Instrumentation for Sample Curation Facility

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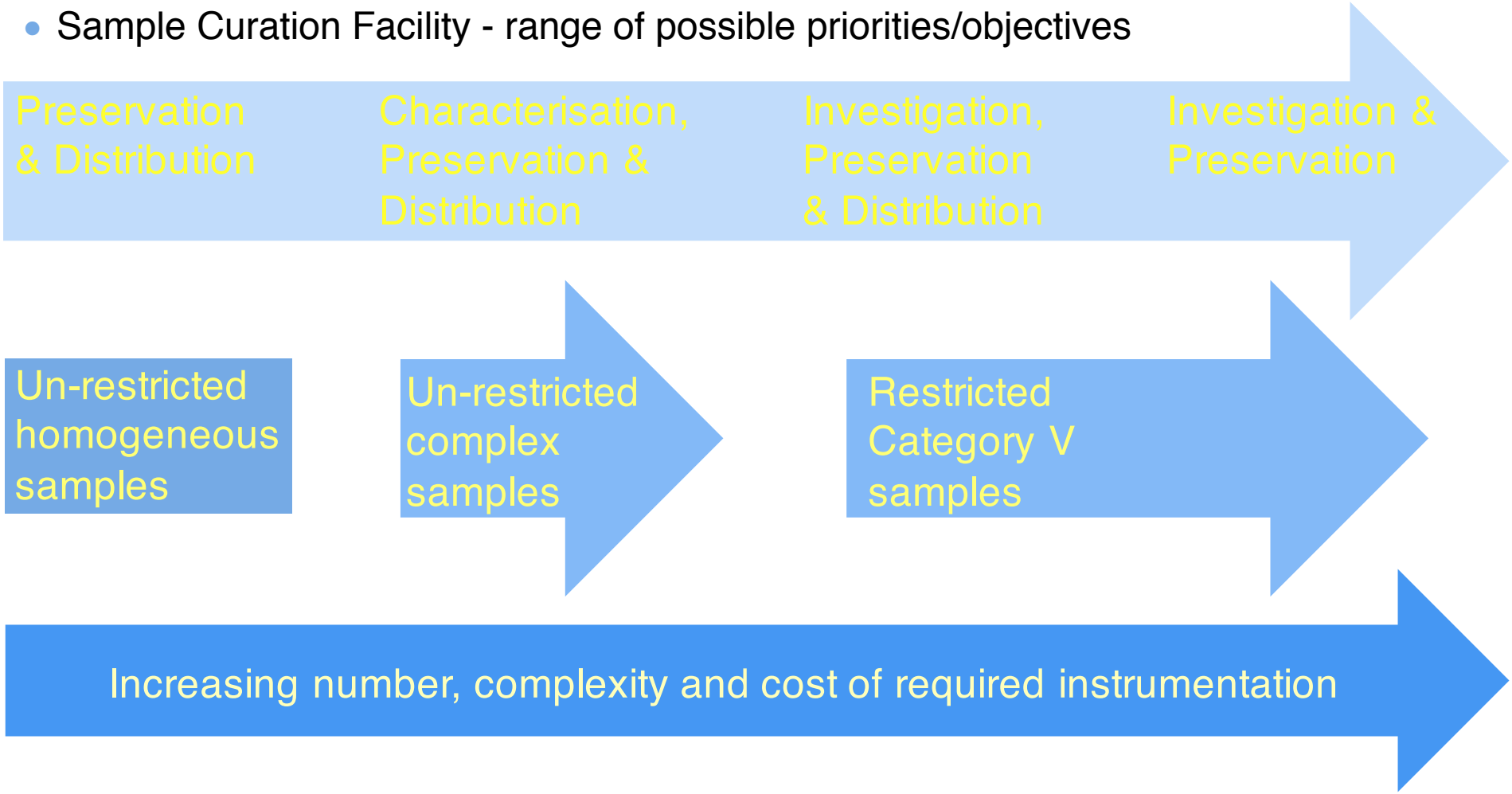
Life-changing Learning

Curation Facility

- Sample Curation Facility - range of possible priorities/objectives



Sample Characterisation

For un-restricted or non-hazardous samples

Sample characterisation required to:

- Documentation of sample
  - Understand the diversity of material present
- Optimise sample allocation
- Monitor behaviour of samples in
- Contamination control/knowledge
  - Monitor environment, cleaning procedures, sample processing

For planetary protection

Sample investigation required to:

- Determine if evidence for life (past or present)
- Determine bio-burden/bio-hazard
- Determine the effectiveness of sterilisation

Sample Characterisation

For un-restricted samples

Requirements of sample characterisation:

- Without modification of the sample
  - Minimal processing of sample
  - Minimal interaction/contact of instrumentation with sample
  - Minimal energy imparted into sample
- Without addition of contaminating material
  - Analyses performed in glove boxes
  - Instrument should not be a source of contamination

- Identify essential instruments

- Instruments major source of particulate and volatile contamination
- Minimise/eliminate operation of instruments inside glove boxes (or containment?)

Sample Characterisation

Instrumentation for un-restricted large samples

- Optical methods for documentation

3D shape profiler
Reconstruct spatial relationship of sub-samples
Inside transparent container?
Rotate laser instead of sample?

Range of optical microscopes

Light field cameras (extended depth of field)

High levels of automation – inside box?
Incorporated into wall of glove box?
Long working distance lens – outside box?

Sample Characterisation

Instrumentation for un-restricted large samples

- Physical properties

At least 2x X-ray CT
Larger capacity for sample canister
Higher resolution for samples
Samples remain in container? Or Glove box?

Development:
Scanner rotates round sample?
Next generation – energy spectrum/voxel

Range of balances
Glove box compatibility limits?

Sample Characterisation

Instrumentation for un-restricted large samples

- Spectral properties

Laser Raman microscope

Measurements inside container?
Measurement through glove box wall?
Fibre connection to microscope in glove box?
UV-resonance Raman?

FTIR Microscope
FTIR Fibre microscope?
Measurement inside container?
Measurement through glove box wall?

Sample Characterisation

Instrumentation for un-restricted large samples

- Electron microscope

For detailed sample characterisation
Liable to contaminate and damage sample

Also useful for contamination control

Requires support instrumentation
Coaters
Sample cutting, grinding and polishing

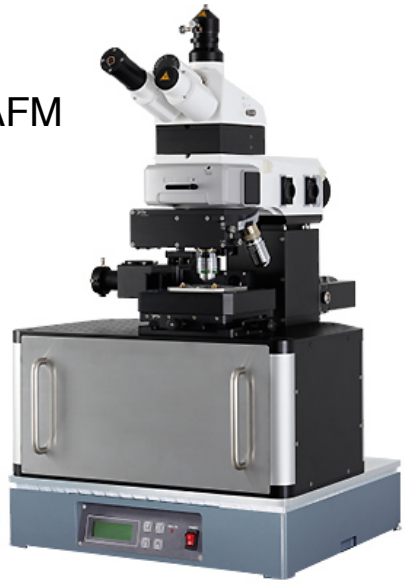
Transfer systems available
Require adapting/redesign for compatibility

Sample Characterisation

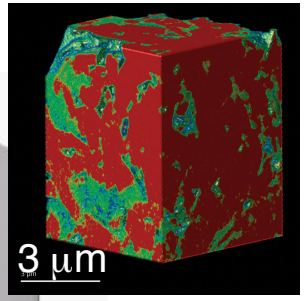
Instrumentation for un-restricted small samples

FIB SEM

SNOM/AFM



3D Microscope



TEM

Clean Room Support

Instrumentation for contamination analyses

- GC-MS systems
  - Multi-automated sample introduction systems
  - Automated extraction/analyses of witness plates, solution residues, etc

- Gas monitoring mass spectrometers
  - Part of clean room install

Plus several facilities that could be off-site

- Stable isotope MS
- TOF-SIMS
- XPS, etc

- ICPMS
  - Automated extraction/analyses of witness plates, solution residues, etc

Sample Investigation

For Restricted Samples

- All measurements must be meet Planetary Protection requirements
- Long list of instruments identified

Solid sample analysis	Gas sample analysis	Liquid sample analysis
• 3D X-ray micro-tomography • Surface imaging and spectroscopy	Not applicable	Not applicable
• Microscopy • Fluorescence • IR, visible, UV, deep UV spectroscopy • SEM	• IR, visible, UV, deep UV spectroscopy	• Microscopy • Fluorescence • IR, visible, UV, deep UV spectroscopy
• SEM, TEM, nano-X-ray-tomography • XRD, XANES • GC-MS, GC-IRMS, FTICR-MS, LC-MS, TOF-SIMS, Nano-SIMS • Target independent biopolymer sequencing	• GC-MS, GC-IRMS, FTICR-MS, LC-MS	• GC-MS, GC-IRMS, FTICR-MS, LC-MS, TOF-SIMS, Nano-SIMS, • Target independent biopolymer sequencing, flow cytometry

Non-destructive and non-invasive	Non-destructive and minimal invasive (no sample preparation	Destructive (specific sample preparation)

From Kminek et al 2014

Sample Investigation

For Restricted Samples

- All measurements must be meet Planetary Protection requirements
- Long list of instruments identified
  - and growing….

TECHNIQUE	Dimension	Weight Automated/ Manual	Cost	Energy	Clean Room/BSL-4 compatibility
Fluorescence microscopy				2	1
X-Ray CT				2	1
Optical microscopy				2	1
Electron microscopy - SEM				2	1
Electron microscopy - TEM				2	1
GC-MS				2	1
LC-MS				2	1
MALDI-TOF				2	1
NMR				2	1
Chromatography				2	1
FTIR				2	1
Raman (Resonance?)				2	1
Marker Chip with antibody				1	1
High Performance Liquid Chromatography (HPLC)				2	1
Polymerase Chain Reaction (PCR)		1		1 (or autom.)	1
Gel electrophoresis (GE)		1		1 (or autom.)	1
Sequenciation (many techniques…)		1		1 (or autom.)	1
ELISA - Enzyme-linked immunosorbent assays				1	1
FISH - Fluorescent in situ hybridization				1	1
Solid Phase Extraction (SPE)				1	1
Capillary Electrophoresis (CE)		1		1 (or autom.)	1
Protein microarray/Marker chip		1		1 (or autom.)	1
Isotope Ratio Mass Spectrometry (IRMS)				2	1
SIMS				2	1
MC-ICP-MS				2	1
13C-NMR				2	1
SEM-EDX				2	1
XRD				2	1
XRF				2	1

From WP2 (March 2016)

Sample Investigation

For Restricted Samples

- All measurements must meet Planetary Protection requirements
- Long list of instruments identified
  - and growing….
- Are all techniques essential?
- Compatible with DWI/BSL4?
  - Some operate within contained zone
  - Some operate through containment
  - Some highly imparctical
- Large number of highly skilled experts
- Huge complexity of requirements

TECHNIQUE	Dimension	Weight	Automated/ Manual	Cost	Energy	Clean Room/BSL-4	compatibility
Fluorescence microscopy						2	1
X-Ray CT						2	1
Optical microscopy						2	1
Electron microscopy - SEM						2	1
Electron microscopy - TEM						2	1
GC-MS						2	1
LC-MS						2	1
MALDI-TOF						2	1
NMR						2	1
Chromatography						2	1
FTIR						2	1
Raman (Resonance?)						2	1
Marker Chip with antibody						1	1
High Performance Liquid Chromatography (HPLC)						2	1
Polymerase Chain Reaction (PCR)			1			1 (or autom.)	1
Gel electrophoresis (GE)			1			1 (or autom.)	1
Sequenciation (many techniques…)			1			1 (or autom.)	1
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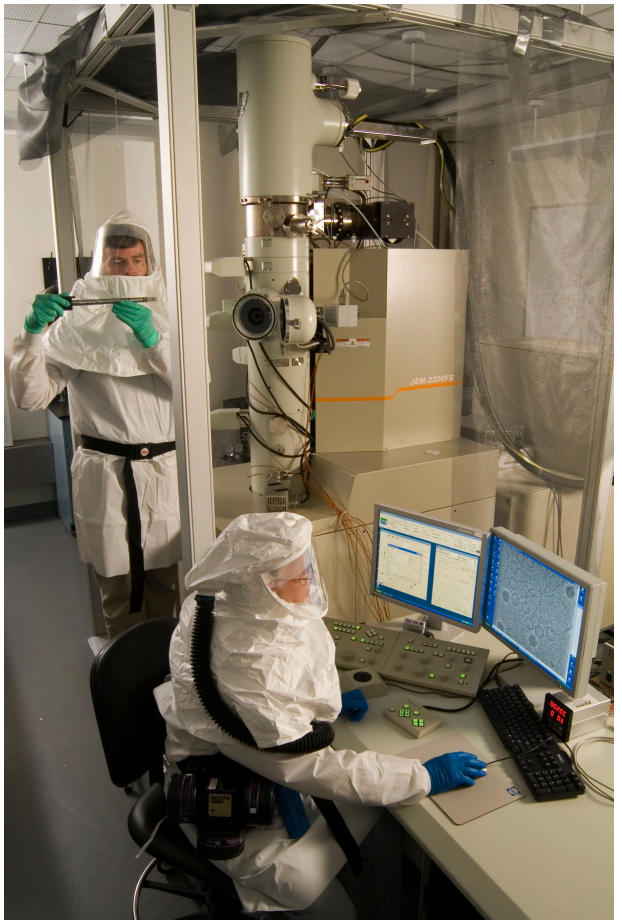
MC-ICP-MS						2	1
13C-NMR						2	1
SEM-EDX						2	1
XRD						2	1
XRF						2	1

From WP2 (March 2016)

Instrument Maintenance

In a bio-containment facility

- First rule - complex machines they will breakdown
  - Instruments likely to be several (many?) years old by time samples arrive
- Second rule – minimise # and complexity of machines in clean/containment areas
- Decontamination to allow access by service engineers?
  - Hydrogen peroxide vapour? Chlorine dioxide?
- Both aggressive reagents – some materials incompatible?
  - Require extensive re-engineering of instruments?
- Can vapour reagents sterlise a rock fragment?
  - Not possible to control friable samples in vacuum.
- UTMB cryo TEM modified for high T bake
  - Known, microscopic samples – so max T clearly identified
- Once contaminated – stays contaminated
- BSL staff undertake all maintenance inside facility
  - Staff retention critical



Cryo TEM in BSL3 virus imaging lab, Univ Texas MB

Instruments – in or out?

Arguments to minimise equipment inside containment

- Not possible to sterlise equipment exposed to rock fragments
  - Other examples may control nature of hazardous material to ensure sterlisation
- Cost and criticality of staffing to maintain and operate instruments
  - Highly specialised staff for each instrument
- Can't use contaminated instrument for un-restricted samples
  - Duplication of instrumentation
  - Additional cost for instruments, maintenance, infrastructure, staffing
- Reduced flexibility
- Instruments a huge source of particle and volatile contamination
- Environment requirements (esp vibration) challenging to meet in clean areas

Instrumentation for PP

Minimse the instrumentation working with hazardous samples

Perform measurements on sterilised samples if possible

But still need to know….

- What is required to define bio-hazard in samples?
- What is required to define acceptable sterilisation?
- What sterilisation techniques will be used?
  - Gamma radiation from ^{60}Co source? What dose?
  - Thermal processing? What temperature?
  - Chemical treatment? How aggressive?
- What effects of sterilisation on sample?
  - What science will be lost by sterilisation of samples?
  - What science must be performed on un-sterilised samples?