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

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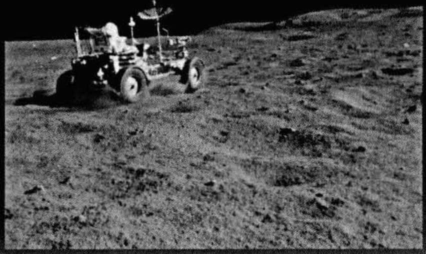
## Overview

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

# Dust and surface stabilization

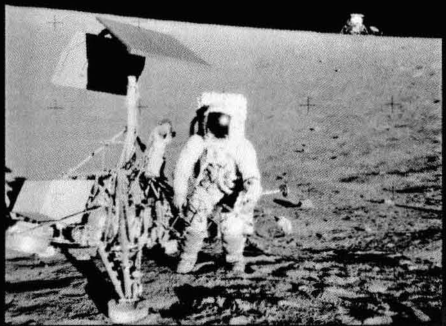
- Dust ejecta during lunar launch/landing can affect visibility, erode nearby coated surfaces and get into mechanical assemblies of in-place infrastructure
- Dust mitigation will necessary for certain lunar habitat
- Surface stabilization can be used for roads, pads and other free areas



John Young, Photo S72_37002

# Surveyor III

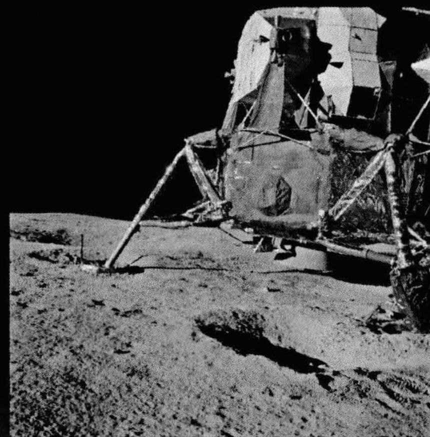
- Apollo 12 LM landed 155m from the Surveyor III craft
- NASA-SP-284: Analysis of Surveyor 3 material and photographs returned by Apollo 12 – found "sandblasting" with shadows showing that the blast came from the LM
- Immer et al. Icarus 2010, 2011; Lane et al. this conference



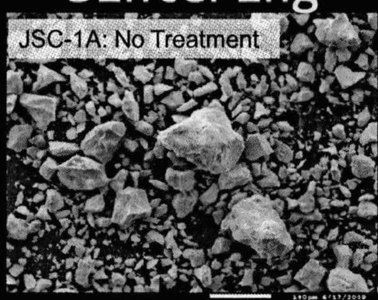
Charles Conrad Jr. and Surveyor III

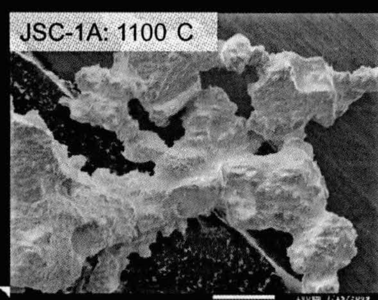
## Stabilization Methods

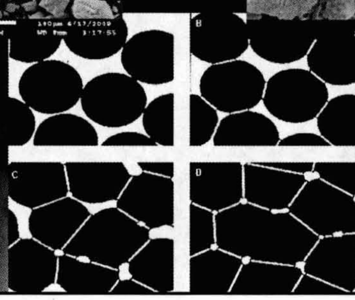
- Polymer regolith Composites
- Sintering/melting regolith
- Others…



## Simulant Laboratory Study: Sintering



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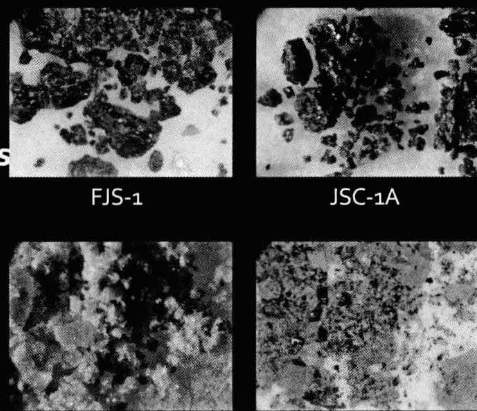
## Simulant Laboratory Study: Simulants

- 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

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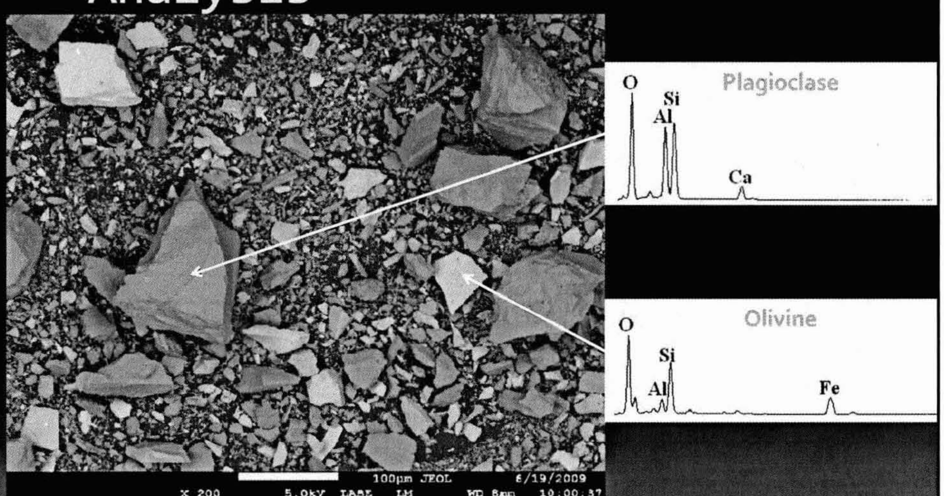
## Simulant Laboratory Study: Analysis




OB-1 simulant

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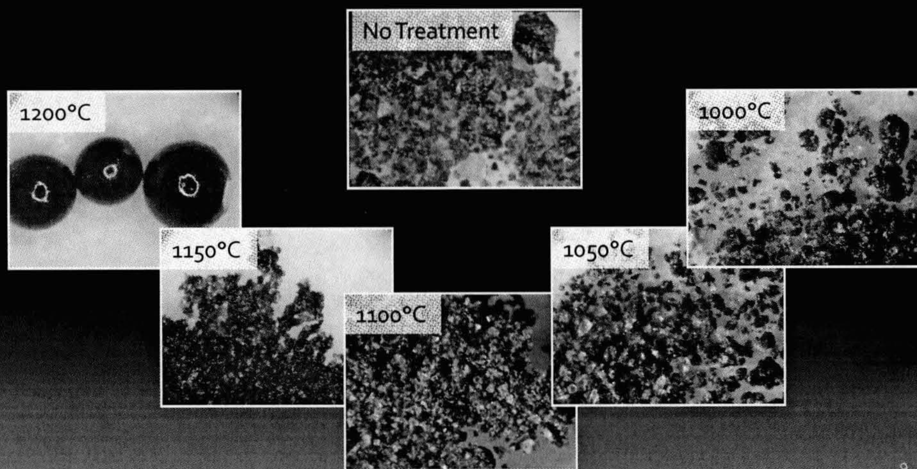
# Simulant Laboratory

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

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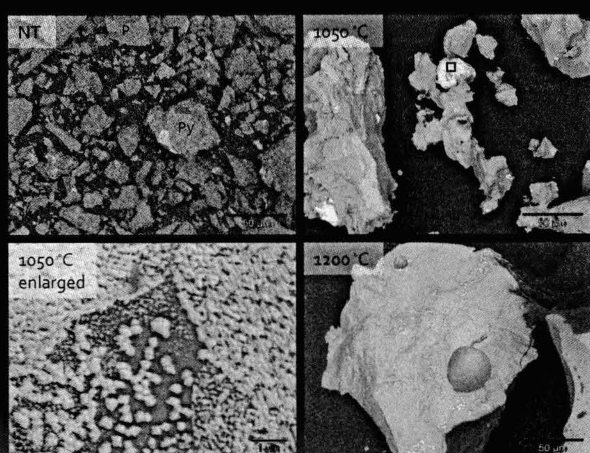
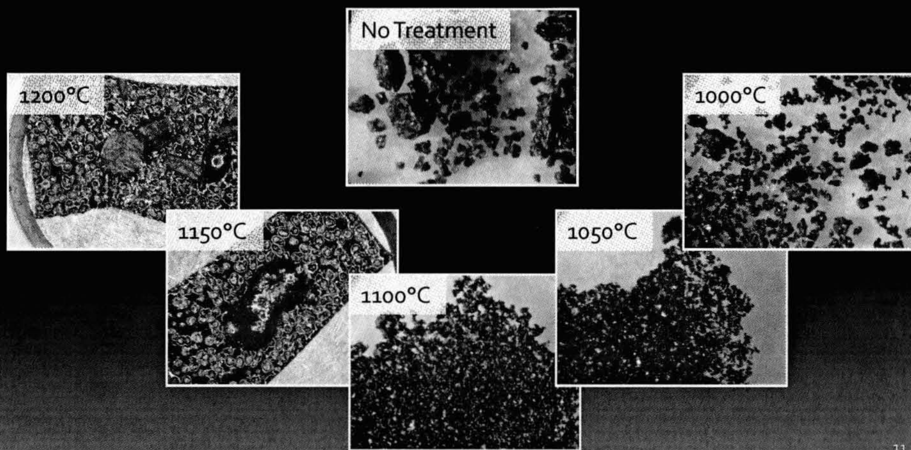
# Simulant Laboratory Study: FJS-1



# 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 |

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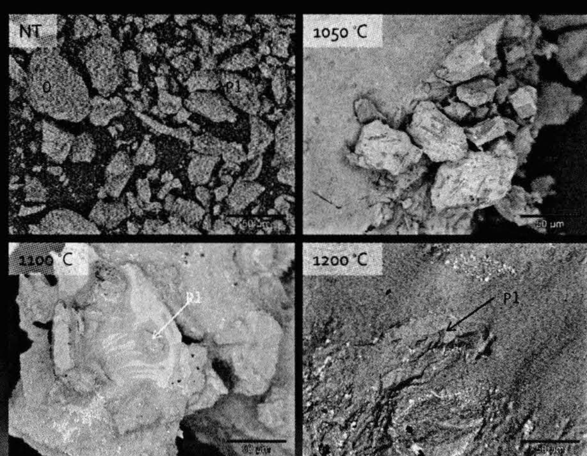
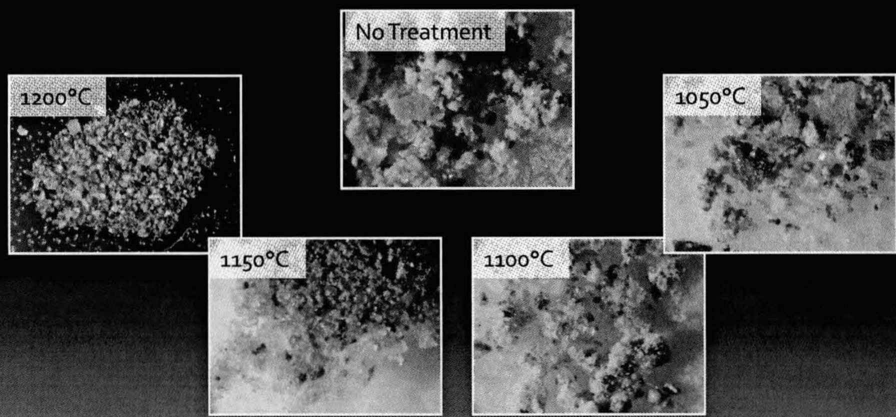
# Simulant Laboratory Study: JSC-1A



# 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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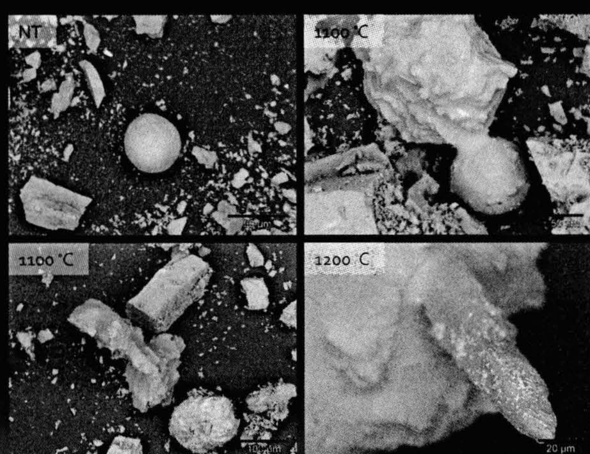
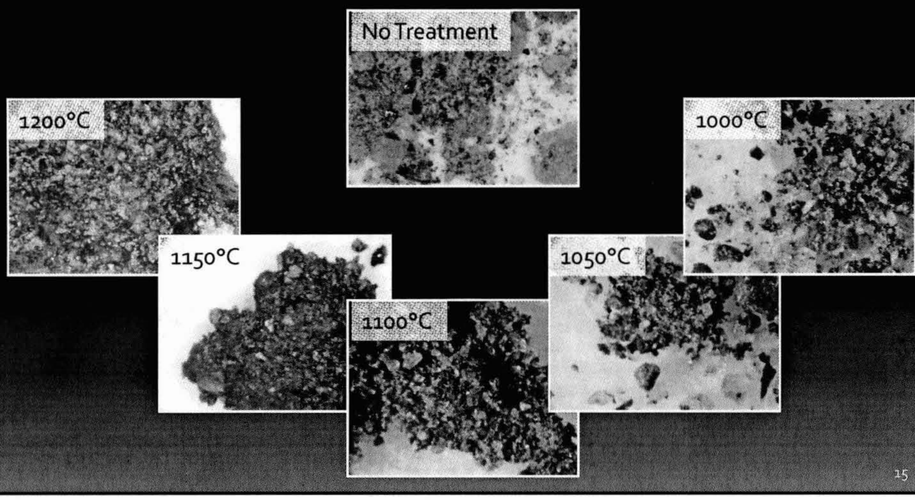
# Simulant Laboratory Study: NU-LHT-2M



# OB1

| 1200°C | 1150°C | 1100°C | 1050°C | 1000°C |
|---|---|---|---|---|
| partial melt, formed plate | sintered | sintered | loosely sintered | few loosely sintered pieces |

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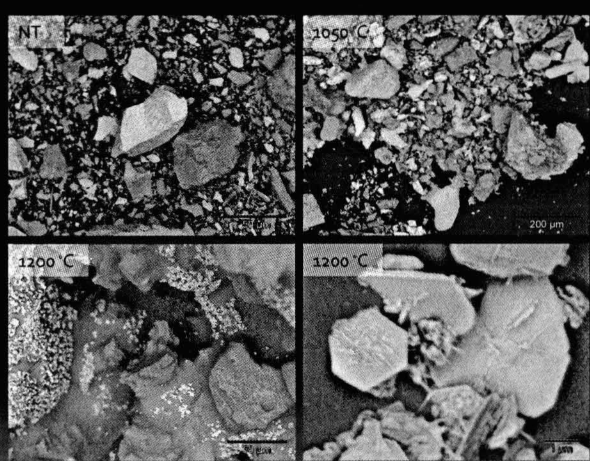
# Simulant Laboratory Study: OB-1

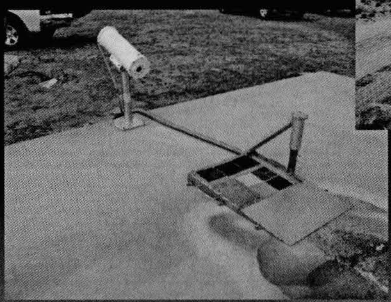


## Simulant Laboratory Study: Conclusions

- Sintering occurs when on 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)

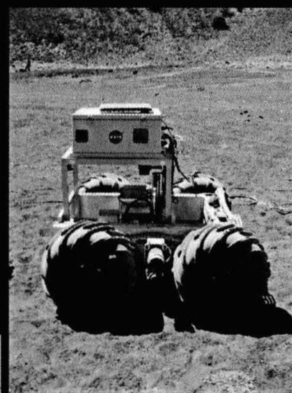
## Field Demonstrations

- Hawaii field demo
- Masten Space Systems

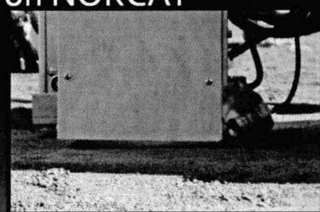


## Mauna Kea, Feb. 2010

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



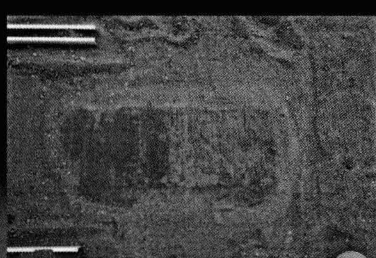
LASSS



Heater

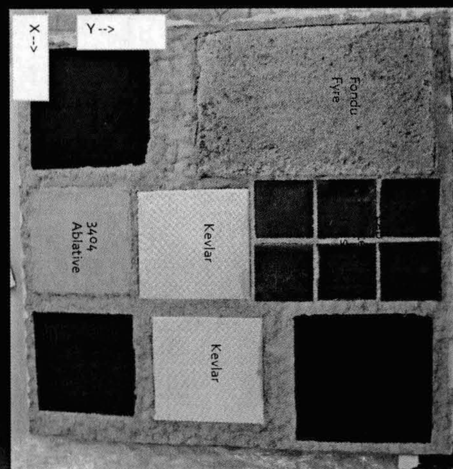
## Mauna Kea, Feb. 2010

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

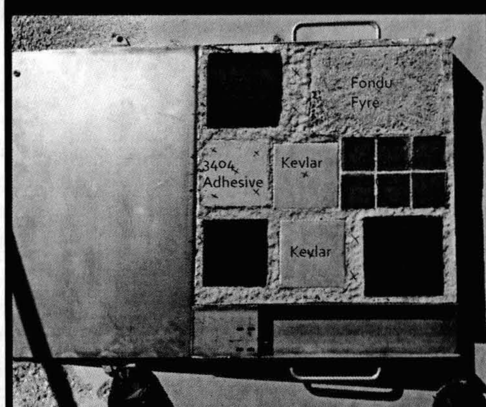


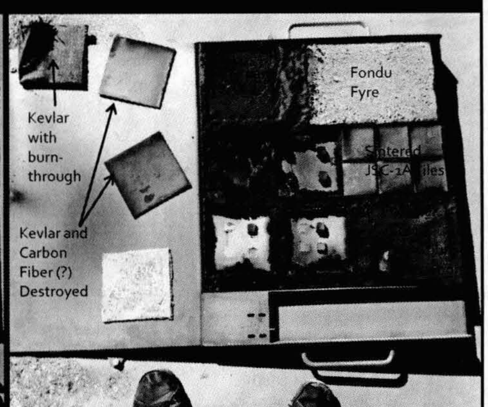
## Masten Space Systems: Nov 2011

- 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)
  - Slicone Ablative (LC39)
  - Kevlar and Carbon fiber



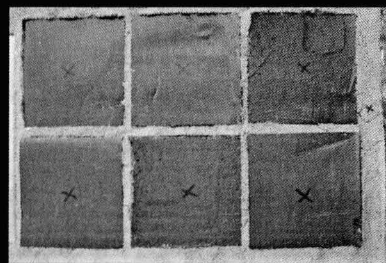

## Masten Space Systems: Nov 2011



# 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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