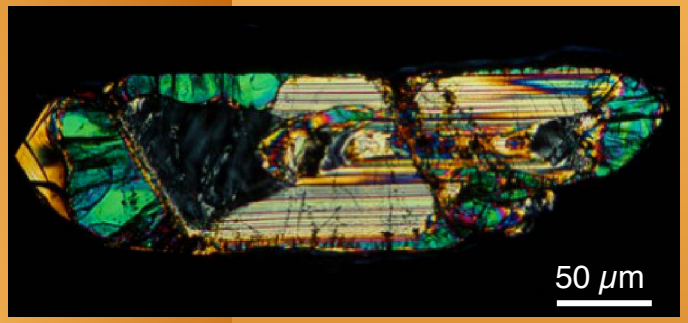
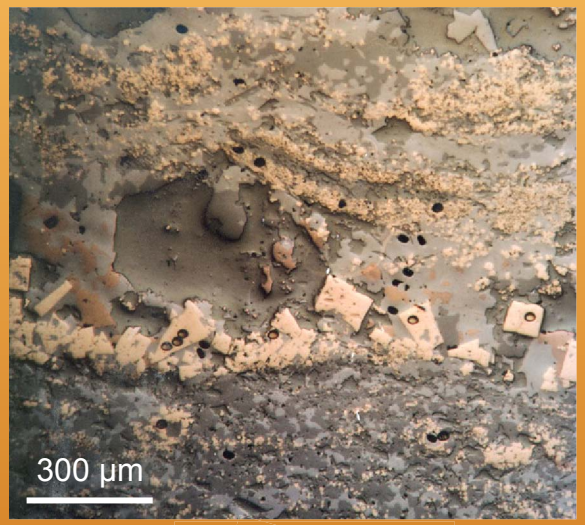
The Wonderful World of SHRIMP

Sensitive High Resolution Ion MicroProbe

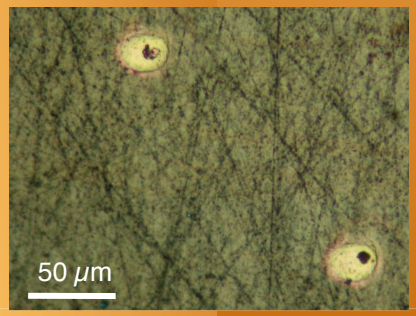


Geochronology

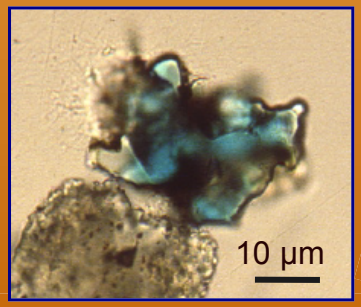


Ore genesis

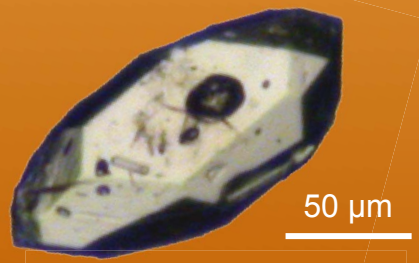
Palaeoclimatology



Nuclear monitoring



Cosmochemistry



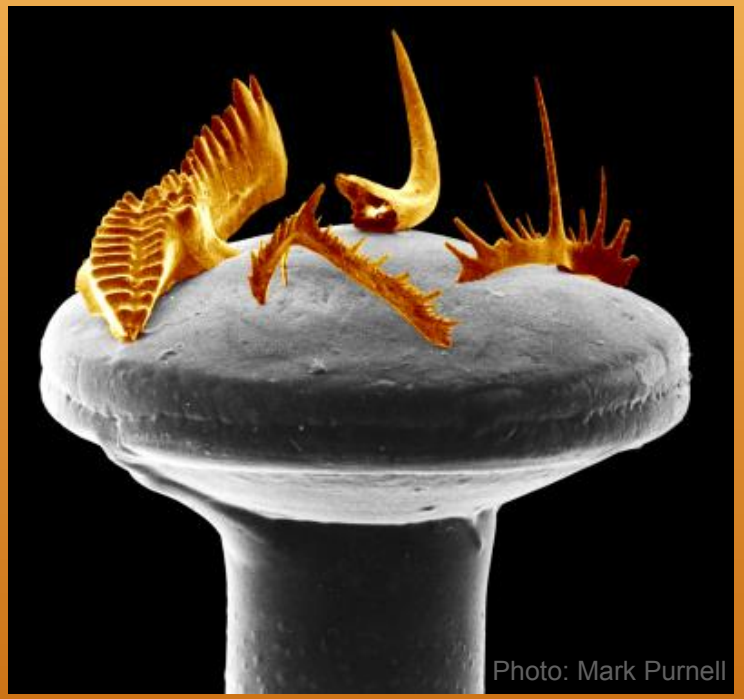
Geothermometry

Archaeology

The Wonderful World of SHRIMP

Many things we need to analyse are very small

Zircon crystals for dating rocks



Microfossils for climate studies

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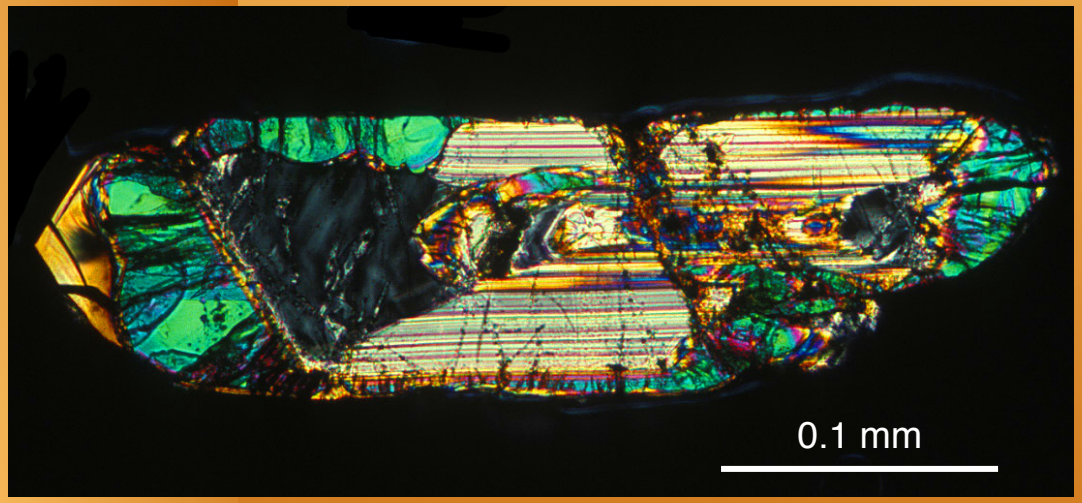
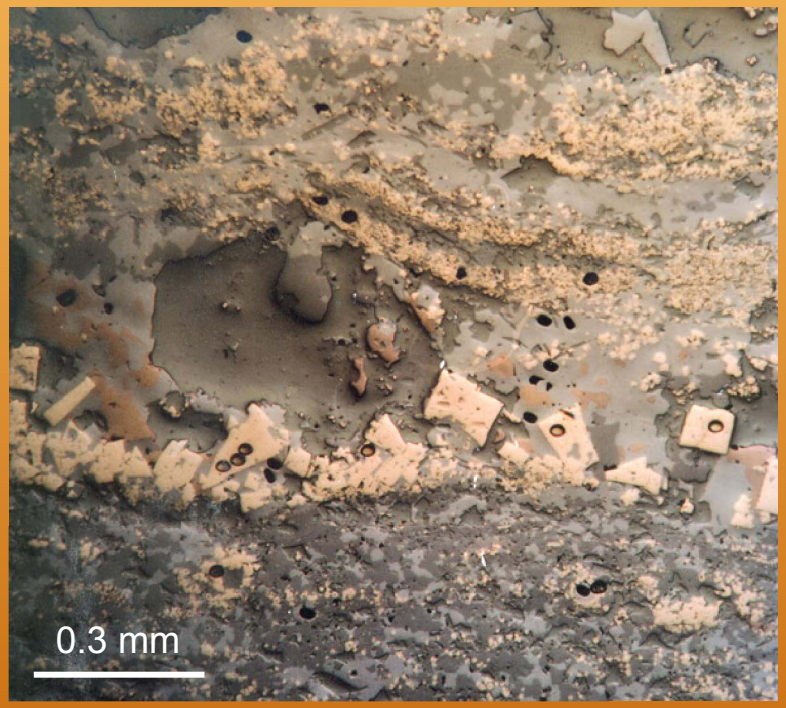
Many things we need to analyse are complex



A billion years of growth history
in a single zircon crystal



Pb, Cu and Fe sulfides
in high grade ore

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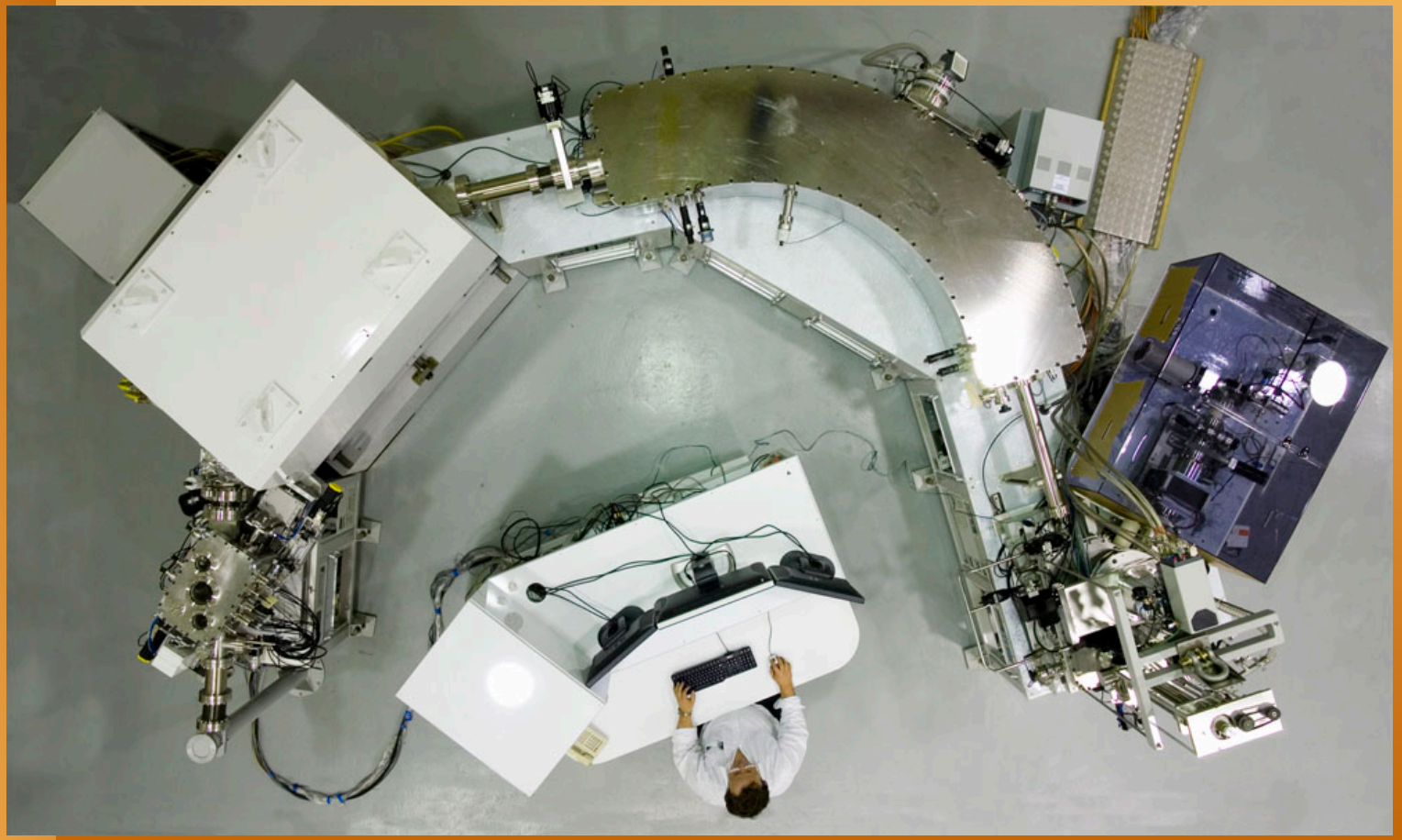
SHRIMP analyses isotopes on a 0.01 mm scale



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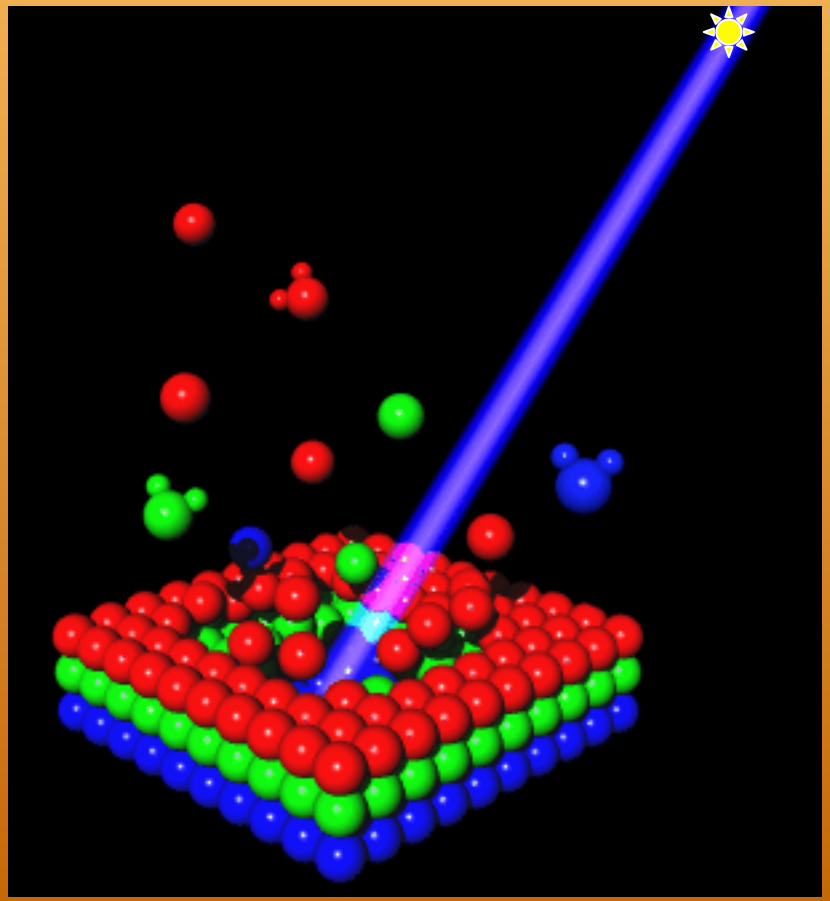
The sample is bombarded by 10,000 volt ions



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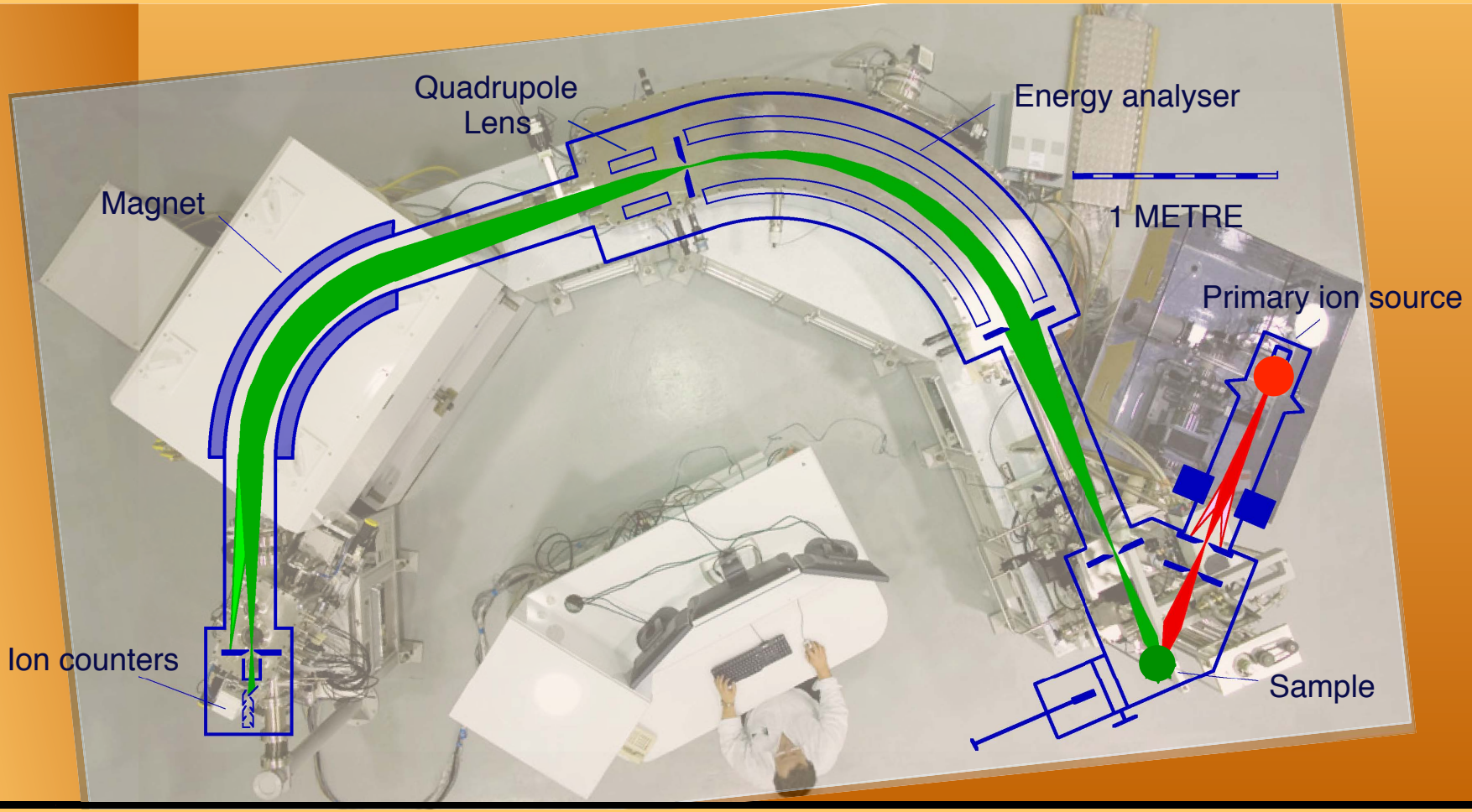
SHRIMP analyses the ejected atoms



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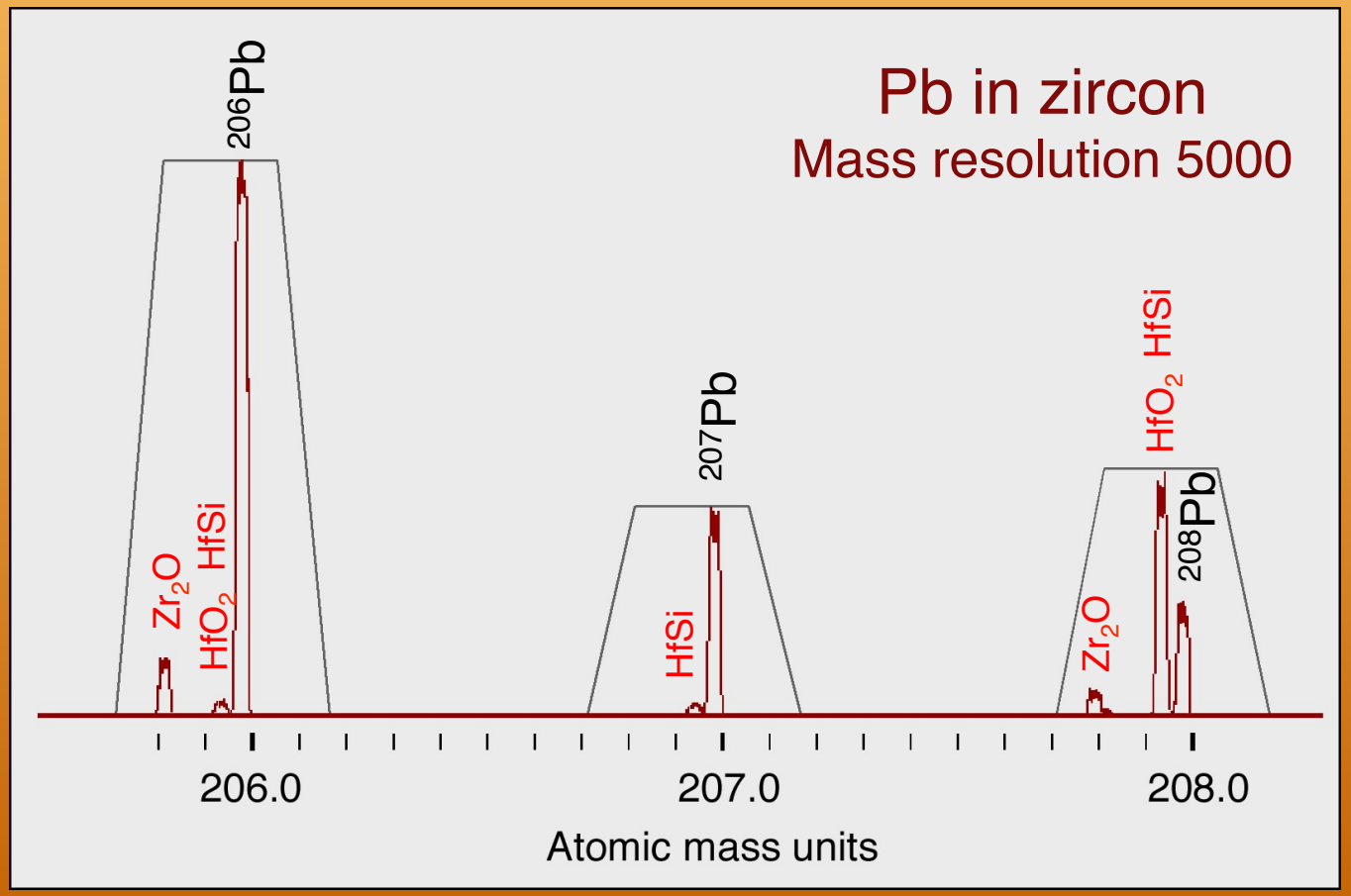
SHRIMP is big to separate atoms from molecules



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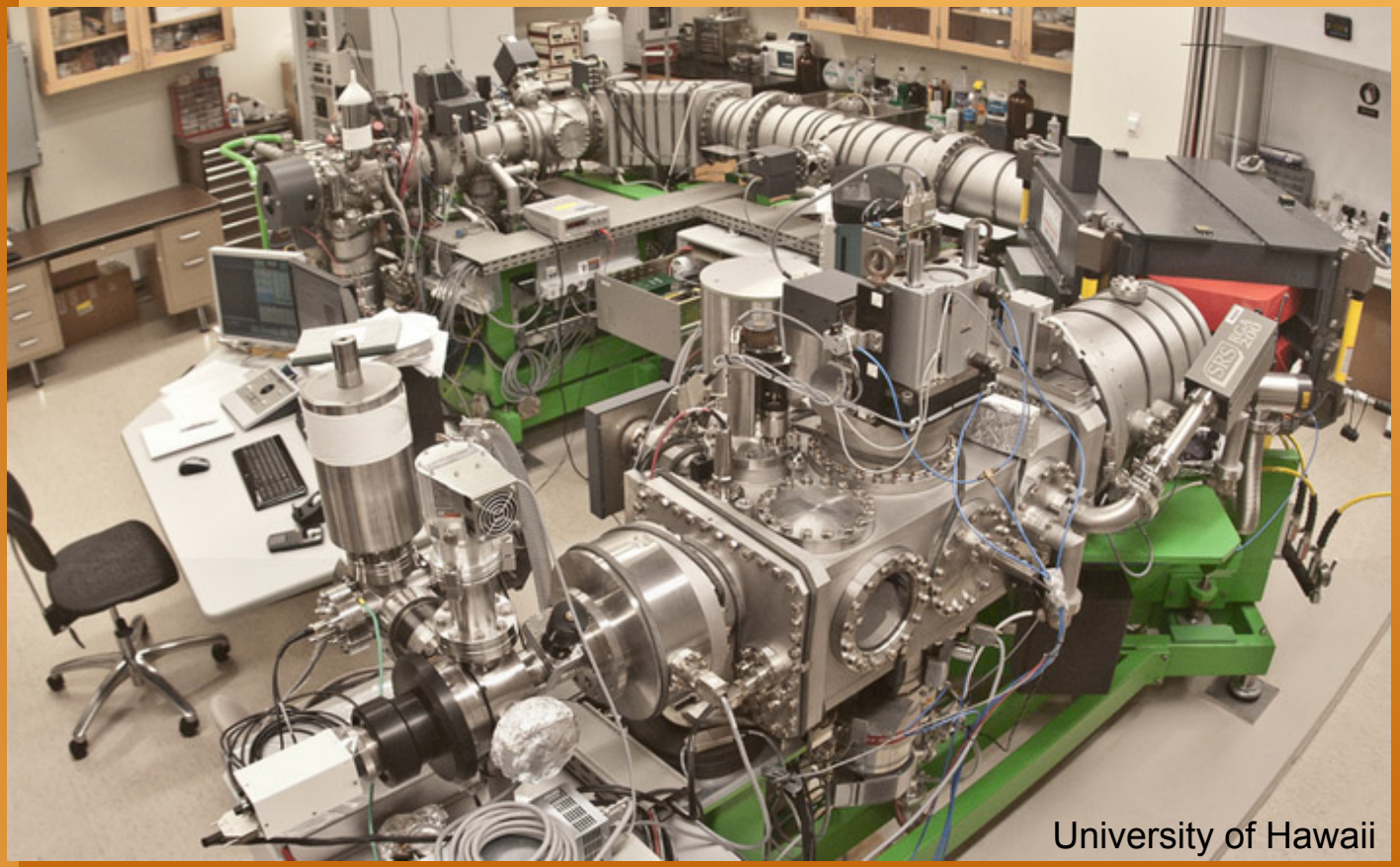
Cameca IMS 1280 is big for the same reason



University of Hawaii

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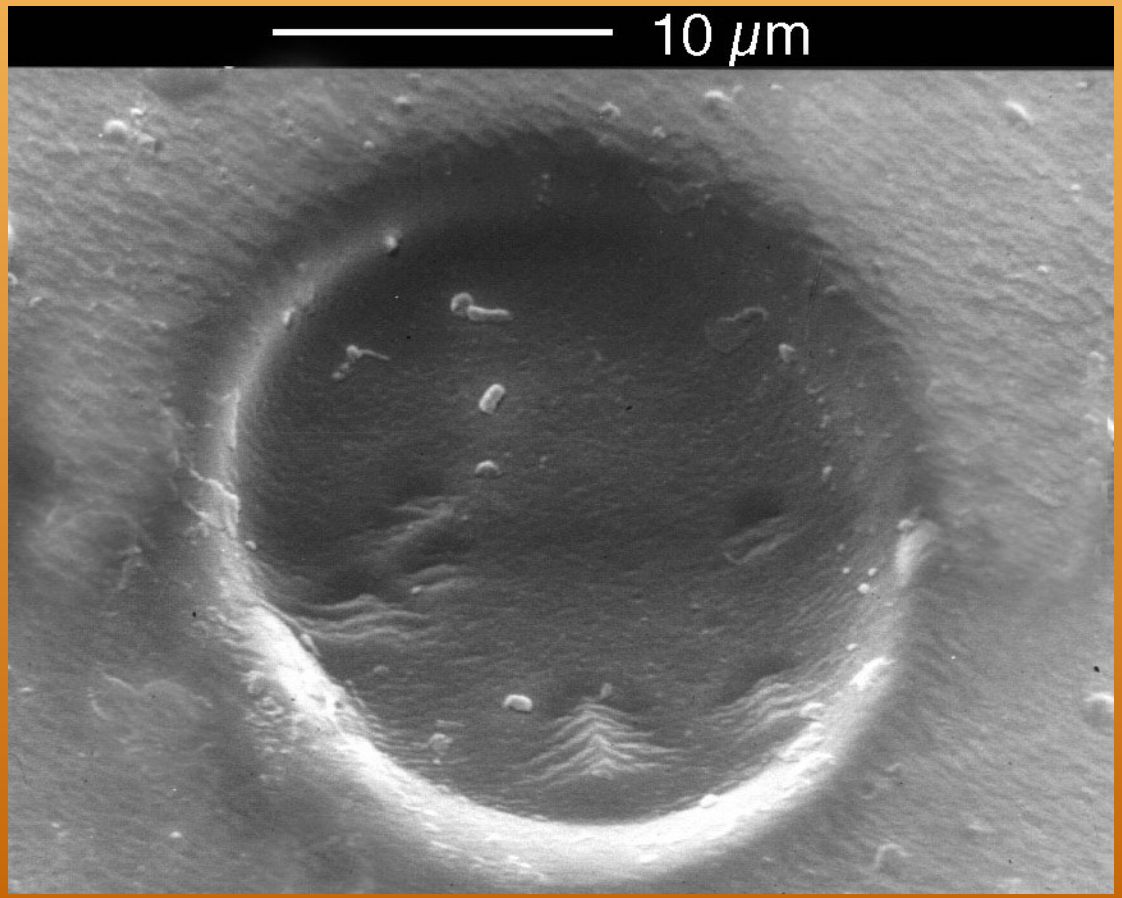
Surface analysis: 0.000000002 g of sample



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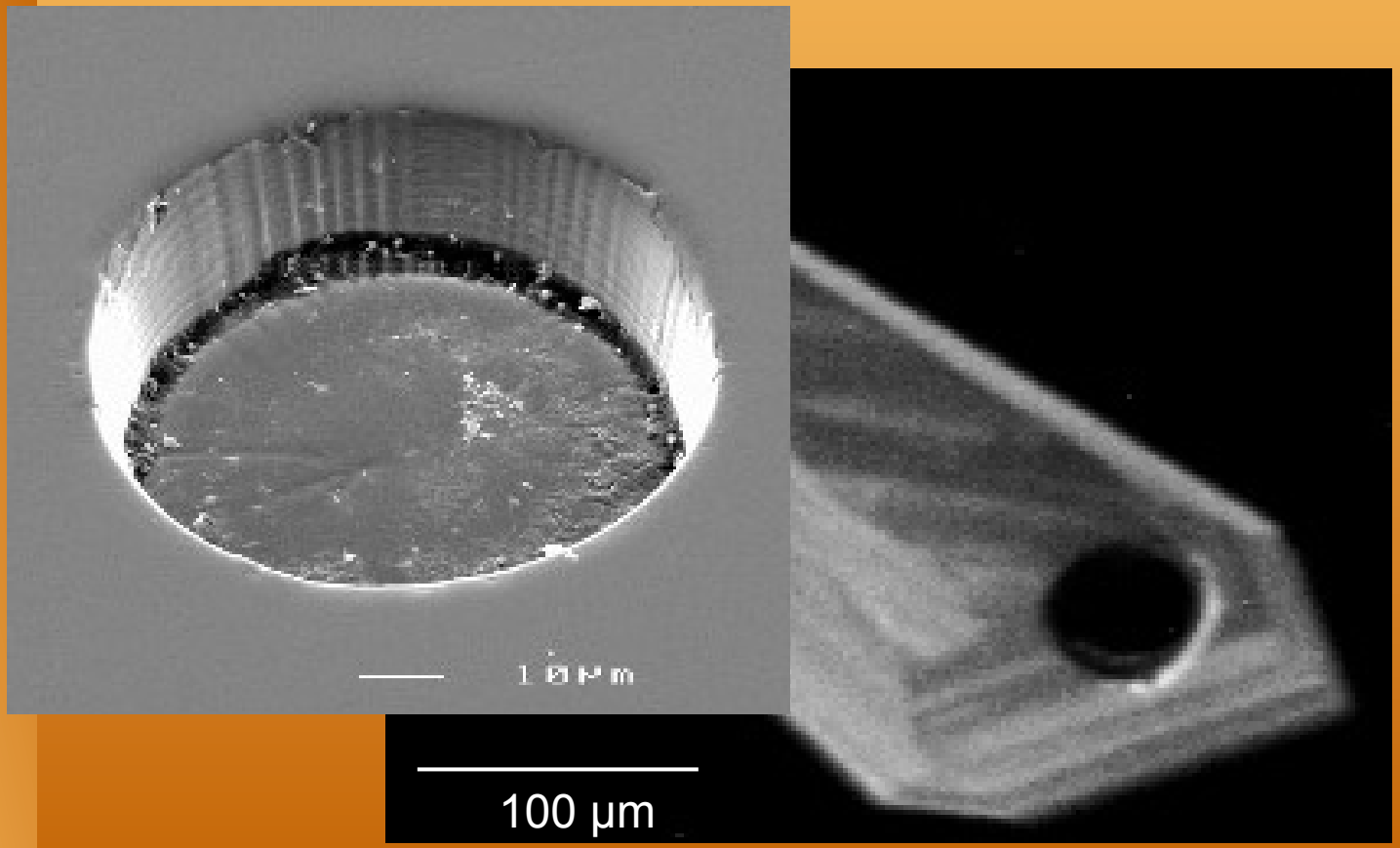
Laser dating penetrates deeply into the grain



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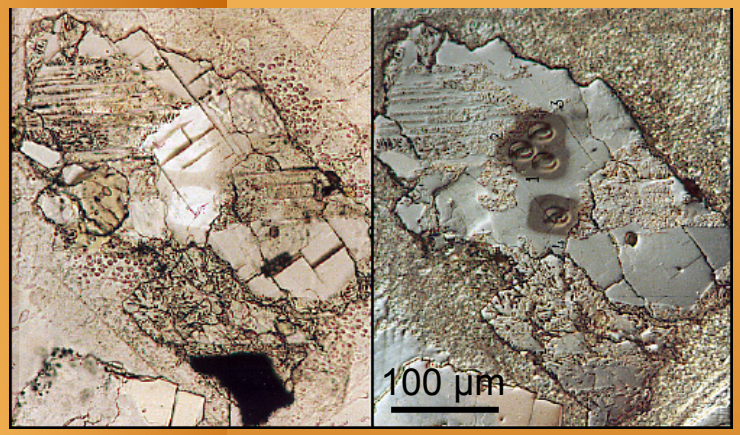
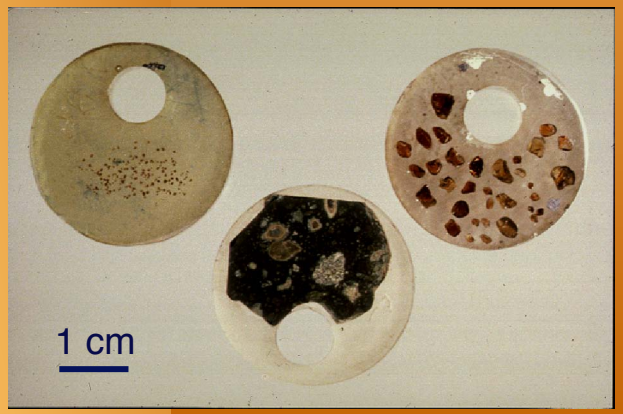
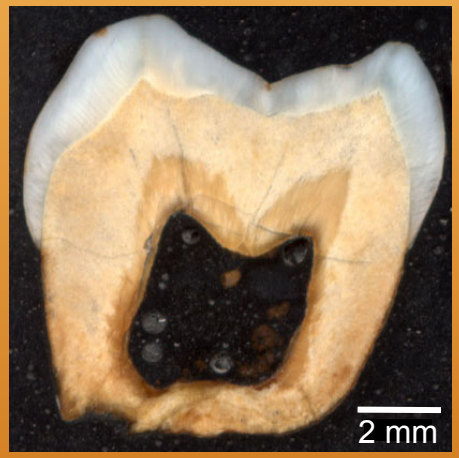
Wide range of solid samples possible



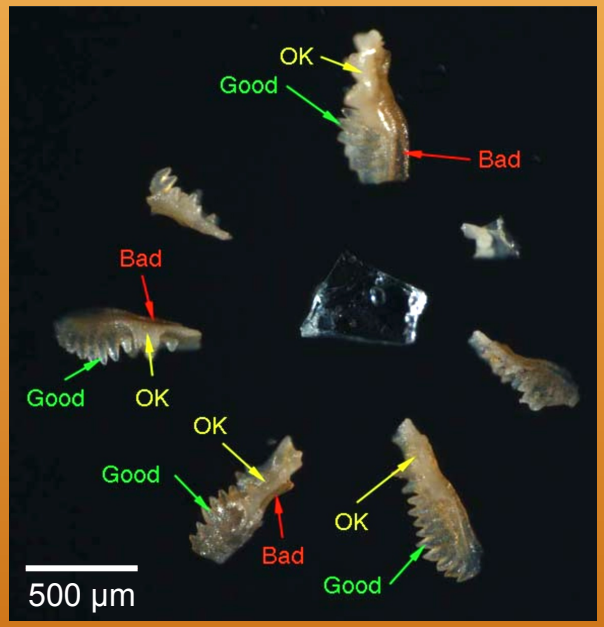
Polished thin sections



Separated minerals
Blocks of rock



Archaeological material



Microfossils

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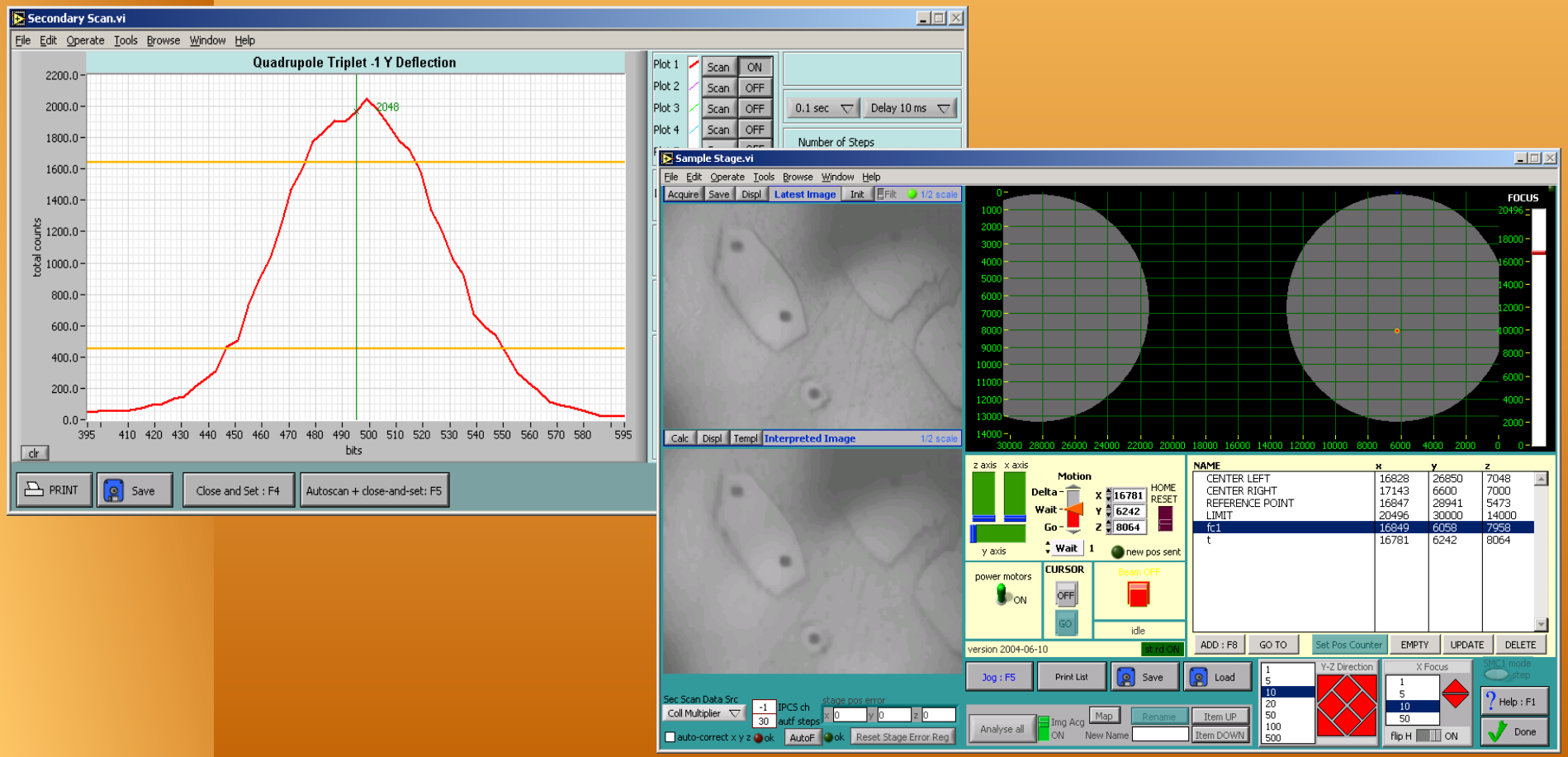
Analysis is manual or fully automatic



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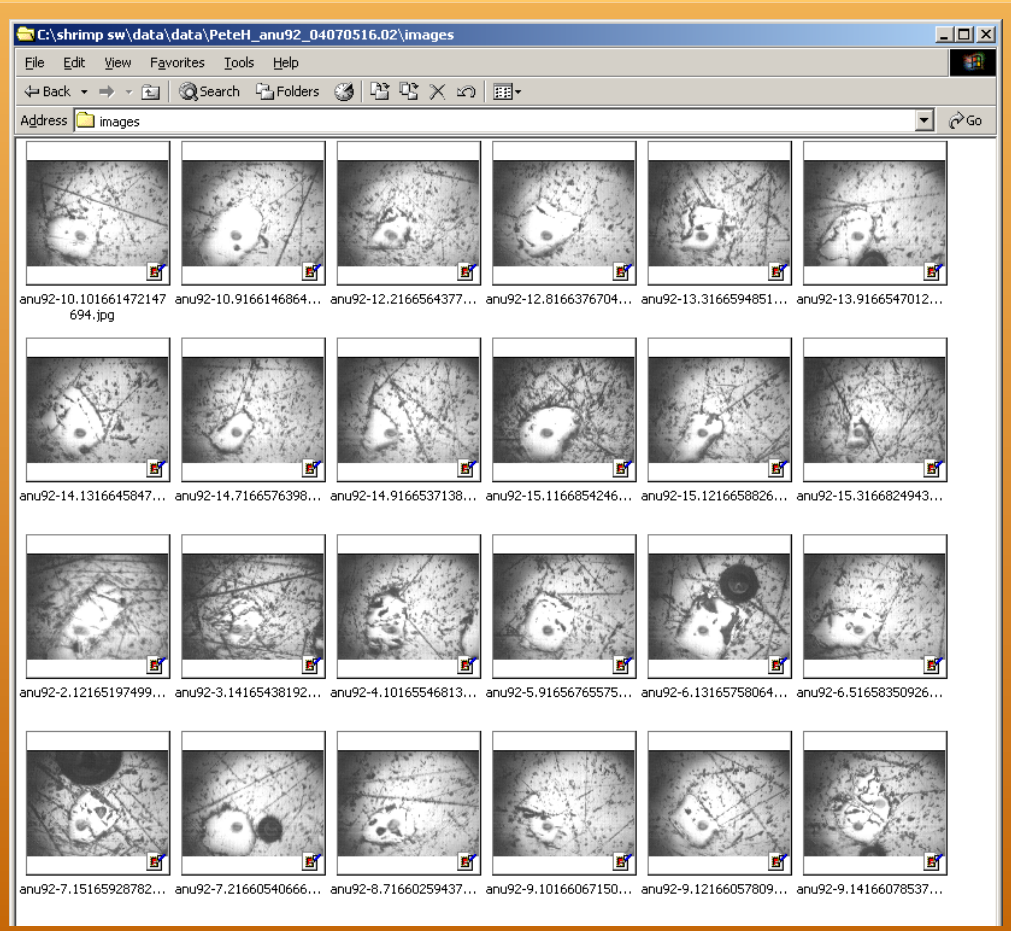
Spot photos are stored with the analyses



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Wide range of applications

- Geochronology
- Isotope anomalies
- Trace elements
- Stable isotopes
- Two case studies
  - Sea surface temperatures in the Early Palaeozoic
  - 'Keyhole' geochronology of the Polish basement

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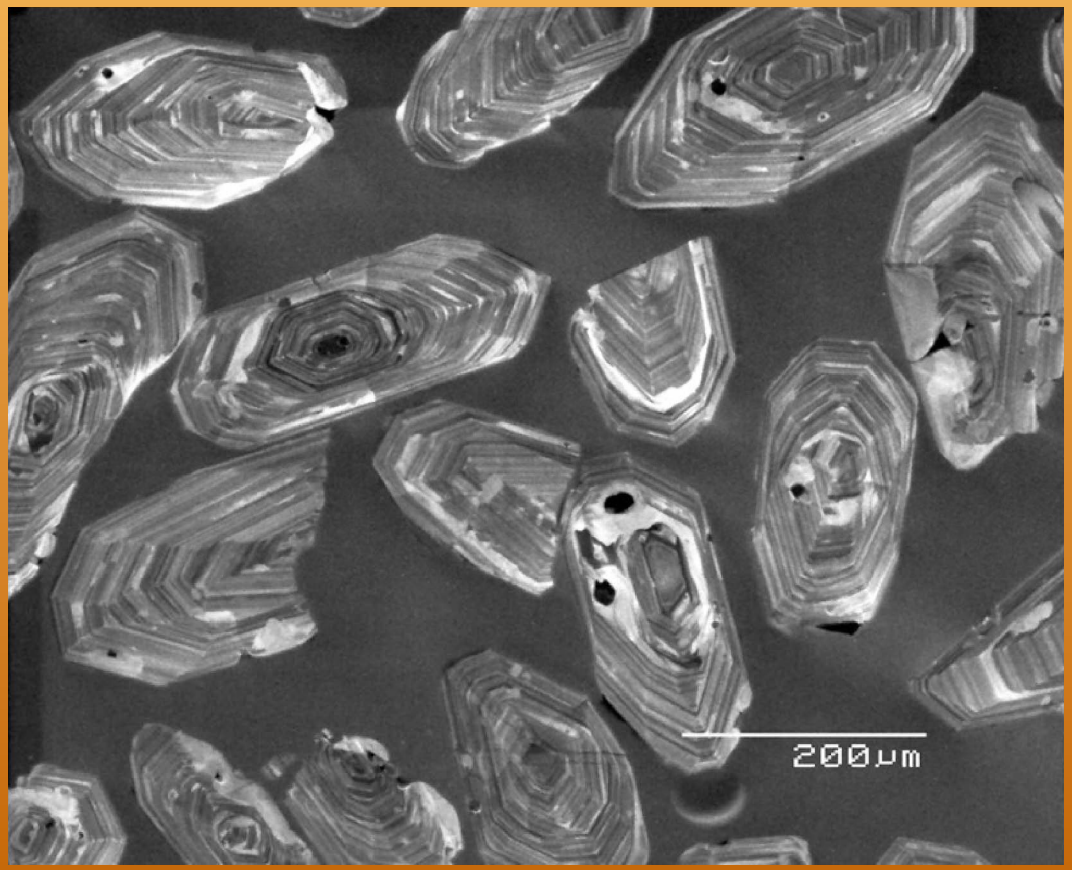
Wide range of applications - geochronology

Accurate mineral ages of igneous rocks

Zircon, monazite, apatite, titanite, baddeleyite, rutile, allanite, perovskite



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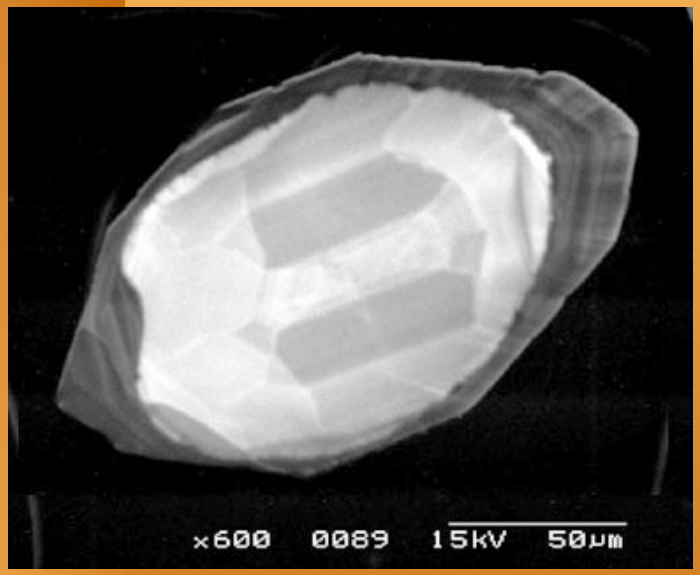
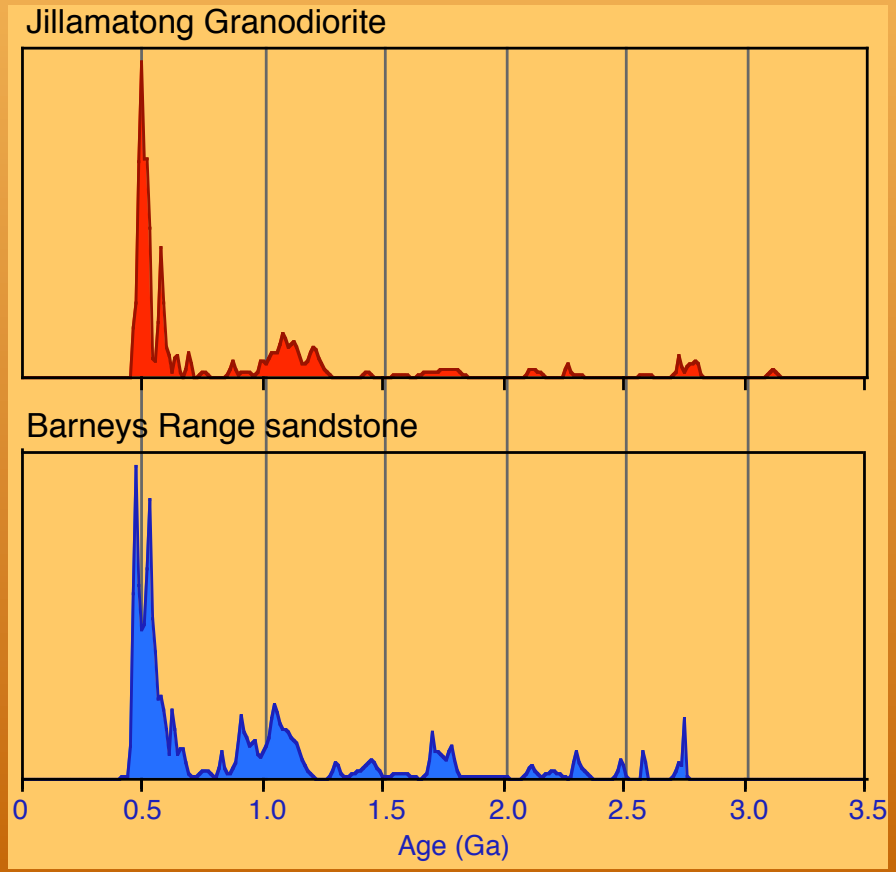
Wide range of applications - geochronology



Magma sources from inherited zircon cores



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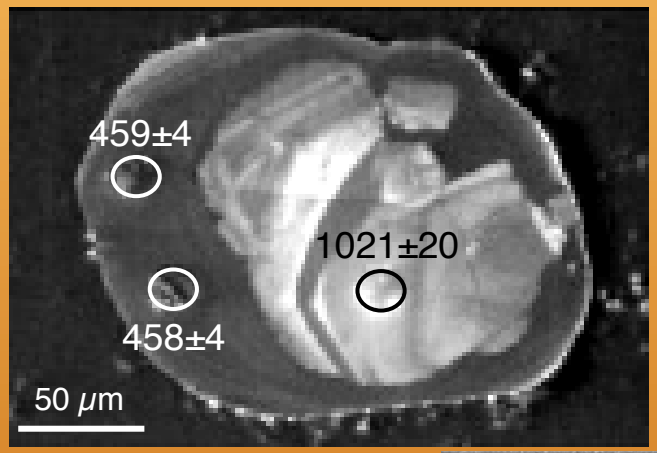
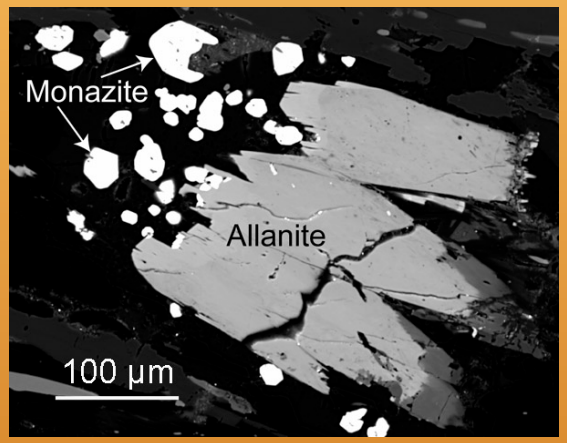
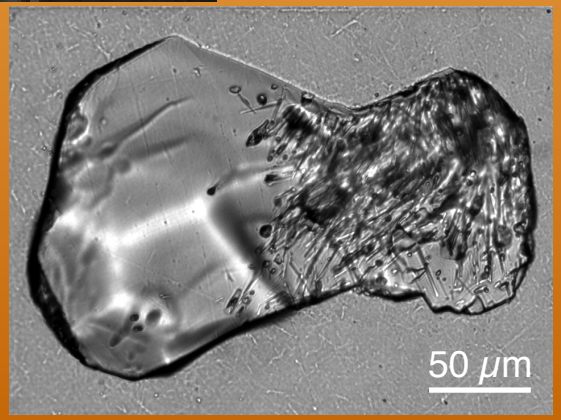
Wide range of applications - geochronology

Metamorphic ages from zircon overgrowths, monazite and titanite







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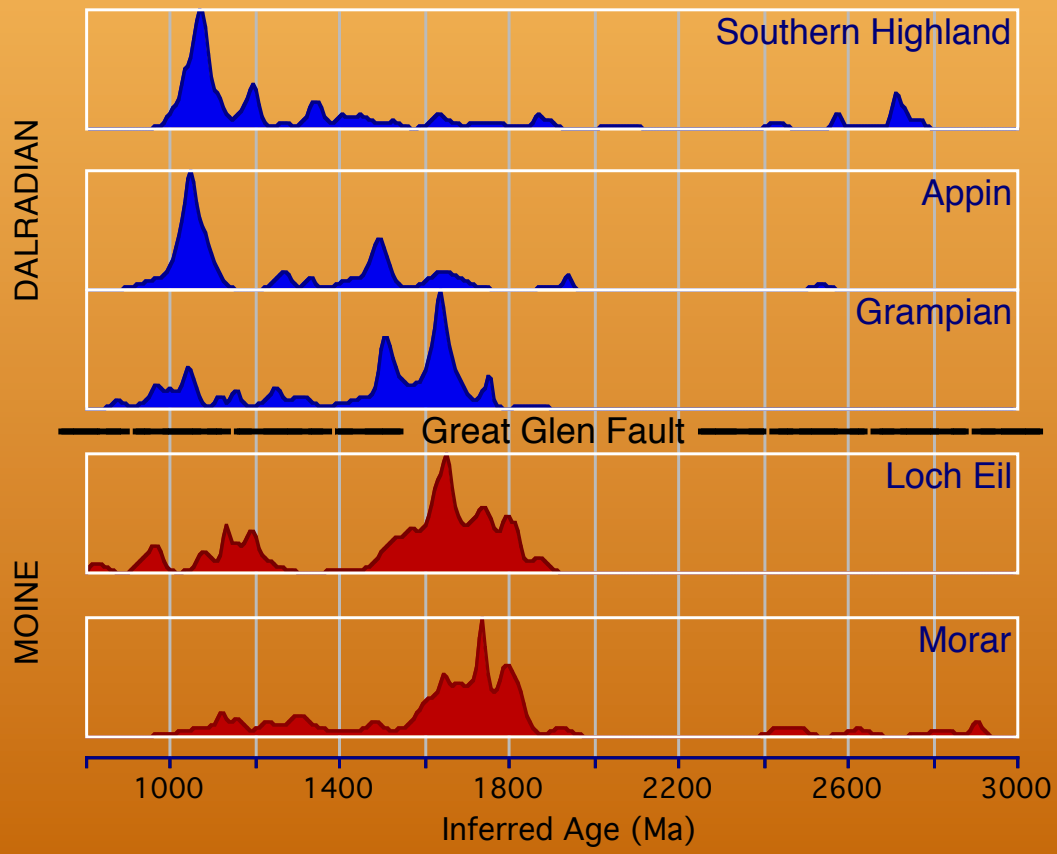
Wide range of applications - geochronology

Sediment provenance and correlation

Zircon, monazite, titanite, rutile



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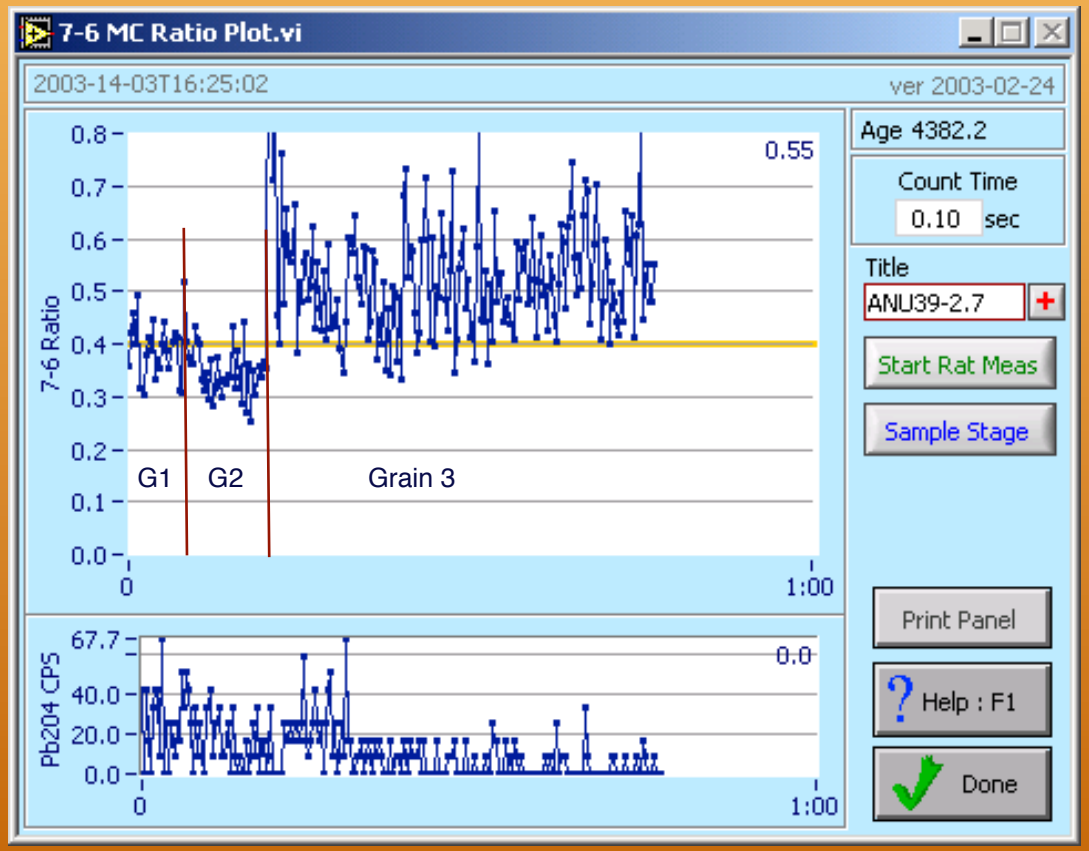
Wide range of applications - geochronology

Survey radiogenic mineral Pb isotope dates in 5 seconds



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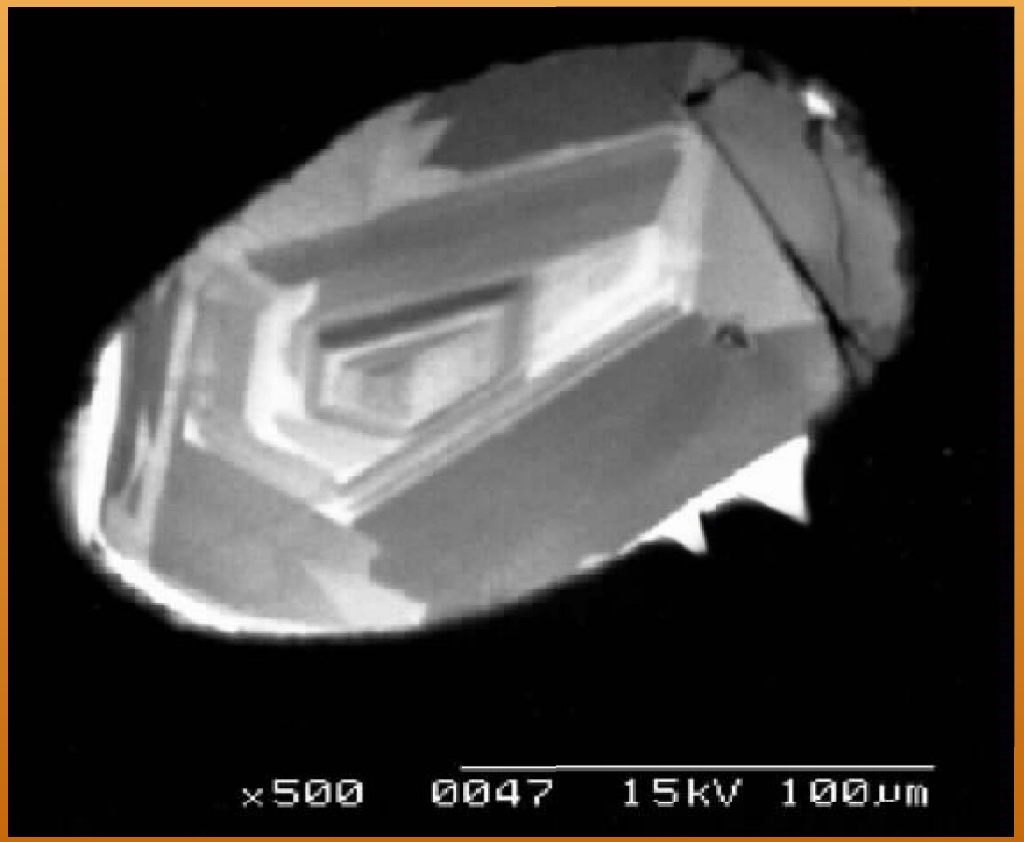
Wide range of applications - geochronology

Deposition and fluid flow ages from phosphate overgrowths

Monazite, xenotime



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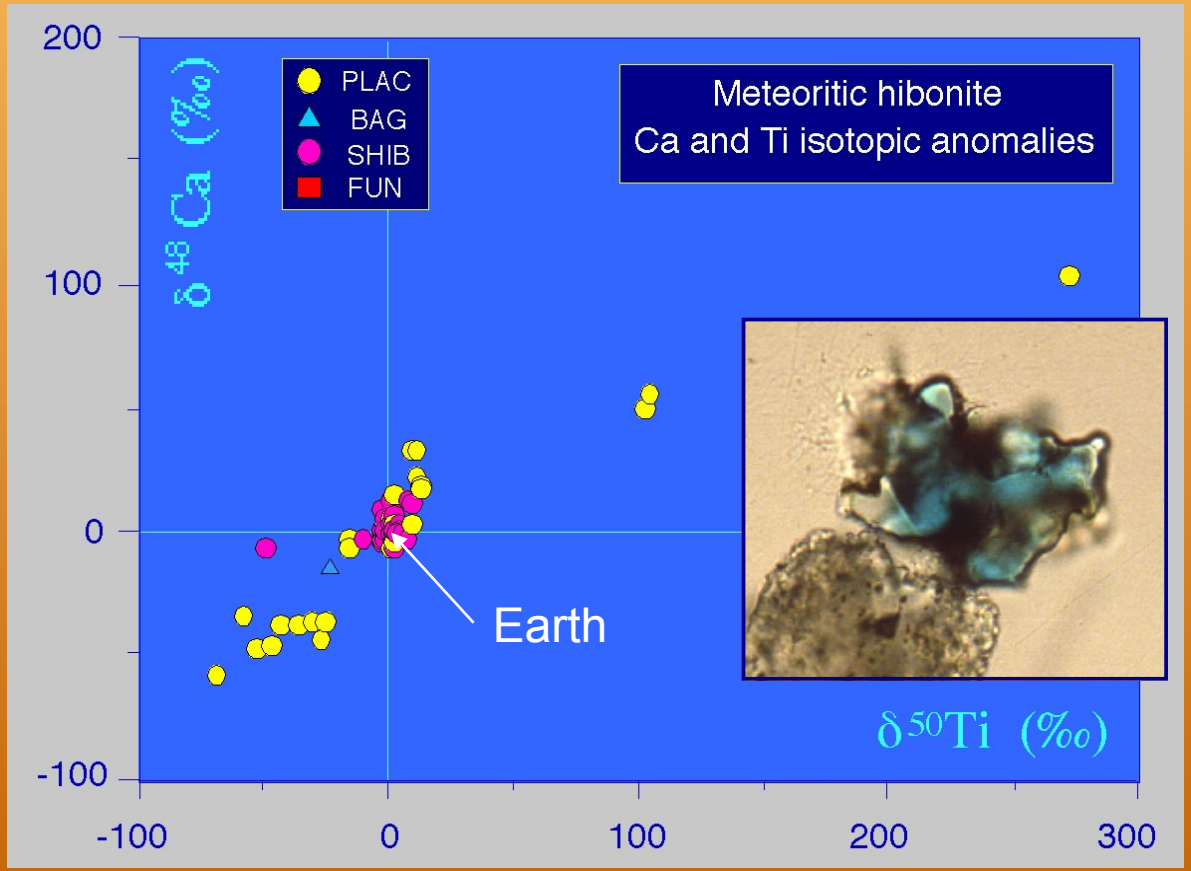
Wide range of applications - cosmochemistry

Isotope anomalies in star dust from meteorites



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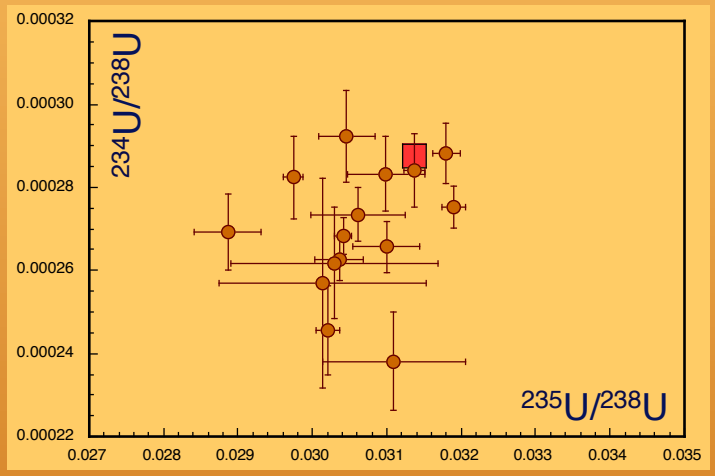
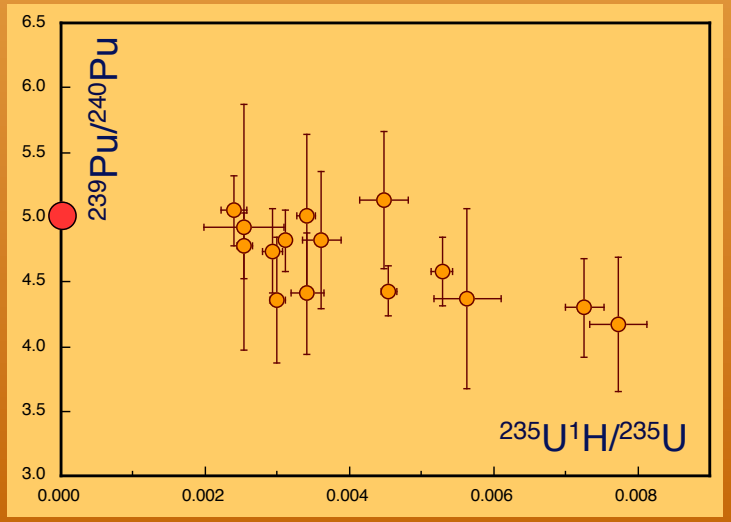
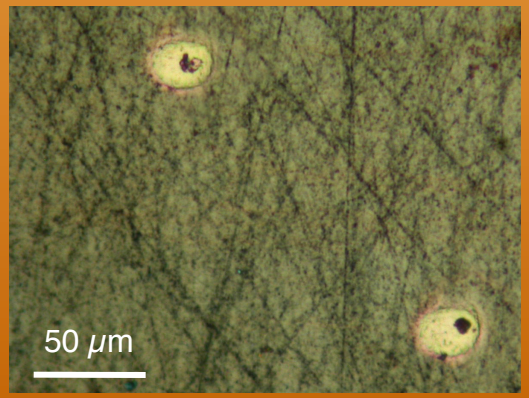
Wide range of applications – nuclear safeguards

U-Pu isotopic analysis of wind-blown radioactive dust particles







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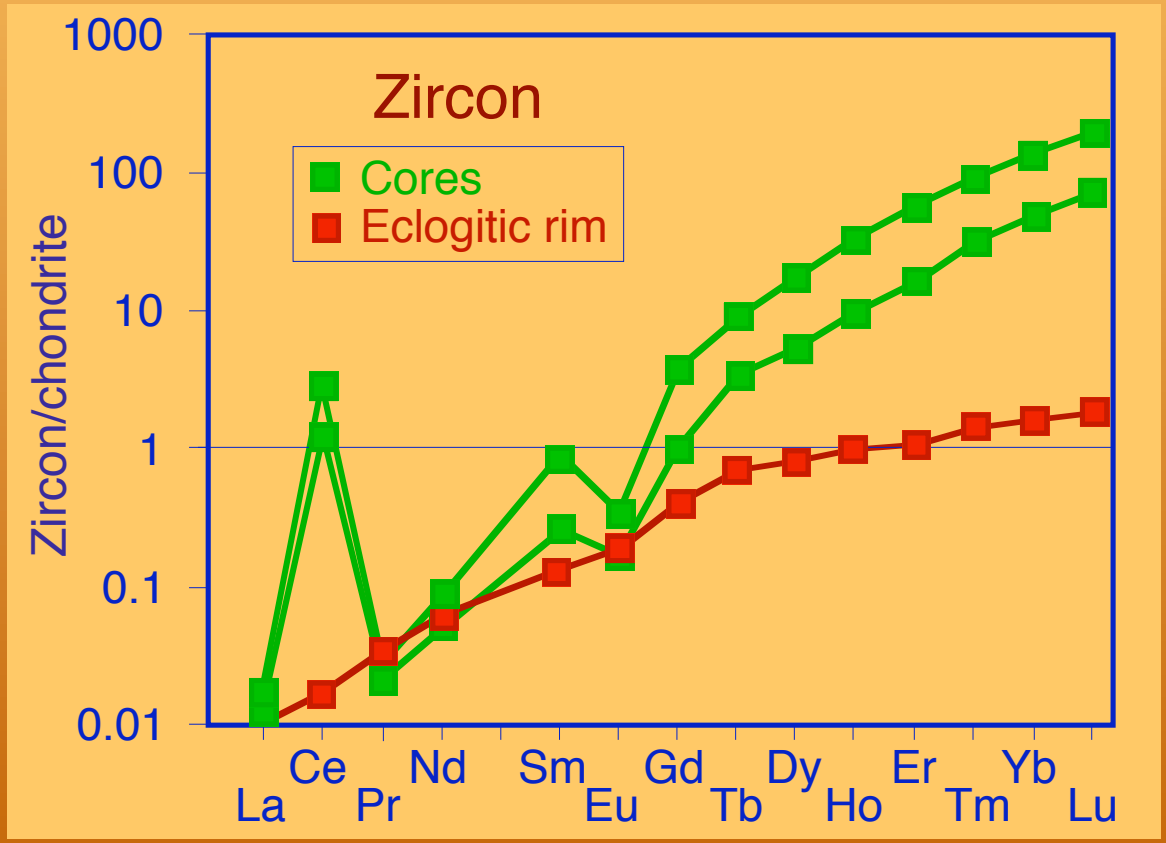
Wide range of applications – trace elements

REE in protolith zircon cores and metamorphic overgrowths



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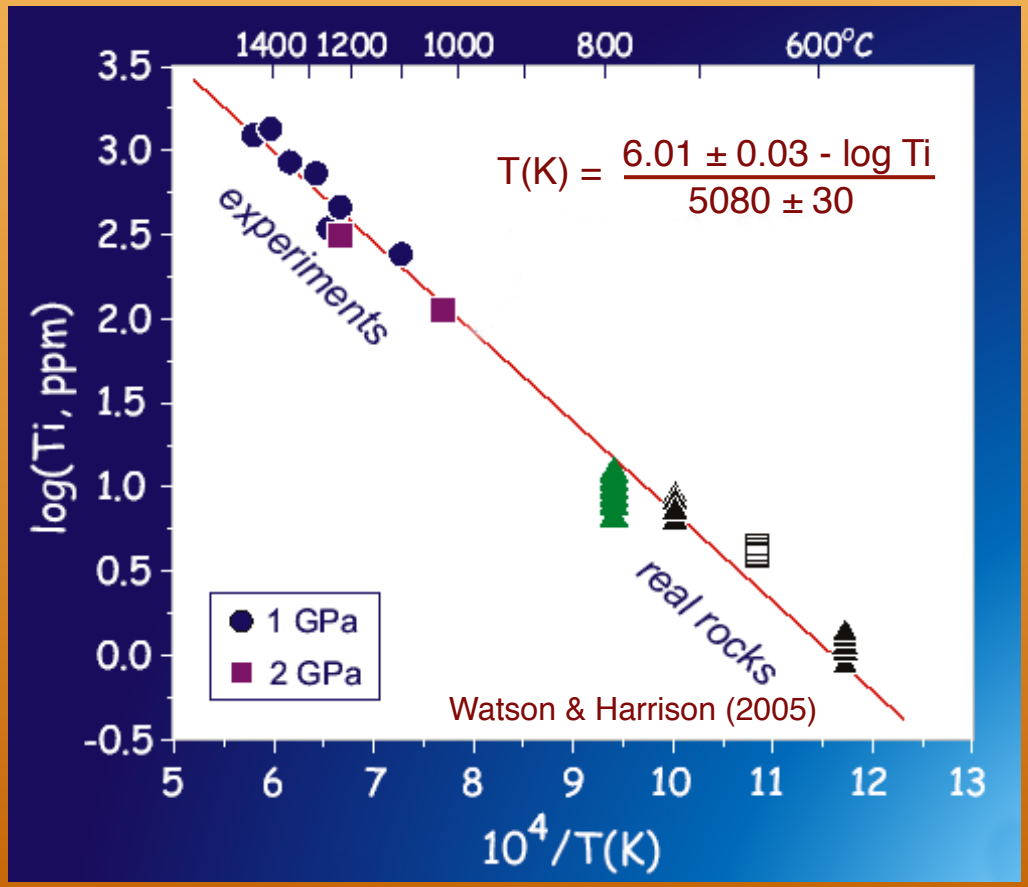
Wide range of applications – thermometry

Temperatures of igneous and metamorphic events from titanium thermometry in zircon



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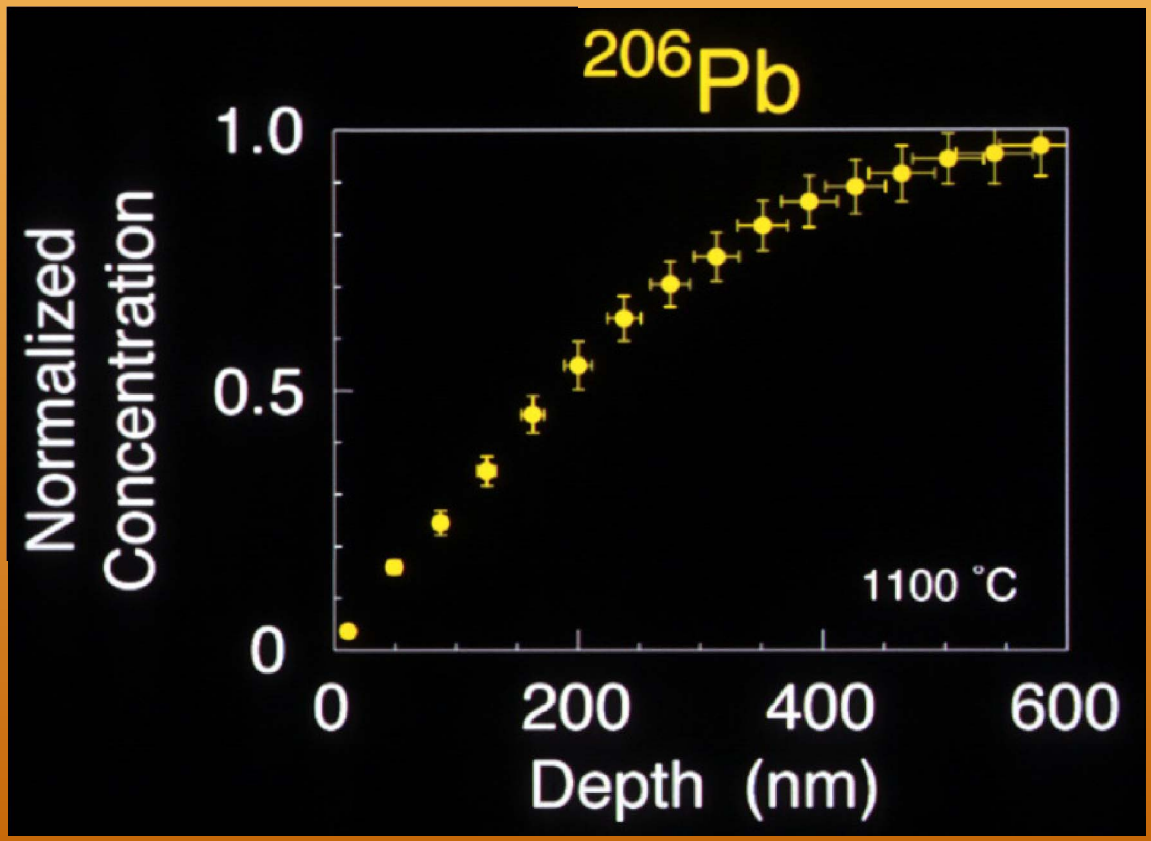
Wide range of applications – depth profiling

Depth profiling of surface films and diffusion profiles



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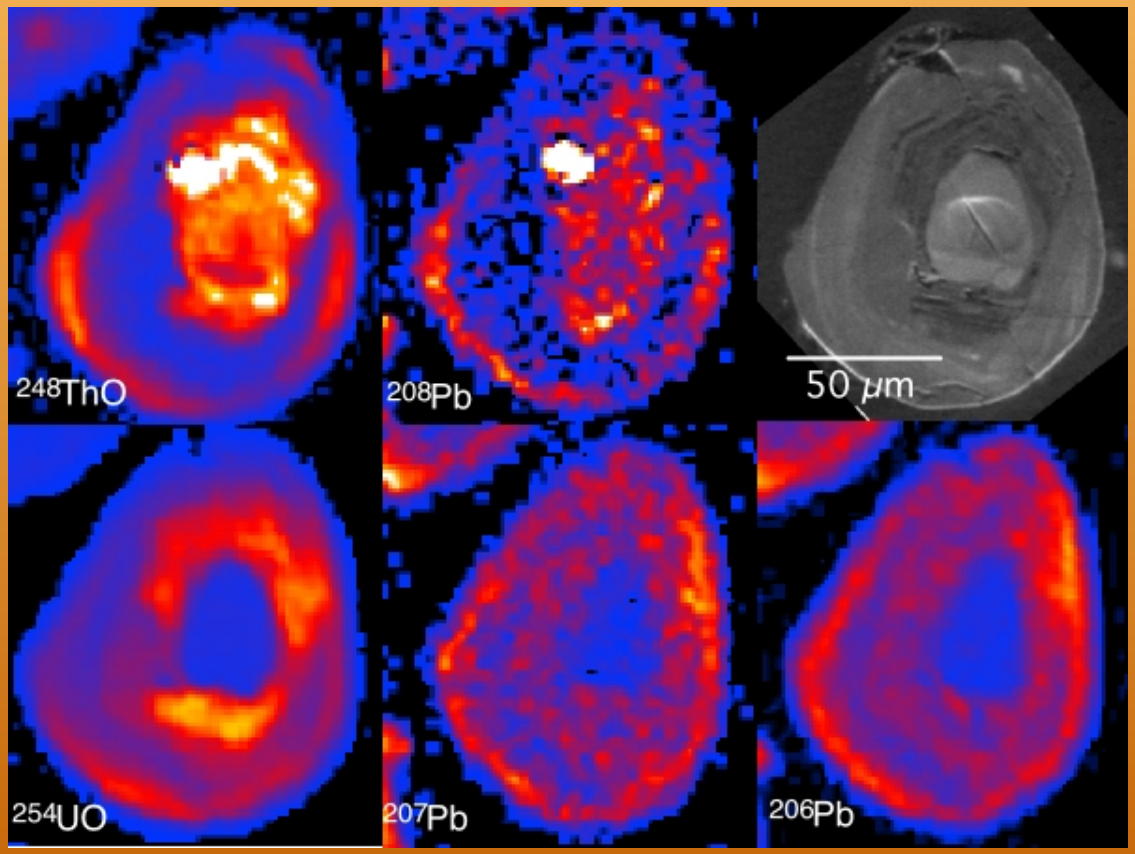
Wide range of applications – isotopic imaging

Imaging of isotope abundances at ppm levels (5 μm spot) by sample rastering



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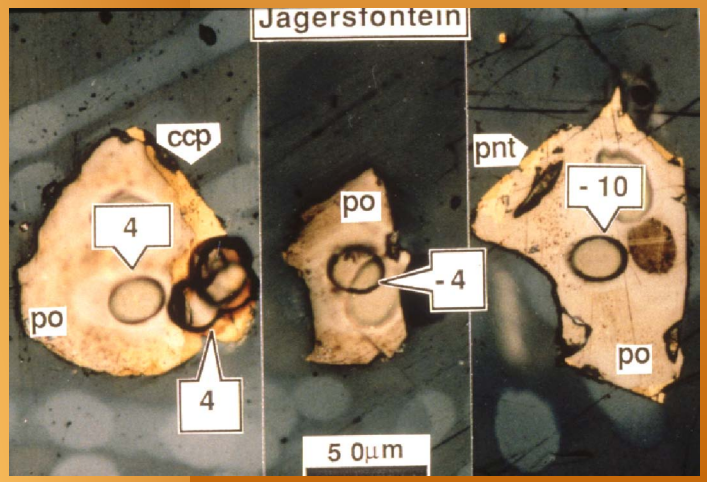
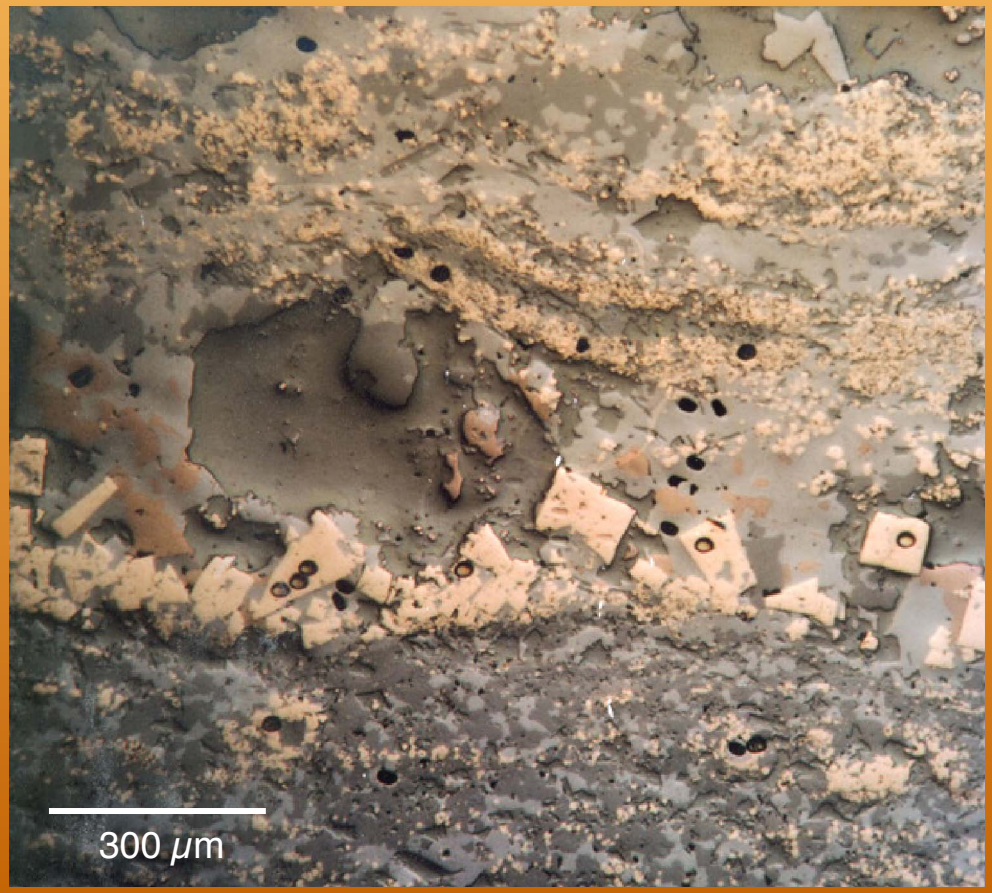
Wide range of applications – stable isotopes

Sulfur isotopes in massive sulfide deposits and diamond inclusions





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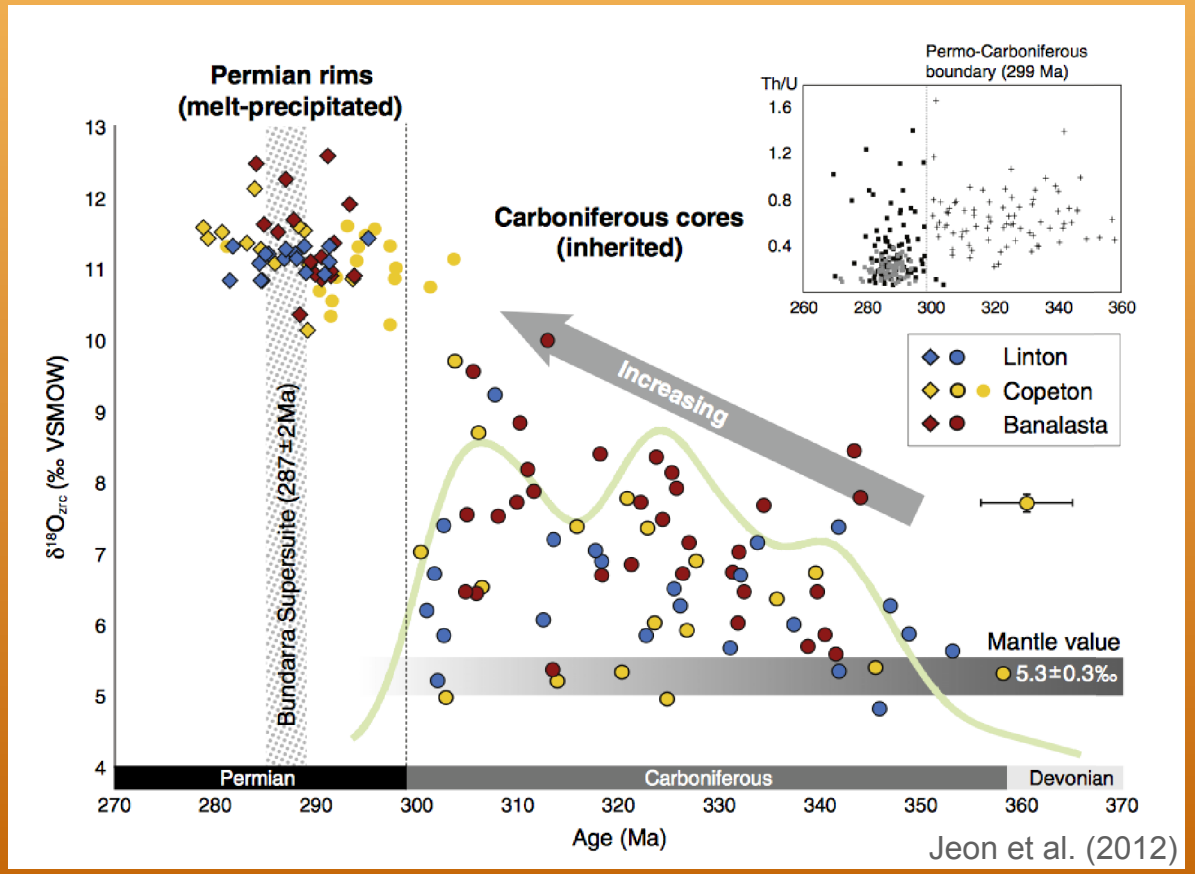
Wide range of applications – stable isotopes

Magma genesis from oxygen isotopes in zircon inherited cores and igneous rims



Jeon et al. (2012)

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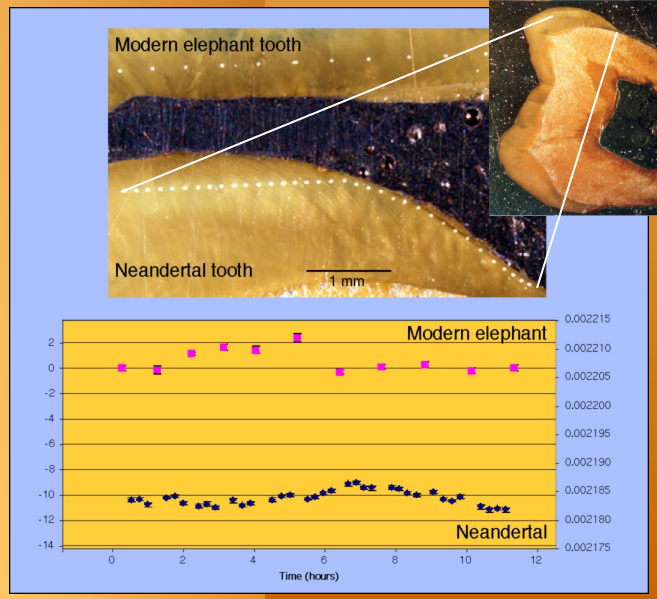
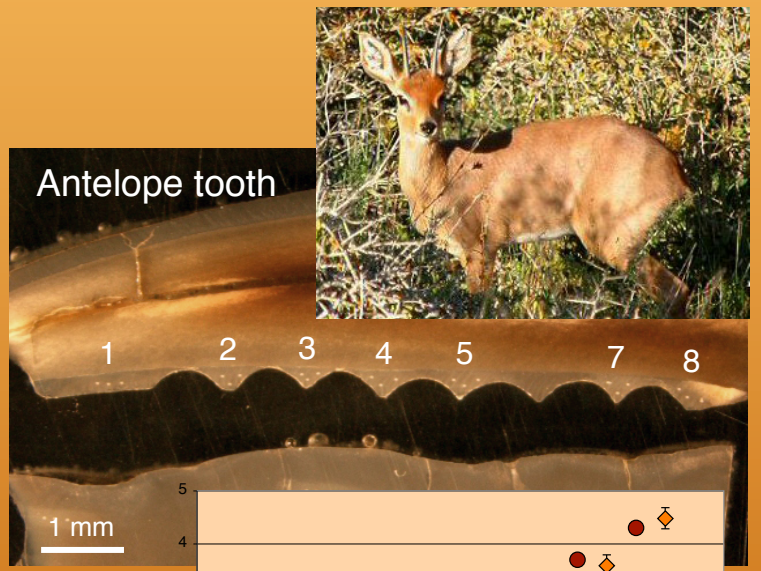
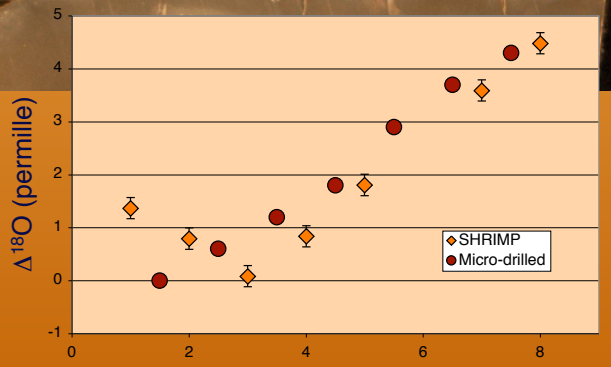
Wide range of applications – biogenic minerals

Tooth enamel oxygen from animals and early humans records changes in diet and environment







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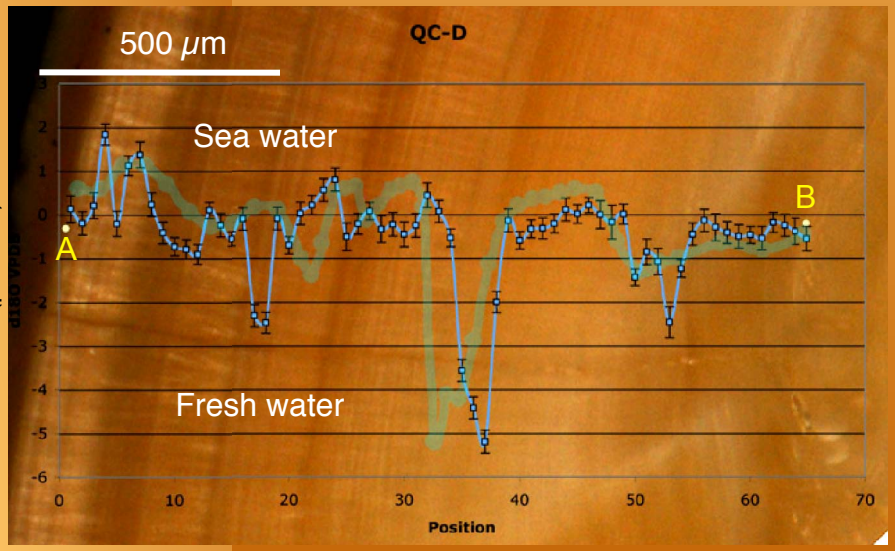
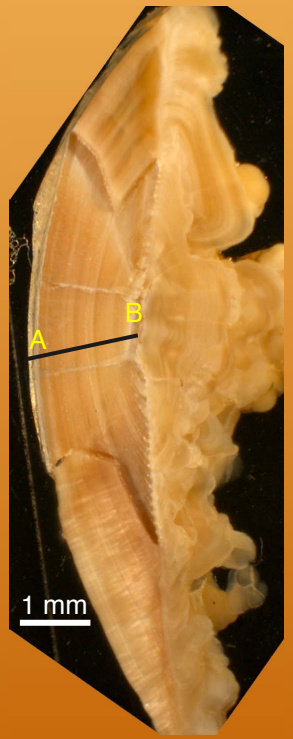
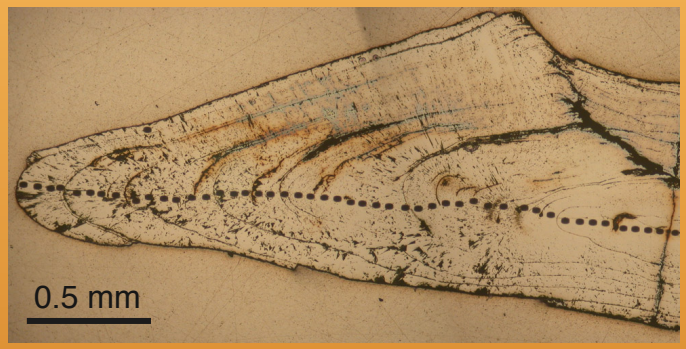
Wide range of applications – biogenic minerals

Oxygen from otoliths (fish ear bones) records changes in water temperature and salinity







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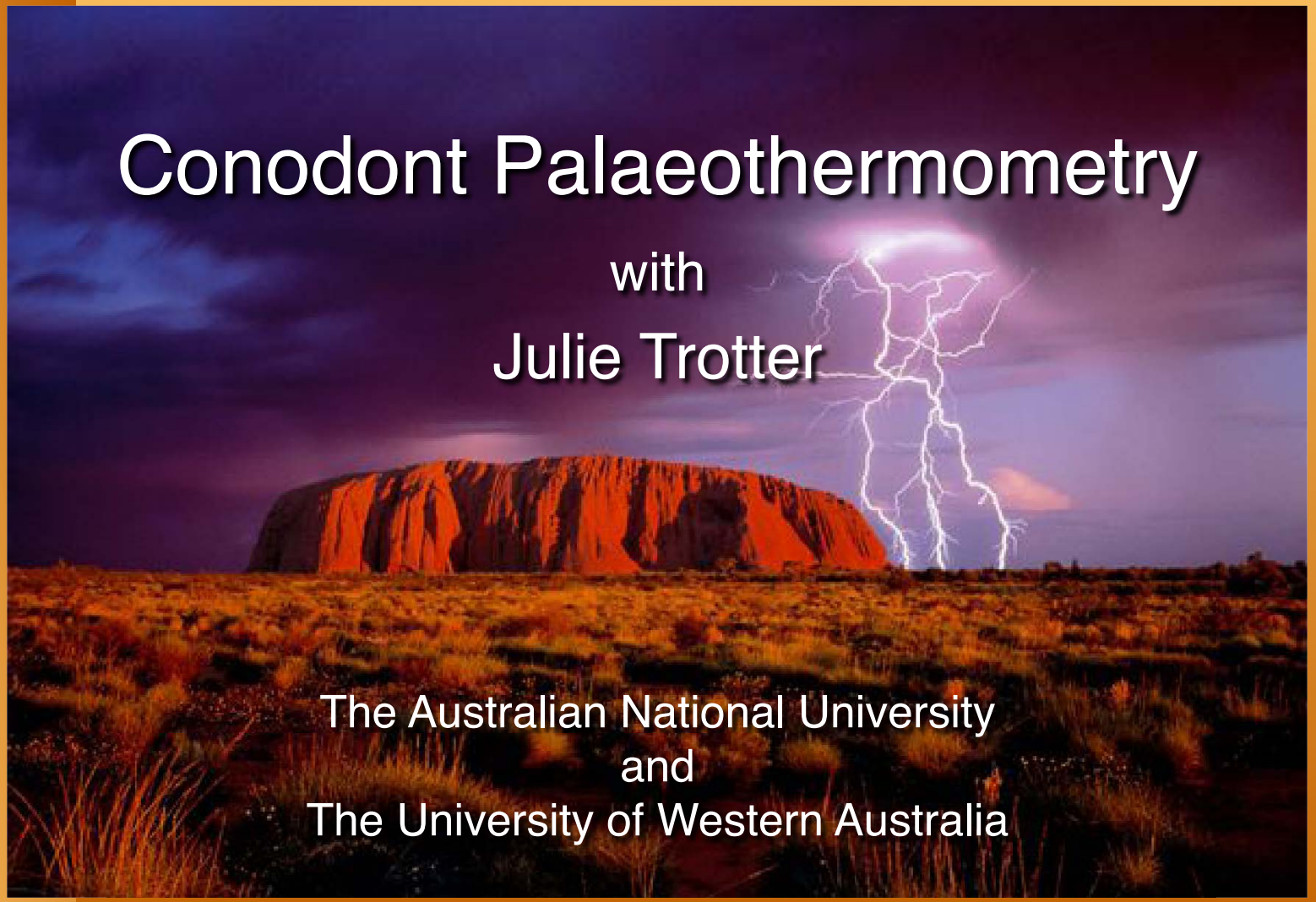

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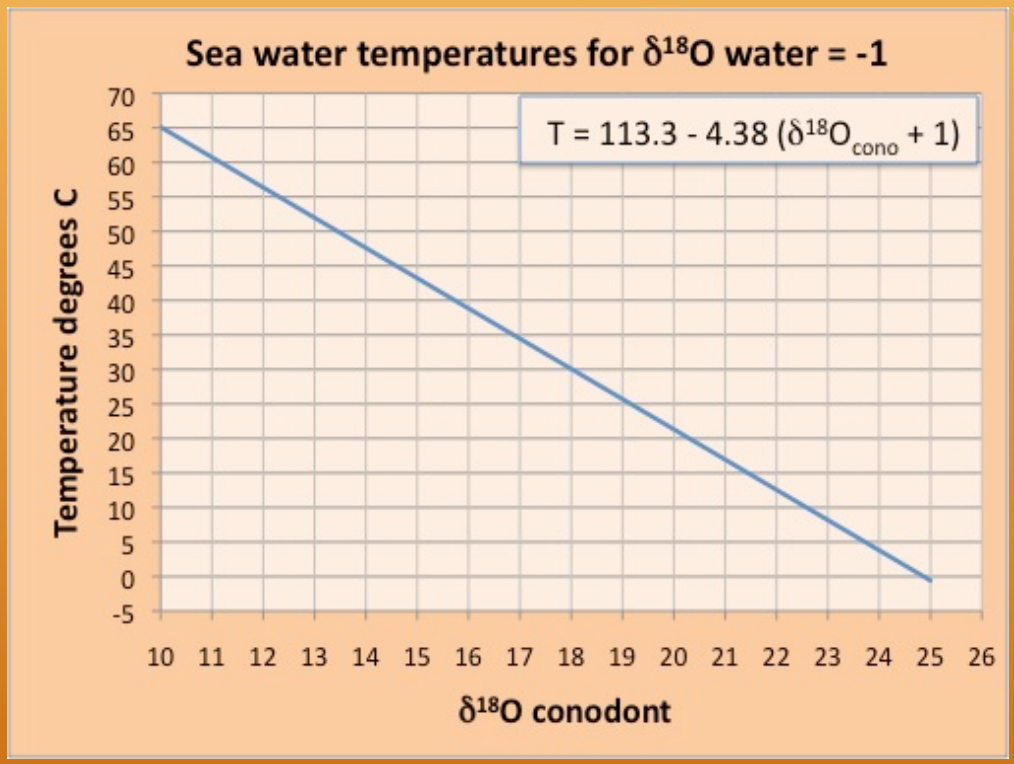
465 million years ago, in the mid Ordovician, biodiversity exploded
20 million years later, in a great extinction event, it collapsed

Was this caused by climate change?

The Wonderful World of SHRIMP

The oxygen isotope compositions of some fossils record the temperature of the water the animal lived in



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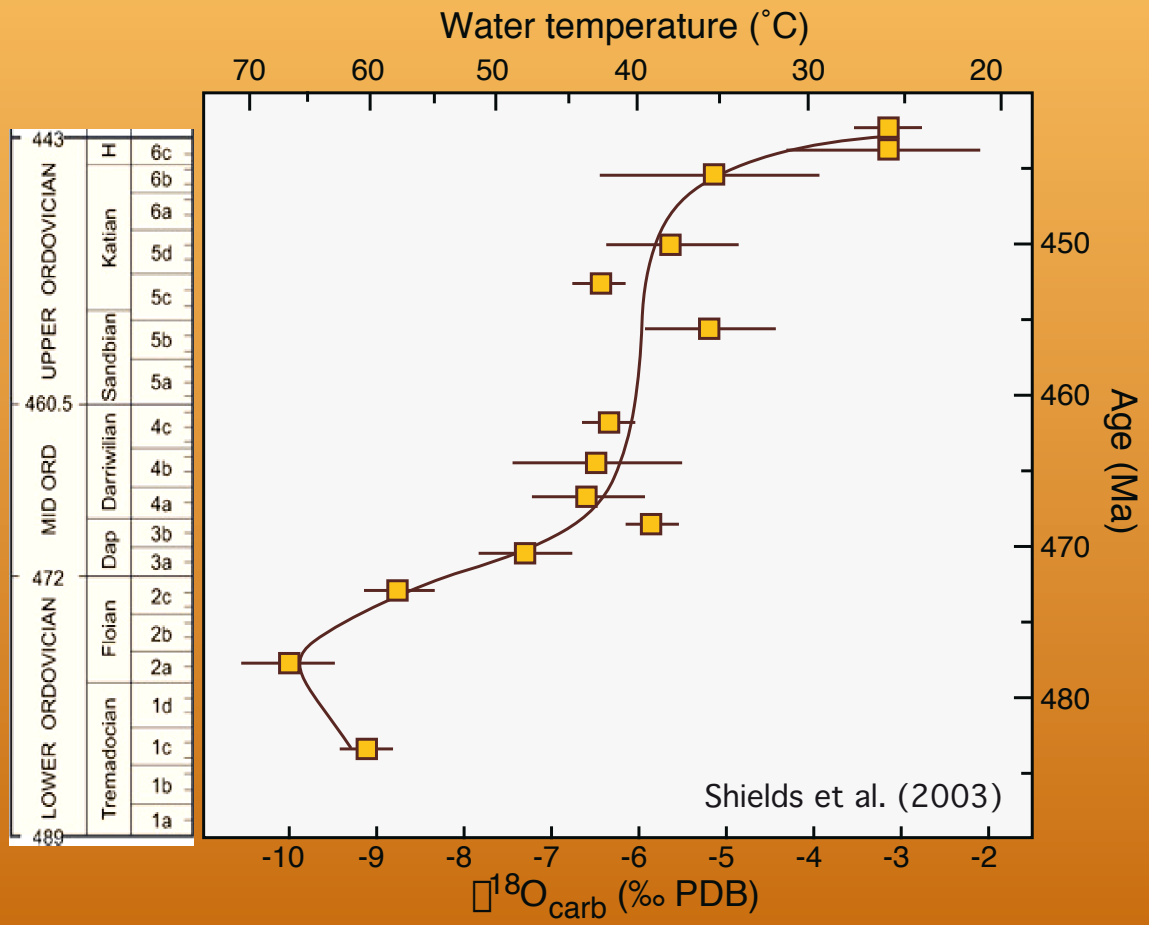
Sea surface temperatures inferred from conventional oxygen isotope analyses of sea shells seem crazy



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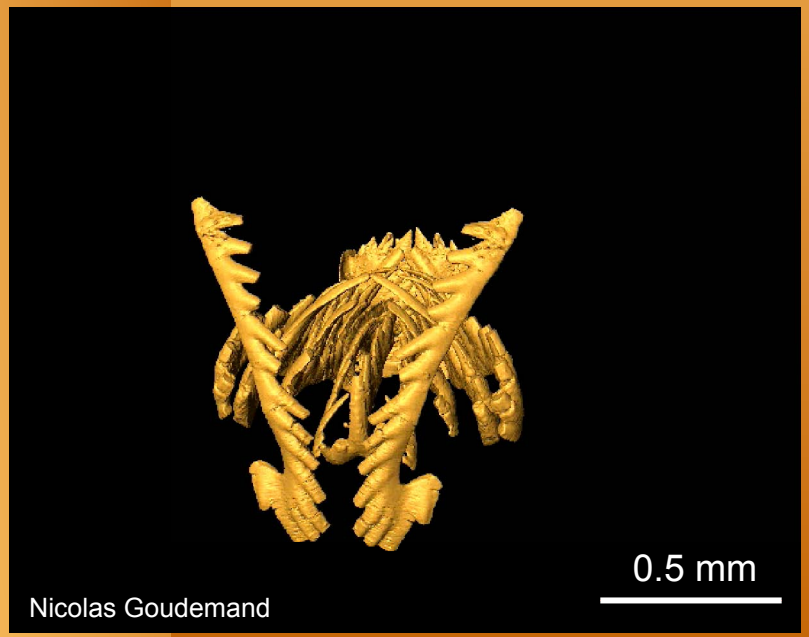
Conodonts are phosphate microfossils from the mouths of marine animals that survived the Ordovician extinction



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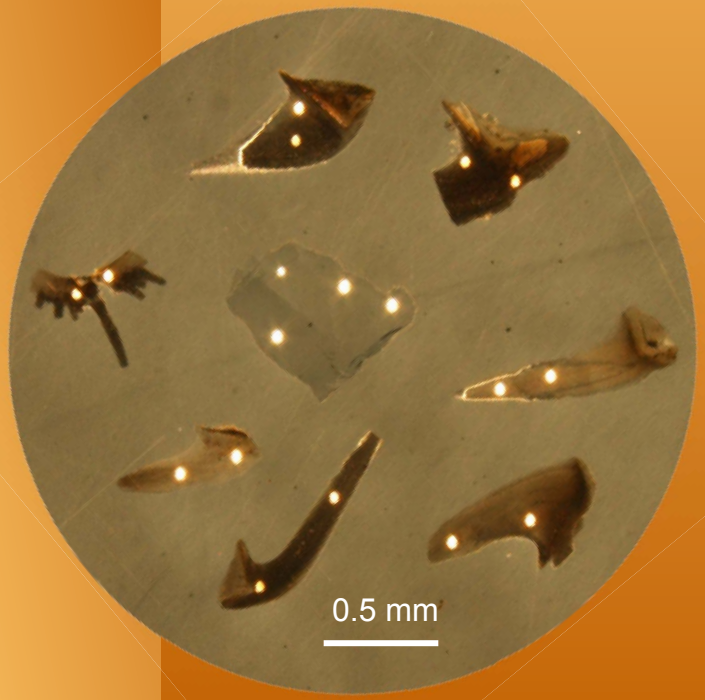
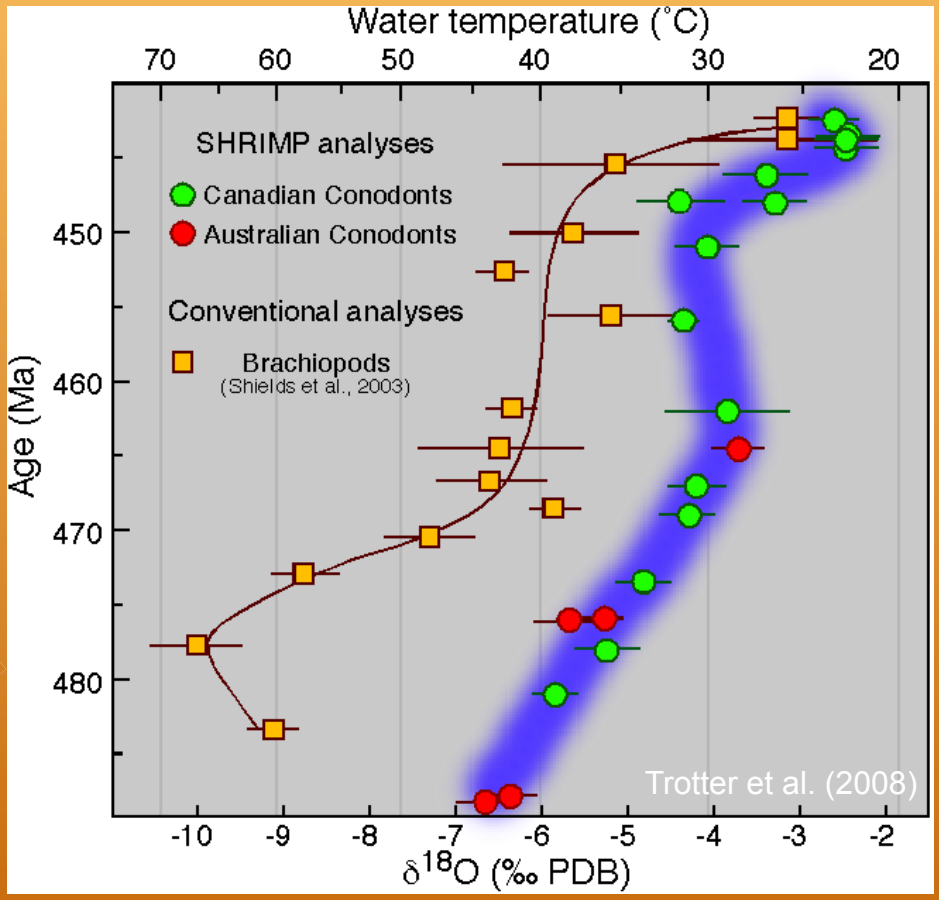
Water temperatures measured on conodonts by SHRIMP are much more realistic





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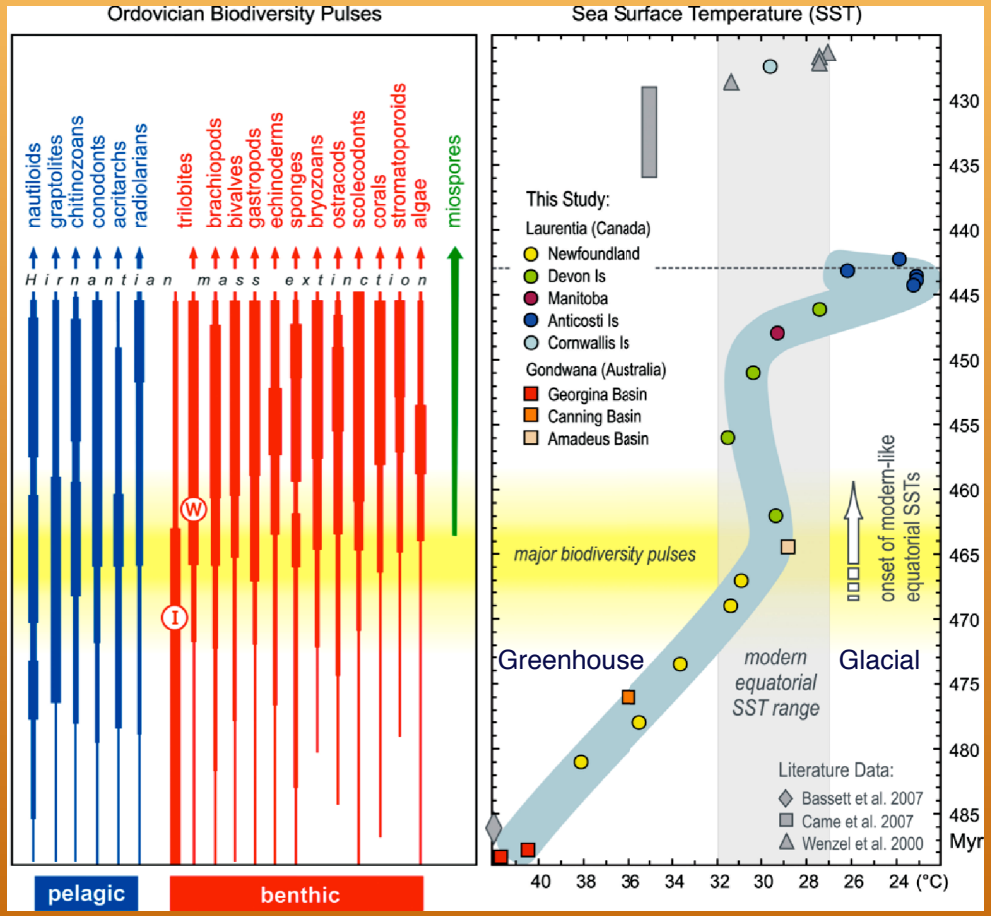
Marine animals flourished once the ocean cooled to modern temperatures, then most died out with the onset of widespread glaciation



Trotter et al. (2008) *Science*, ***321***, 550–554

The Wonderful World of SHRIMP

‘Keyhole’ geochronology of the basement of NE Poland

with

The PGI Group

Polish Geological Institute, Warsaw

Photo: Doug MacKenzie

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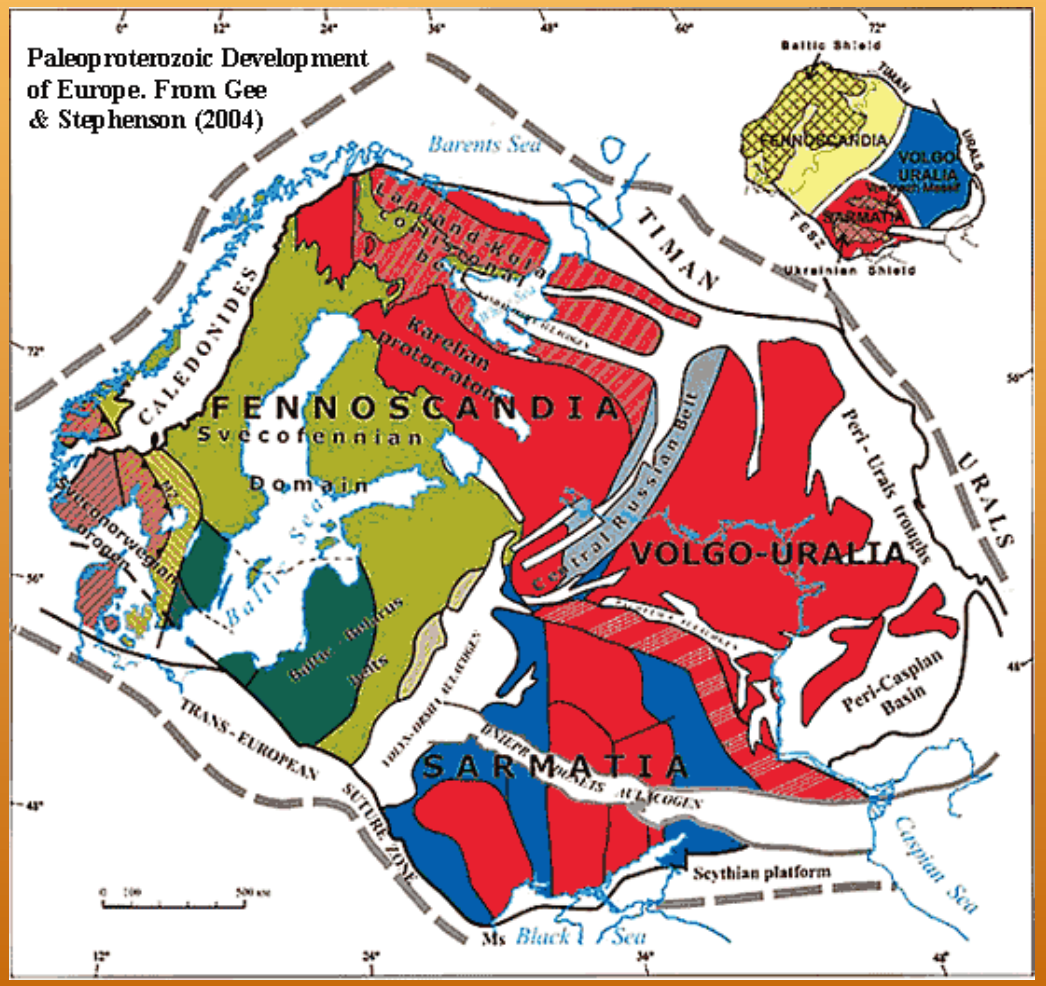
The basement rocks of northern Poland are covered by thick sediments of the East European Platform

The Wonderful World of SHRIMP

Tectonic models predict that Svecofennian basement rocks might extend below the Platform as far south as the Trans-European Suture Zone



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Trends in basement magnetic anomalies also suggest that the Svecofennian might extend as far south as central Poland

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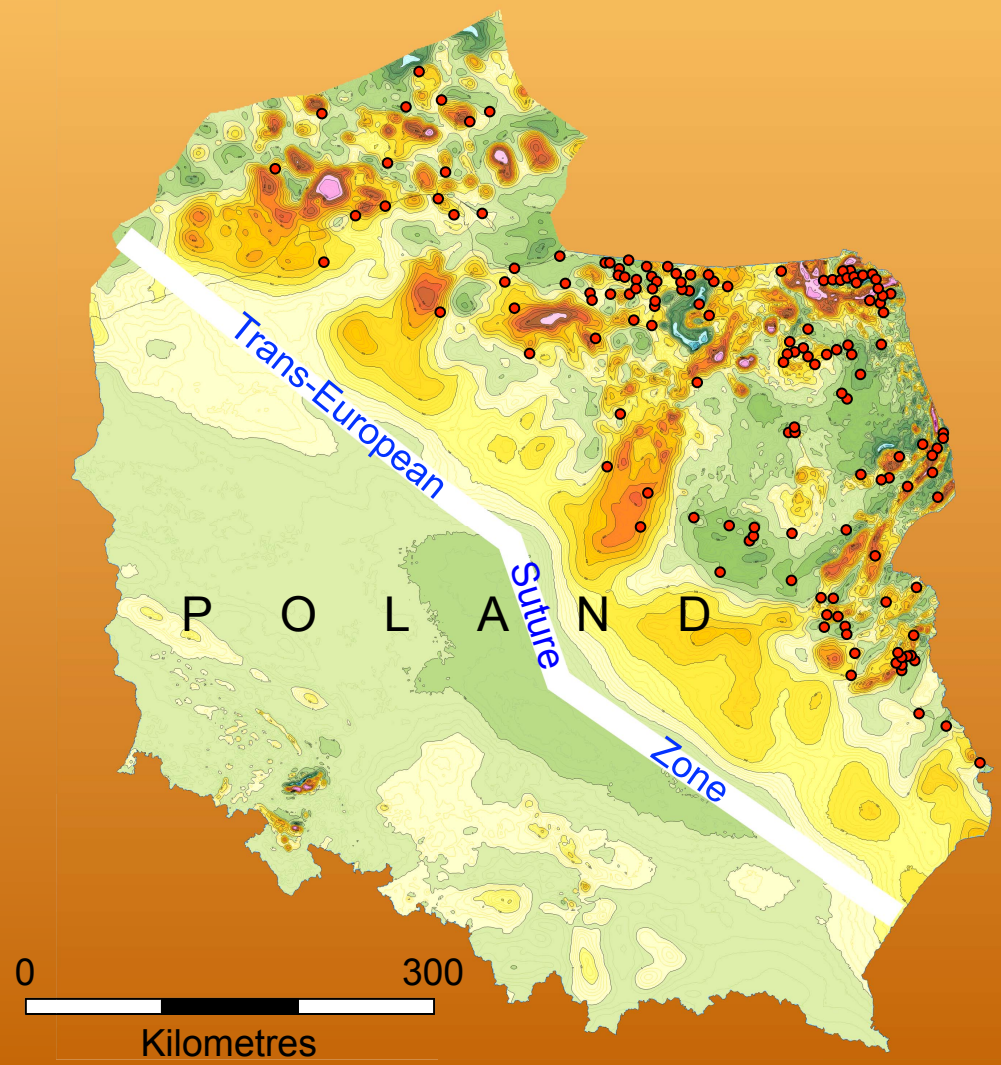
Extensive drilling provides valuable samples of the basement through 'keyholes' in the sediments



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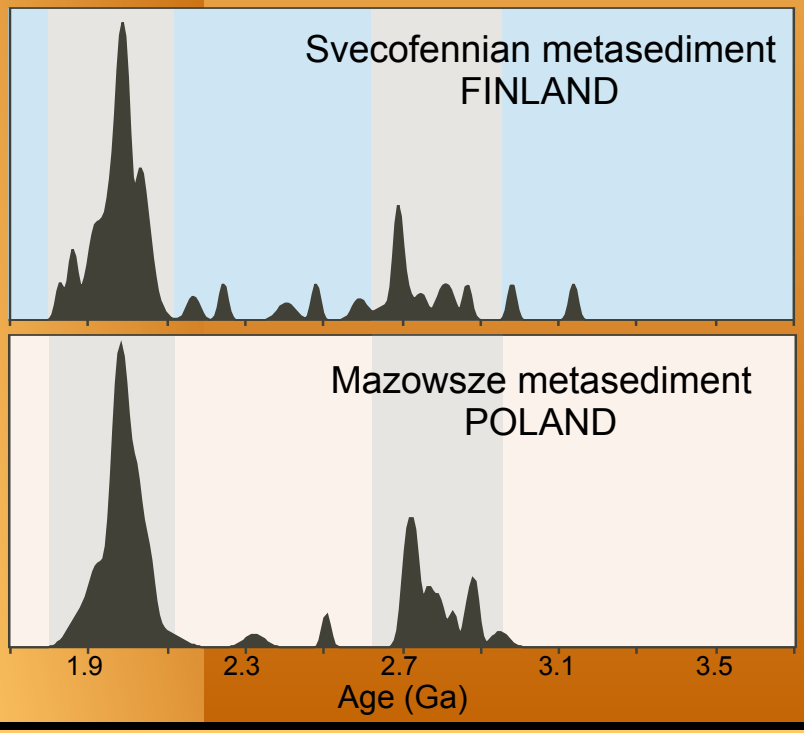
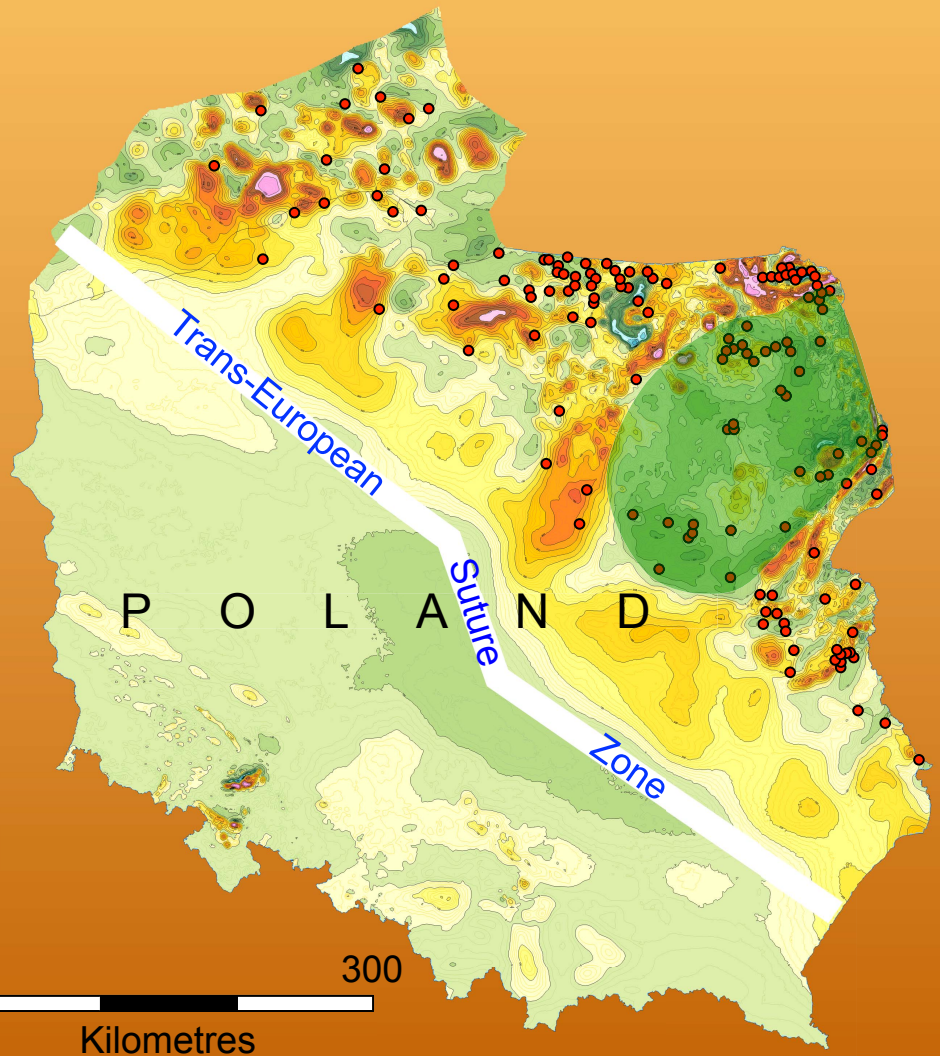
The Mazowsze Domain is Svecofennian metasediment with 1.84-1.80 Ga igneous intrusions





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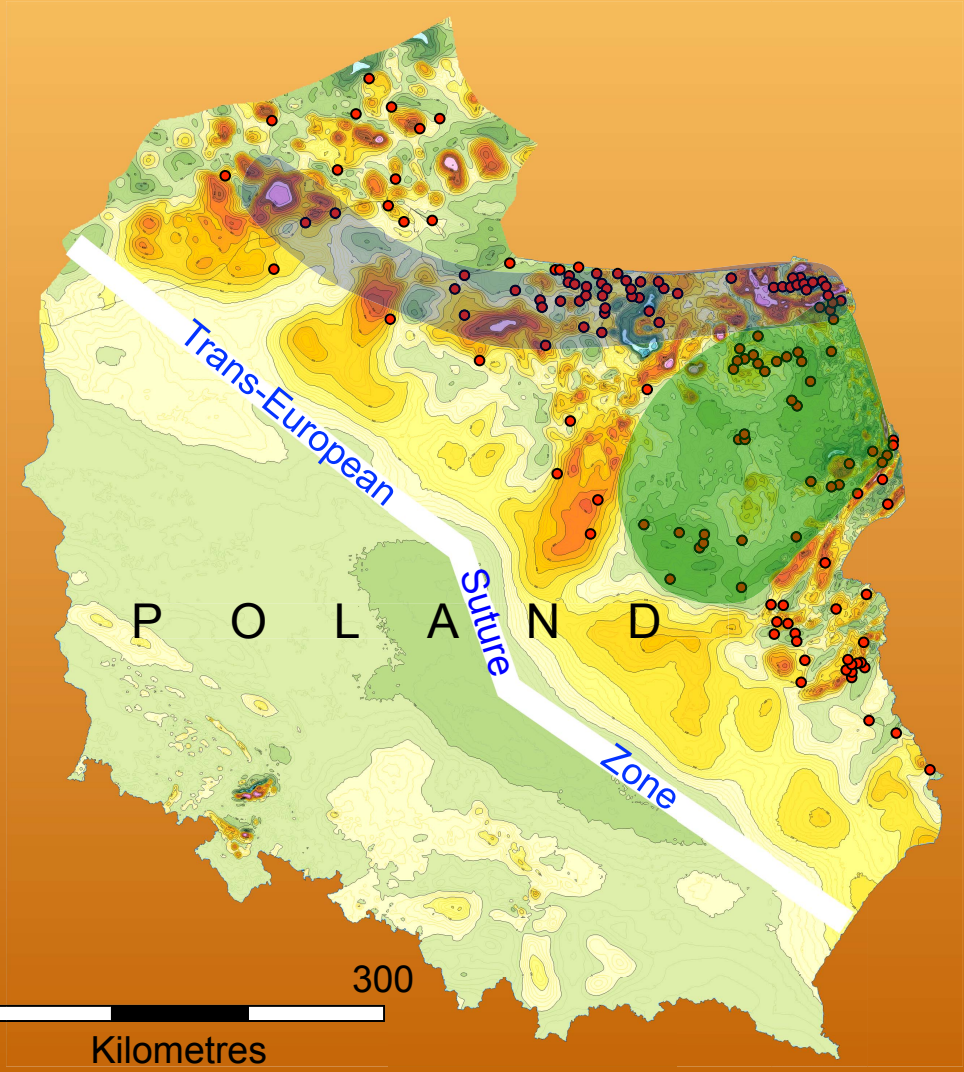
The 1.52–1.50 Ga anorthosite-charnockite-granite Mazury Complex extends under the Baltic Sea



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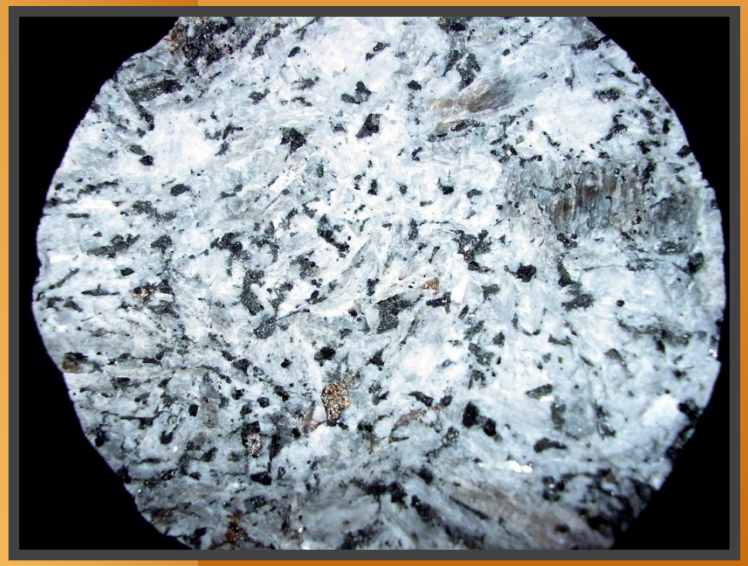
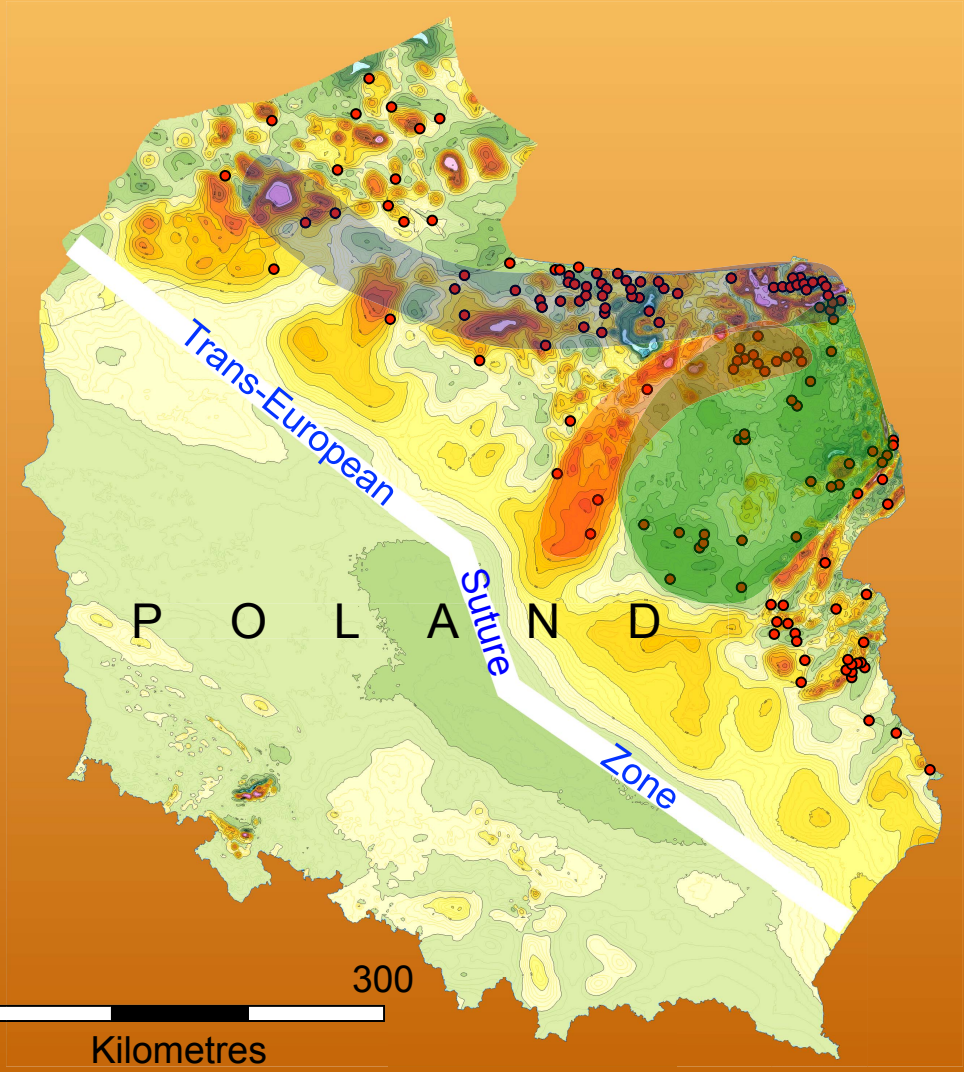
A belt of ~345 Ma alkaline intrusions marks an Early Carboniferous deep crustal discontinuity





The Wonderful World of SHRIMP

Now PGI has its own SHRIMP.
A whole new world of opportunities awaits.

Photo: Zbigniew Czupyt