

BUILDING A LUNAR OR MARTIAN LAUNCH PAD WITH IN SITU MATERIALS: RECENT LABORATORY AND FIELD STUDIES

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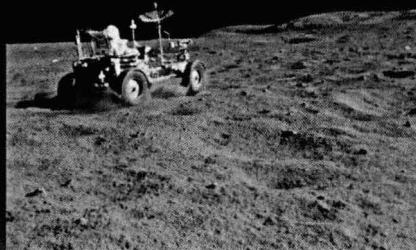
Overview

- Why do we need launch and landing pads?
- Methods
- Effects of using different simulants
- Recent field studies



Dust and surface stabilization

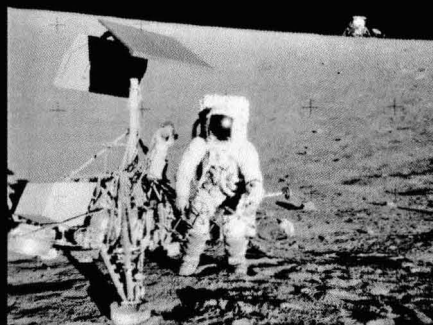
- Dust ejecta during lunar launch/landing can affect visibility, erode nearby coated surfaces and get into mechanical assemblies of in-place infrastructure
- Dust mitigation will be necessary for certain lunar habitat
- Surface stabilization can be used for roads, pads and other free areas



John Young, Photo 572_37002

Surveyor III

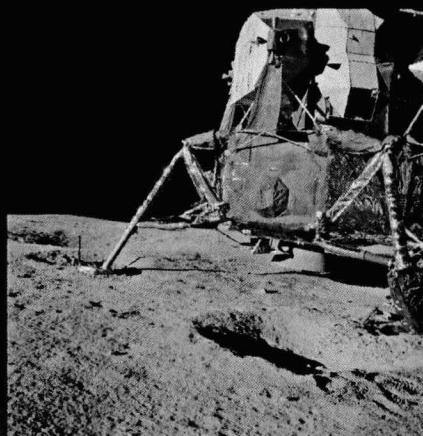
- Apollo 12 LM landed 155m from the Surveyor III craft
- NASA-SP-284: Analysis of Surveyor 3 material and photographs returned by Apollo 12 – found “sandblasting” with shadows showing that the blast came from the LM
- Immer et al. Icarus 2010, 2011; Lane et al. this conference



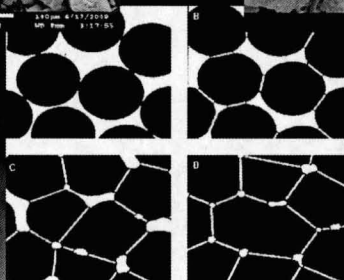
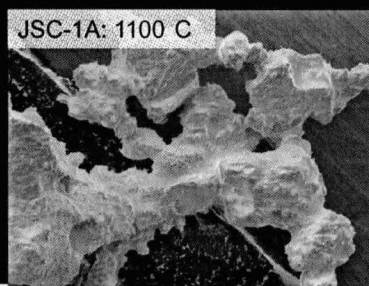
Charles Conrad Jr. and Surveyor III

Stabilization Methods

- Polymer regolith Composites
- Sintering/melting regolith
- Others...



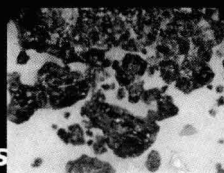
Simulant Laboratory Study: Sintering



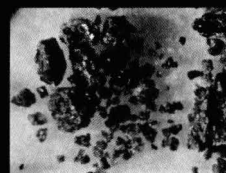
Simulant Laboratory Study:

Simulants

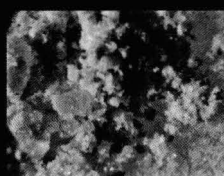
- FJS-1, Japanese Mare
- JSC-1A, Orbitec Mare
- NU-LHT-2M, NASA/USGS Highlands
- OB₁, NORCAT Highlands
- Heated samples to 1000, 1050, 1100, 1150 and 1200 C in nitrogen purged furnace
- Use elemental analysis to identify individual grains and check for changes after heating



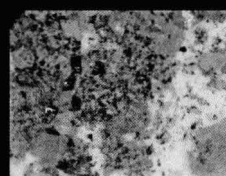
FJS-1



JSC-1A



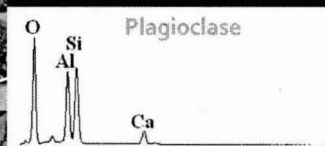
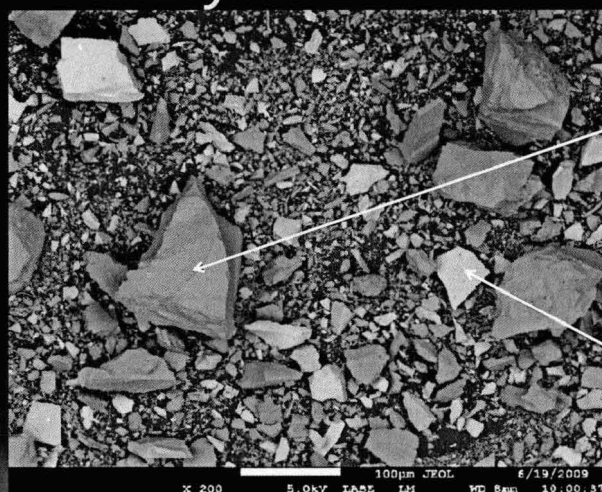
NU-LHT-2M



OB-1

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Simulant Laboratory Study: Analysis



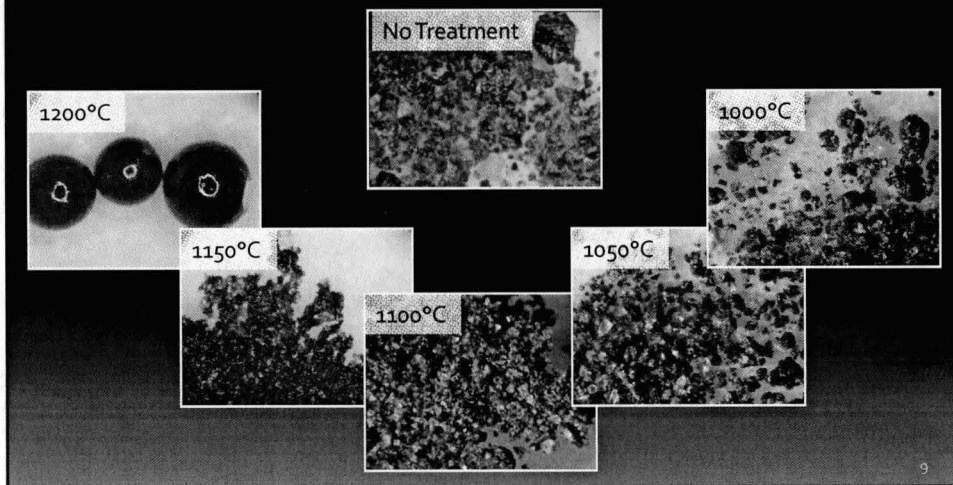
100µm JEOL 8/19/2009
x 200 5.0kV LASE LM WD 8.2µm 10.00.37

OB-1 simulant

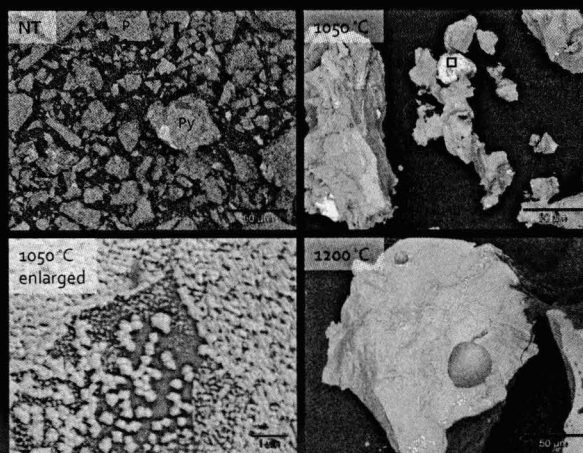
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Simulant Laboratory

1200°C	1150°C	1100°C	1050°C	1000°C
melted, formed sphere	sintered	loosely sintered	few sintered pieces	no sintering

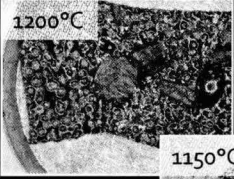


Simulant Laboratory Study: FJS-1

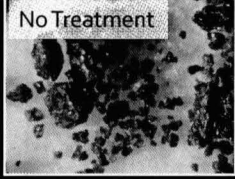


JSC-1A

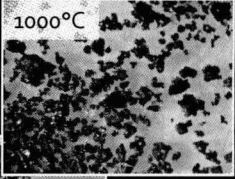
1200°C	1150°C	1100°C	1050°C	1000°C
melted, formed sphere	partial melt, formed irregular shape	sintered	loosely sintered	few loosely sintered pieces



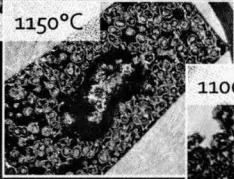
1200°C



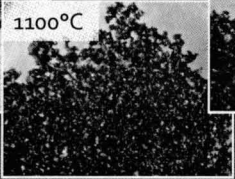
No Treatment



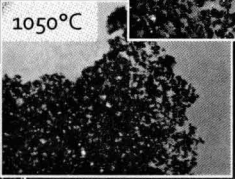
1000°C



1150°C



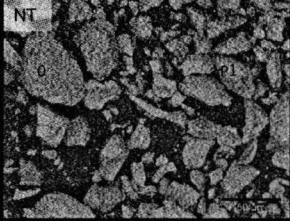
1100°C



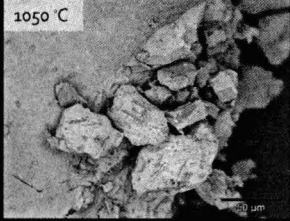
1050°C

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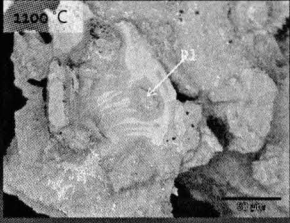
Simulant Laboratory Study: JSC-1A



NT

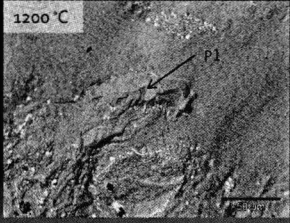


1050 °C



1100 °C

P1

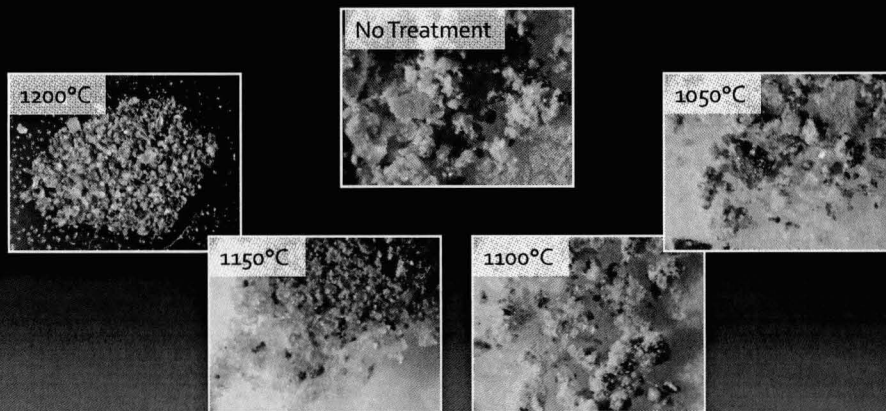


1200 °C

P1

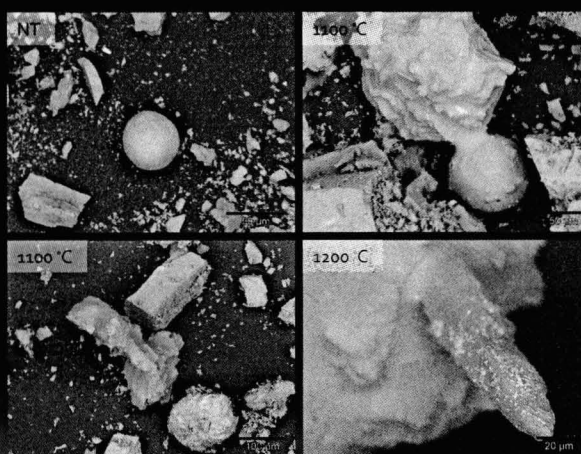
NU-LHT-2M

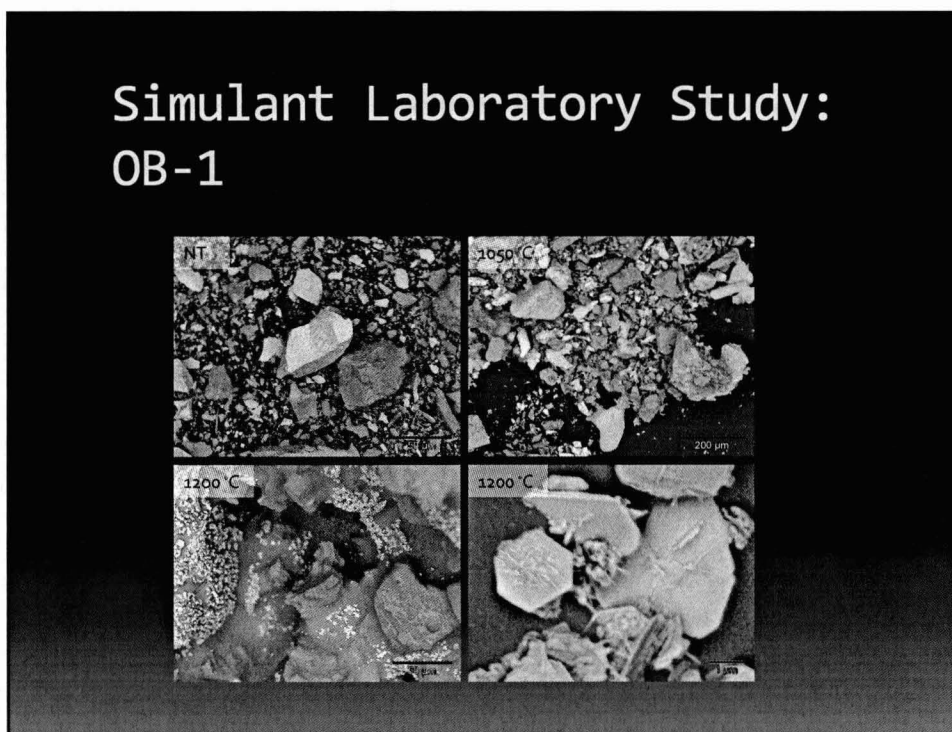
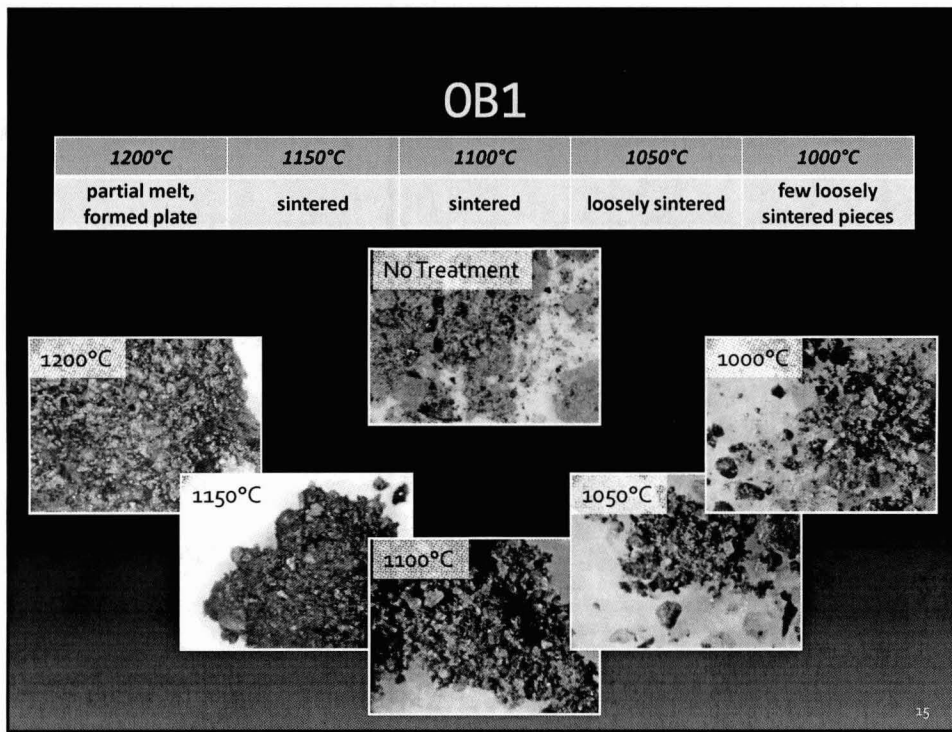
1200°C	1150°C	1100°C	1050°C	1000°C
sintered	sintered	few sintered pieces	no sintering	no treatment



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Simulant Laboratory Study: NU-LHT-2M



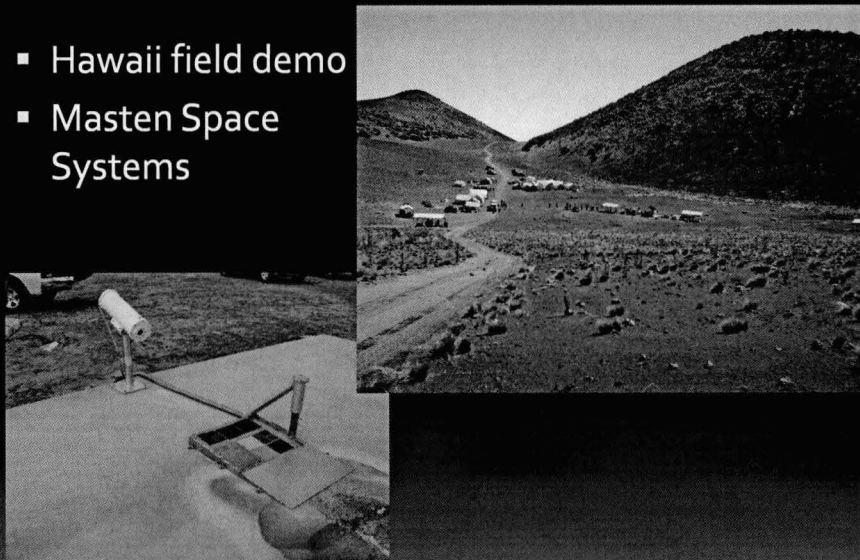


Simulant Laboratory Study: Conclusions

- Sintering occurs when one phase melts or starts to flow onto other particles
- Glasses melt and flow at lower temperatures
- Calcium rich plagioclase was the last mineral to melt in all simulants
- OB-1 and NU-LHT-2m behaved similarly, due to glass phase and high melting point phase
- Simulants for sintering should have a high melting point mineral and glass phase to match desired regolith composition (for lunar case)

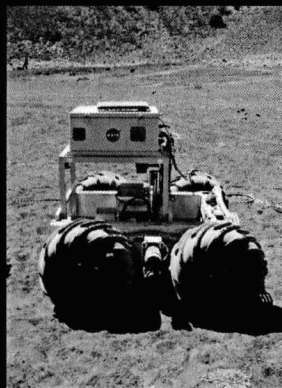
Field Demonstrations

- Hawaii field demo
- Masten Space Systems

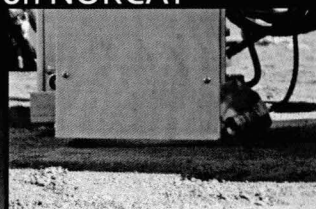


Mauna Kea, Feb. 2010

- Large Area Surface Sintering System (LASSS)
- Uses resistive heater
- Incorporates layered sintering and temperature feedback
- Mounted on NORCAT rover



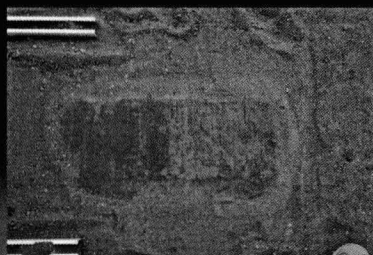
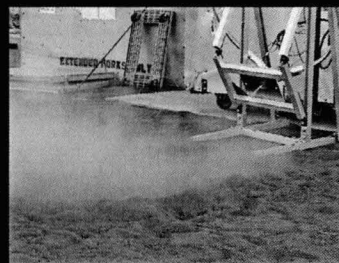
LASSS



Heater

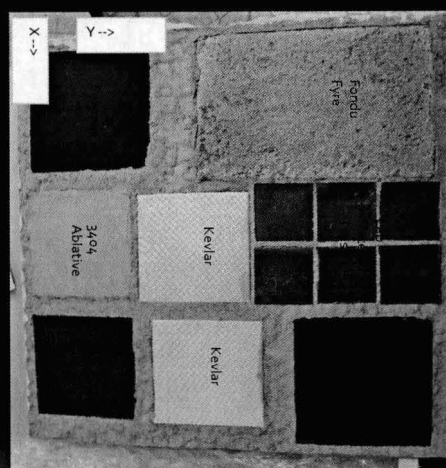
Mauna Kea, Feb. 2010

- Able to layer tephra and connect sintered areas
- Strengths from 30 – 240 psi
- Fired thruster on sintered area
- Environmental conditions caused issues

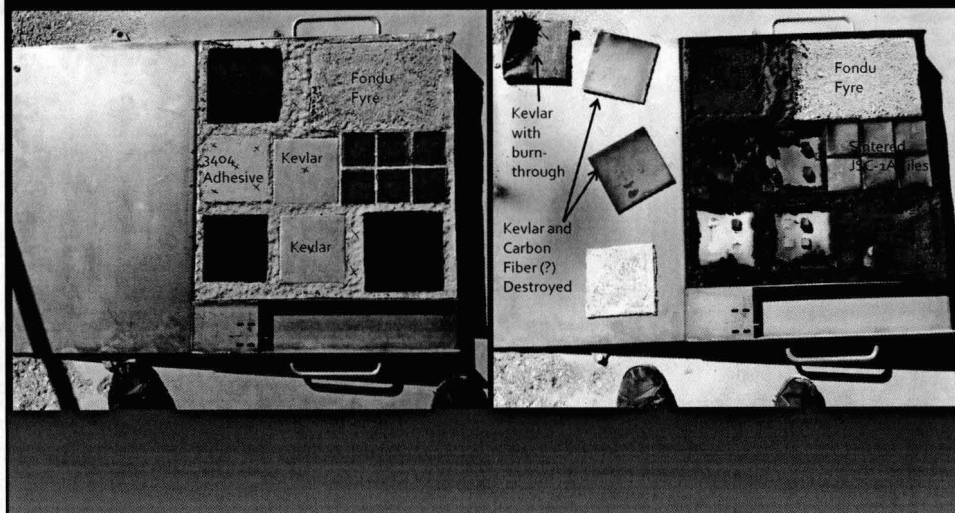


Masten Space Systems: Nov 2011

- Sample coupons were mounted on a steel plate and placed near the vehicle exhaust
 - Fondu Fyre (used in LC39 flame trench)
 - Sintered JSC-1A tiles
 - Polymer/Regolith Composites (Adherent Technologies)
 - Silicone Ablative (LC39)
 - Kevlar and Carbon fiber

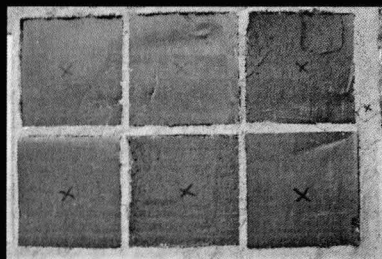


Masten Space Systems: Nov 2011



Masten Space Systems: Nov 2011

- Sintered Regolith
 - Little to no erosion
- Polymer/regolith composite
 - Did well considering it was not designed for this
- LC39 materials
 - Expected performance
- Fabrics failed due to poor attachment to plate



Acknowledgements

- NASA KSC
 - Phil Metzger
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 - Teddy Back
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 - Brittany Griffin