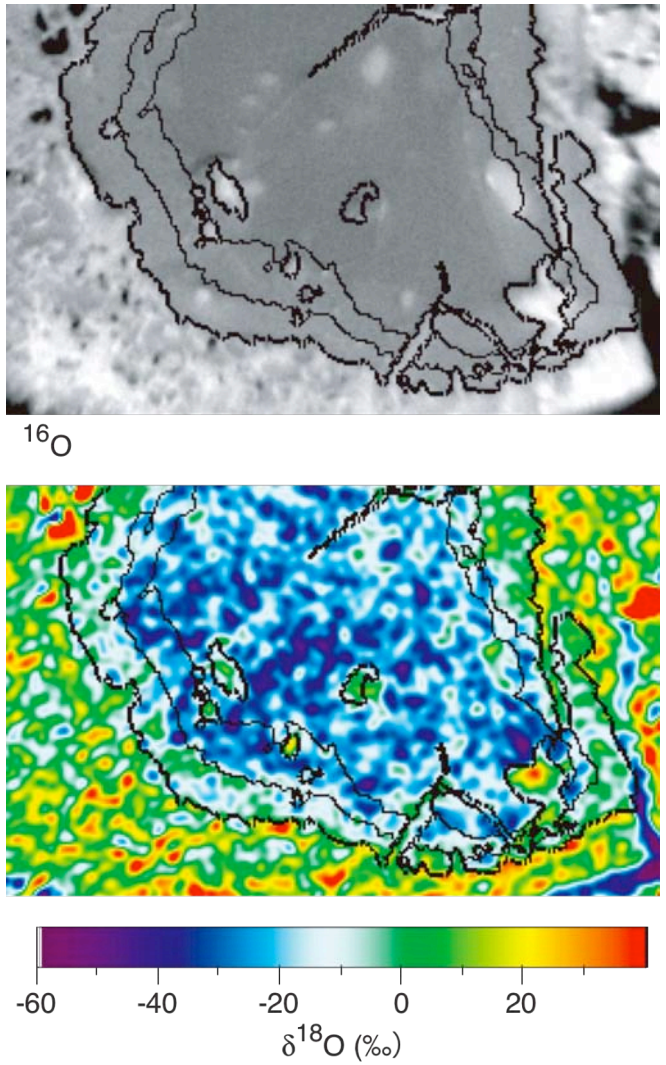


Bimodal O isotopic distribution

Isotopography of oxygen



CAI in Acfer 094
This CAI was directly condensed from gas.



Nebular gas changed ^{16}O-rich to ^{16}O-poor.

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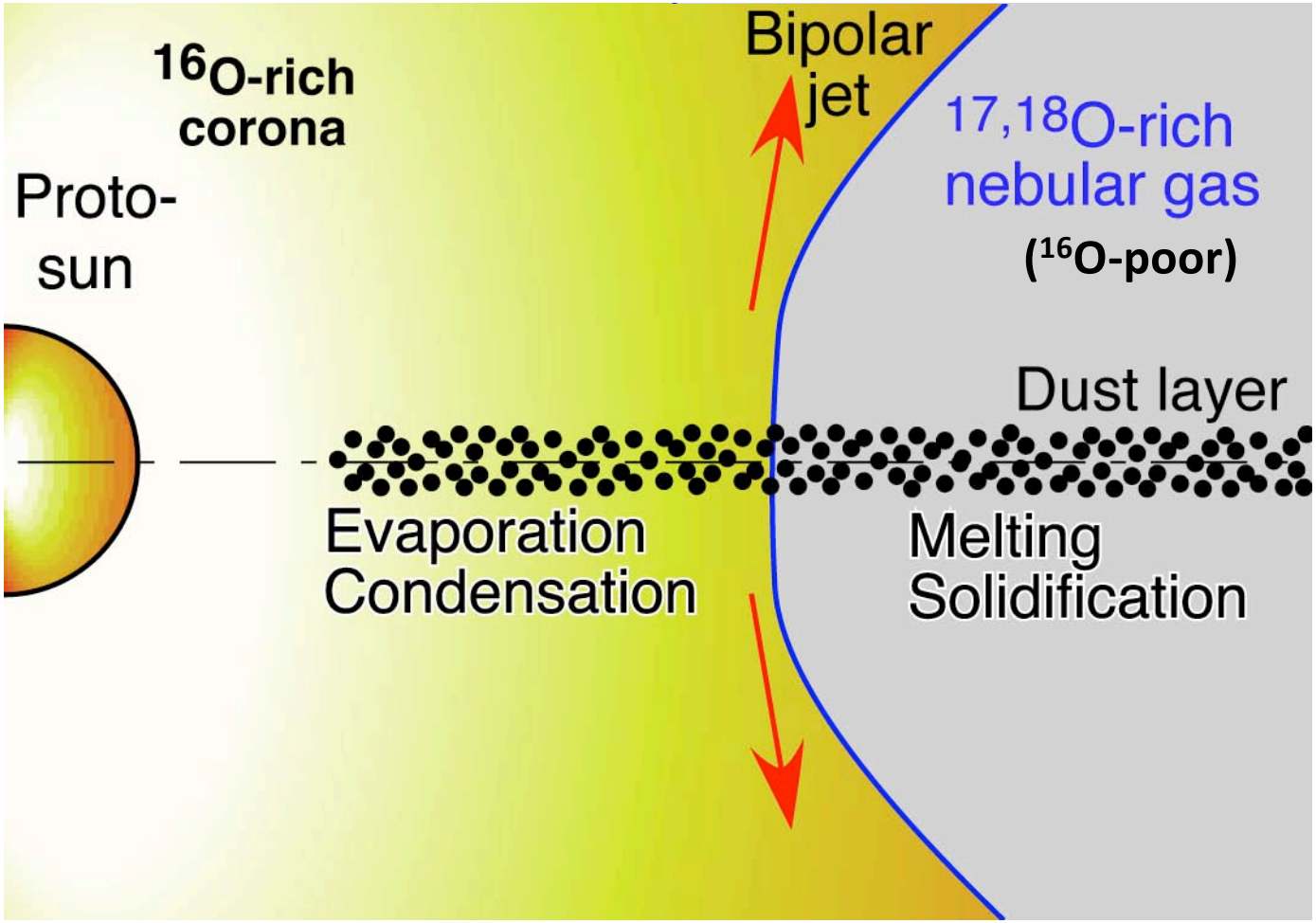
Astrophysical setting of CAI formation



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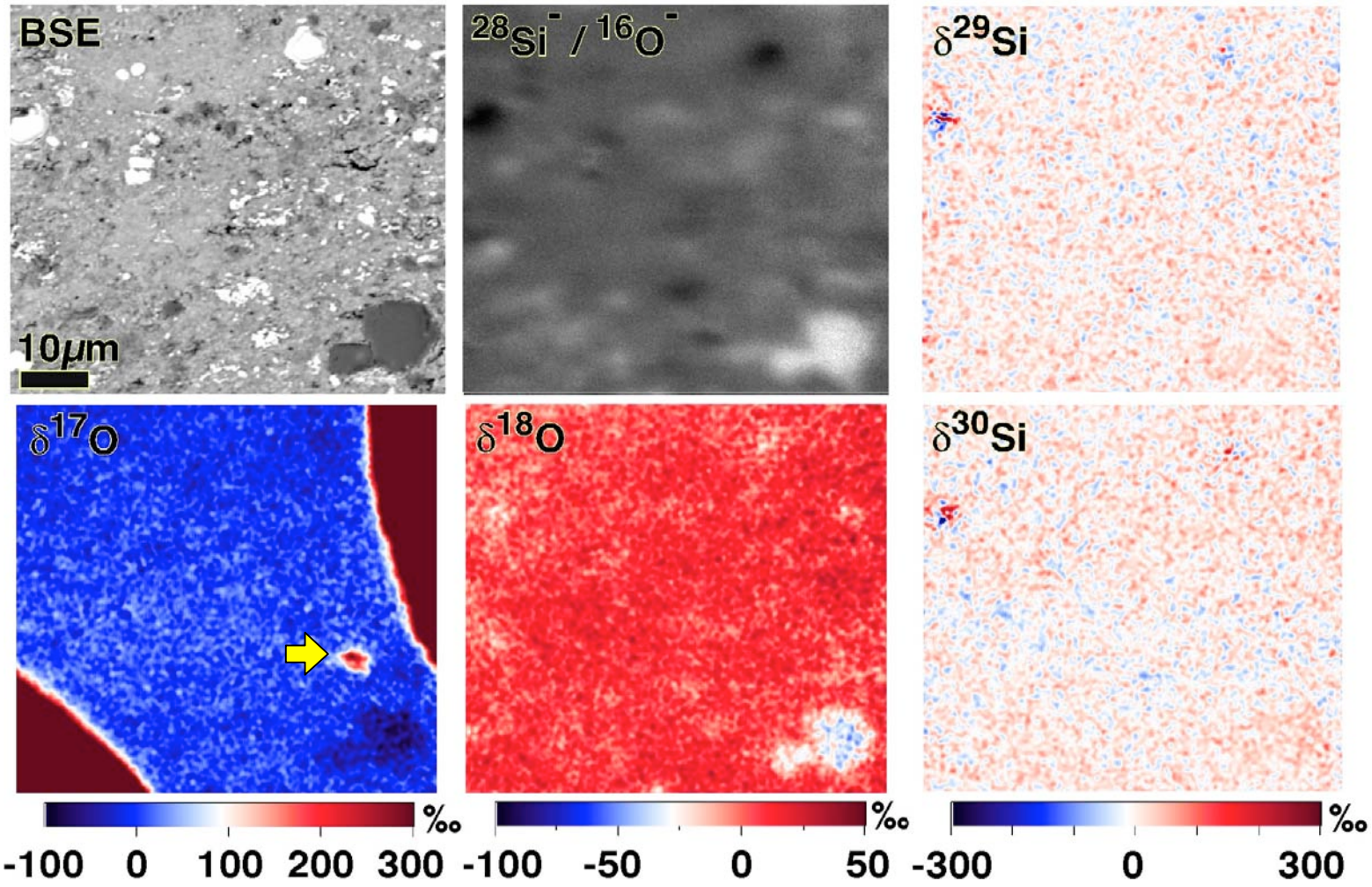
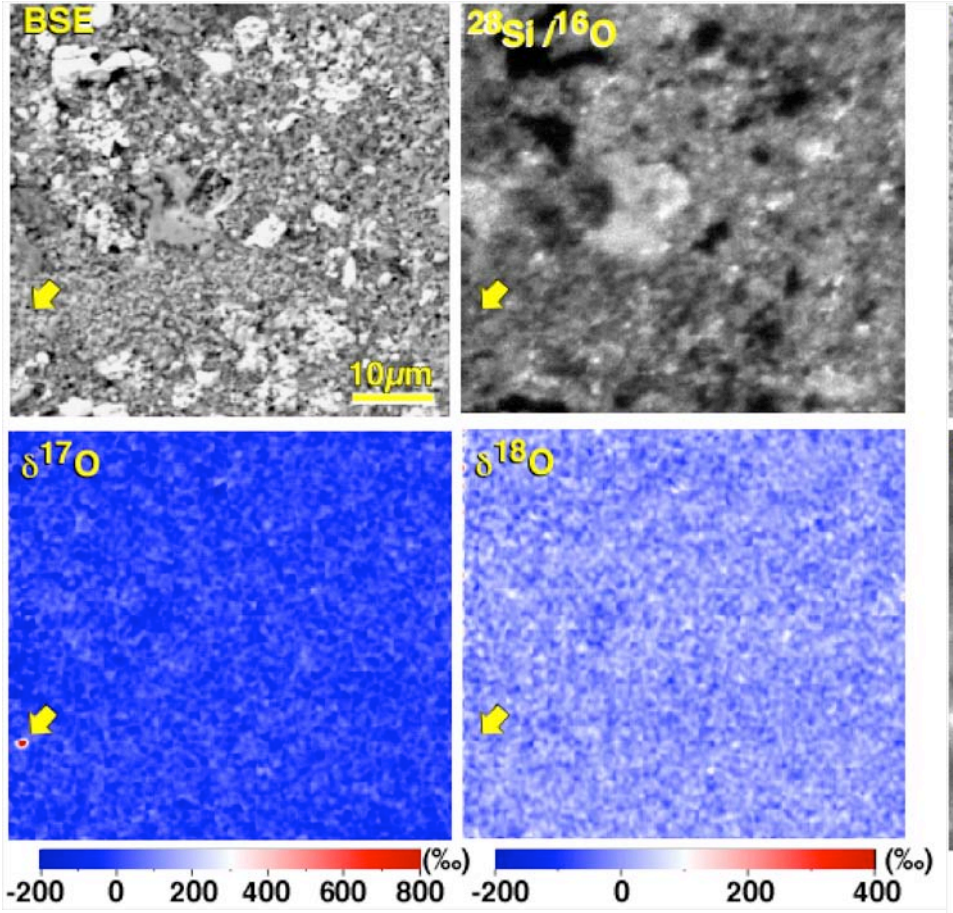
- Development of isotope nanoscope

Surprises: in situ observation of presolar grains

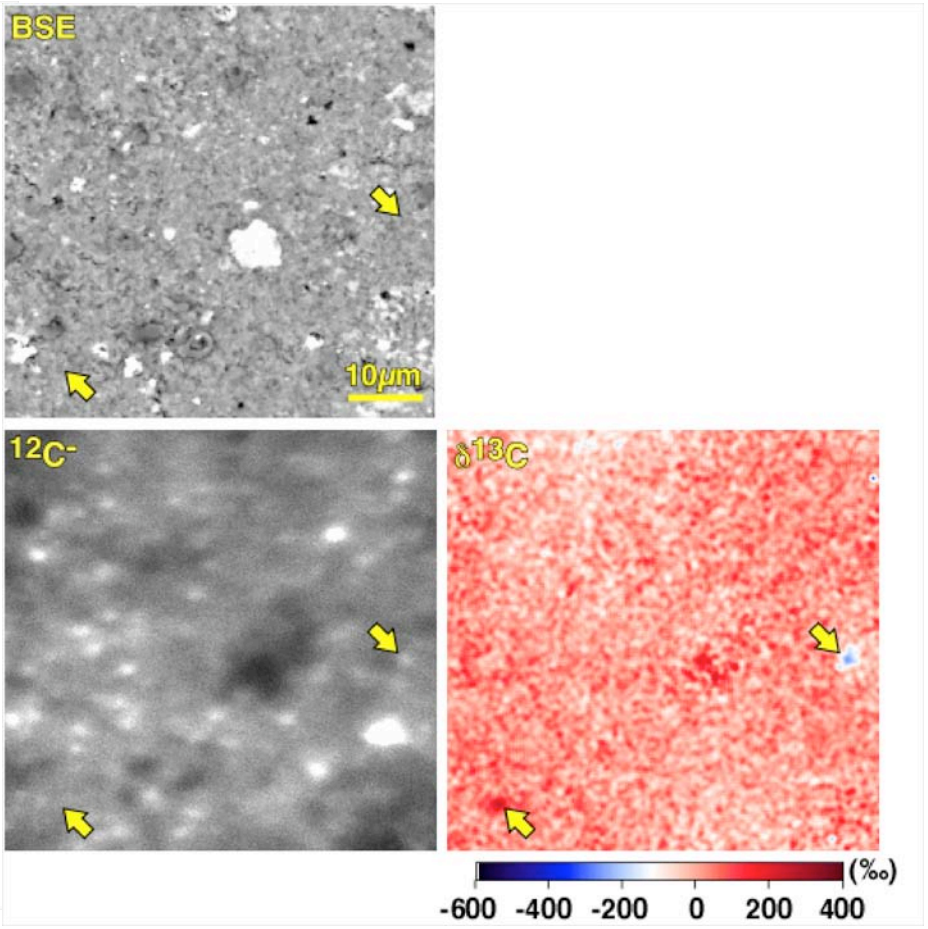


Nature (2004)

Surprises: in situ observation of presolar grains

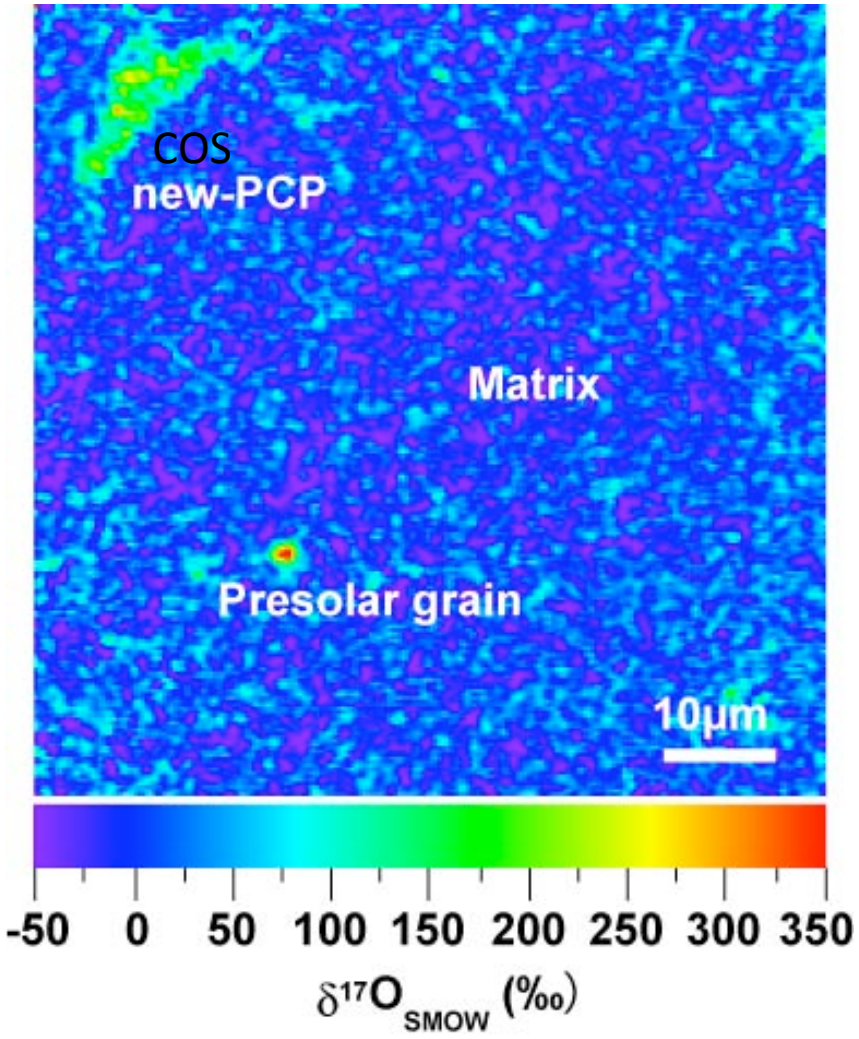


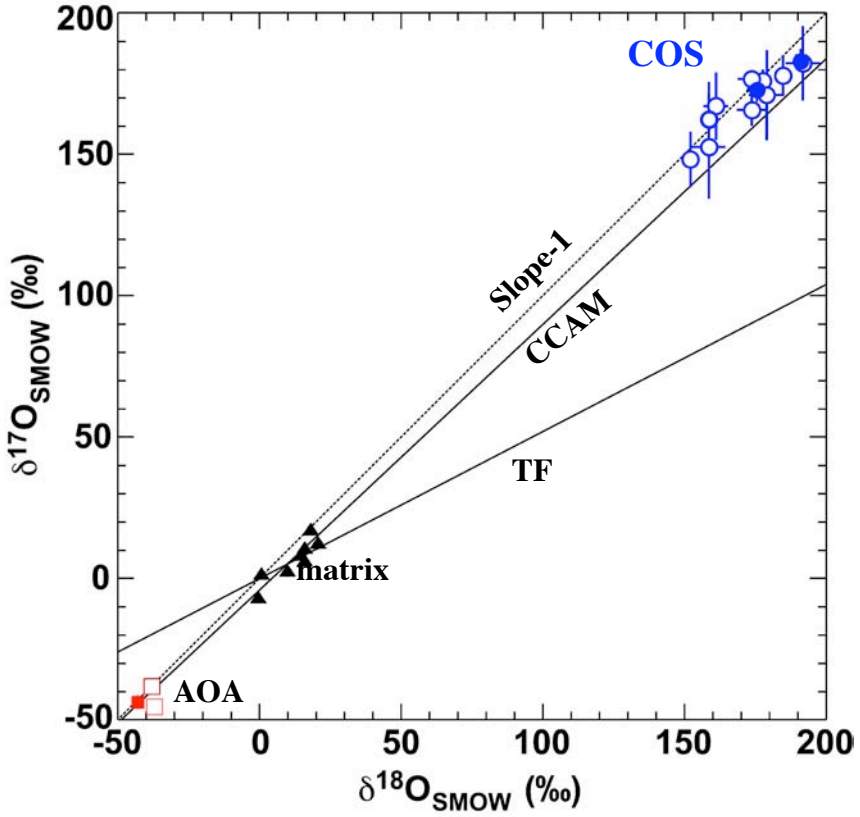
Presolar silicate grain



Presolar carbonaceous grains

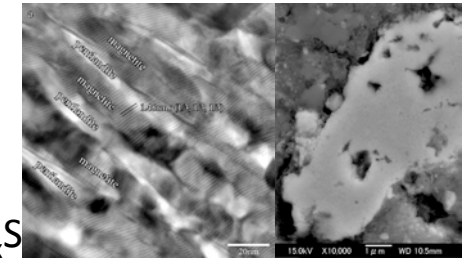
Surprises: Cosmic symplectite (COS)



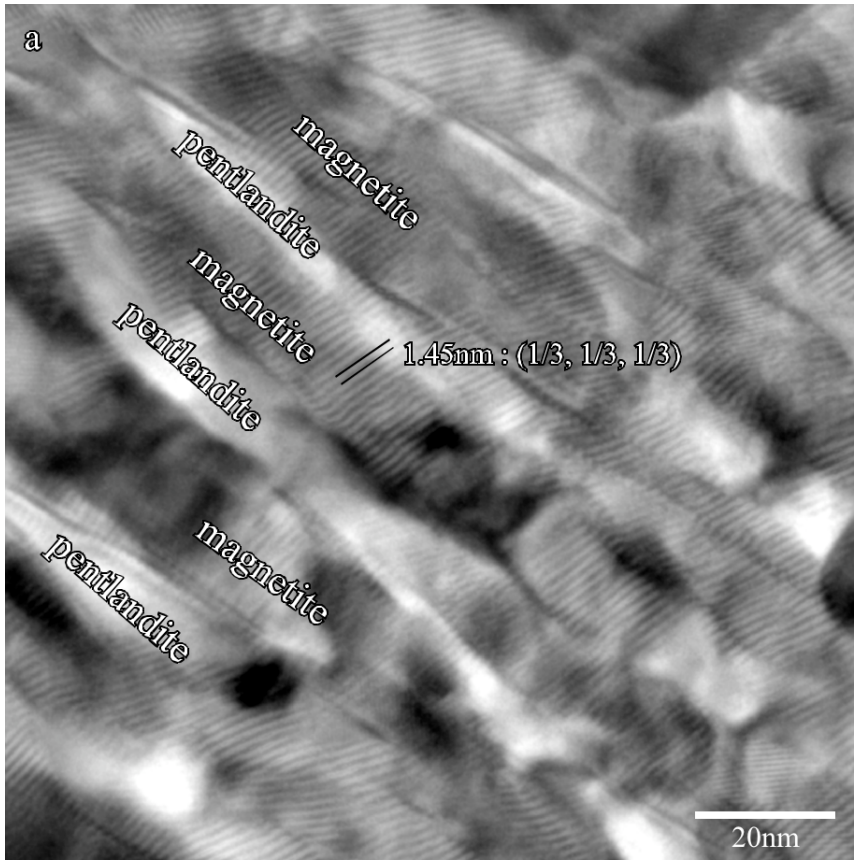


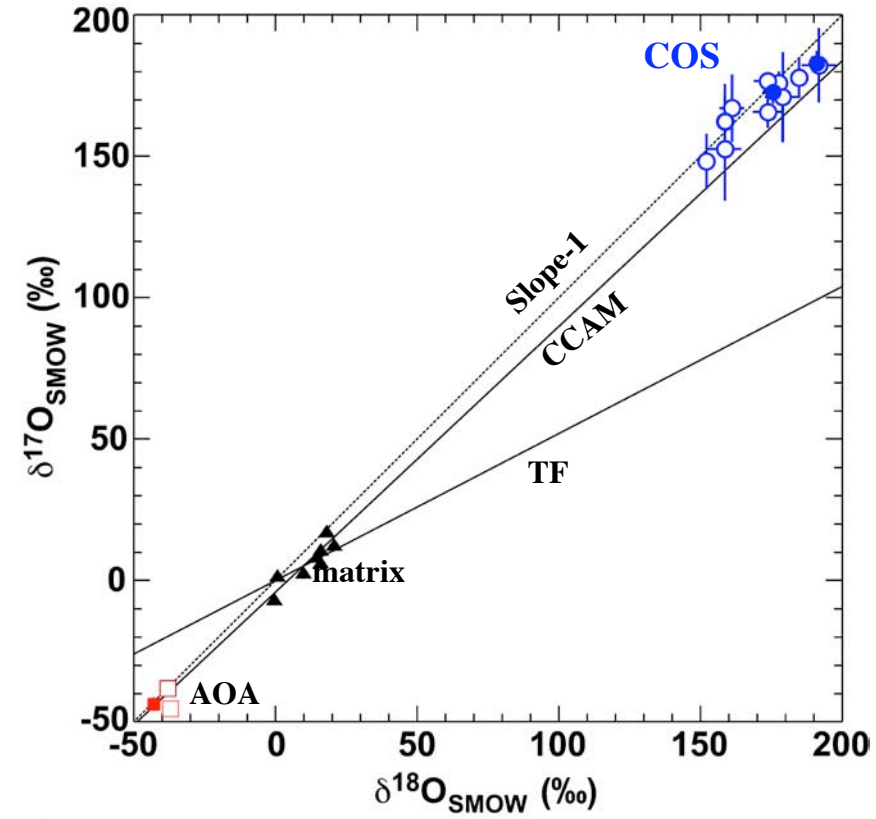
in Acfer 094, Science (2007)

Fe_2O_3+Fe_xS



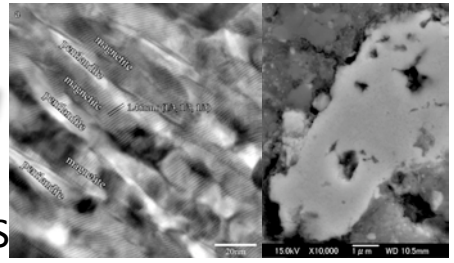
Surprises: Cosmic symplectite (COS)





in Acfer 094, Science (2007)

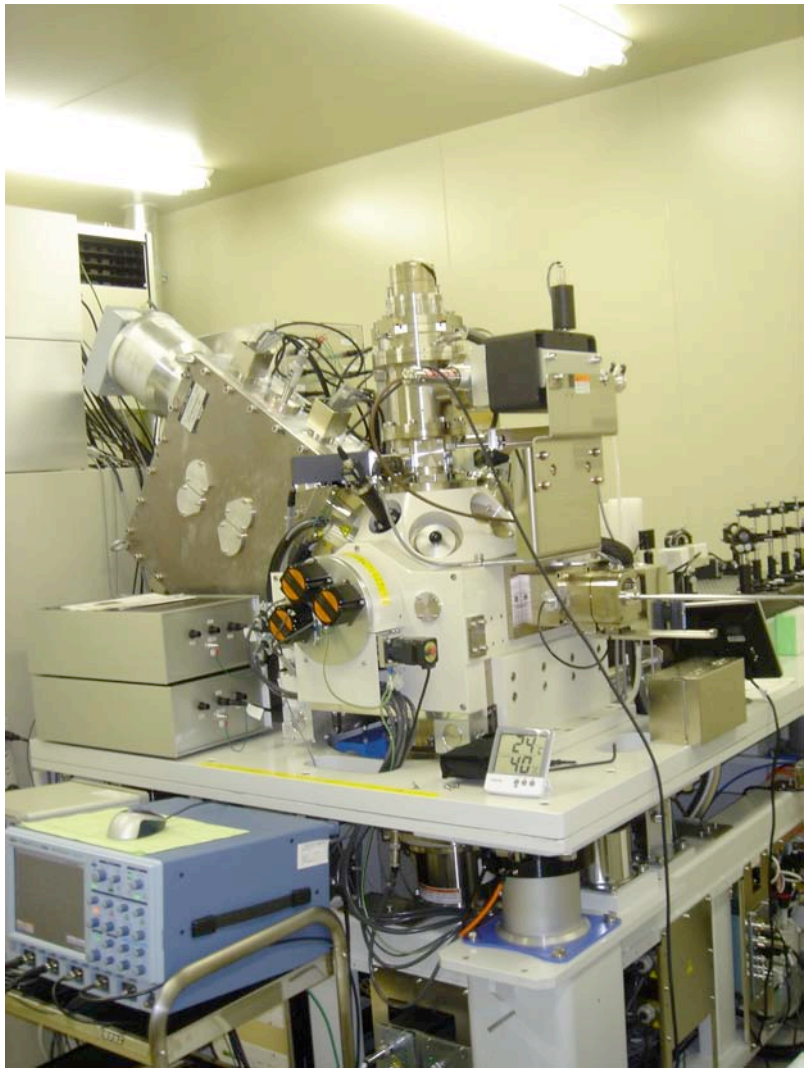
Fe_2O_3+Fe_xS



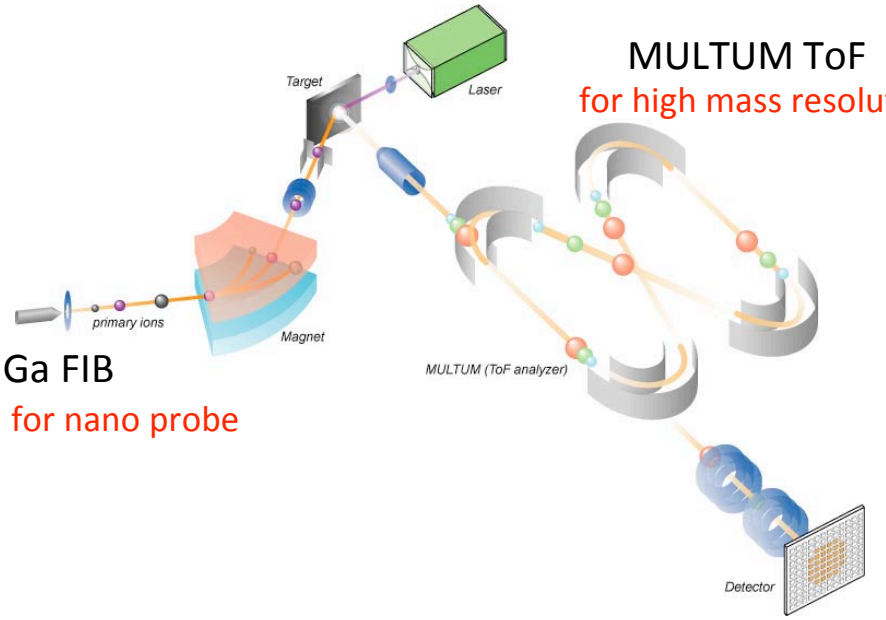
Outline

- Paradox between chemical and isotope petrography of CAIs
- Point to Line SIMS analysis
- Development of isotope microscope
- Advancement of Isotopography
- Astrophysical dynamic setting for CAI formation
- Surprises
  - Presolar grains
  - Cosmic symplectite (COS)
- Development of isotope nanoscope

Development of Isotope nanoscope



for post ionization
fs Laser

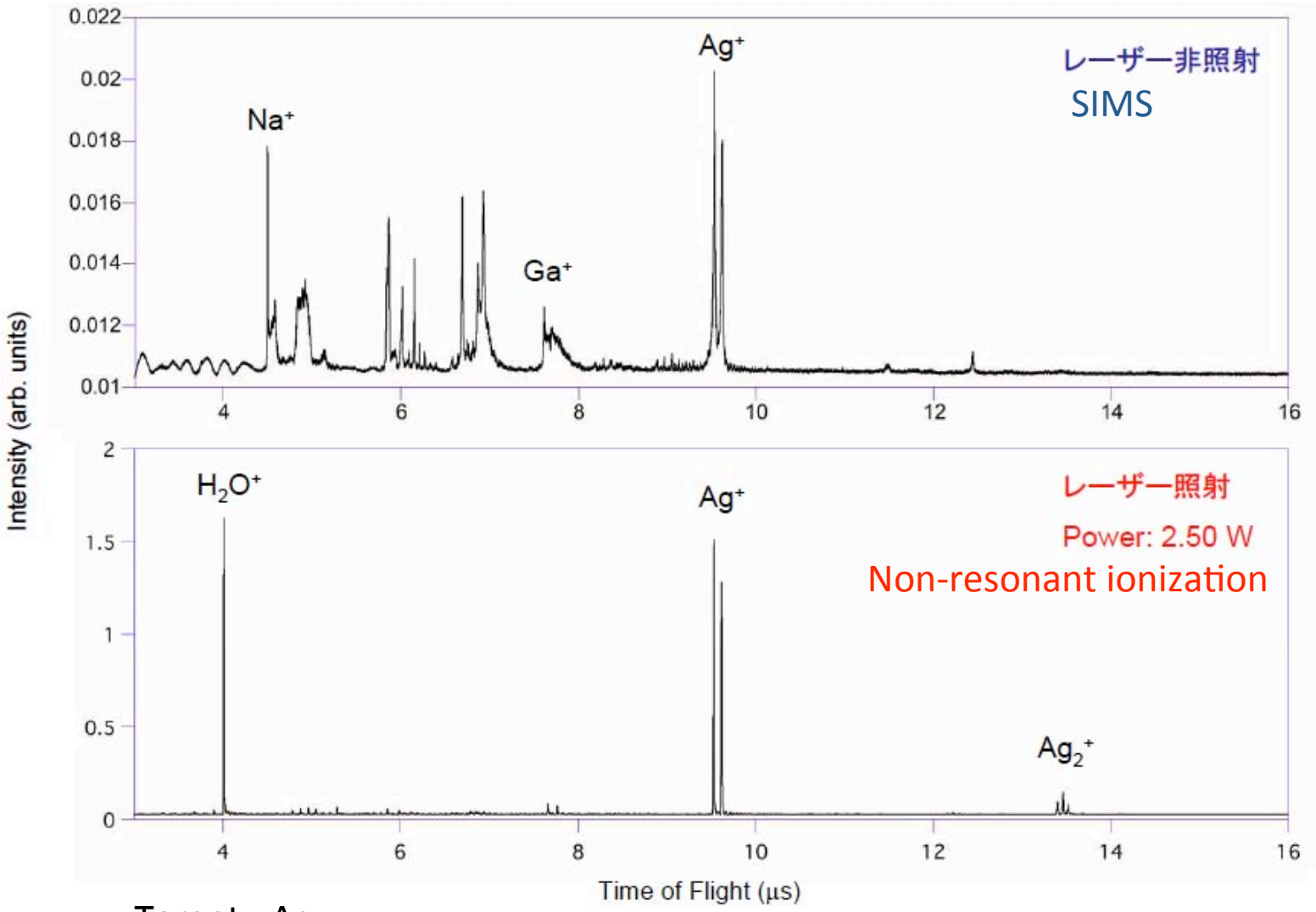


MULTUM ToF
for high mass resolution

Ga FIB
for nano probe

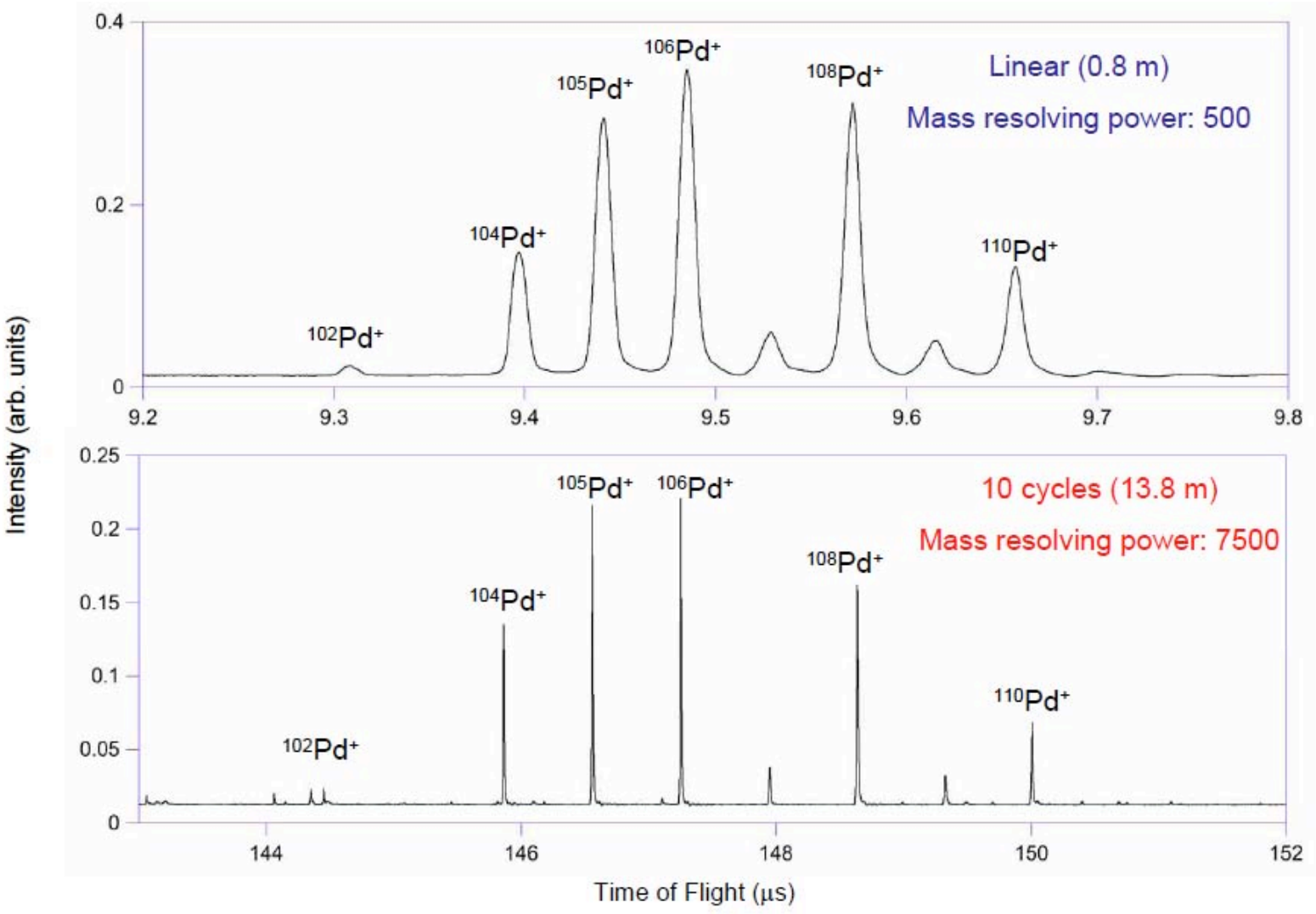
SCAPS detector
for simultaneous measurement

Development of Isotope nanoscope



Target : Ag

Development of Isotope nanoscope



Isotopic Petrography: State and Prospects

- Isotopic petrography reaches real micrometer scale.
- Nano-scale is a treasury of pre-solar history information.
- Isotopic petrography on real nano-scale should be advanced.