Examining the Uppermost Surface of the Lunar Regolith

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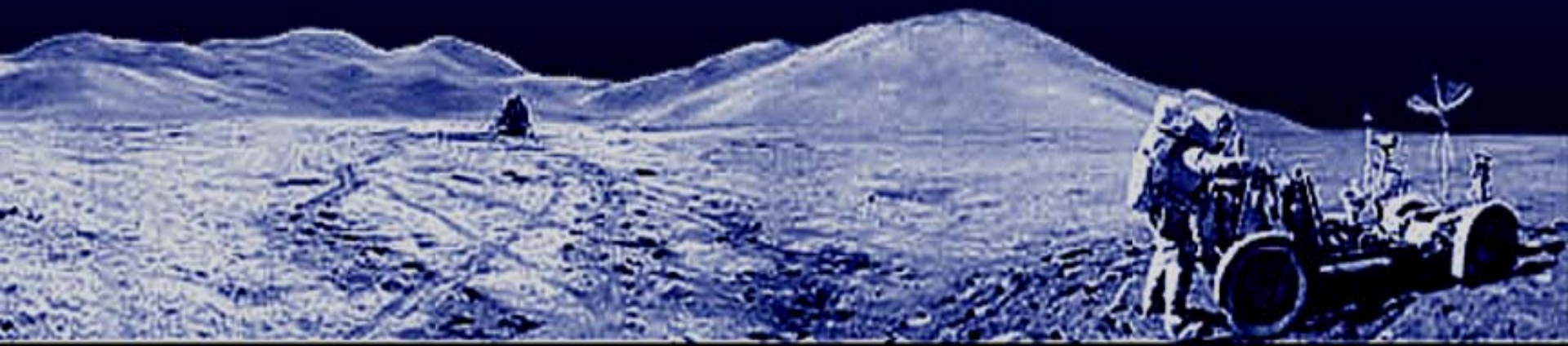
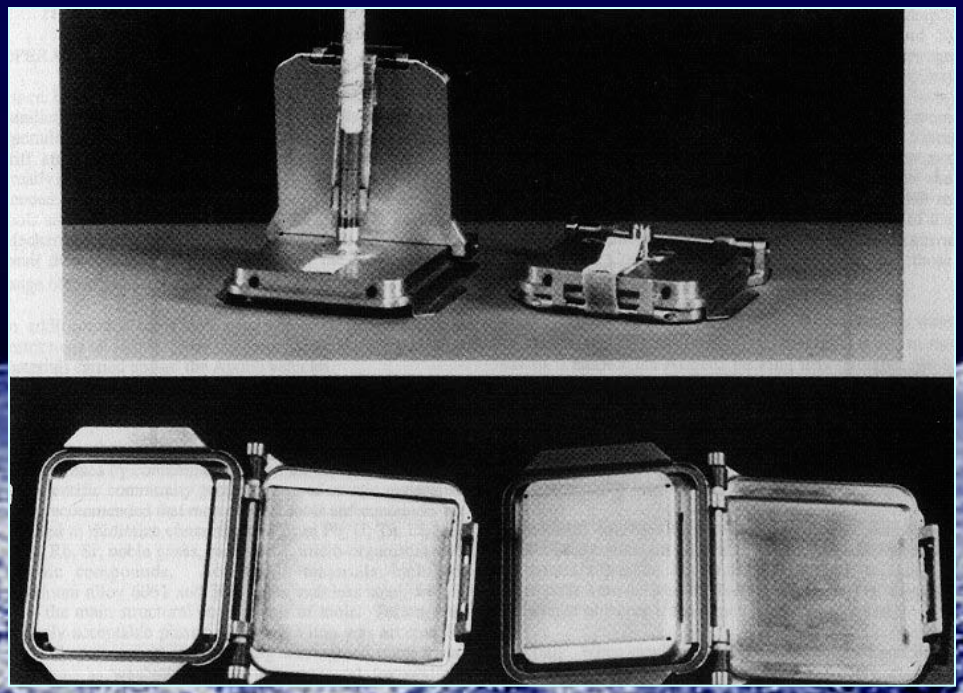


The Clam Shell Sampling Devices

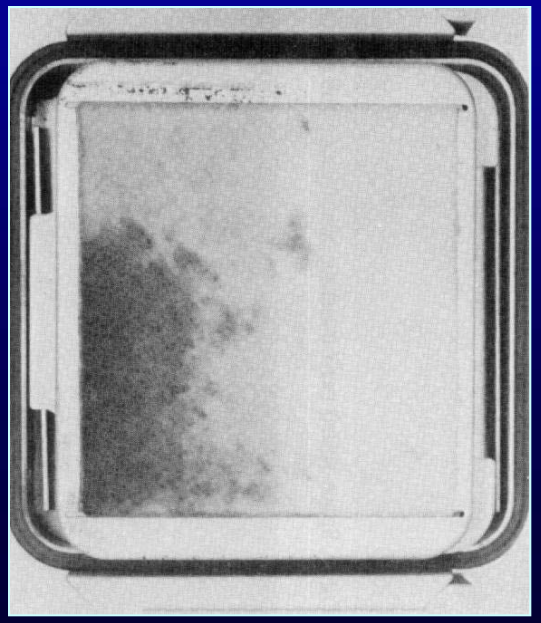
- The Apollo 16 Clam Shell Sampling Devices (CSSDs) were intended to sample the uppermost surface of the lunar soil
- Unfortunately, very little material was collected



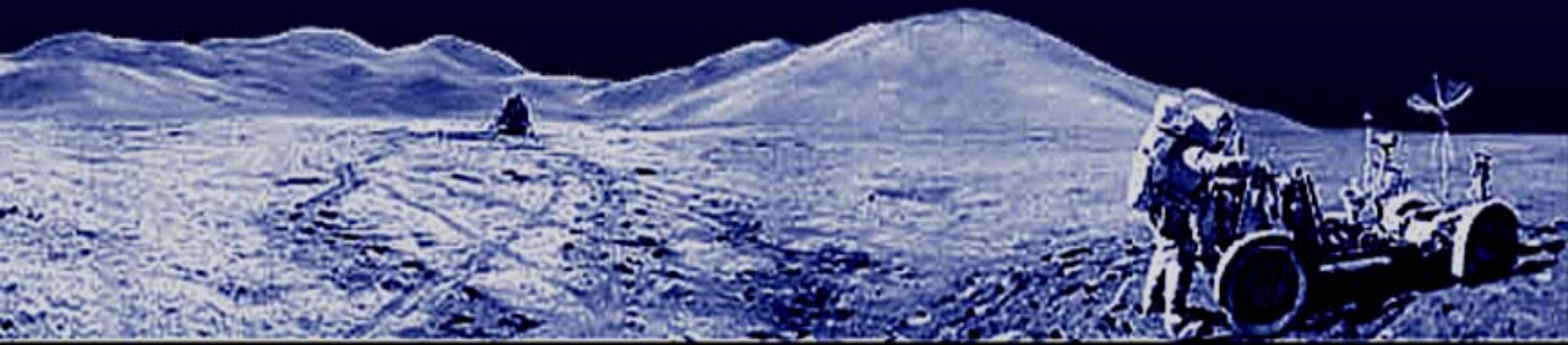
John Young practices using the CSSD at KSC

The Clam Shell Sampling Devices

Beta Cloth (100 μm)

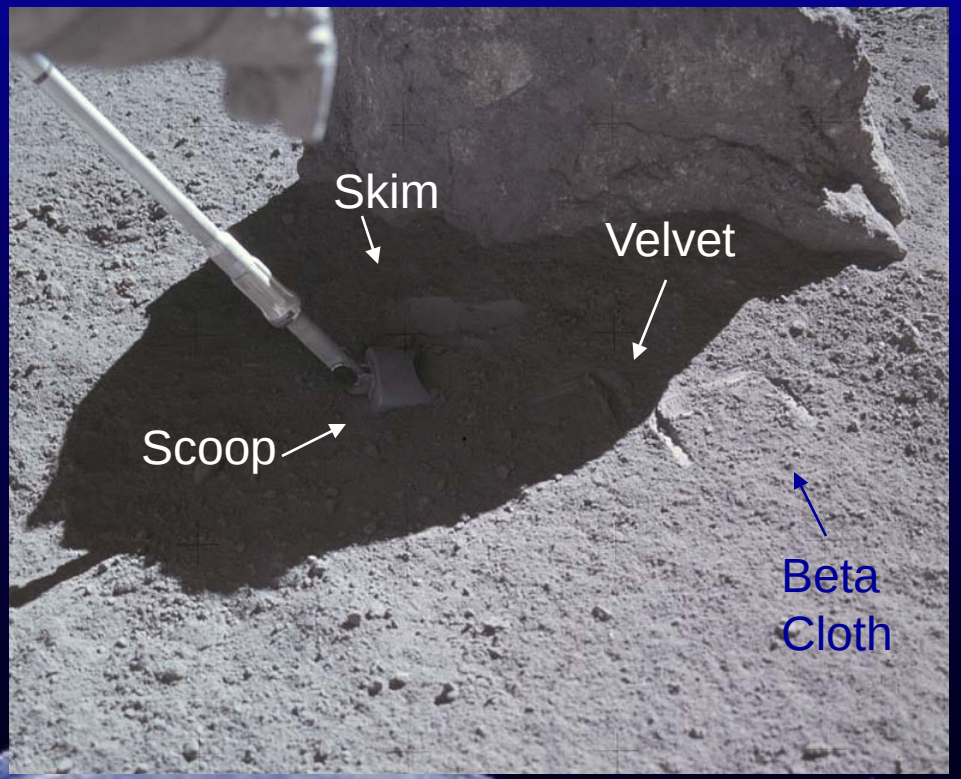


Velvet (0.5 mm)



Collecting the samples

In addition to the velvet and beta cloth samples, a skim sample (top ~5mm) and a regular scoop sample (top ~3cm) were also collected

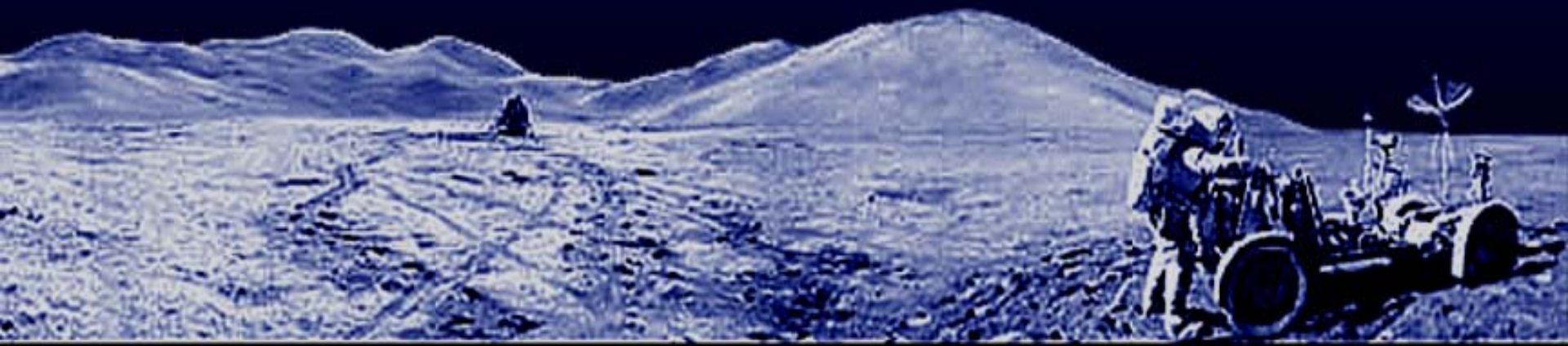


Importance of the CSSDs

The uppermost surface is:

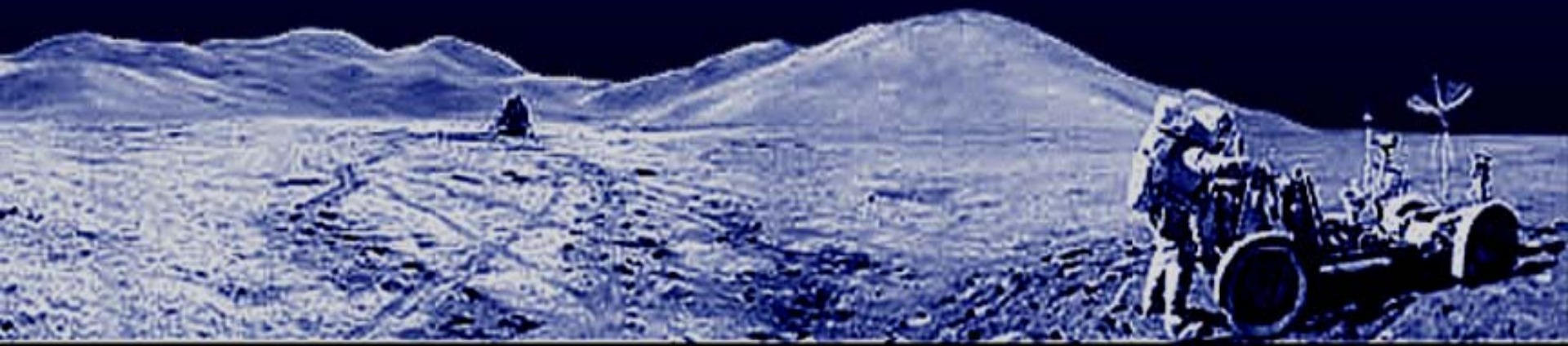
- The material which is sensed by many of our remote instruments
- The material with which astronauts will be interacting

The CSSD material is unique in that it has never been handled or sieved.



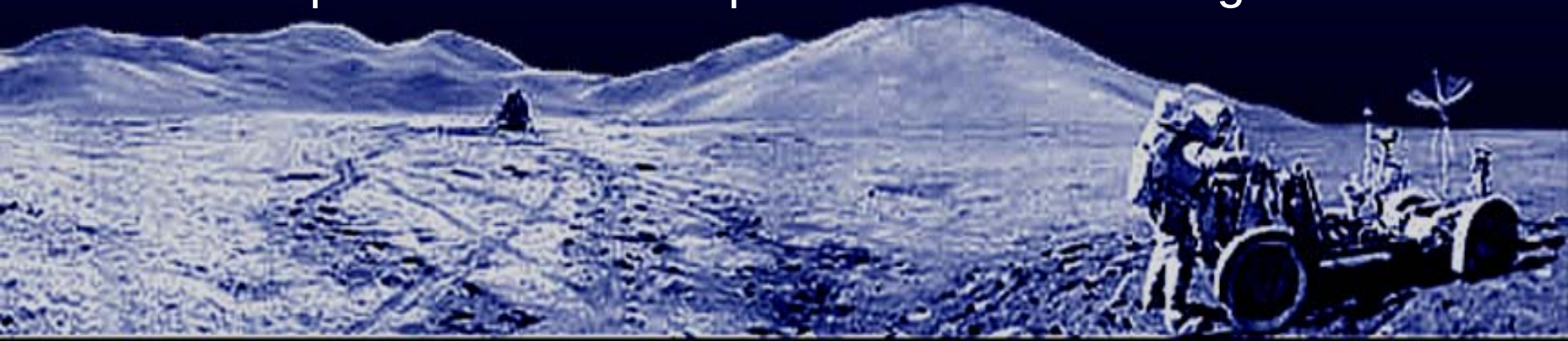
Obtaining samples

- Samples were originally obtained from the material that had fallen off of the fabric and was collected from inside the case. However, this was found to be inadequate as fractionation had clearly occurred and that material was not representative.
- Permission was granted to obtain samples directly off of the beta cloth.

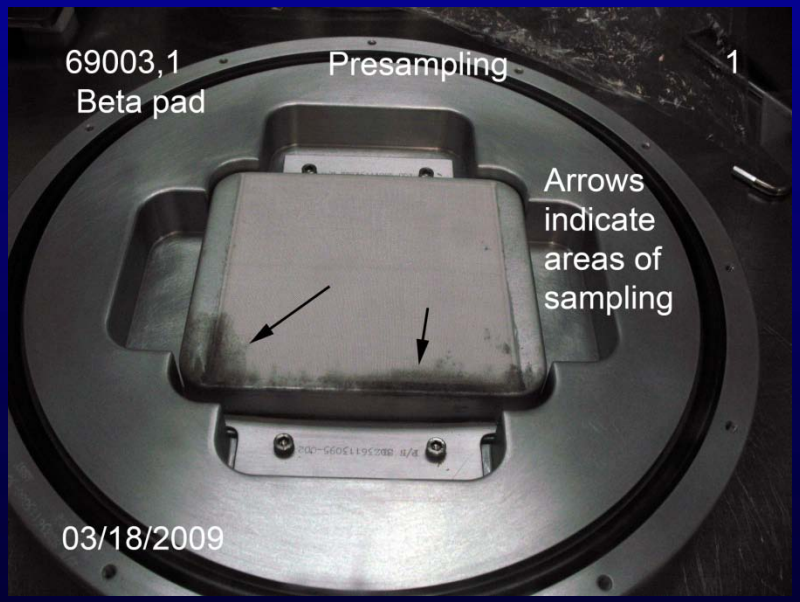


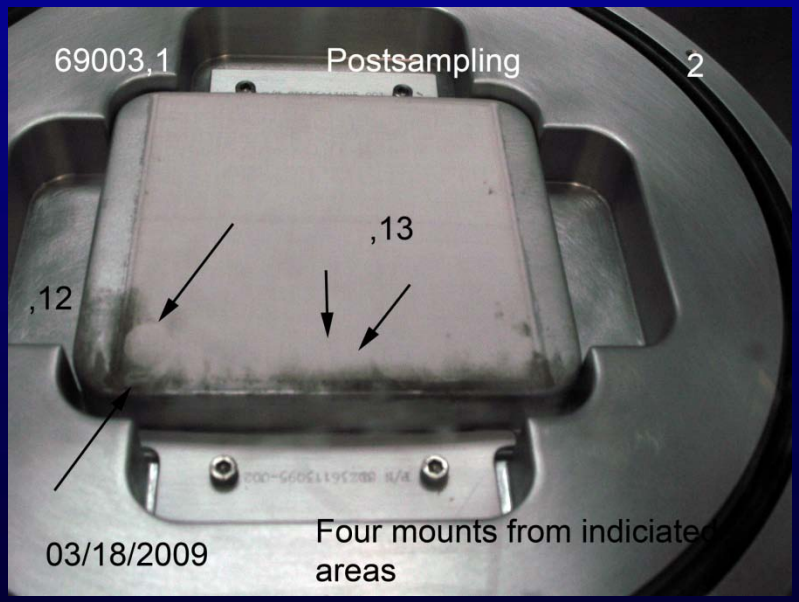
Obtaining samples

- Sampling was performed inside a glovebox
- Carbon double stick tape was placed on aluminum stubs
- The tape stubs were gently pressed onto the fabric in the “dirtiest” areas.
- The samples were then coated with a thin layer of carbon to prevent charging and examined in the SEM at JSC.
- Scoop sample was prepared by sprinkling small amount of sample onto carbon tape and carbon coating it.

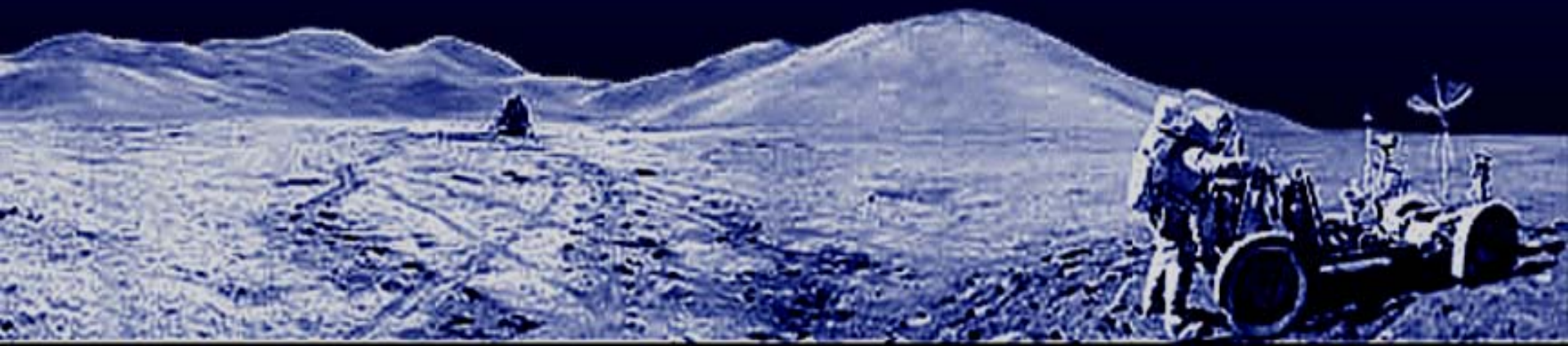


Before and after sampling



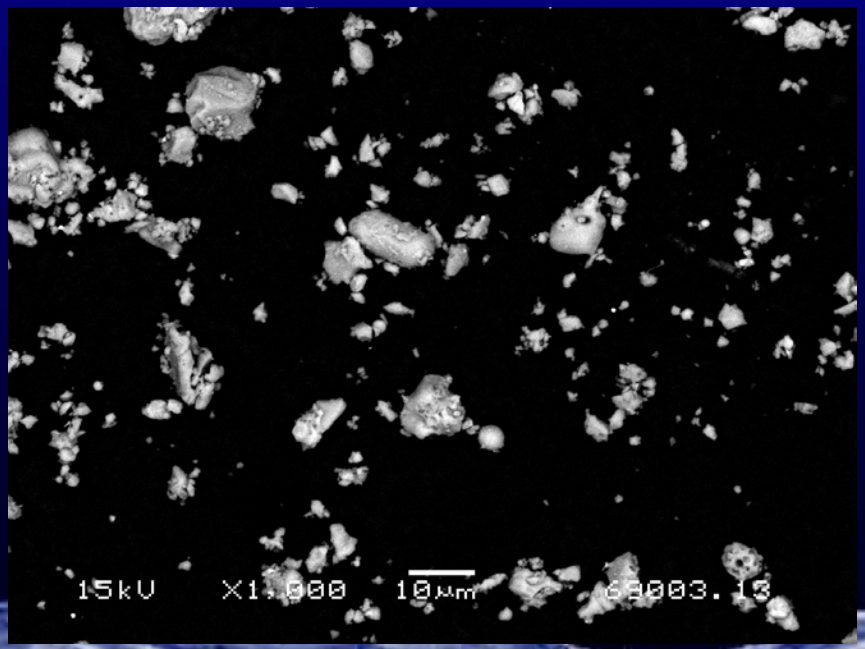


Note the “clean” circles left behind by the sampling, indicating good recovery

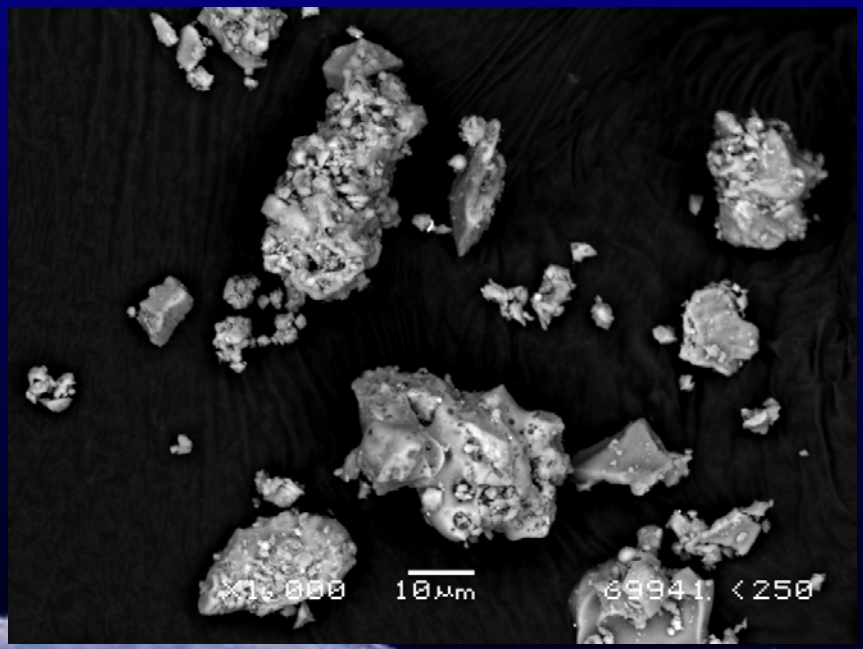


Comparison
(same scale)

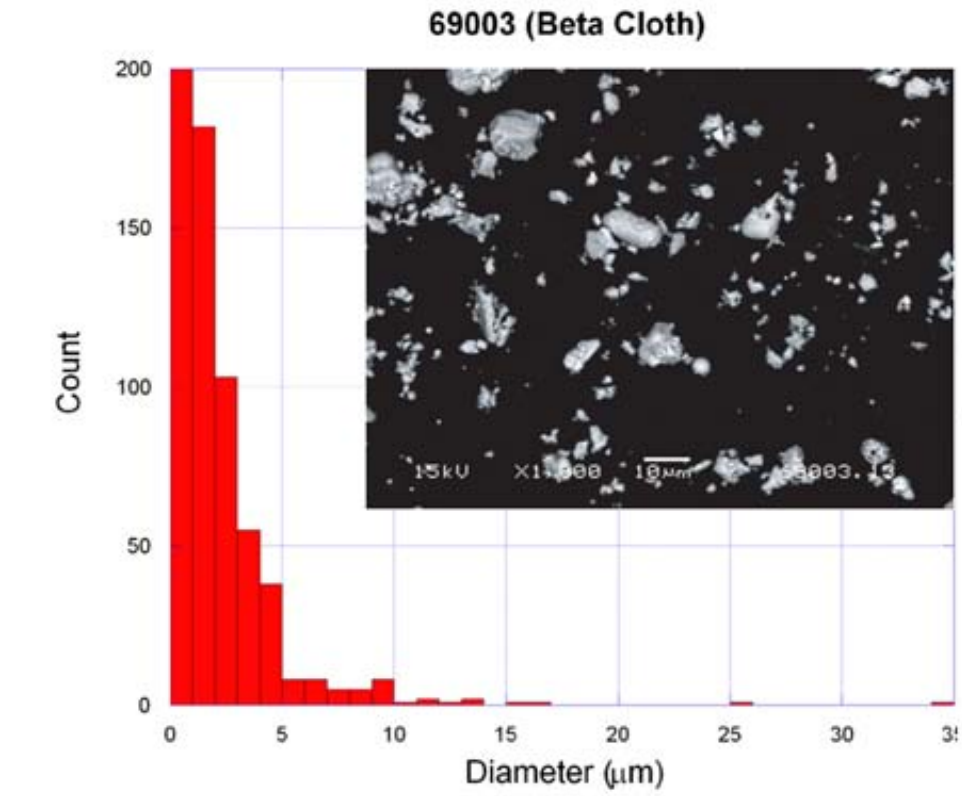
Beta Cloth sample (69003)

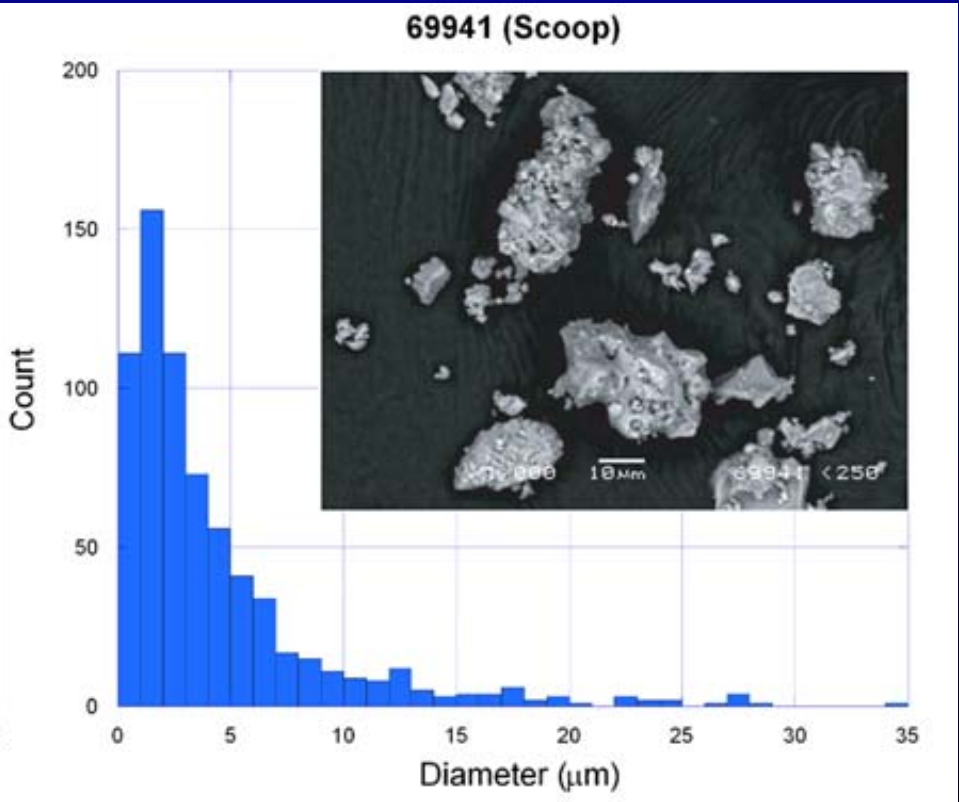


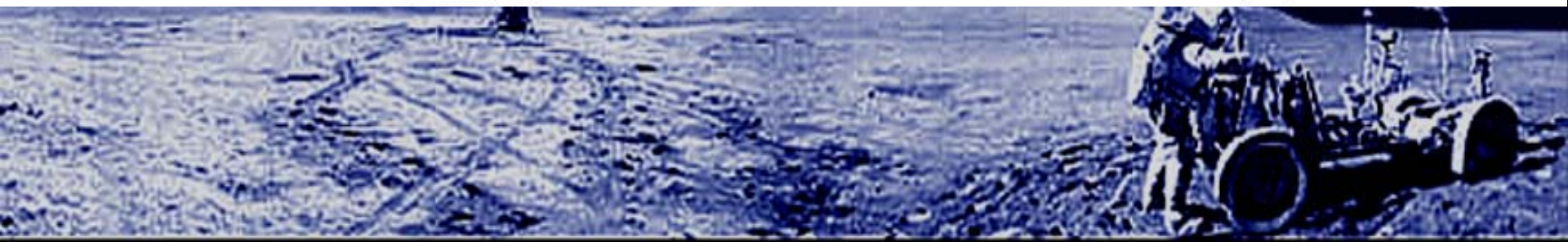
Bulk scoop sample (69941)



Initial Size Distribution Comparison Results





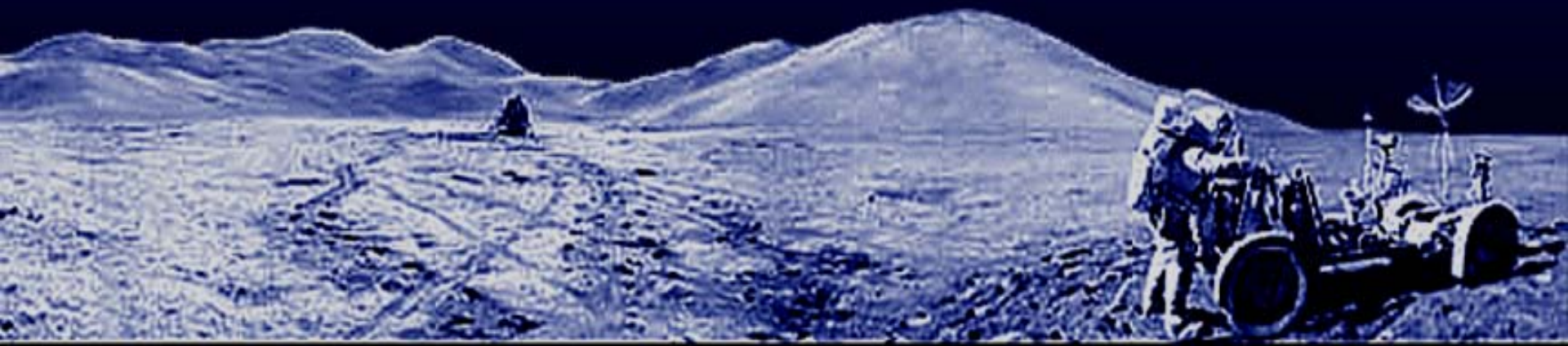


Further testing

Possible sample bias may exist:

1. Fine grains may preferential stick to the fabric
2. Larger grains may fall off during handling leaving only fine grains on the fabric
   - analysis of soil stuck to space suit fabrics also show a concentration of fine-grained material
3. The Beta cloth fabric may shed material

To test this, we reproduced the experiment using JSC-1a…



JSC-1a experiment

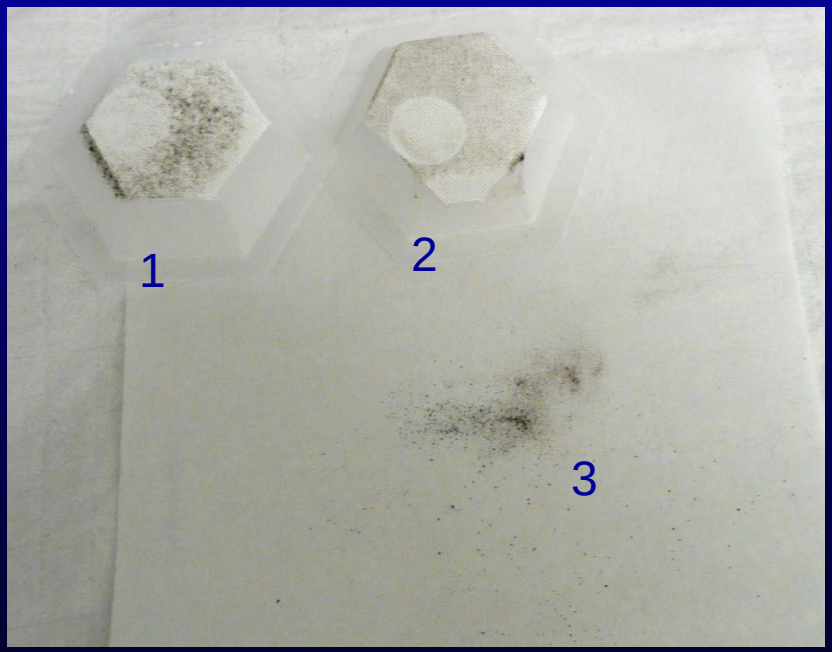
Samples:

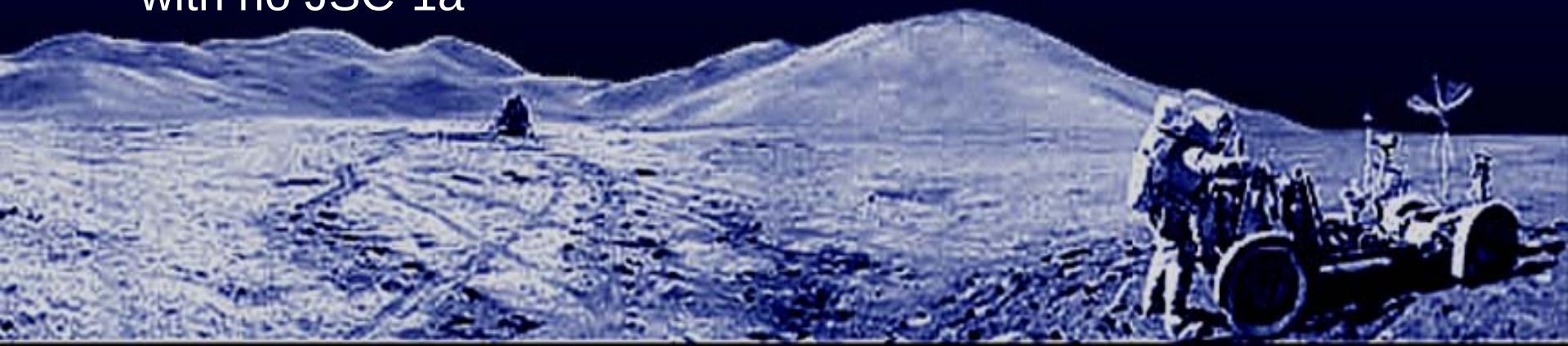
1 - Beta cloth pressed into JSC-1a

2 - Beta cloth pressed into JSC-1a and then tapped and shaken to remove loosely adhering grains

3 - Grains that fell off of 2

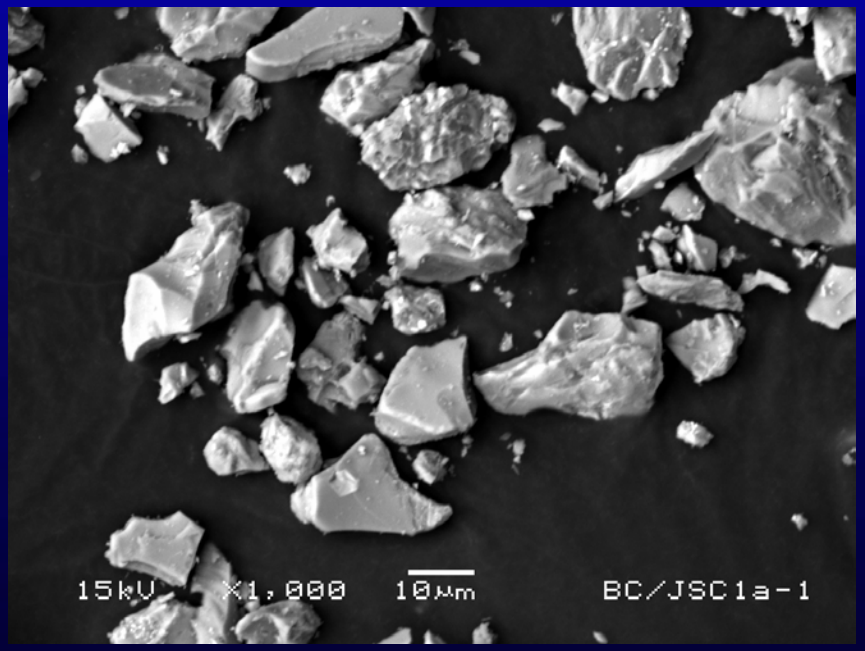
4 - (not shown) Clean Beta cloth with no JSC-1a





JSC-1a experiment results

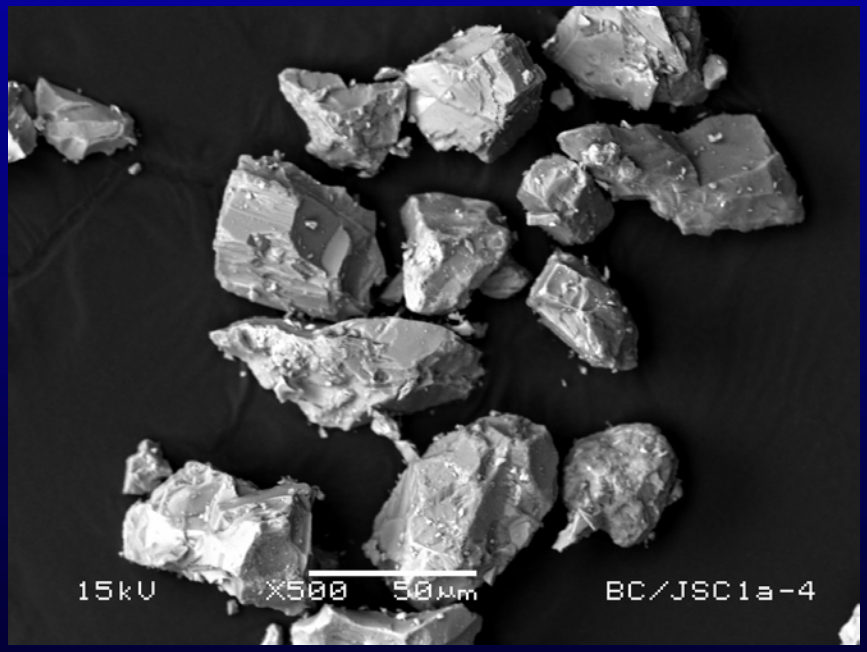
- **Grains of all sizes stick to the Beta cloth**



Sample #1, carbon tape pull off of Beta cloth pressed to JSC-1a

JSC-1a experiment results

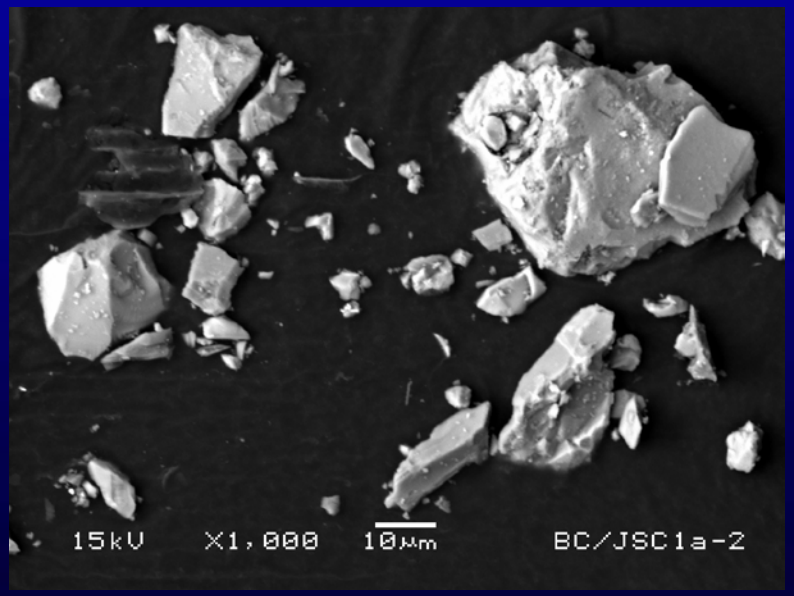
- Grains of all sizes stick to the Beta cloth
- **The larger grains do tend to preferentially fall off when tapped,**



Sample #3, grains that fell off of sample that was tapped.

JSC-1a experiment results

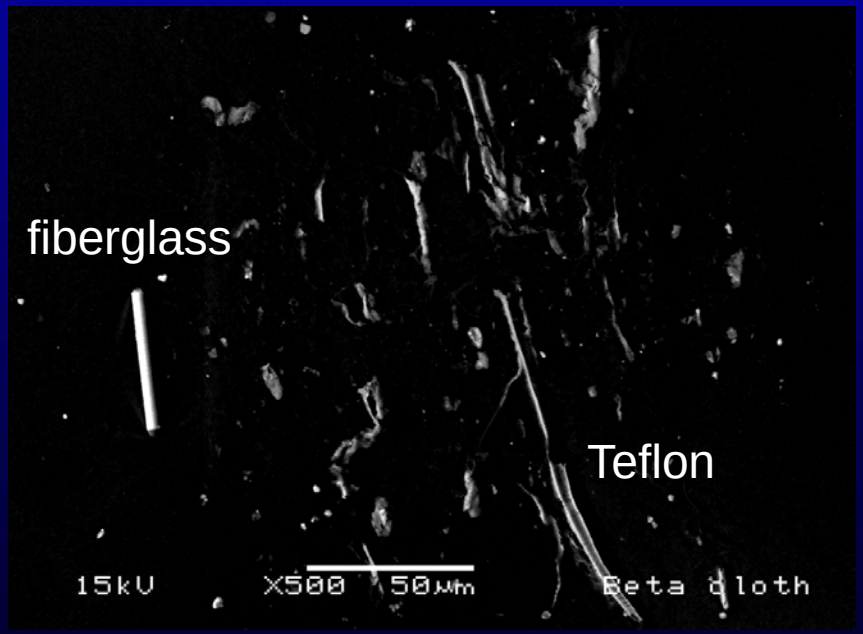
- Grains of all sizes stick to Beta cloth
- The larger grains do tend to preferentially fall off when tapped, **though some larger grains remain stuck despite vigorous tapping**



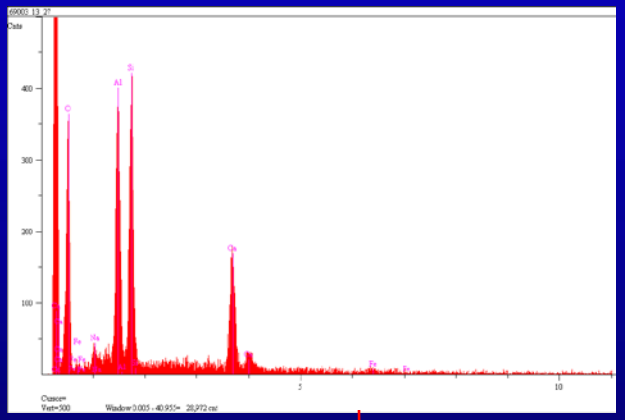
Sample #2, carbon tape pull off of Beta cloth pressed to JSC-1a and then tapped to remove loose material

Beta Cloth shedding

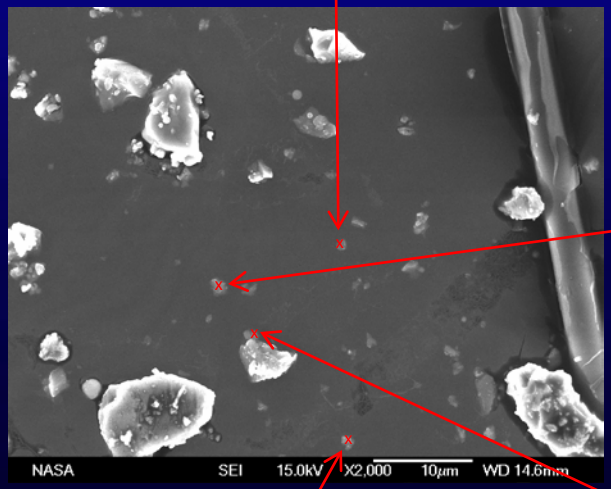
- Grains of all sizes stick to Beta cloth
- The larger grains do tend to preferentially fall off when tapped, though some larger grains remain stuck despite vigorous tapping
- **Beta cloth can shed bits of Teflon and fiberglass**

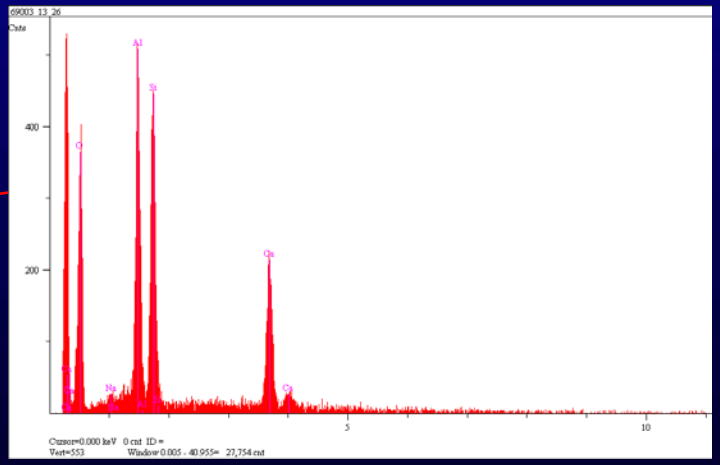


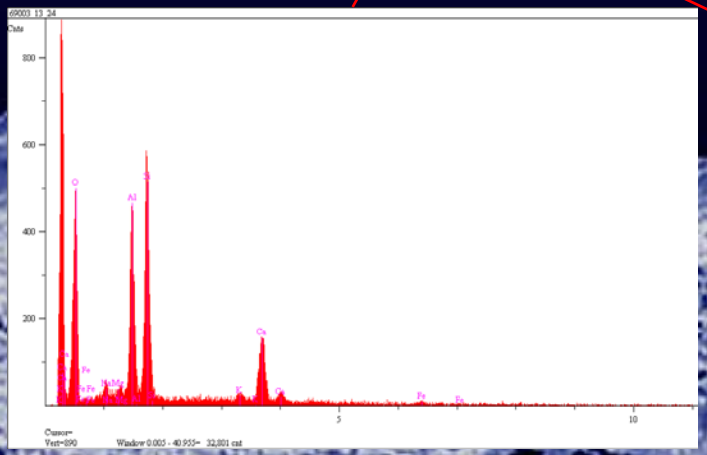
Sample #4, carbon tape pull off of “clean” Beta cloth.

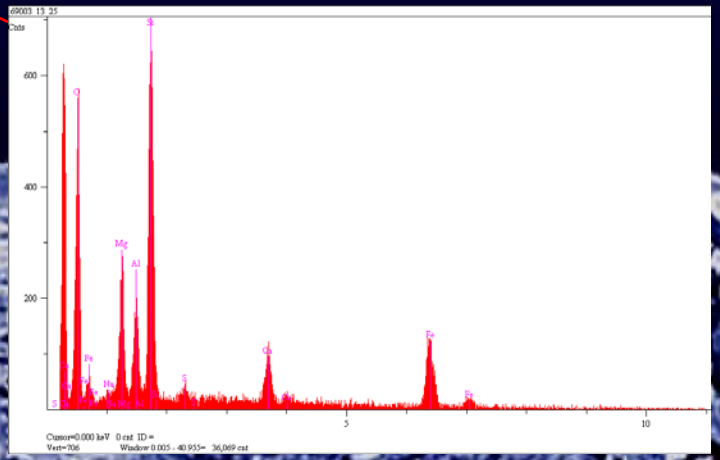


All fine grains analyzed to the limit of our capabilities (down to about 1 micron) were found to be lunar in composition, though non-lunar contaminants may exist in the submicron population.



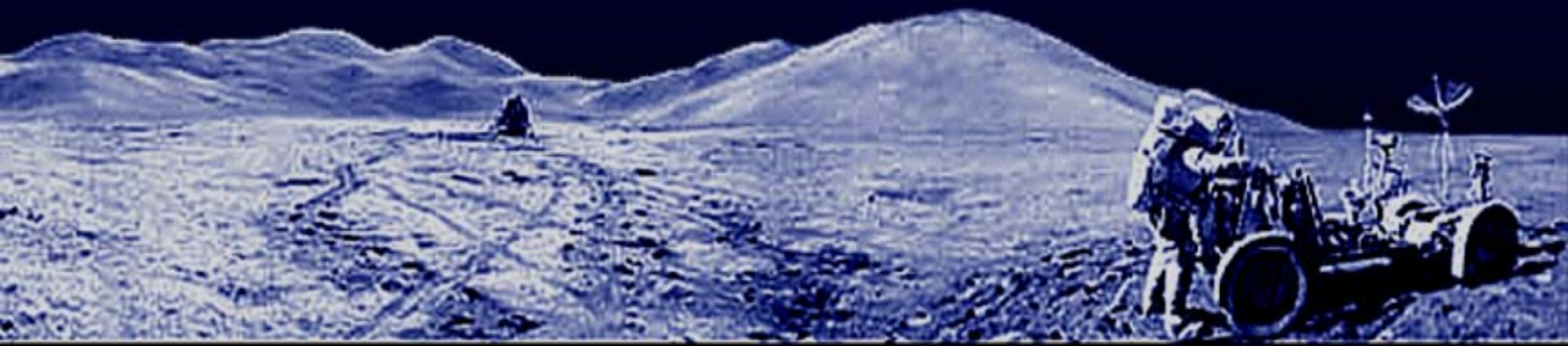






Conclusions

- Although further work is needed to understand the details of our results, it appears that the uppermost surface is enriched in fine (<2 micron) grains compared to the bulk soil.



Next steps

- Sample the velvet clam shell to compare to the Beta cloth.
- Compare chemistry/mineralogy of Beta cloth and/or velvet samples to the bulk.