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Title:	Science of Signatures Workshop on Secondary Ion Mass Spectrometry (SIMS) Applications July 24, 2012
Author(s):	Hickmott, Donald D Riciputi, Lee D
Intended for:	On site workshop presentation with external (non-LANL)participants

Science of Signatures

Workshop on Secondary Ion Mass Spectrometry (SIMS) Applications

July 24, 2012

Don Hickmott
Lee Riciputi

Los Alamos NATIONAL LABORATORY EST. 1943

NNSA National Nuclear Security Administration

Agenda

Secondary Ion Mass Spectrometry (SIMS) Workshop
July 24, 2012
Location: TA-51-25 Conference Room

8:00-8:30 – Coffee
8:30-8:45- Introduction, purpose of workshop (Hickmott)
8:45-10:00 – Introduction to SIMS/Materials Applications (Hervig)
10-00-10:15 - Coffee
10:15-10:45 – SIMS applications to planetary science (Shearer)
10:45-11:30 - SIMS applications to nuclear forensics & subsurface science (Riciputi)
11:30 – 12:00 – Additional SIMS capabilities/applications (Hickmott)

12:00 -1:00 – Lunch (Fill out Quiznos order forms)

1:00-2:00 – Brainstorming session (unclassified) – Hickmott/Riciputi
2:00-2:15 – Wrap-up

3:00-4:00 – SIMS lab tour for external visitors

Science of Signatures Focus Areas

- Radiological and Nuclear
- Chemical and Materials (including explosives)
- Biological: Signatures of Disease and Health
- Energy
- Climate
- Space

SIMS can contribute to all of these focus areas

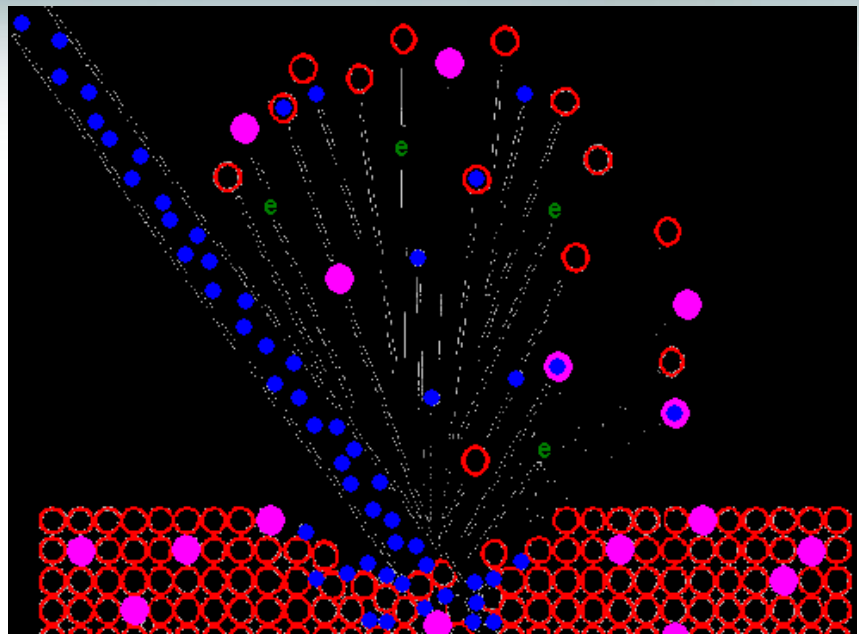
LANL Cameca 1280 - History

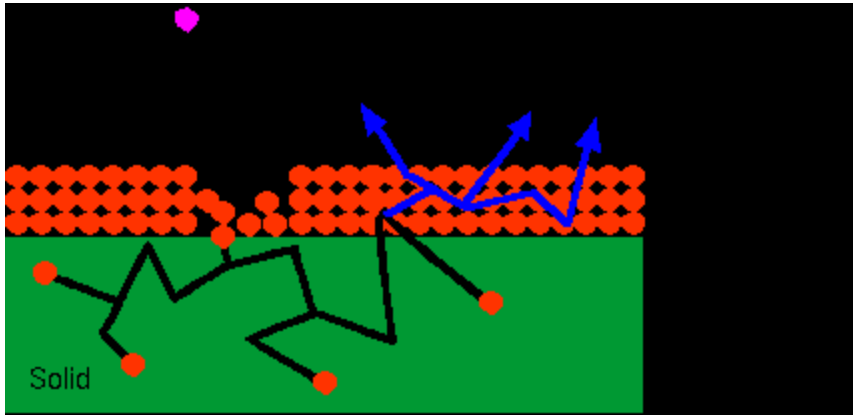
- Purchased end of FY 2009 (~ $ 5 M)
- Fully Installed & Operational in NISC-

  September 2011
- Currently working operational issues
  - IWD approved

Cameca 1280 SIMS

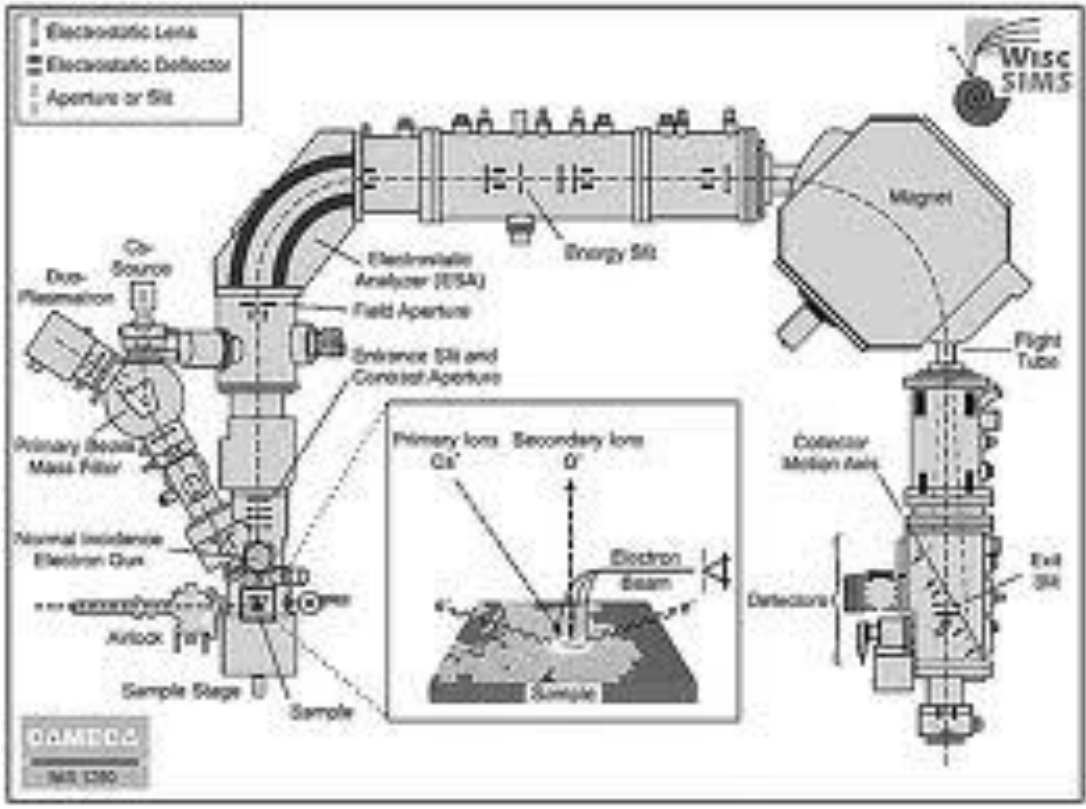
- Cameca 1280 (~ 2 dozen worldwide)
- TE to ppb level, isotopes to 0.1 per mil
- All elements
- Depth profiles
- Sputtering - ‘Destructive’
- Standards crucial
- Beam size (down to ~ 1 micrometer)
- RAE for imaging (micrometer resolution)





Cameca 1280 SIMS

- HMR SIMS (MR > 10,000)
- Doubly focusing magnetic sector instrument
- Multi-collector (8 EM and 2 FC)
- Positive and negative primary beams
- Optimized for isotopes
- Polished surfaces, particulates
- High vacuum sample chamber

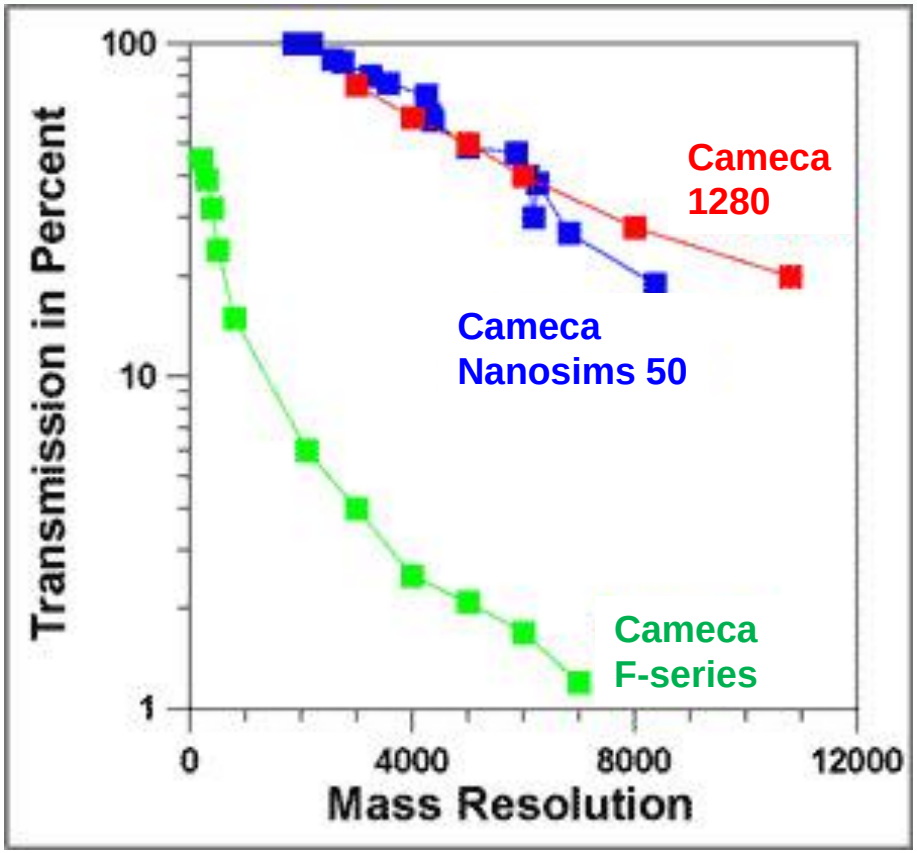


Cameca 1280 SIMS

Other SIMS instruments – DOE Complex

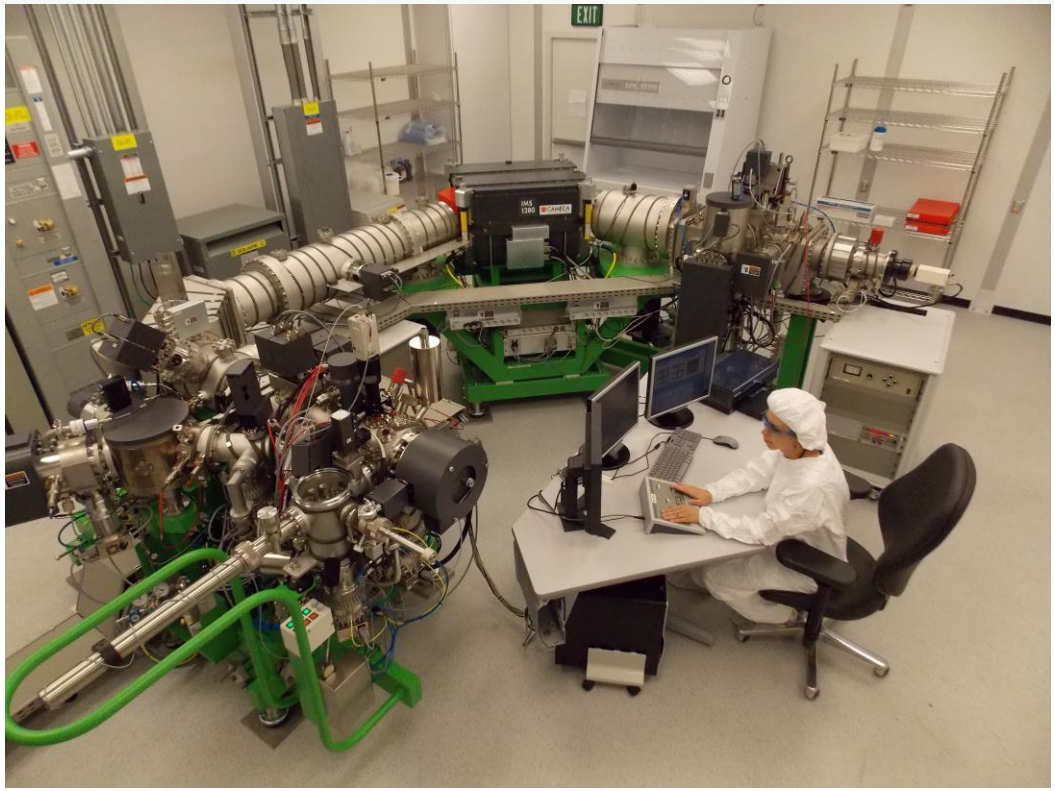
- NanoSIMS (LLNL, PNNL)
  - Spots to 200 nm
- SHRIMP series (none)
  - Optimized for U-Pb dating
- F-series SIMS (SNL/UNM, ORNL, LLNL)
- TOF, quadrupole SIMS (many)

- 'MegaSIMS' (none)

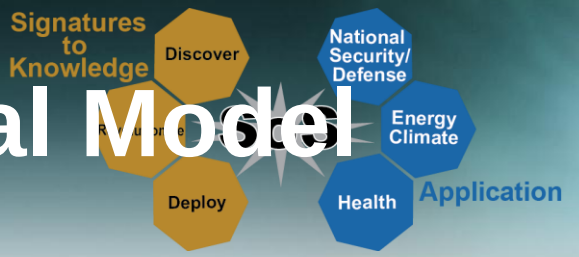


Goals of Workshop

- Familiarize LANL staff with 1280 SIMS
- Socialize SIMS applications with staff
- Brainstorm programmatic opportunities for SIMS
- Precipitate proposals/R&D in existing programs



Path Forward/Operational Model



- Startup mode – 6 months
  - Standard development, pilot projects for select customers
- Transition mode – 1 year
  - Limited user access through steering committee
- Ultimately - 50% user facility (Lujan model)

Additional SIMS Applications

CAMECA nf

CAMECA 1270, 1280

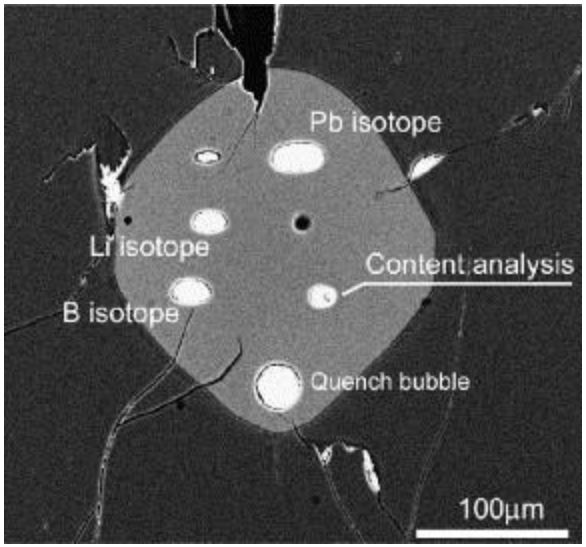
CAMECA NANOSIMS

SHRIMP RG

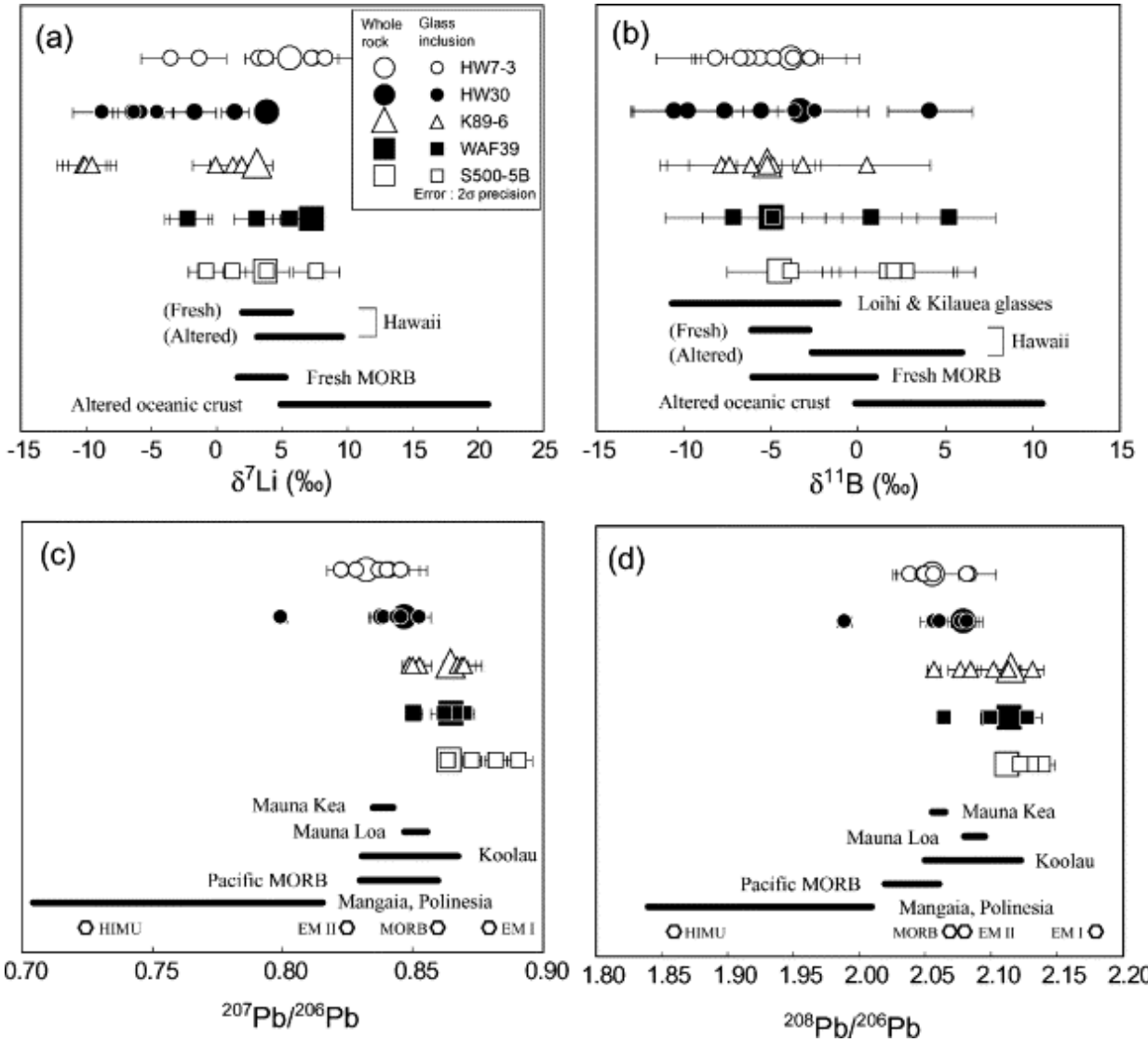
Isotopes in Igneous Rocks – Volcanic Hazards

Cameca 1270

Recycled materials in source regions of Hawaiian volcanoes



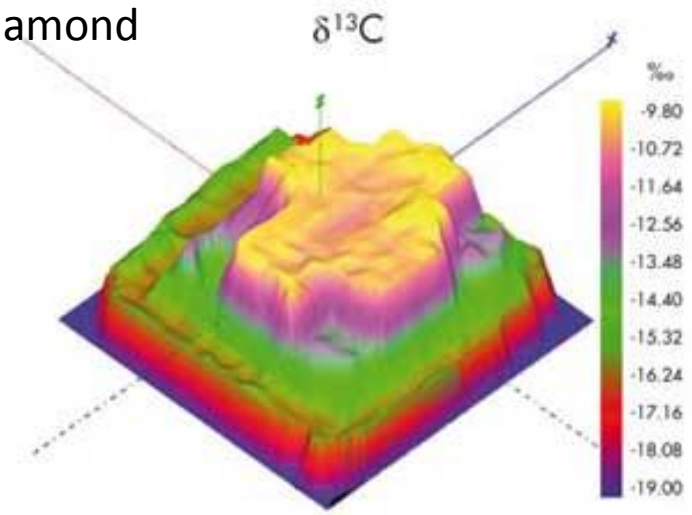
Melt Inclusions



Kobayashi et al, Chem. Geol., 2004

Carbon Isotopes For Tracing Fluid Flow

Venezuelan Diamond



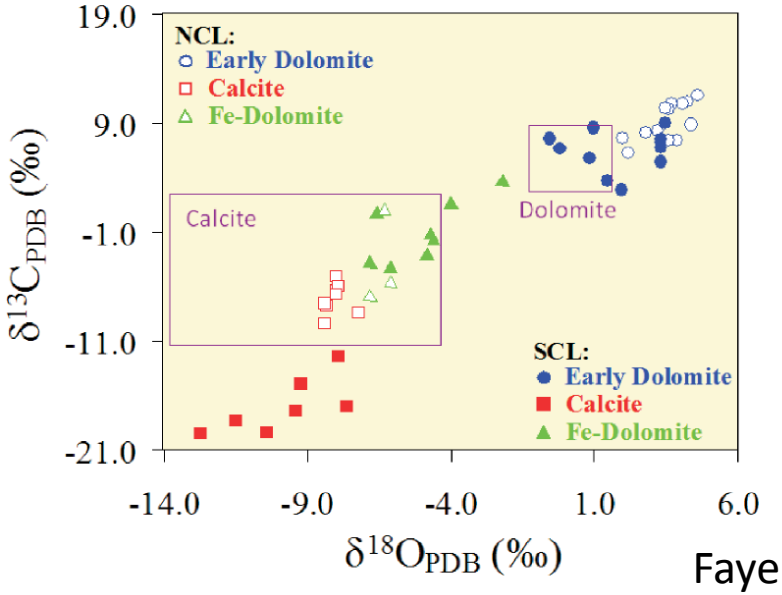
Courtesy University of Edinburgh, UK

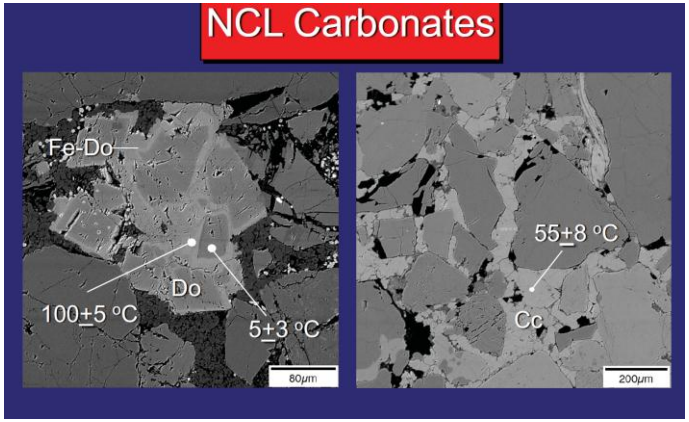
Cameca 1280

2 mm

Oil and Gas Applications

Schulze et al Nature 2003

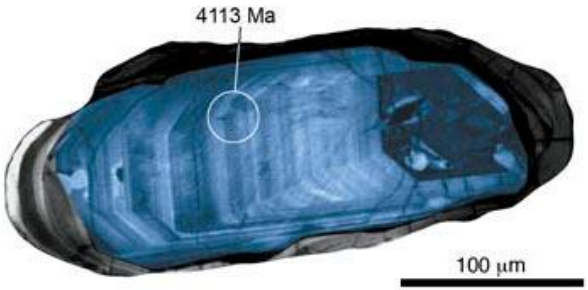




Fayek et al., J. Sed. Res. 2001

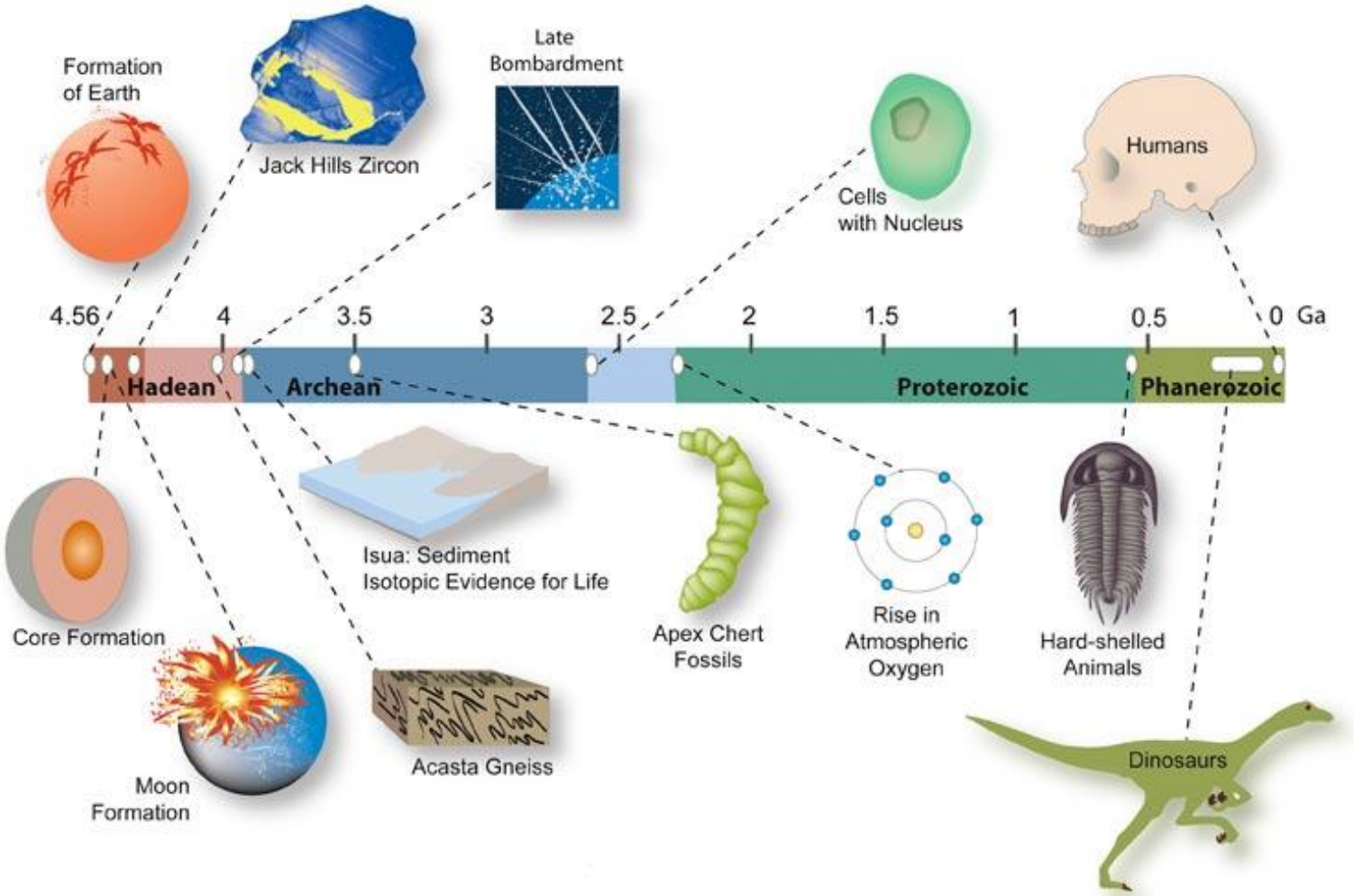
Cameca 1270

U-Pb Zircon Dating – Earth's Oldest Rocks



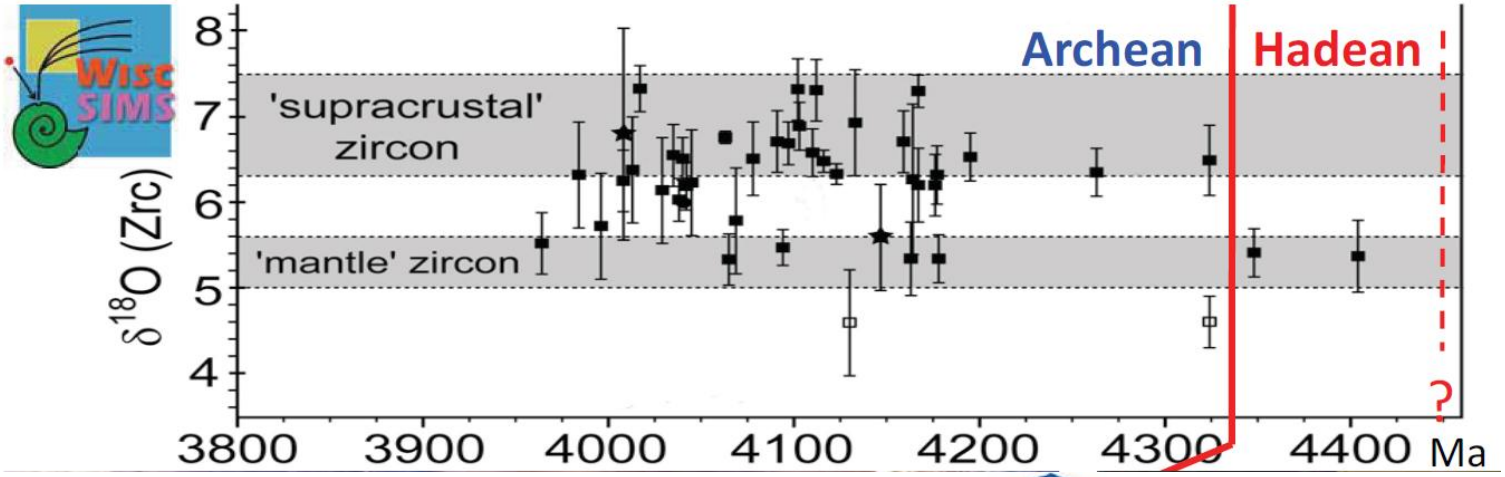
4.4 Billion Year old zircons

SHRIMP II

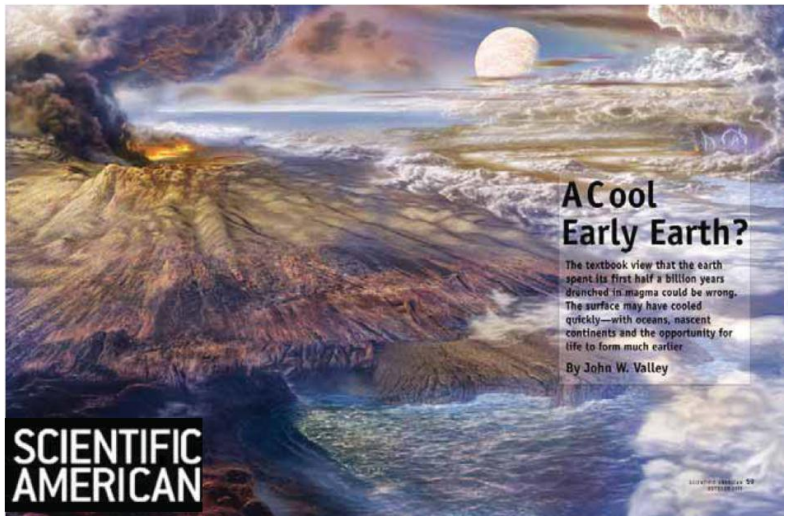


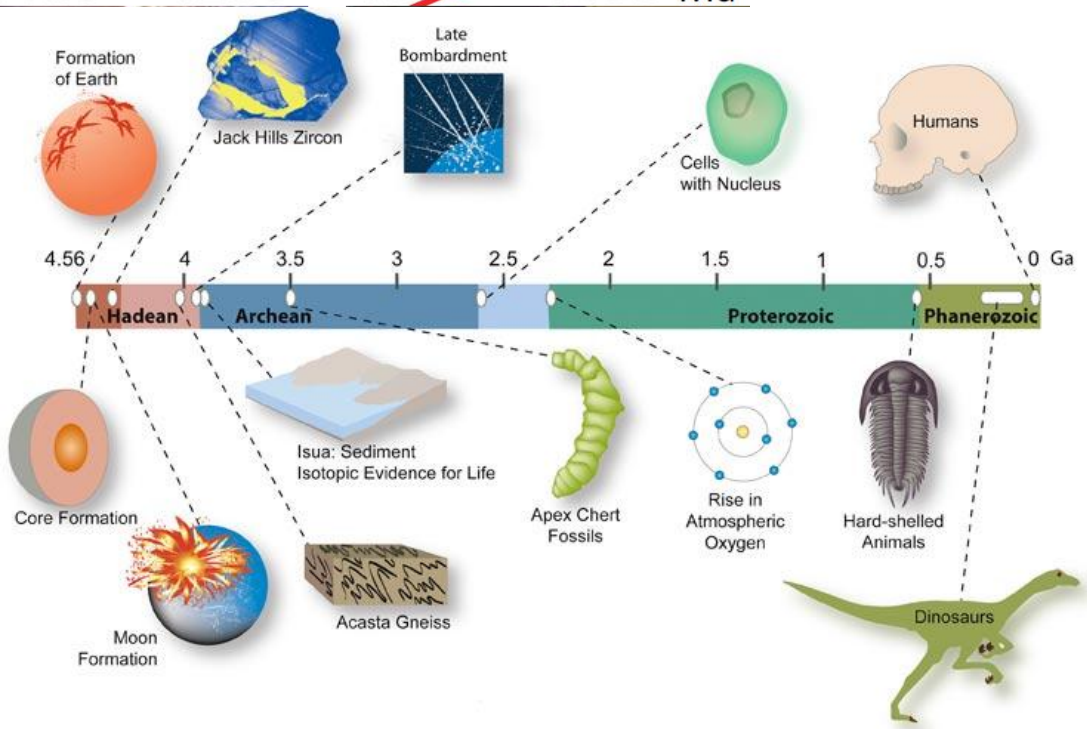
Wilde et al, Nature, 2001

$\delta^{18}O$ in Zircon– Evidence for Oceans During the Archaen



Cameca 1270

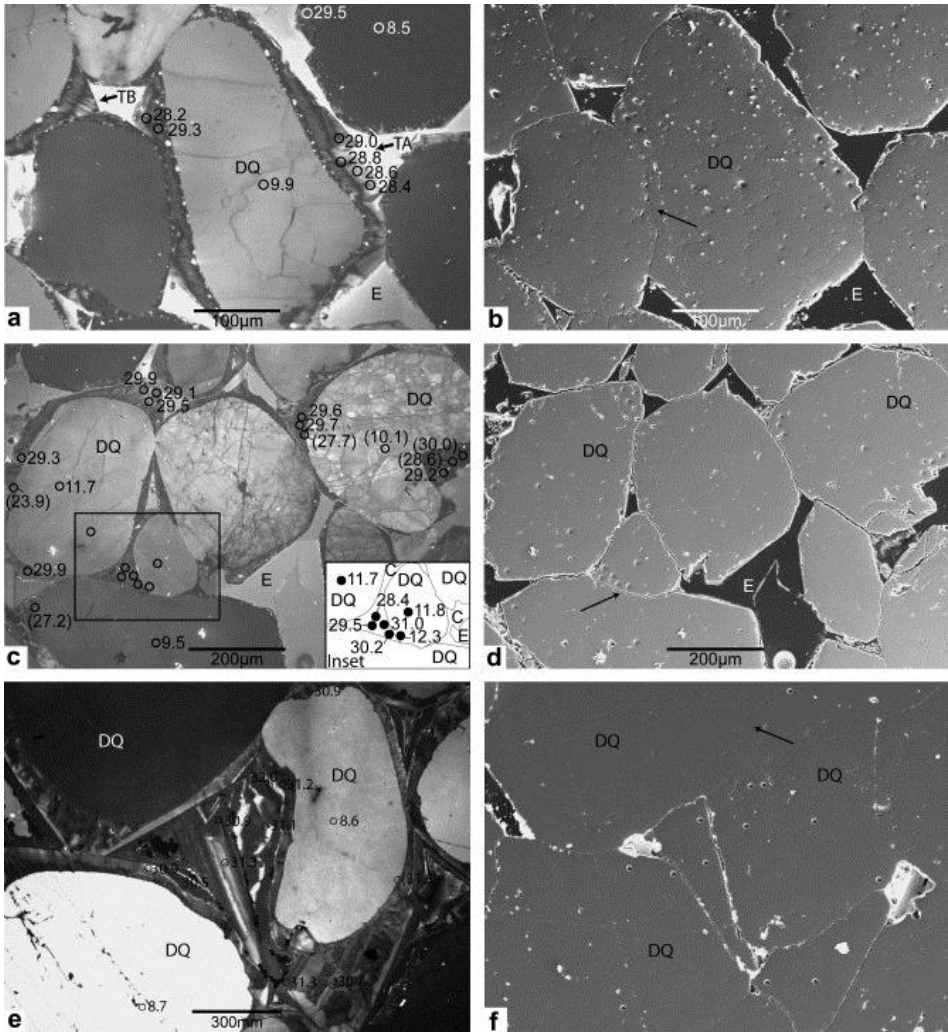


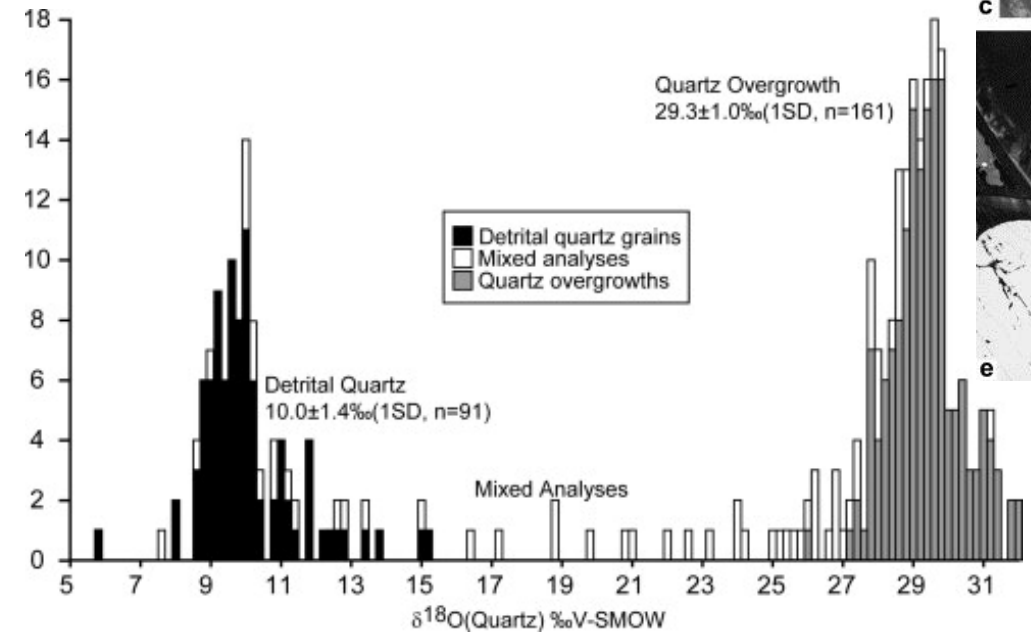


Cavosie et al, EPSL 2005

Cameca 1280

$\delta^{18}O$ of Diagenetic Minerals - Evolution of Sedimentary Basins – Oil And Gas

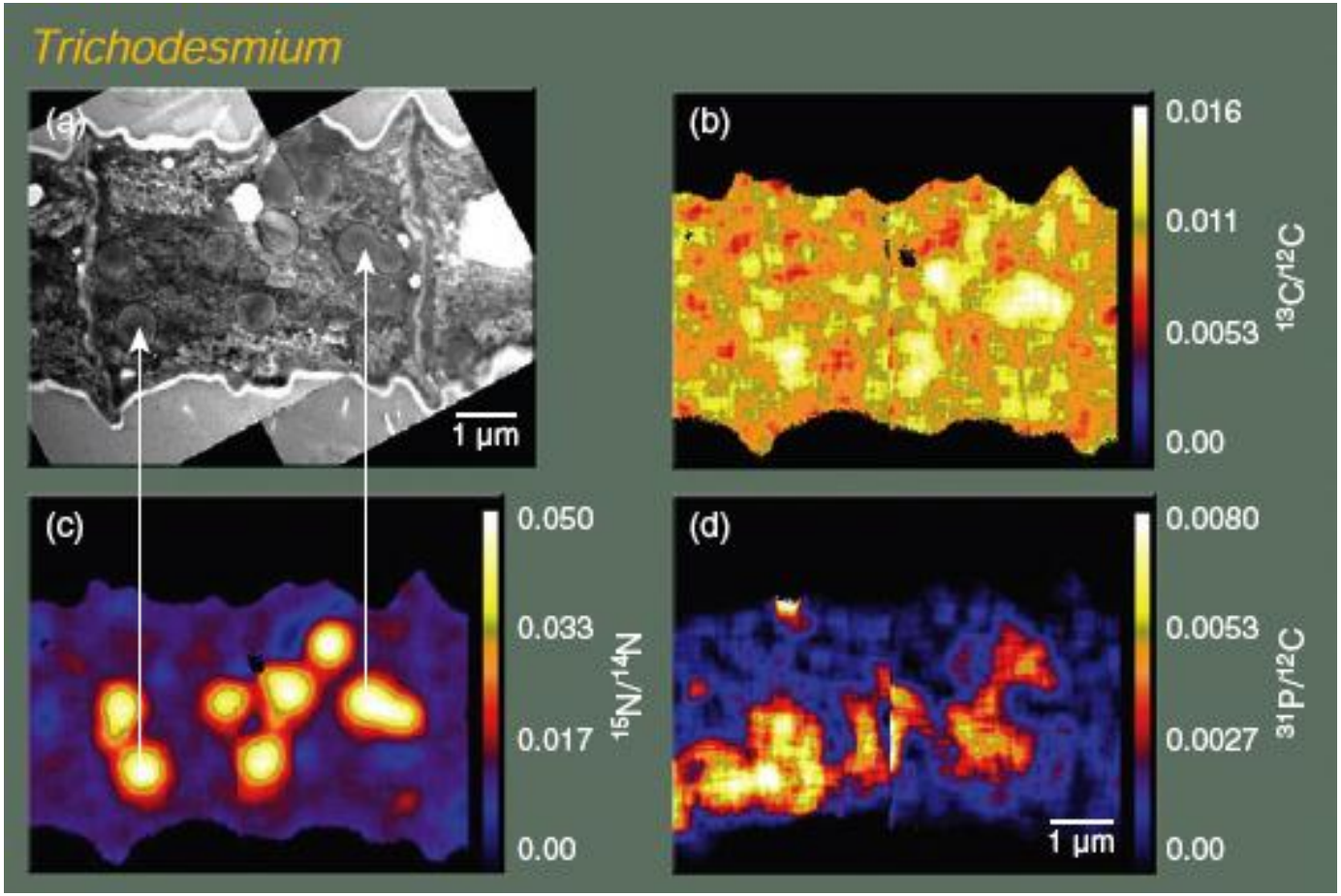




Kelly et al, GCA 2007

Biological Applications

NanoSIMS

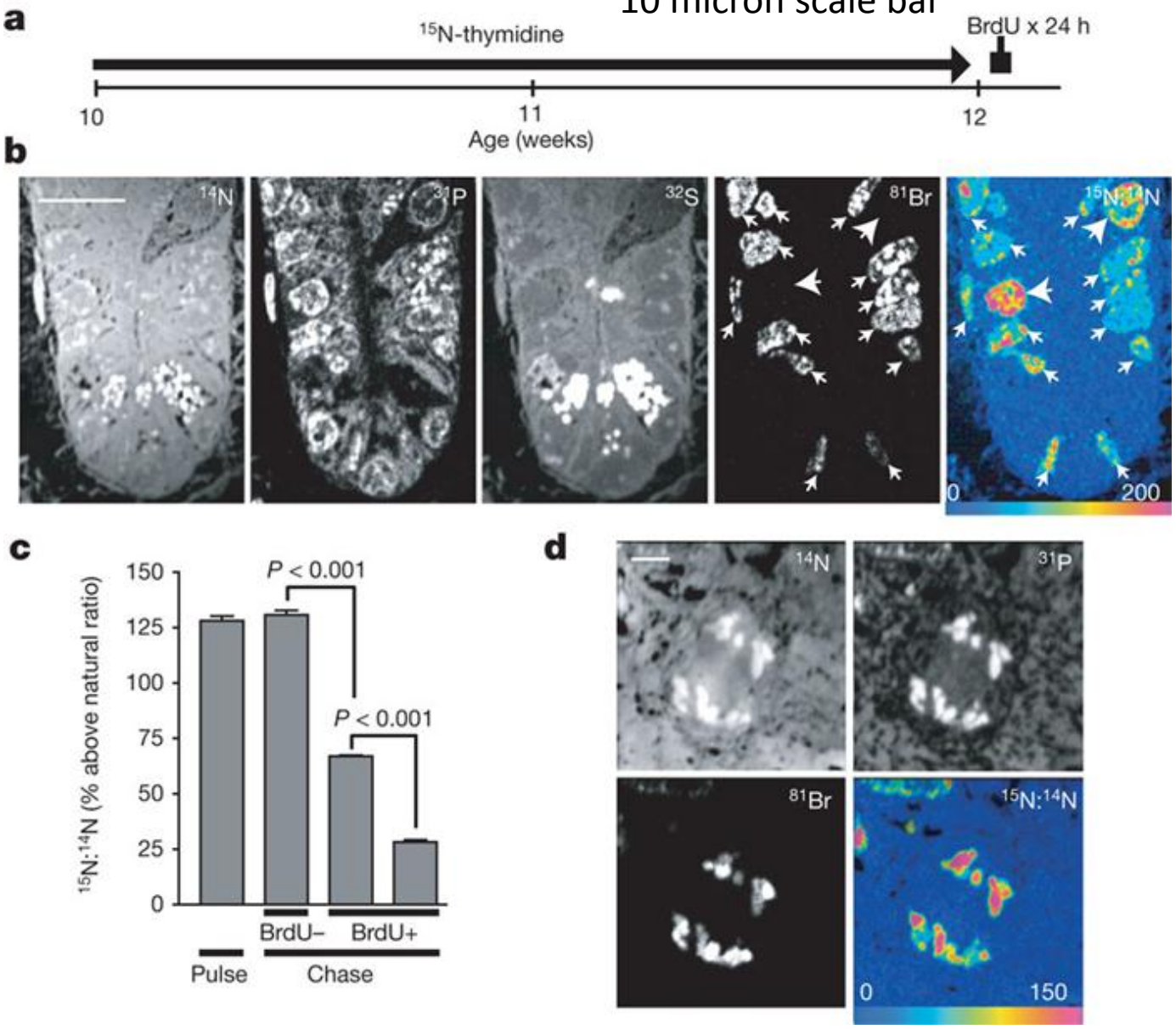


Marxer et al, Biophys J, 2005

Biological Applications

NanoSIMS

10 micron scale bar



Label-dilution in adult mice indicates random segregation of DNA strands.

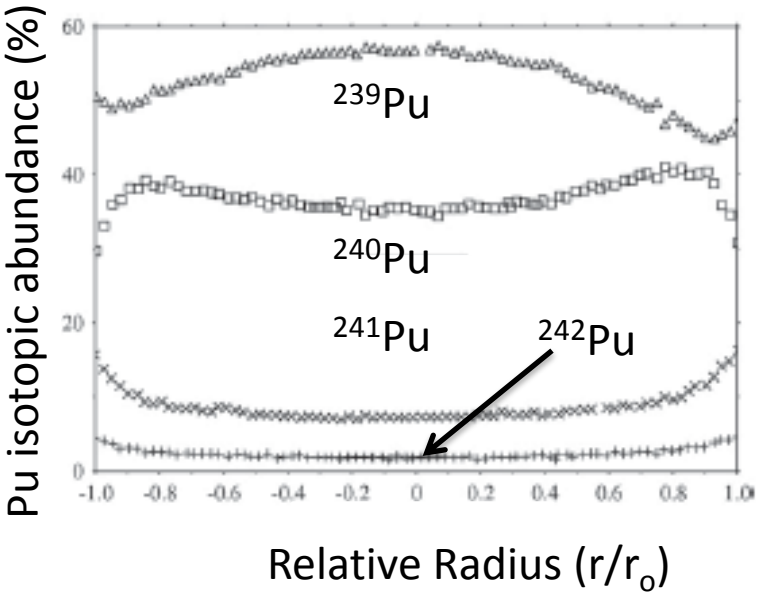
ML Steinhauser *et al*. *Nature* (2012)

Nuclear Reactor Applications

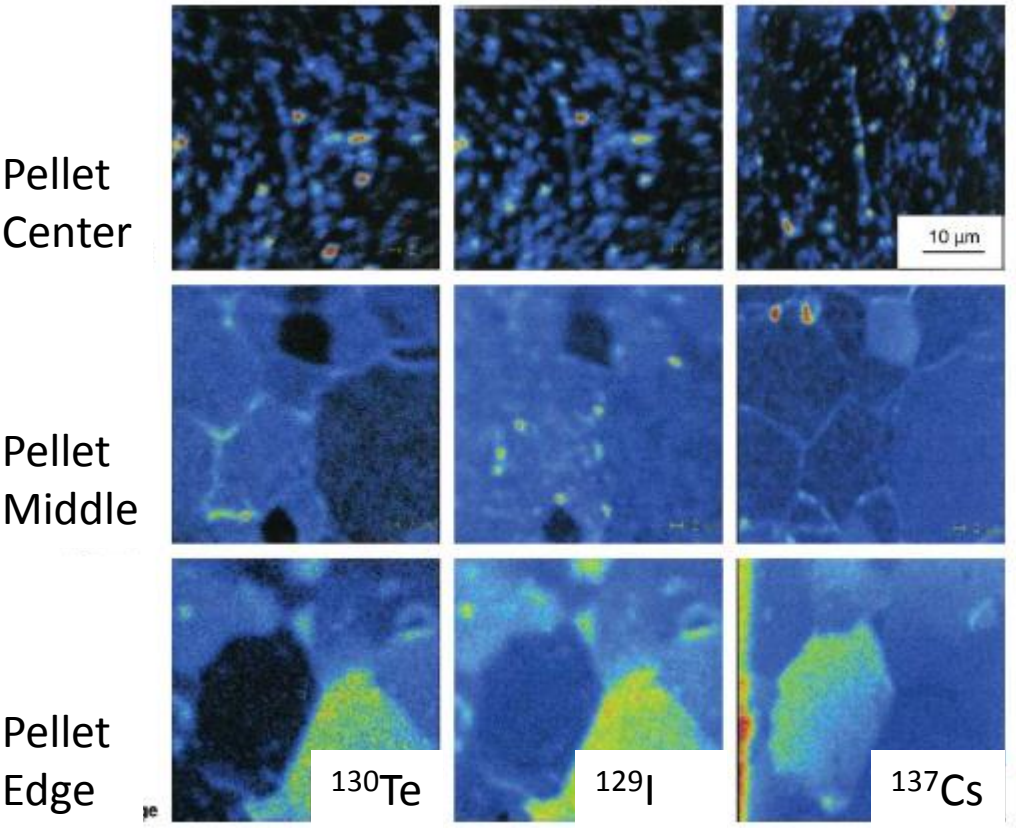
'Shielded' Cameca 6f

Irradiated Nuclear Fuel and Cladding

MOX Fuel Element



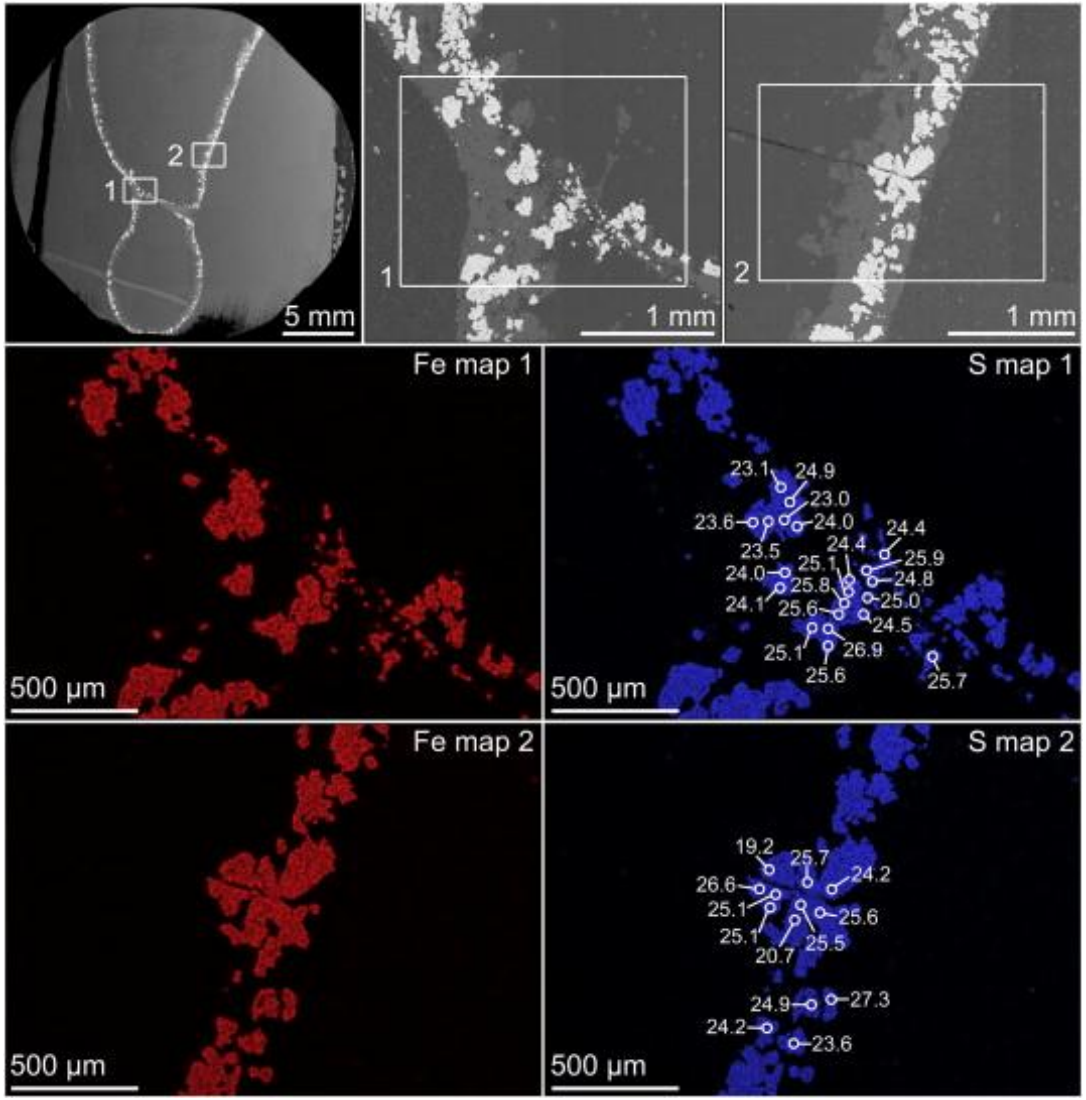
UO_2 Fuel Element – Ramp tested to 520 W/cm



Portier et al., Int. J. Mass Spectr. 2007

Sulfur Isotopes – Formation of Ore Deposits

$\delta^{34}S$ of sulfides reflects origin of ore-forming fluids



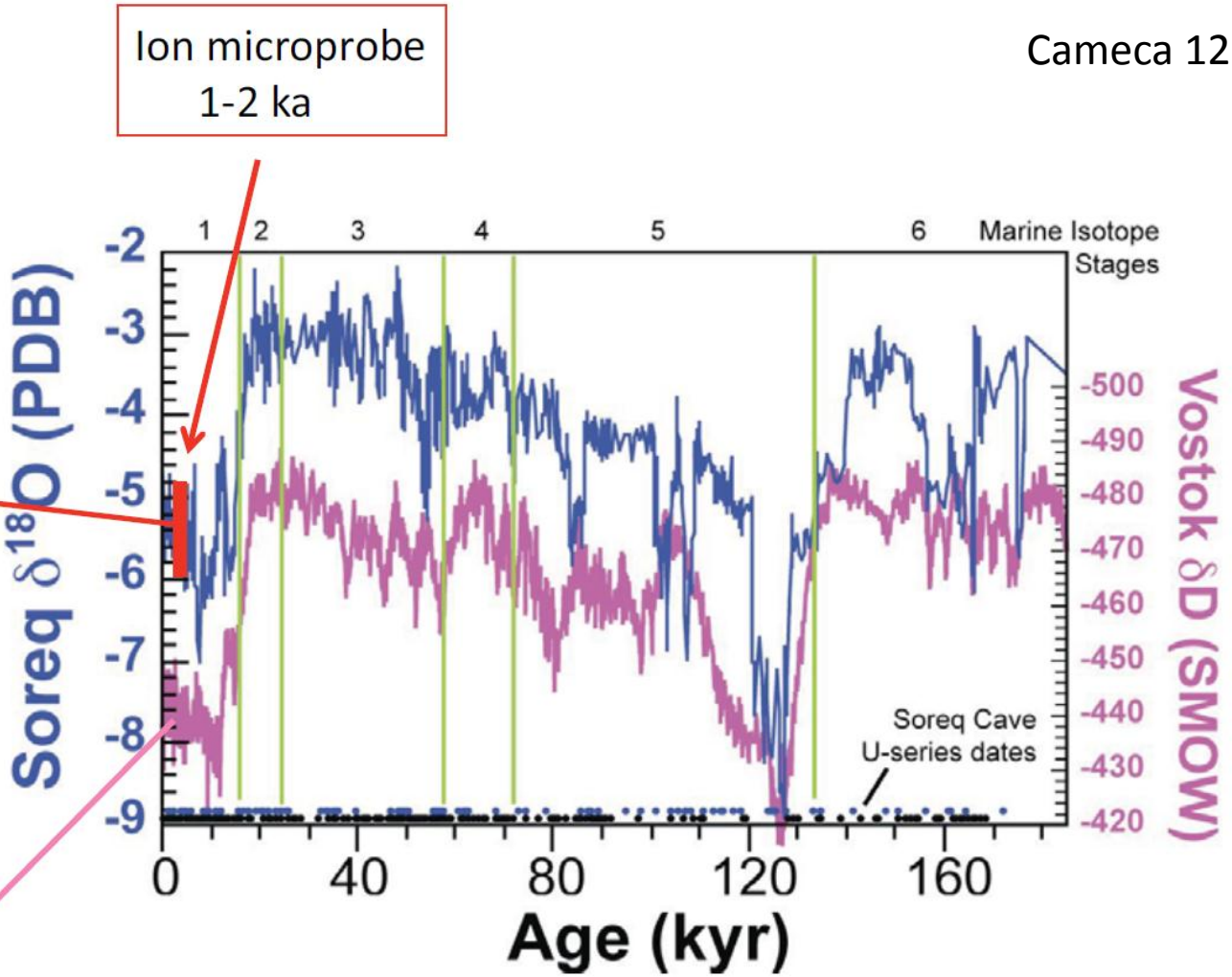
Xiao et al., EPSL 2010

Paleoclimate Applications

Cameca 1280

Soreq Cave
Israel

Antarctic Ice Core



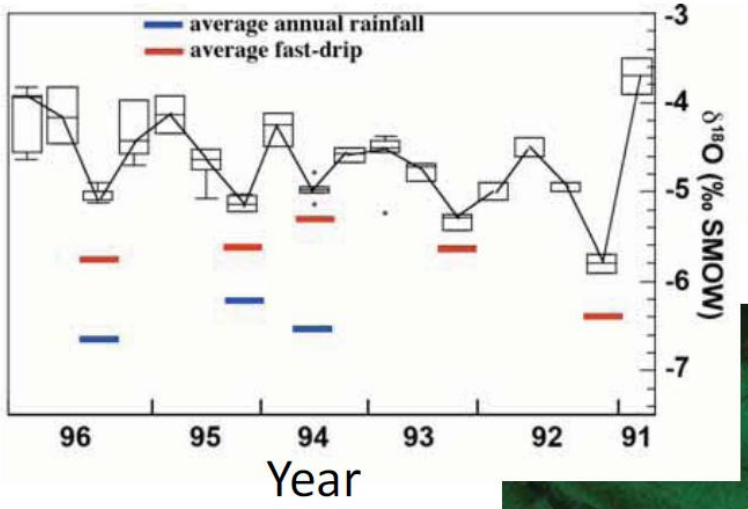
adapted from Bar-Matthews et al., 2003 and Petit et al., 1999

Orland et al., Quat. Res, 2009

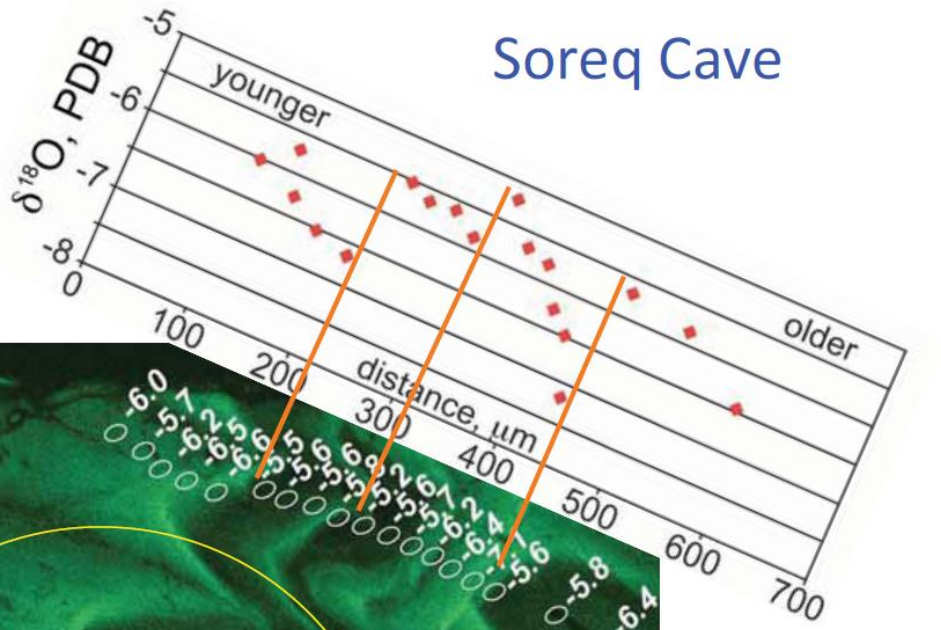
Paleoclimate Applications

Cameca 1280

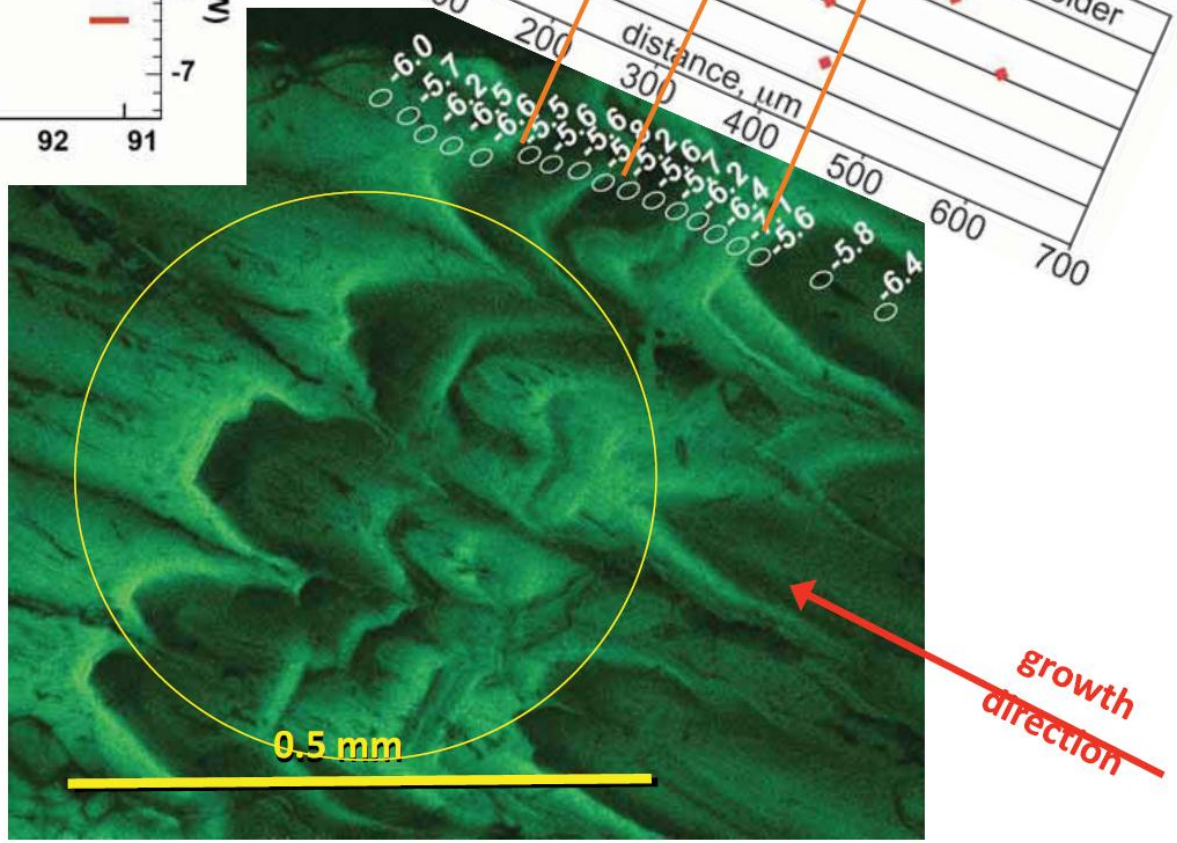
Modern Drip Water



Soreq Cave



Confocal Fluorescent Microscope

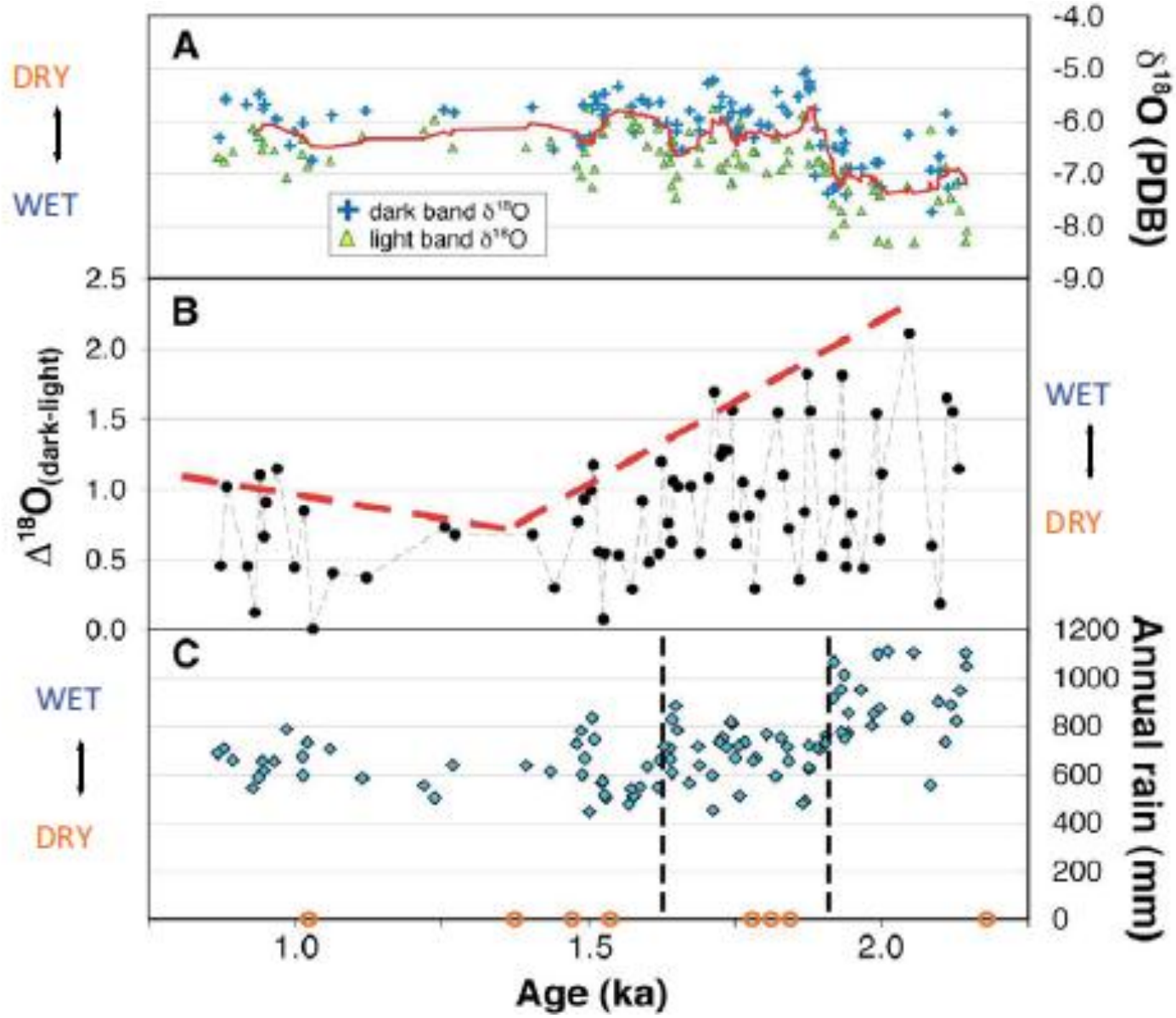


Orland et al. 2009
Quat. Res.

Orland et al., Quat. Res, 2009

Paleoclimate Applications

Cameca 1280



Orland et al., Quat. Res, 2009

A Few Other Applications ….

Hydrogen isotopes in volcanic glasses (e.g. Hauri et al., Chem. Geol. 2002)

K-Ca and Rb/Sr dating of high K/Rb materials (Harrison et al., EPSL 2010)

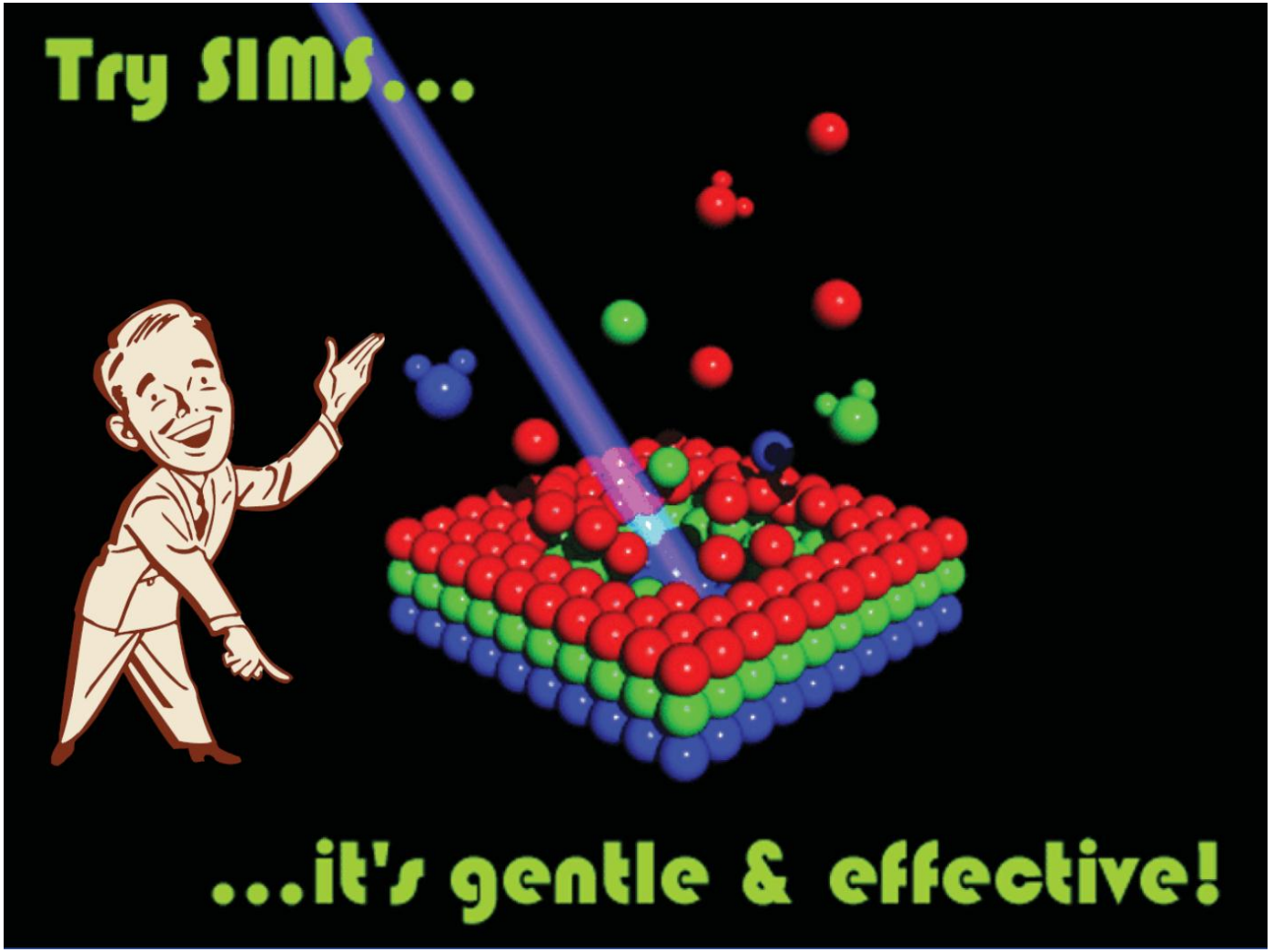
Cl isotope analysis of magmas (e.g. Layne et al., Geology 2009)

U-series dating of Quaternary volcanics (e.g. Reid et al., EPSL 1997)

Si-isotopes in Pre-Cambrian cherts (e.g. Heck et al., GCA 2011)

What's Next ?

- Lunch
- Brainstorming
- Indicate on signup sheet – areas of interest
- Follow-on workshops? Classified
- Tours – signups
- Proposal Development



Useful Websites

WiscSIMS – http://www.geology.wisc.edu/~wiscsims/

WHOI (NENIMF) - http://www.whoi.edu/page.do?pid=18655

UCLA - http://www.whoi.edu/page.do?pid=18655

Nancy - http://www.crpg.cnrs-nancy.fr/Sonde/intro-sonde.html

ASU - http://sims.asu.edu/

Cameca - http://www.cameca.com/