Overview Genesis Contamination Control and Curation

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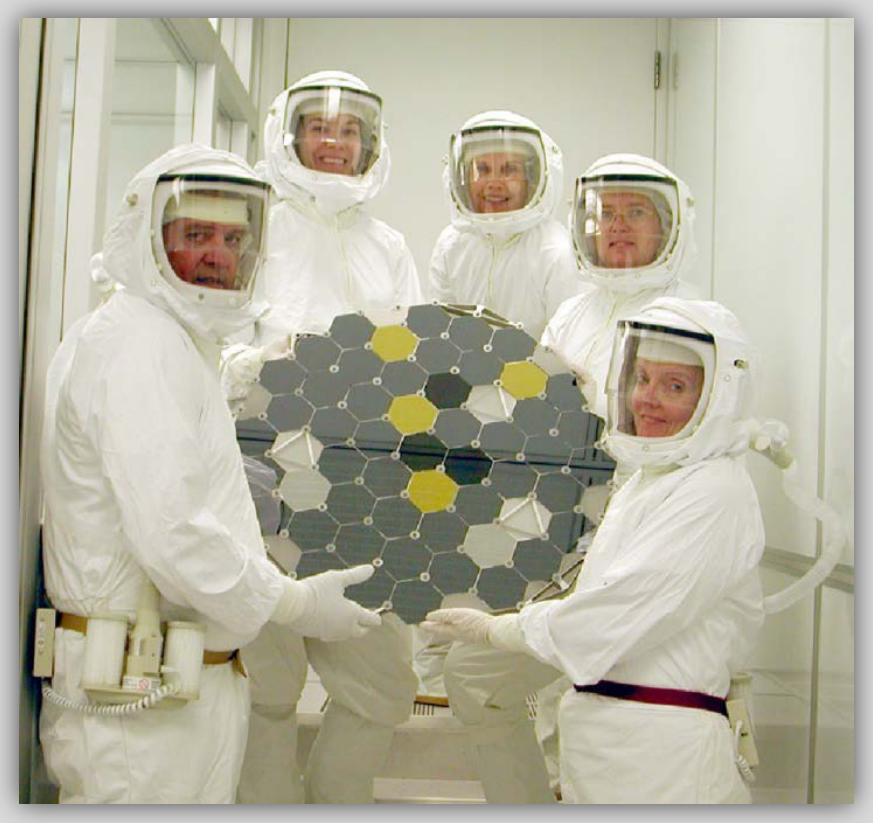
ASTROMATERIAL CURATION

JSC



- **Preservation of scientific integrity**
  - Controlled environment storage and handling
  - Controlled documentation and sample accountability
- **Characterizing the collection**
- **Dissemination of information about the collection**
- **Allocation of samples for research and education**
- **Reserve portion for future studies**

Responsibility assigned to Director of the Johnson Space Center per NASA Policy Directive 7100.10E

ASTROMATERIAL CURATION

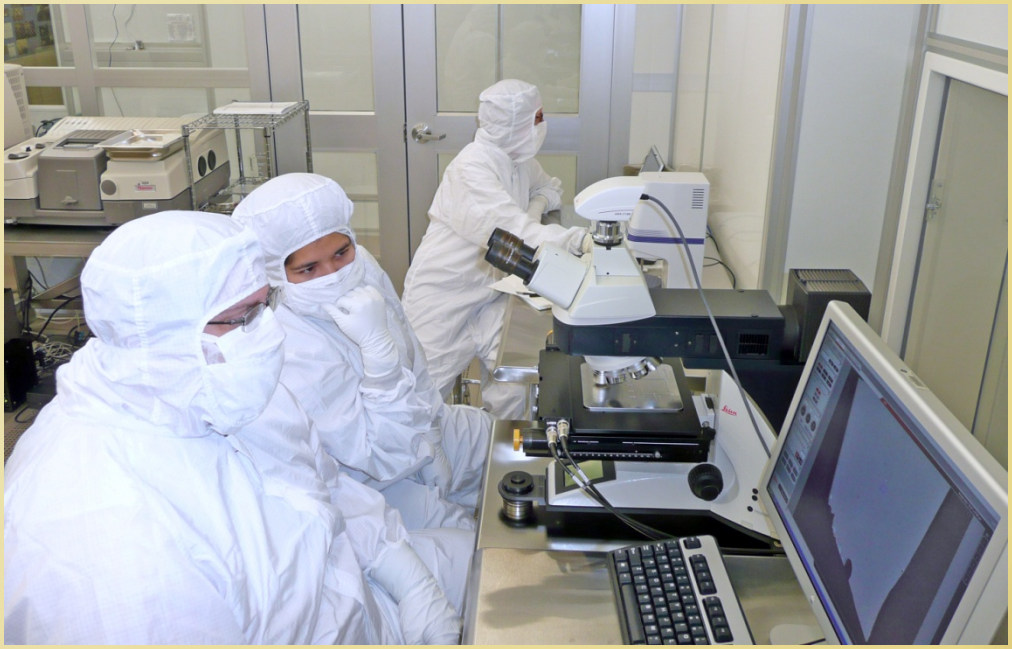
JSC

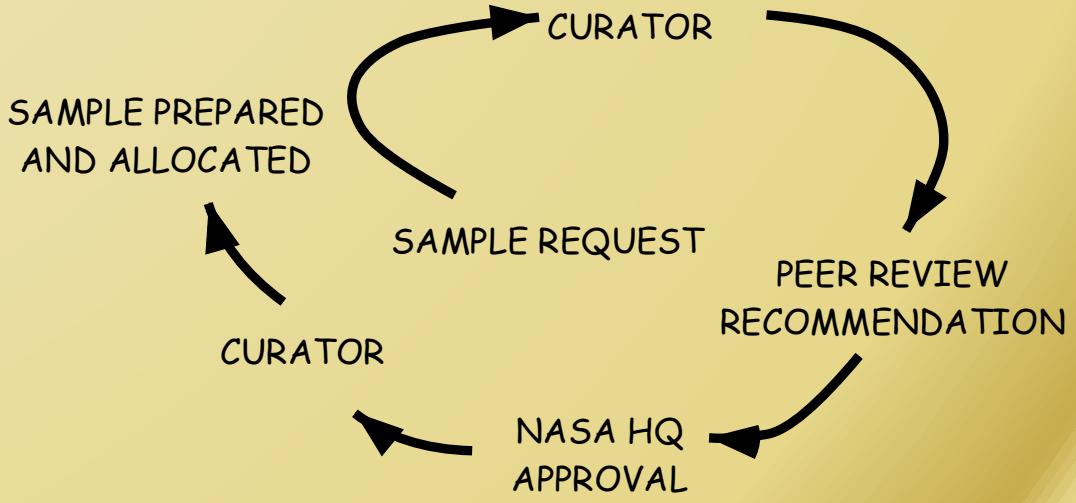
- **Begins with mission design and hardware design**
  - Set requirements for contamination control based on science requirements
  - Active participation in mission planning
- **Continues through fabrication, cleaning and assembly**
  - Attention to detail of fabrication and assembly process is critical
  - Active participation and contamination control oversight
- **Continues through launch, flight and return phases**
  - Active participation
- **Recovery operations optimized for scientific integrity**
- **Curatorial facility operation for preservation of scientific integrity**

CURATION – SCIENCE FROM THE SAMPLES

JSC

- Sample Characterization and documentation
- Dissemination of information about the collection
- Facilitating peer review and implementing allocation decisions





CURATION – SAMPLE ACCOUNTABILITY

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- **Accurate tracking : collection inventories, investigator inventories**

GENESIS DID IT RIGHT!

JSC

- **Mission plan and budget included contamination control and curation from the beginning**
- **Excellent team work among Principal Investigator, science team, mission design, engineering and curation**
- **“START CLEAN, STAY CLEAN”**
- **Post-landing intense collaboration between curation and science team on cleaning methods and cleanliness assessment**

PRE-LAUNCH CURATION

JSC

- **Assessment of contamination mitigation during flight operations**
  - Sealed payload open only during collection
  - Minimization of thruster plume effects
  - Re-entry pressure equalization and ablation gas mitigation
- **Choice of clean and cleanable materials for payload fabrication**
  - Bare aluminum, minimum lubricants and adhesives
- **Construction of ISO Class 4 cleanroom for payload cleaning & assembly**
  - Cleaning with megasonically energized ultrapure water: 18 meg-Ohm-cm
  - Assembly and sealing of payload
- **Archiving of flight reference coupons and environmental monitoring witness plates**
- **Clean sample storage under nitrogen**

PRE-LAUNCH CURATION:
ISO 4 laminar flow cleanrooms

JSC

PRE-LAUNCH CURATION: Cleaning with UPW

JSC

- 18 MΩ–cm resistivity
- <5 ppb TOC
- Ultrasonic or megasonic energy
- Ionic concentration low parts per trillion = “hungry water”

PRE-LAUNCH CURATION:
Clean assembly, HEPA-filtered people

JSC

PRE-RECOVERY CURATION

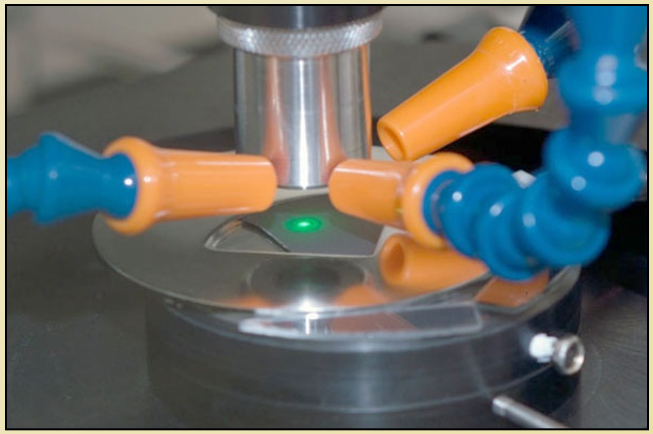
JSC

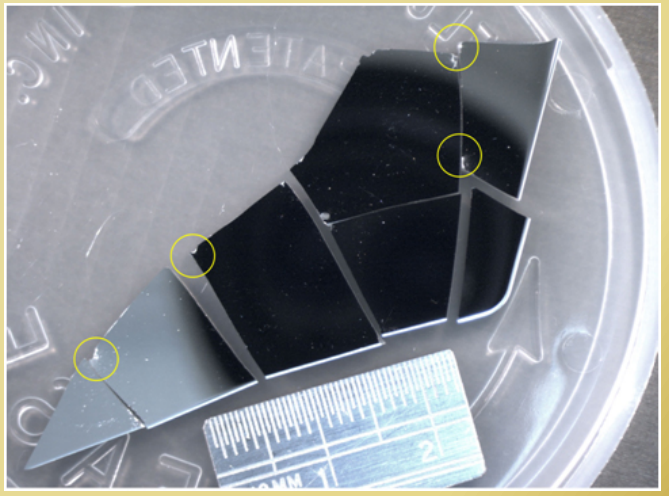
- **Instrumentation for surface cleanliness assessment**
  - High resolution optical scanning for particulates
  - Ellipsometry mapping for molecular films

PRE-RECOVERY CURATION

JSC

- **Capability for clean subdivision of collectors**
  - Laser scribing backside
  - Manual cleaving





POST-LANDING CURATION

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- **Landing site recovery**
  - Field recovery to UTTR cleanroom before sunset
  - Removal of collector fragments from canister
  - Imaging and packaging of >10,000 fragments
  - Transport to JSC in less than a month

JSC CURATION

JSC

- Secure nitrogen storage
- ISO Class 4 handling
- Sample characterization
- Sample information dissemination
- Sample allocation

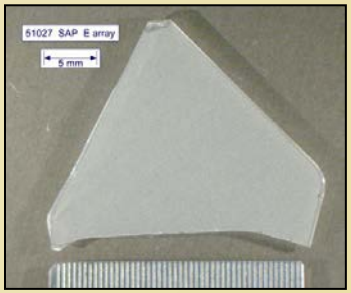
JSC CURATION: Secure nitrogen storage

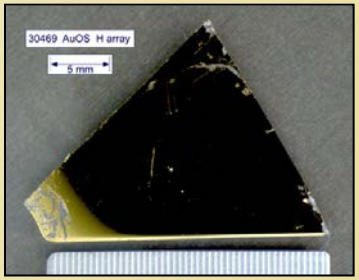
JSC

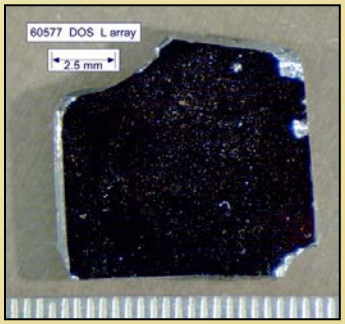
JSC CURATION: Sample characterization

JSC

- Material
- Solar wind regime
- Imaging
- Size and surface quality



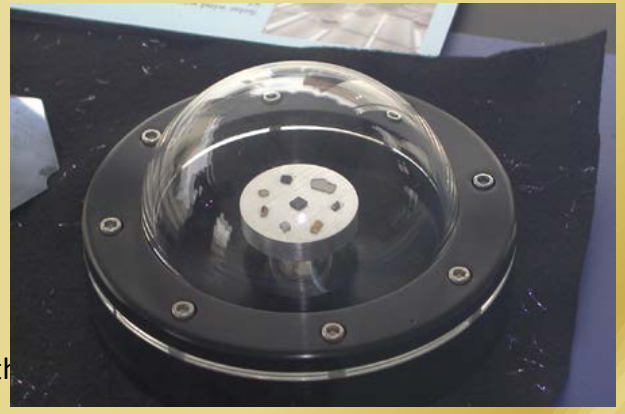




JSC CURATION: Dissemination of sample information, facilitation of peer review, allocation

JSC

- Online catalog updated monthly
- Newsletter
- Investigator Guidebook
- Genesis Oversight Subcommittee of CAPTEM reviews sample requests and recommendations to Discipline Scientist at NASA HQ
- Public display samples

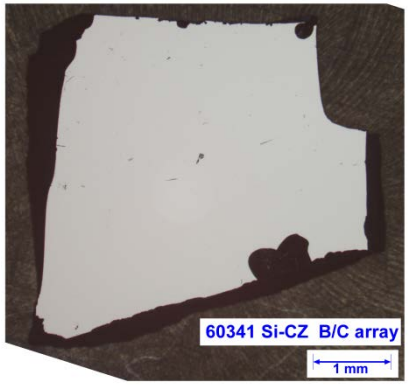


JSC CURATION:
Collaboration with science team, cleaning samples

JSC

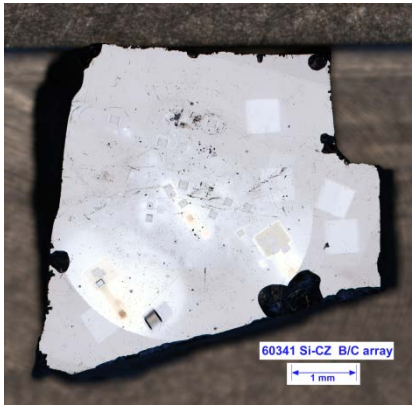
- JSC optical imaging between cleaning steps
- JSC cleaning with ultrapure water (UPW)
- JSC use of UV ozone to remove molecular film

Sample History

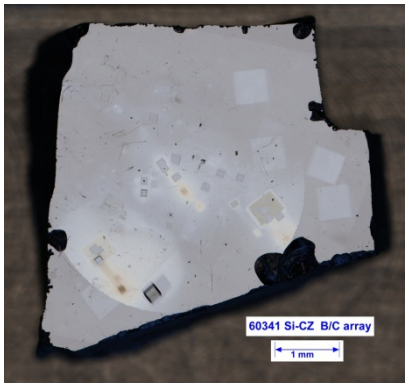


After UPW cleaning
(Step 1)

After UV ozone cleaning
(Step 4)



After ToF-SIMS analysis
(Step 5)



After UPW cleaning
(Step 8)

1. UPW cleaned (2/21/2007) *
2. 25Mg implant, SIMS analysis (6/12/2007)
3. 54Fe implant, SIMS analysis (5/1/2011)
4. UV ozone (6/22/2011) *
5. ToF-SIMS (3/11/2013) *
6. UPW cleaned (8/21/2013) *
7. HCl, hot xylene (8/28/2013) *
8. UPW cleaned (9/4/2013) *
9. ToF-SIMS (3/14/2014)

UPW= Ultra Pure Water

* Followed by optical imaging

Optical Images of 60341

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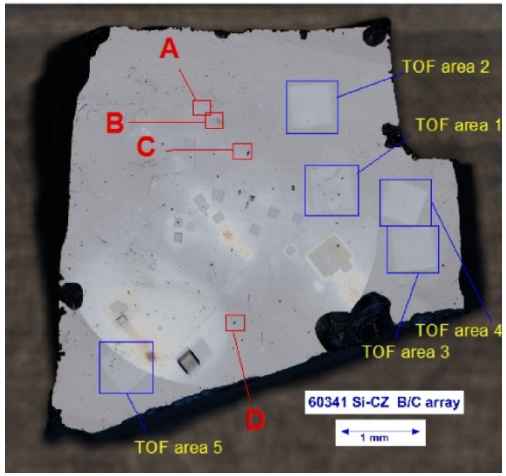
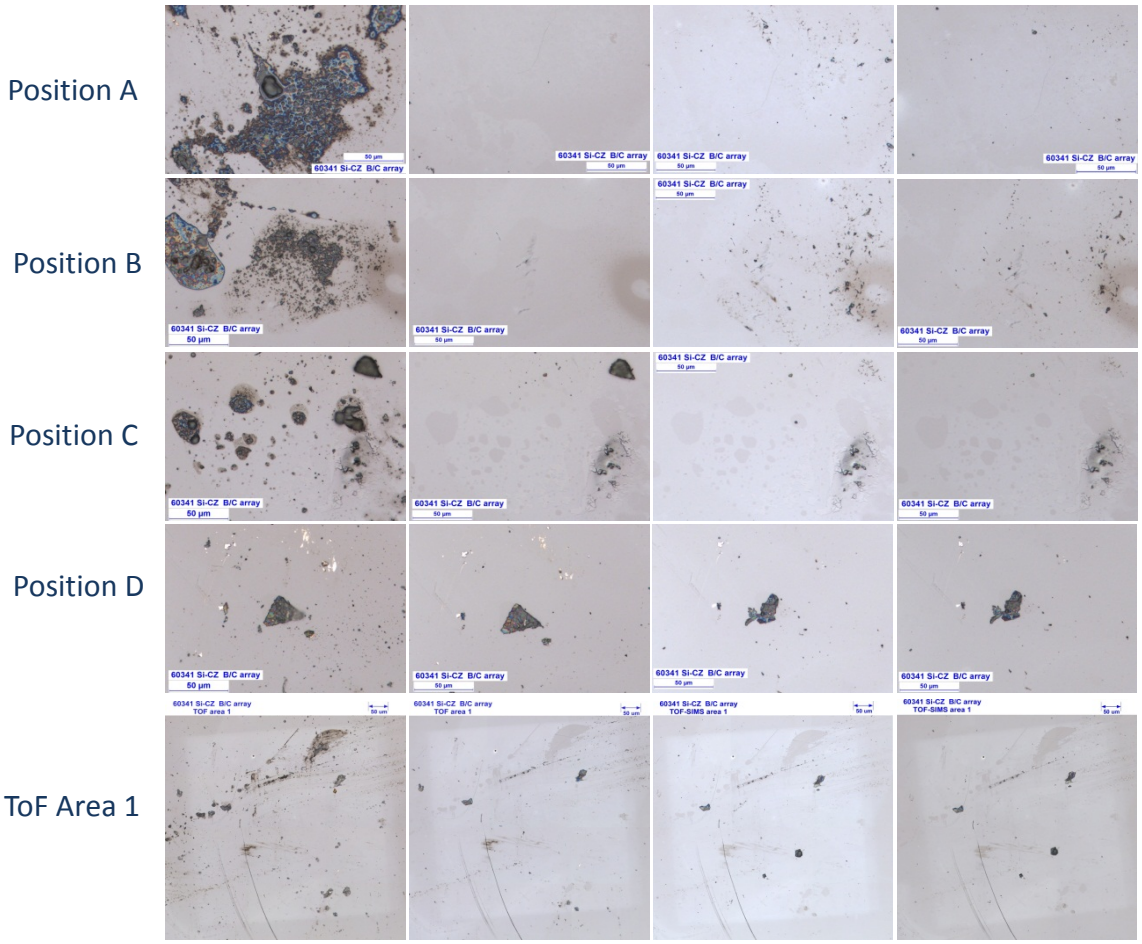


Location of high magnification optical images and ToF-SIMS scans. Overall image taken after 3rd UPW cleaning-Step 8. The bright areas are oxidation introduced during SIMS analysis.



1. Step 6 shows UPW cleaning effectively removed handling debris documented in step 5 (ToF-SIMS);
2. Acid cleaning, hot xylene treatment, and ultrasonic cleaning (step 7) added contamination to positions A and B, but removed in C and D;
3. Images from step 8 show contamination from step 7 handling was partially mitigated in A and B, but there were few visible changes in C and D.

ToF-SIMS Results

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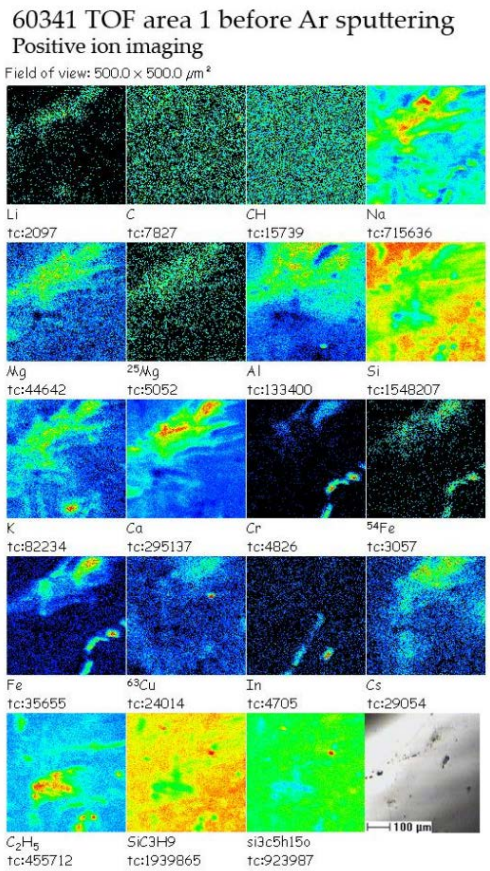
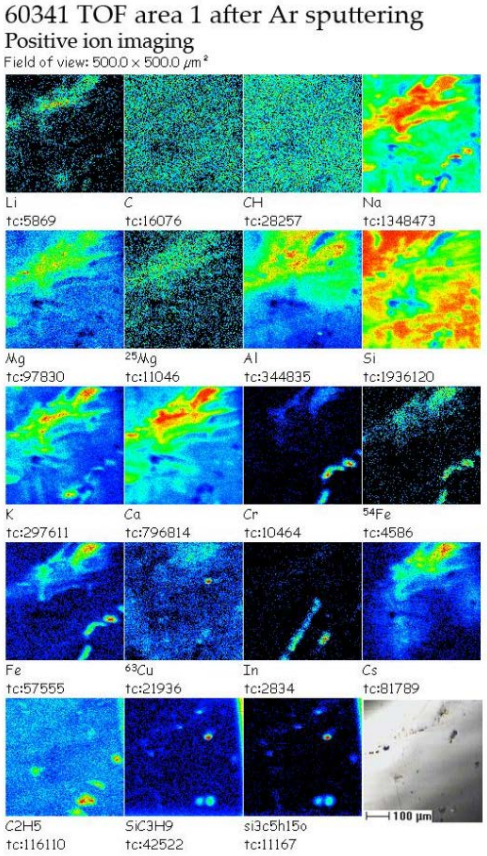
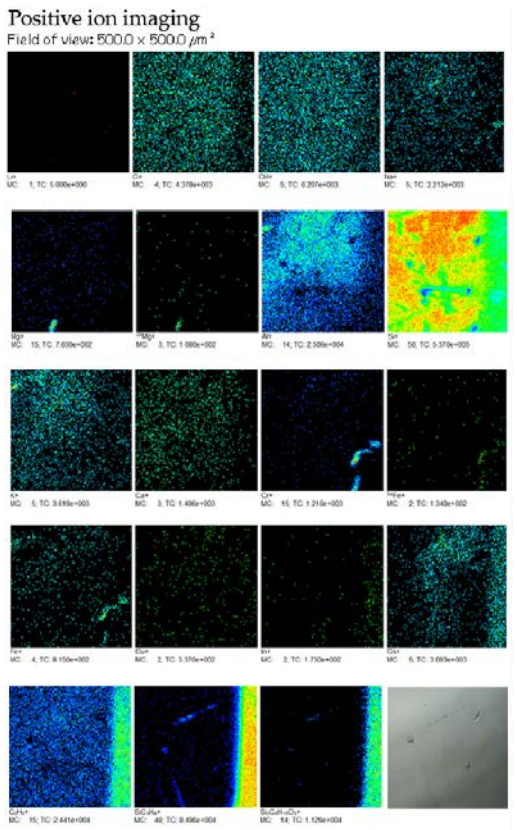


A) ToF-SIMS Area 1 after Step 4
Before Ar sputtering



B) ToF-SIMS Area 1 after Step 4
After Ar sputtering



C) ToF-SIMS after Step 8 (last UPW)

GENESIS SAMPLE CLEANING

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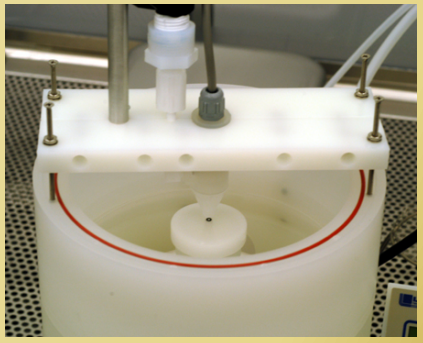
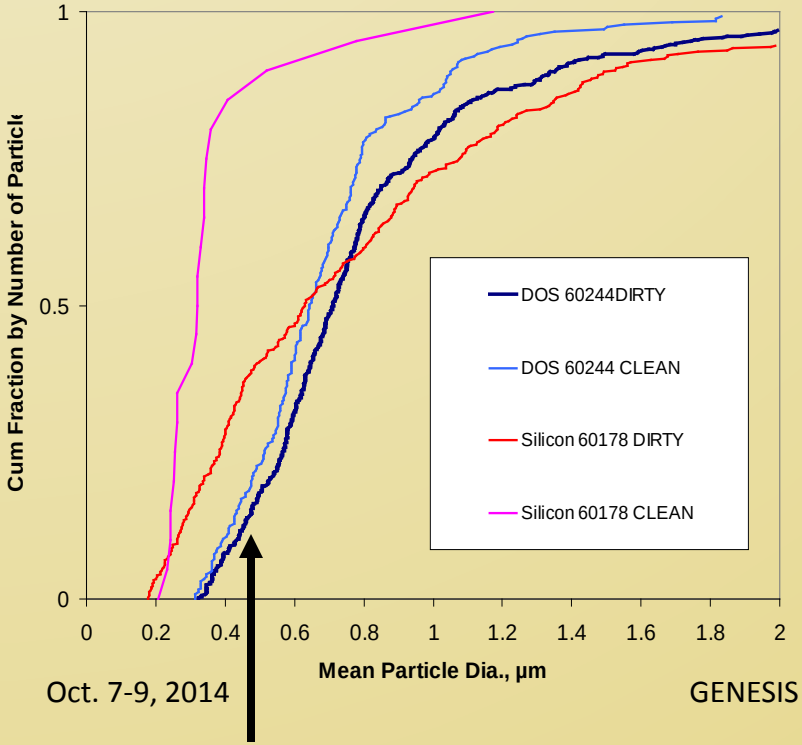
- **Brown stain removal - UV ozone cleaner**

- **Particle removal - UPW megasonic**

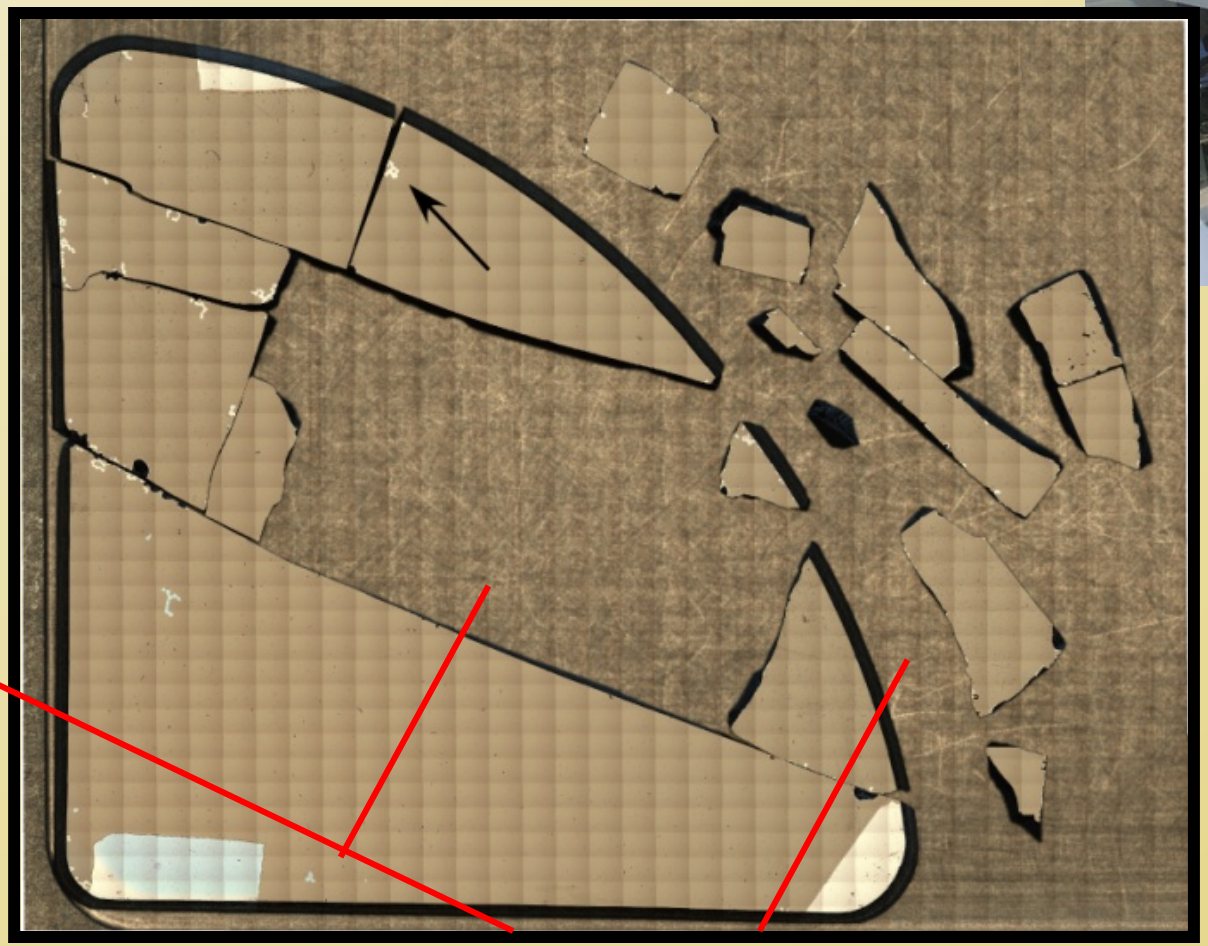




0.5 µm

JSC CURATION: precise sample subdivision

JSC



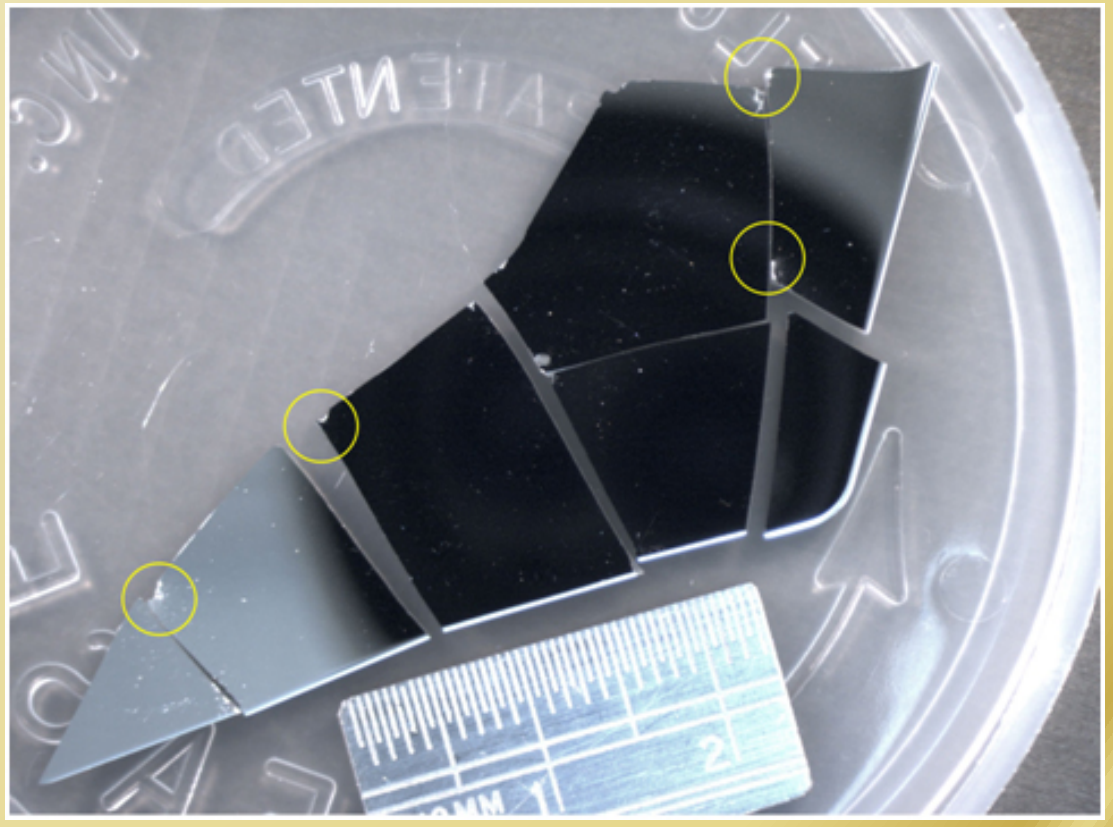
JSC CURATION: clean sample subdivision

JSC

- Subdivision of polished aluminum –
- Yield material for noble gas analysis and two craters

JSC CURATION: clean sample subdivision

JSC



JSC CURATION 10 YEARS: Samples characterized

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MATERIAL	ARRAY	FLOWN AREA (mm2)	AREA CATALOGED (mm2)	TOTAL CATALOGED (%)
CZ Si	B	56493	3123.2	1.8
	C	112986		
	H	43939	2219.0	5.1
	E	56493	2415.7	4.3
	L	56493	2426.7	4.3
FZ Si	B	125540	4580.7	2.0
	C	100432		
	H	106709	1846.8	1.7
	E	106709	2412.8	2.3
	L	138094	1192.9	0.9
DOS	B	18831	1502.9	4.0
	C	18831		
	H	25108	523.7	2.1
	E	25108	985.8	3.9
	L	25108	730.4	2.9

Data as of January 2009

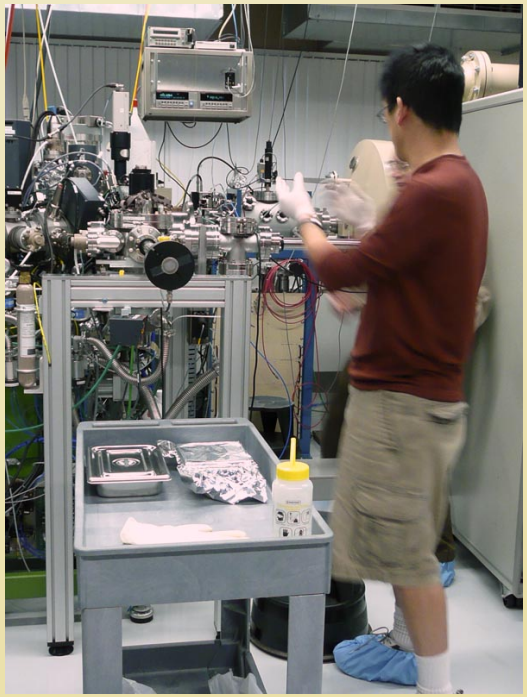
MATERIAL	ARRAY	FLOWN AREA (mm2)	AREA CATALOGED (mm2)	TOTAL CATALOGED (%)
SAP	B	25108	10976.0	21.9
	C	25108		
	H	25108	12147.4	48.4
	E	31184	15096.6	48.4
	L	25108	2796.6	11.1
SOS	B	31385	33690.2	59.6
	C	25108		
	H	25108	14878.5	59.3
	E	25108	16078.6	64.0
	L	25108	9542.6	38.0
AlOS	B	31184	30110.4	42.0
	C	40499		
	H	31385	14747.8	47.0
	E	37461	16488.8	44.0
	L	25108	7992.7	31.8
AuOS	B	24907	31952.1	48.9
	C	40499		
	H	62167	19060.8	30.7
	E	43738	29398.4	67.2
	L	43336	6744.4	15.6
CCo-AuOS	B	12353	6068.3	49.1
	C	0	0.0	0.0
	H	0	0.0	0.0
	E	0	0.0	0.0
	L	0	0.0	0.0

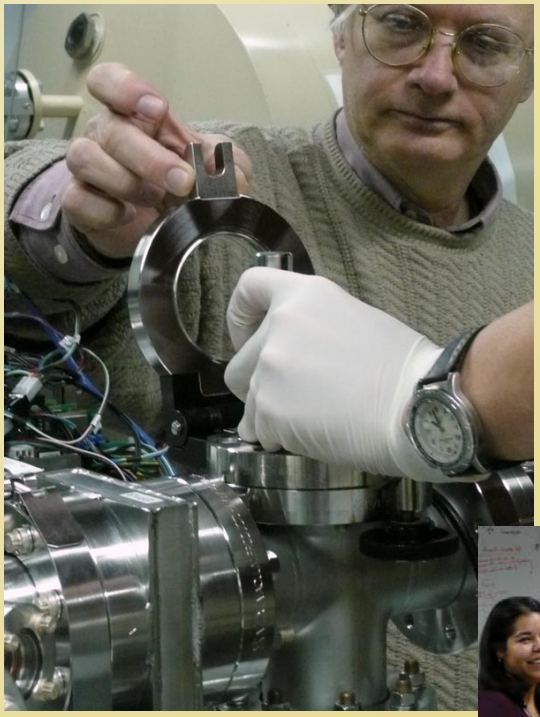
- **Sapphire based: 15-49% cataloged**
- **Silicon based: 1-5% cataloged**

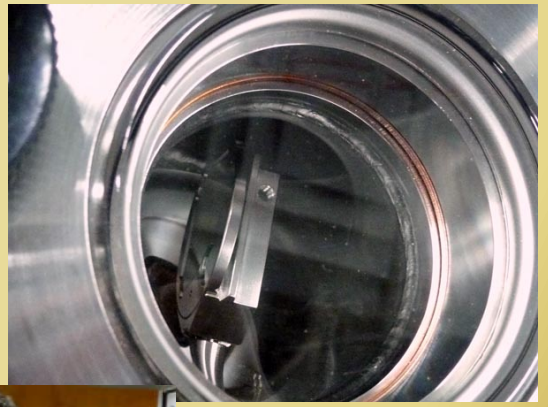
JSC CURATION 10 YEARS: Samples allocated

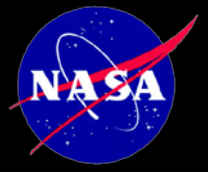
JSC

- 653 Genesis-flown samples
- 327 reference collectors
- 28 research groups in 6 countries









JSC