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CASTING AND ANNEALING EXPERIMENTS OF LUNAR MARE AND ANORTHOSITE REGOLITH SIMULANTS.

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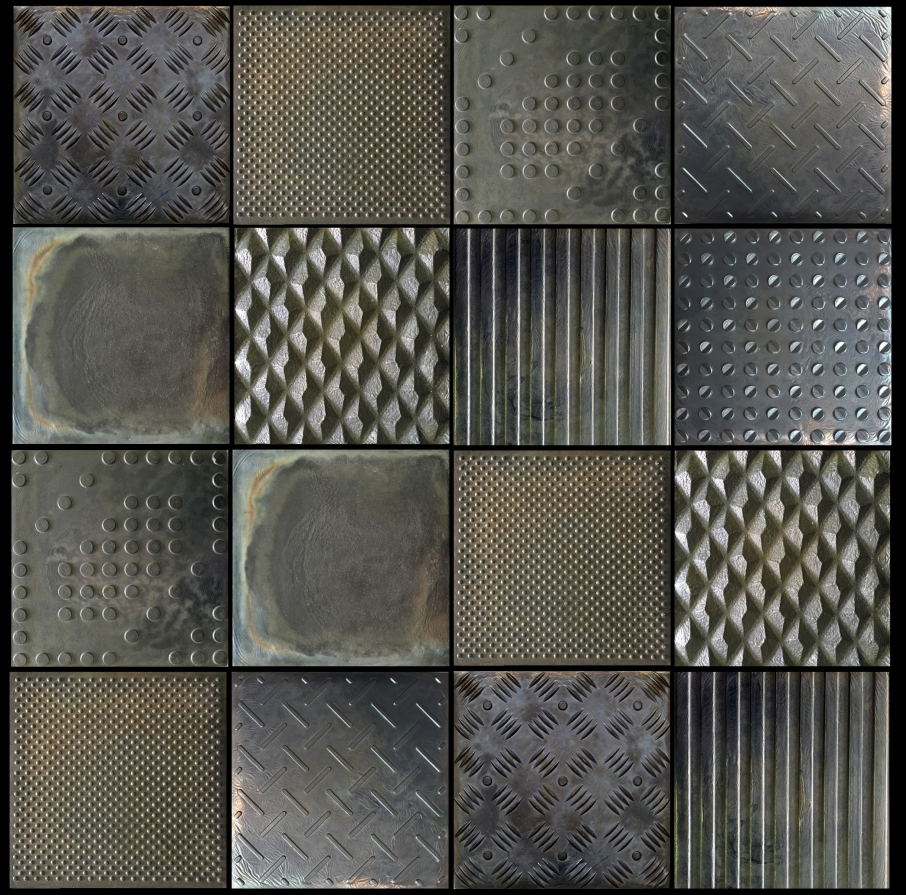


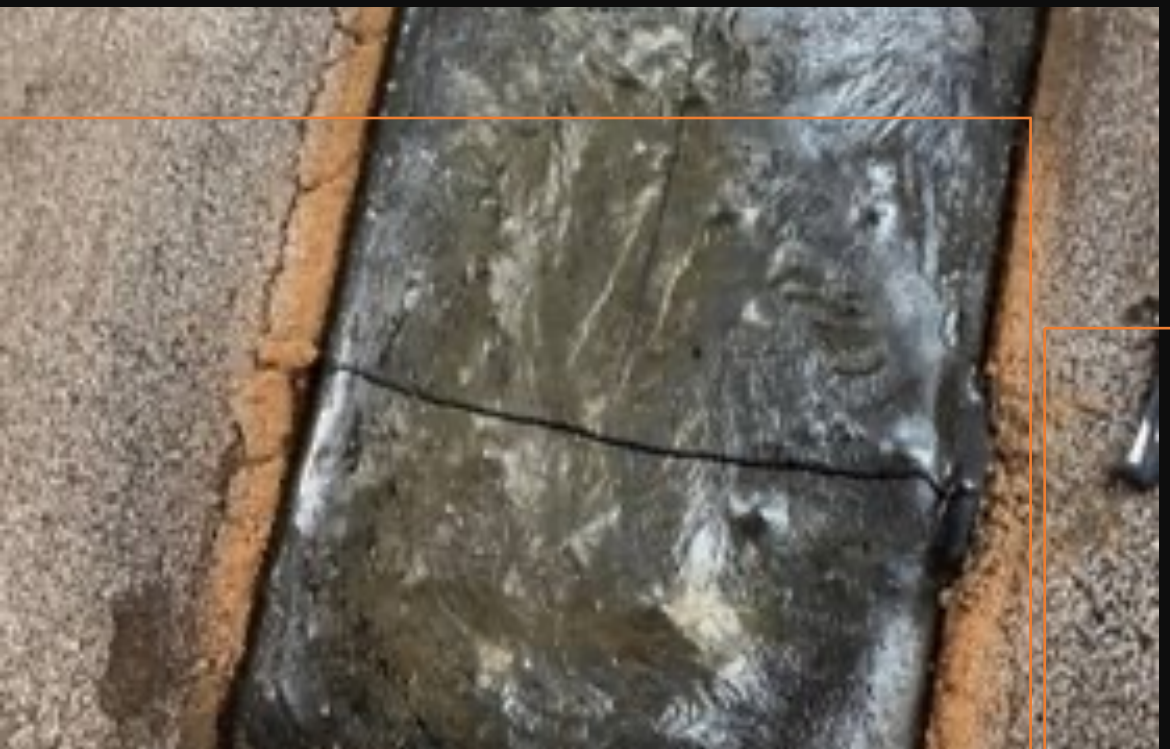
Terrestrial Basalt Casting

Methods

- Natural gas-powered open-air furnace.
  - SiC crucible
- Mold material testing includes
  - SiO2 ceramic shell
  - Closed face and open-faced green sand mold
- Temperature gauging using Type-K thermocouples.
- Lunar regolith simulant
  - Basalt
  - Basalt/anorthosite mix
- Cooling temperature method testing.

Sand Mold & Fracks

- Open-faced green sand mold.
- Fiberglass on top to cool naturally
- Vitrified and cracked into 3 pieces
- Porous throughout



SiO2 Ceramic Shell

- 3D printed Cylinder
- Coated in SiO2 sand to form shell
- Wax burned out
- Molten regolith poured into shell and put in a kiln for annealing

Temperature Control

- Pouring temperature was not hot enough shown by:
  - Did not fill mold
  - Melt pulled from the body of the tile.
- Put in the annealer too soon
- Many deformities and pores

Basalt/Anorthosite Mix

- Melt was much hotter and runnier than basalt melt.
- Hand sample of solidified melt showed possible signs of unmelted anorthosite clasts.
- Produced the shapeliest material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Basalt (B) / mixed (B/A)	Temp. °C	Mold	Annealed (?)	Material Characteris-tics
B	N/A	Open-faced green sand	N	Vitrified and shattered
B	N/A	Closed-faced green sand	N	Vitrified and shattered
B	N/A	Ceramic Silica Shell	Y	Non-vitrified and intact
B	N/A	Open-faced green sand	Y	Slightly vitrified, un-shapely, and intact
B	1,330	Open-faced green sand	Y	Non-vitrified, better shape, intact
B	1,330	Open-faced green sand	Y	Non-vitrified and intact
B	1,330	Open-faced green sand	Y	Non-vitrified, well shaped, and intact
B/A	1,350	Open-faced green sand	Y	Vitrified and shattered
B/A	1,360	Open-faced green sand	Y	Non-vitrified, well shaped, and intact

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Results

1) Ceramic silica shell produced a nonvitrified intact material.
   - Difficult to cut into but revealed numerous large pores.
2) Sand molds produce good materials but harder to anneal.
3) Basalt/anorthosite blend created a hotter temperature melt.
   - When poured it showed a smoother, more liquid flow.
4) Allow melt to outgas before pouring
5) Materials improved once the top layer of melt was poured out into an ingot
   - Less pores
   - More cohesive materials
   - Nicely shaped materials
6) Varying colors and textures dependent on type of regolith melted and at what temperature.

Moving Forward

1) Pure anorthosite pour
    a) Materials must be procured
2) XRD of the various melts and compare to original material
3) SEM for microstructures after melting
4) Calculate the amount of energy is needed to melt regolith
5) Work on the annealing schedule
6) Strength testing
7) Thermal shock testing
8) Pour complex shapes
9) Pour an aluminum/basalt clast tile
10) Test various fluxes to bring melting temperature down.

Questions?

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