

Search for the inception of life on Earth and beyond

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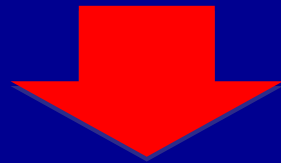
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Earth & Planetary samples are COMPLEX

Unique, fragile, challenging samples

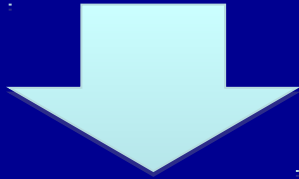
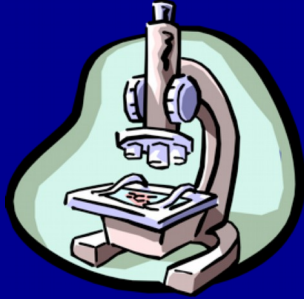
- ★ nondestructive, non-invasive analysis is a **MUST**
- ★ sample environment within few cm around: **HT**, B, **HP**
- ★ hyperspectral analysis: 2-3 **simultaneous** probes
- ★ multiscale: sample heterogeneity (nm -> km)



ESSENTIAL

Sample preparation by **Ion milling/FIB** cuts

Solution: X-Rays



- ★ High Ene. is non/little **destructive**
- ★ penetrative \equiv non-**invasive**
- ★ sample environment: *in situ*
bio, cryo, HP, HT, etc
- ★ hyperspectral analysis: 2-3
simultaneous analyses
- ★ multiscale: **nm** – **mm**



X-ray probes

XRF (X-Ray Fluorescence)

- ★ elementary signature in 1D/2D/3D: Ident. + Quantification
- ★ scale dependent element correlations @ local conditions
- ★ elementary morphology: HOW - processing/kinetics/ageing?
- ★ elements: N-Na in vacuum, Si – U in the air

XAS (X-ray Absorption Spectroscopy)

- ★ molecular signature of specific elements: Mg, P, S, K, Mn, Fe, etc
- ★ access to Solar system re-processing – thermodynamics

XCT (X-ray Computed Tomography)

- ★ “scalpel-free” morphology by density imaging
- ★ access to intricate properties: density, porosity, mixtures

XRD (X-Ray Diffraction)

- ★ crystalline mineral phases – need high T/P conditions???

how to look for LIFE

Element imaging/speciation

1 – **XRF** img. of major/minor **Low Z Elements (LZE): CHONPS**

2 – **XRF+XAS** img. of trace Intermed. Z Elements (IZE) essential for metabolism:

Ca, Ti, **V**, Cr, **Mn**, Fe, **Co**, Ni, **Cu**, **Zn**, **Mo**, **W**, = **METALLOME**

3 – **XRD** of nano-crystalline minerals if present

Morphology of **cocci/filaments**:

1 – XCT (High Energ.) - densities

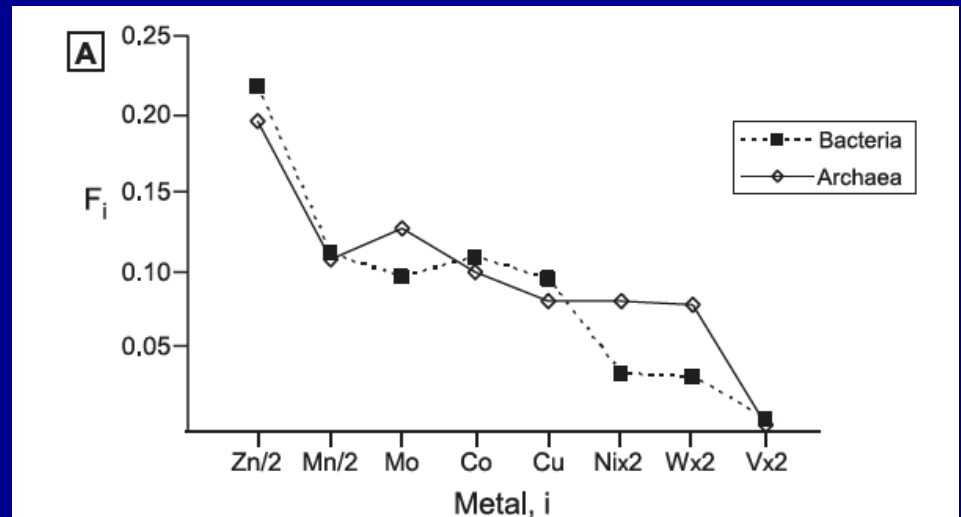
2 – X-fluo-CT – elemental concent.

IR+Raman

1 – **life host** minerals

2 – **H₂O**, C_nH_m compounds, CO₂

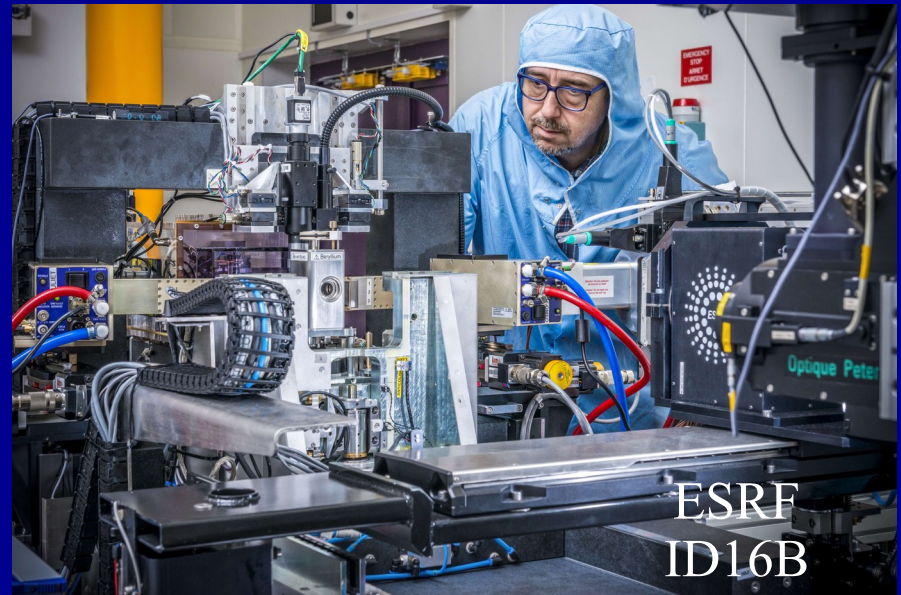
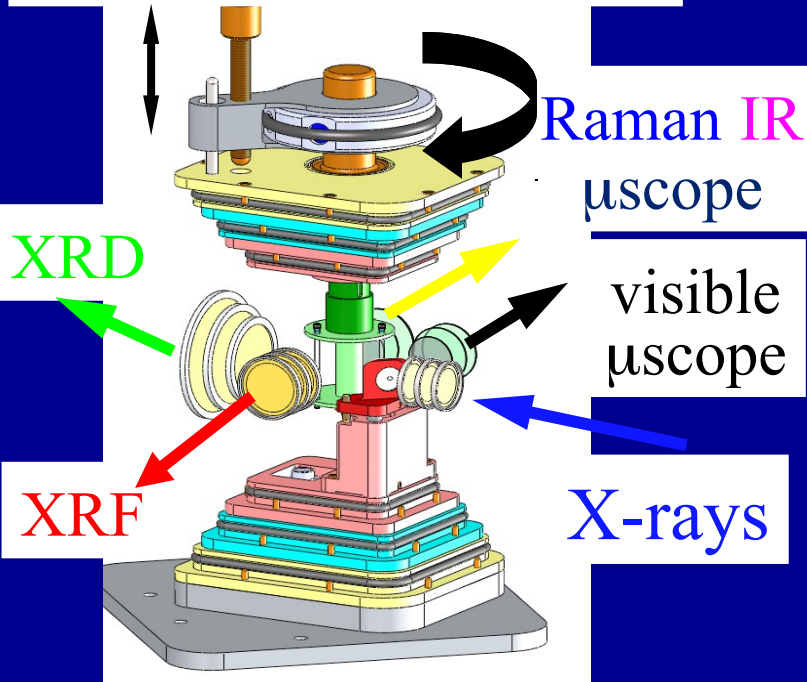
Zerle (2005) metallome



SRM

Sample Return Missions

Magnetic rot/vert. transl.

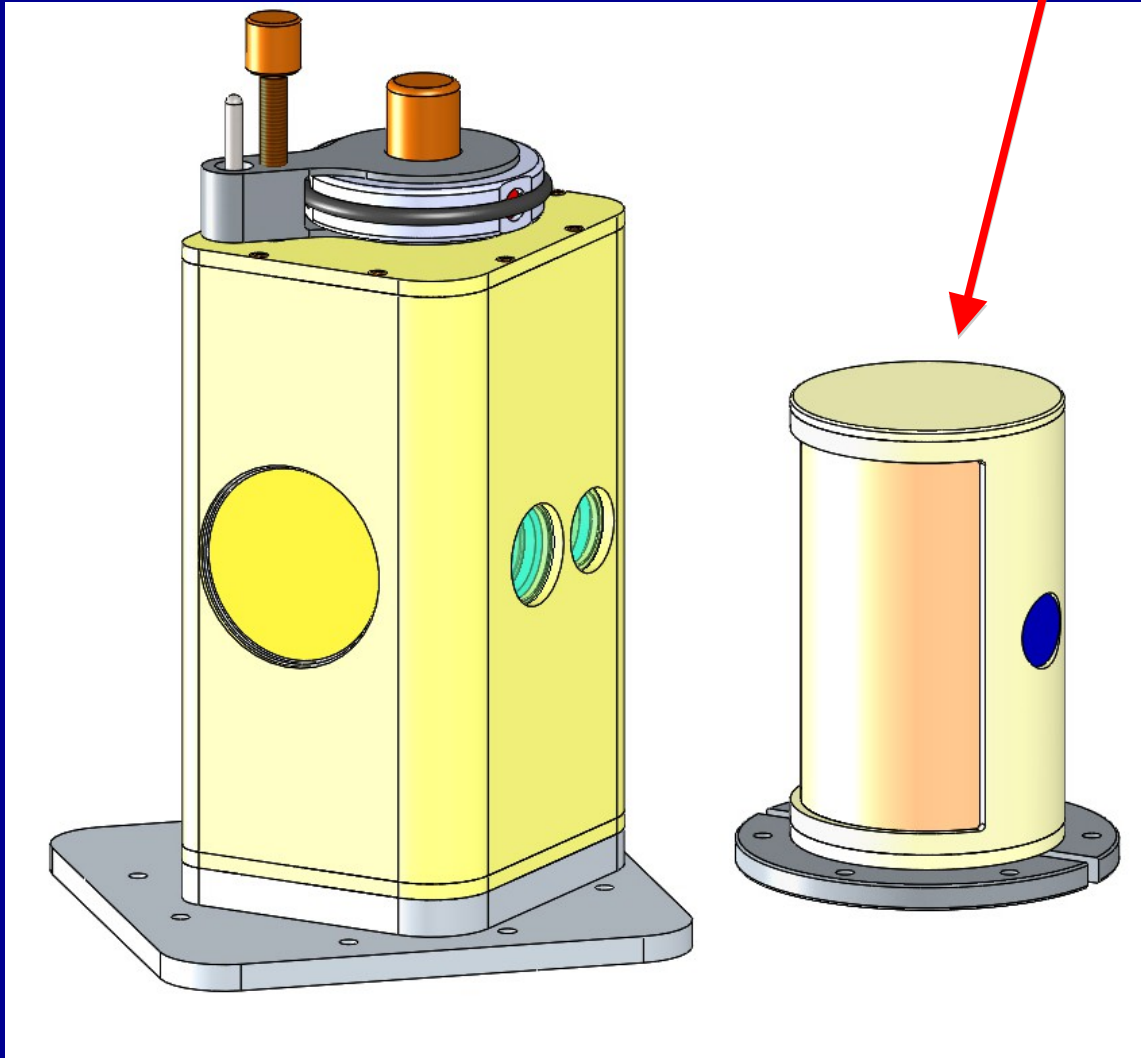


Quarantine Sample Holder (BSL4 protection)

INPI + EPA™ patents



New QSH3



QSH3

- *ESRF new std
- *+ Tomography
- *+ XRD θ range
- *RF P sensing
- *Laser sealing
- *EPA patent pend.

COOL PostDoc

Starting Sept 2019 (ESRF shutdown till June 2020)

- ★ follow-up of Origin of Life on Earth (Archean)
- ★ dating Grand Oxidation Event (2.4 Gy) on Gunflint cherts
- ★ collab. with IBS/CEA on constraining mineral/fluid environment of LIFE: elemental & molecular bio-signatures for remote spectral detection
- ★ prepare for quarantine analyses from Sample Return Missions:
 - 1 – Hayabusa II; 2 – Osiris Rex; 3 – Mars 2025
 - 4 – Roskosmos Phobos ? 5 – Indian/Chinese projects?