

# Heat-weldable and vitrifiable lunar geopolymers concrete

by Samuel Lucas and Orion Lawlor



# Motivation for Lunar geopolymer

- For a sustainable Moon or Mars base (or Earth city!), you need to **use local resources** rather than importing bulk materials like cement or concrete
  - Many tonnes of construction materials are needed for rocket landing pads, human habitats, farms, energy and water infrastructure, etc
- Portland cement does not work well in space
  - Portland cement is made by roasting limestone, which has no known off-Earth deposits
  - Portland cement degrades at temperatures over 100 C,

# Presentation

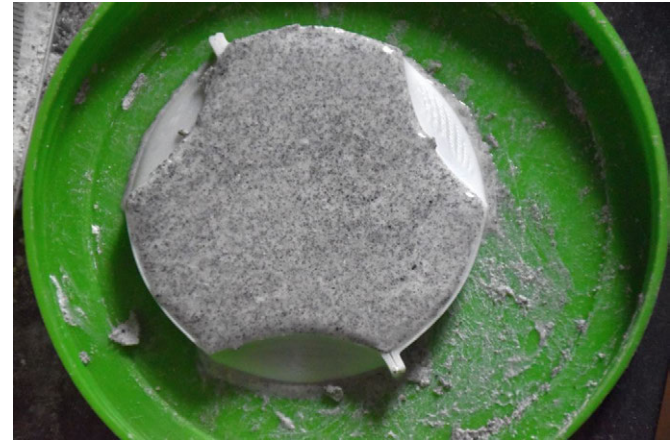
- This presentation aims to show our first results that we have obtained on the subject of heat-weldable and vitrifiable geopolymer concrete.
- Geopolymer concrete composed of the lunar regolith simulant LHS-1 from Space Resource Technology, silica, magnesium hydroxide, sodium hydroxide and water.
- Welding tests with the same mixture consisting of either the Martian regolith simulant MGS-1 or basalt gave the same results.
- Geopolymer concrete obtained with a precursor composed of LHS-1 and sodium hydroxide mixed with raw LHS-1 and water

# #1 Geopolymer concrete

- 23g LHS-1 lunar highlands simulant (anorthosite)
- 7.6 g of silica
- 1.82 g of magnesium hydroxide
- 1.44 g of sodium hydroxide
- 7 g of water



# Mixture, mixing & molding



# Unmolding after 24 hours

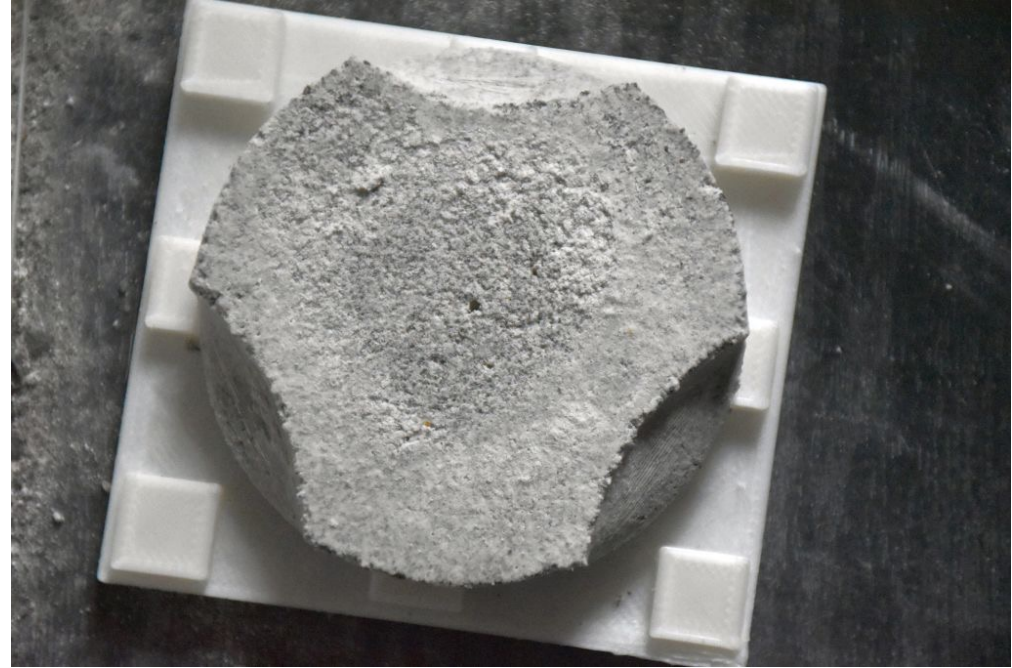
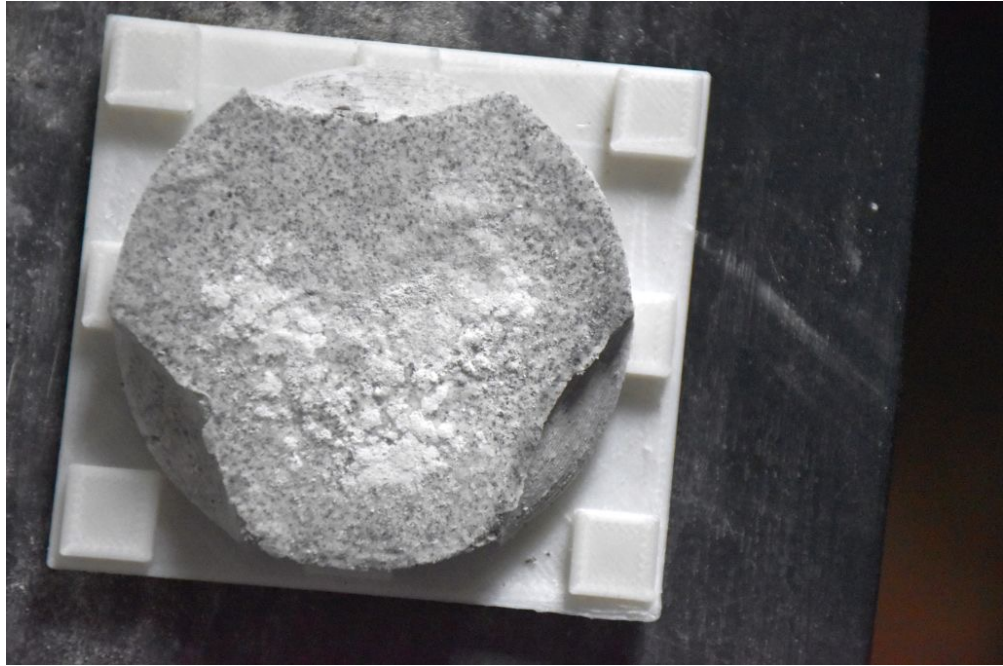




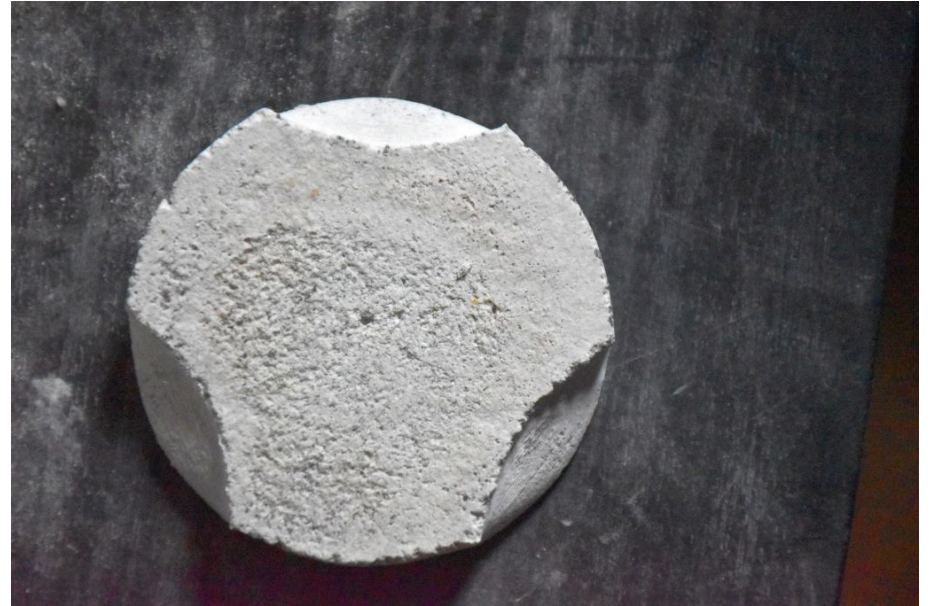
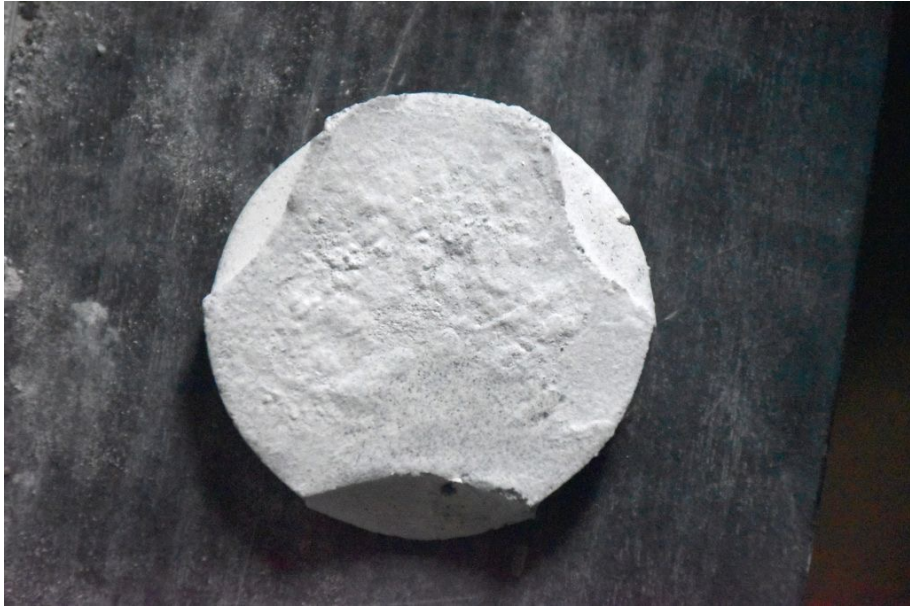
# After 40 hours



**After 72 hours**



**After 3 hours of heating at 150°C**





# The upper and lower joint between the 2 slabs



# The upper and lower joint after being welded with a Fresnel lens





# Vitrification of the upper and lower face of one of the 2 slabs





# Test result with MGS-1 Mars basalt simulant

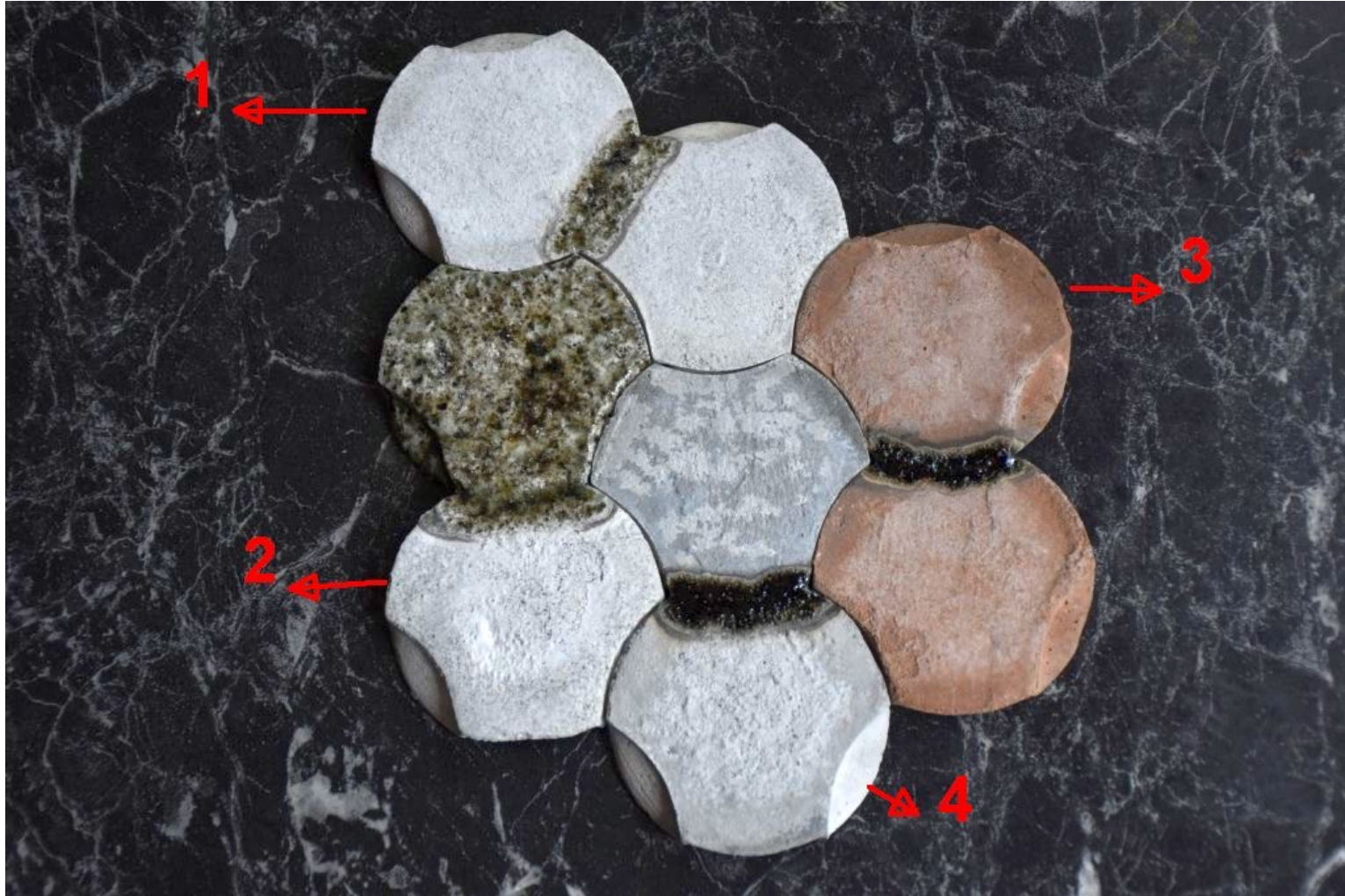


# Test result with local basalt





# All tests performed

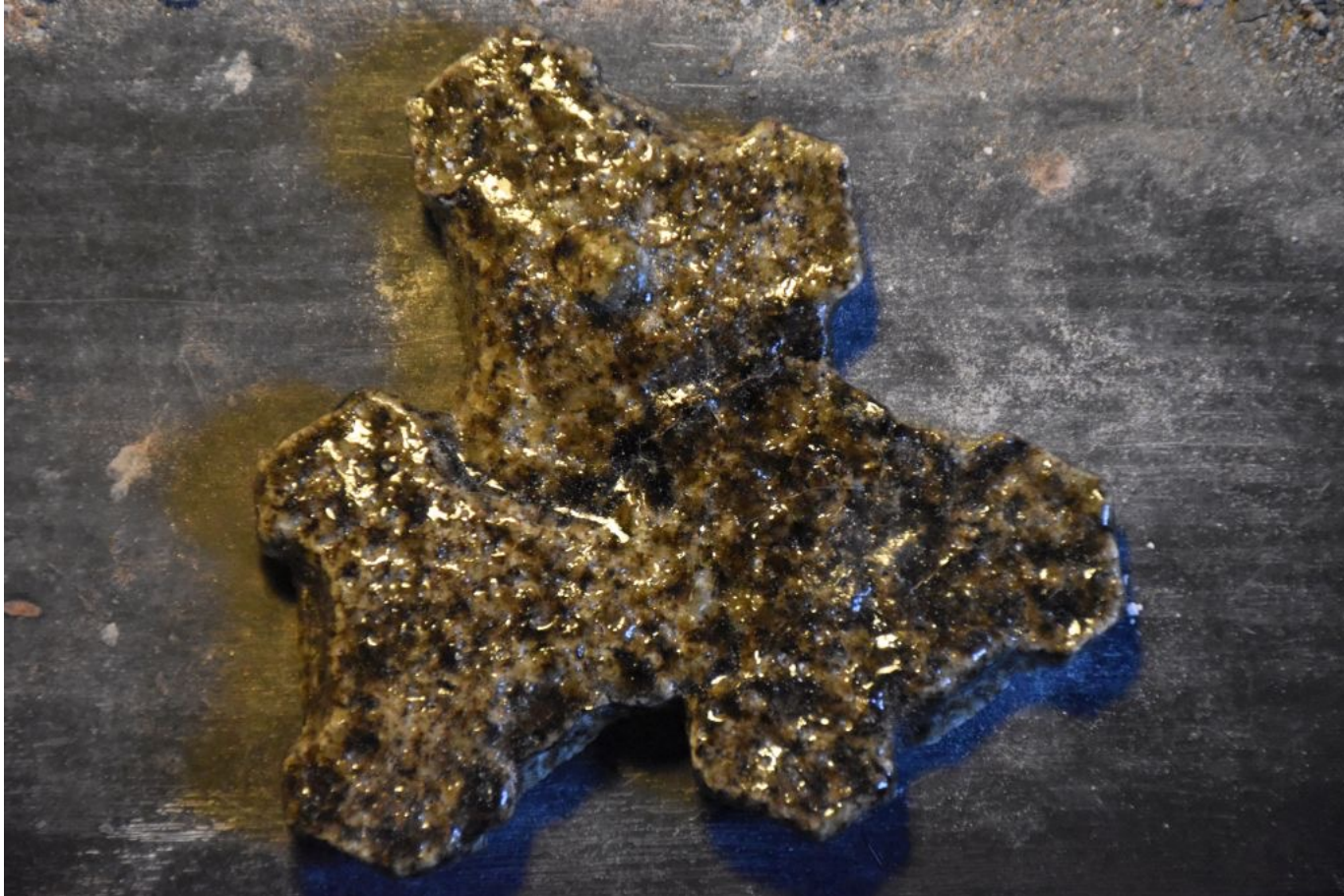


# 3 slabs with LHS-1 welded together with a lens

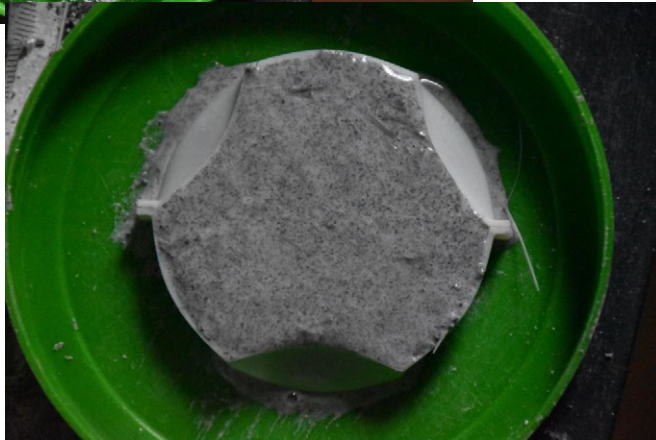




**3 slabs completely vitrified and welded together composed of LHS-1**



# With Basalt Fiber

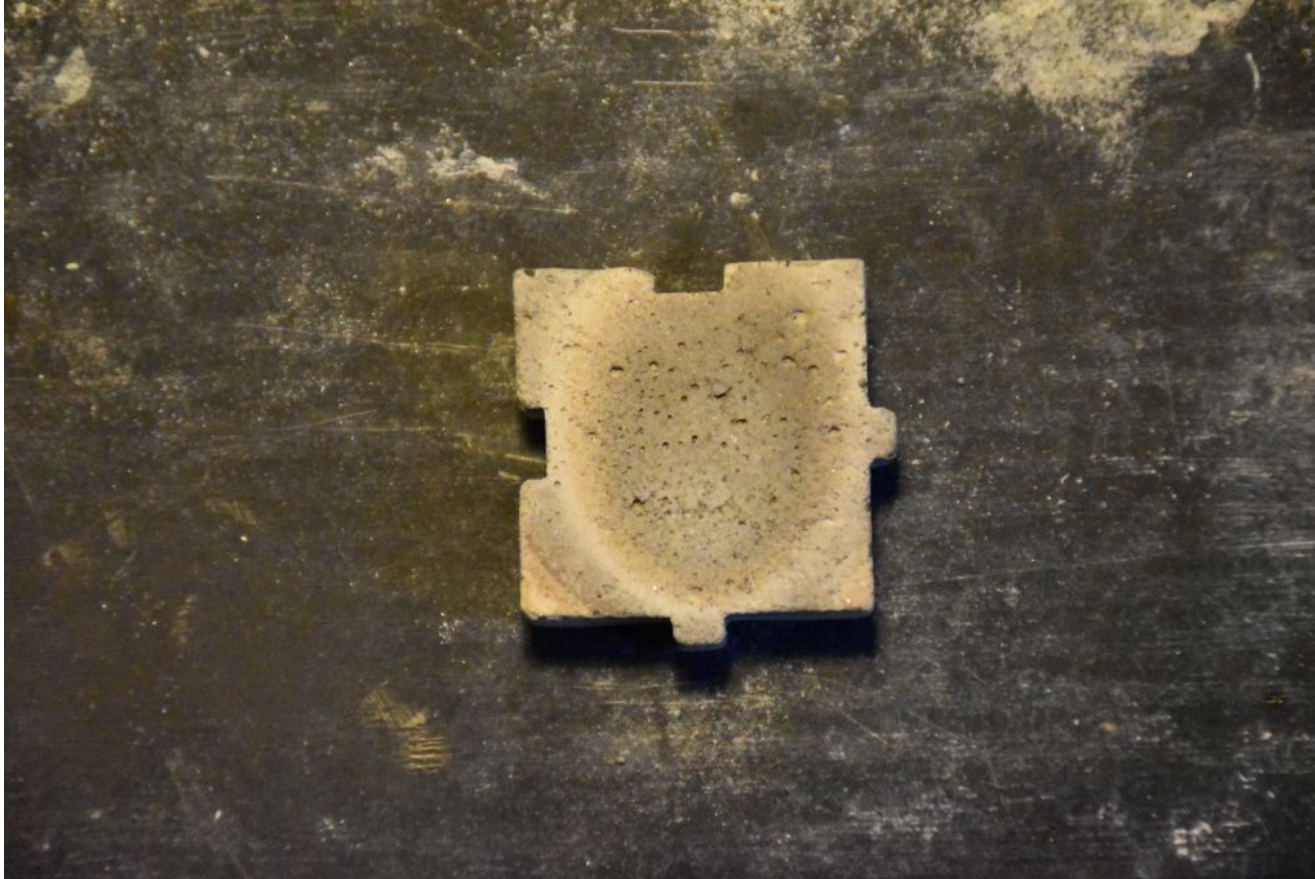




# Two concrete cylinders made of the same mixture welded with a lens



**This slab composed of made of the same mixture was heated 25 times at temperatures between 800 and 1200°C for 8 to 20 minutes.**





# Sealing of the joint to a flame jet at 1200°C



## #2 Geopolymer concrete

- Precursor : 5g LHS-1 and 2g NaOH (heated with a blowtorch 10 min/1200°C)
- Crushed and mixed with 23g of raw LHS-1 and 5g of water

# Précurseur





# Mixture obtained after mixing



# Molding

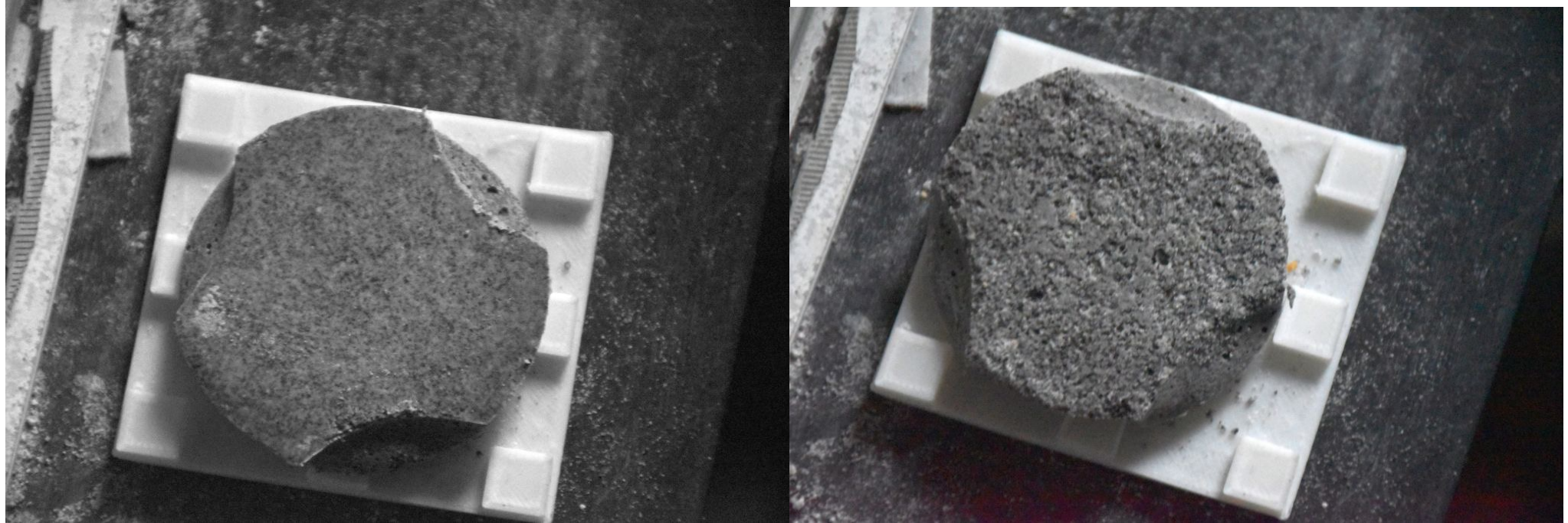




# Unmolding after 32 hours

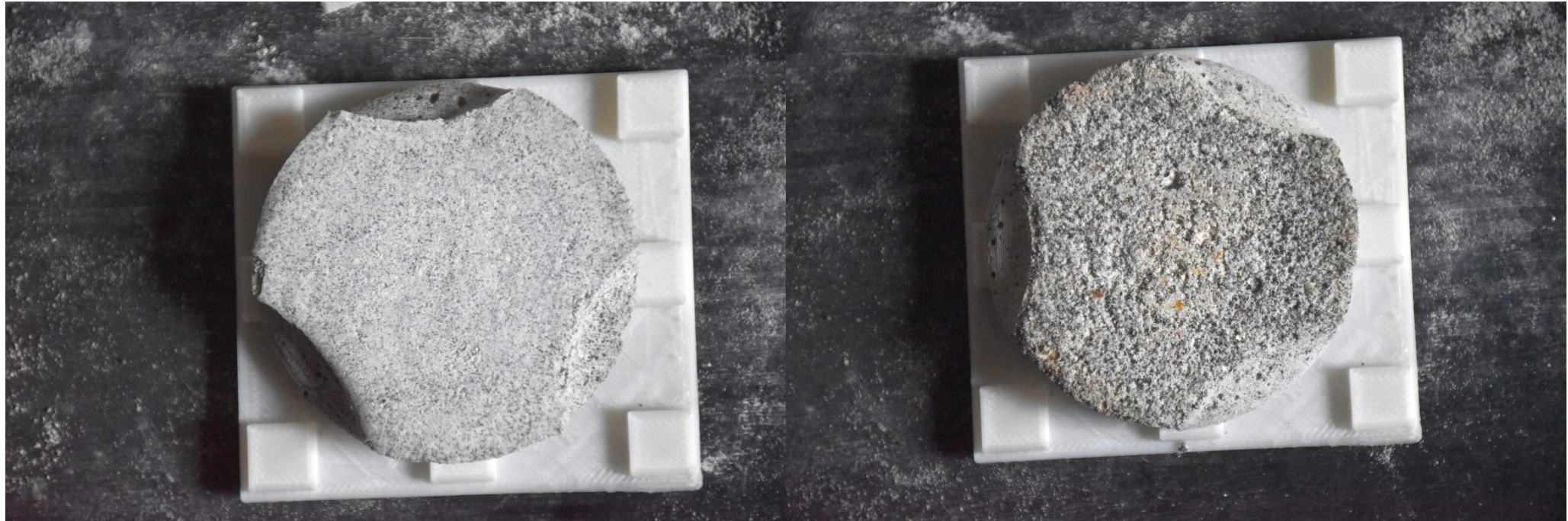


**After 32 hours**





**After 43 hours : 3 hours of heating at 150°C**





# 2 slabs welded together by heat welding the concrete with a Fresnel lens



# Welding causes concrete to crumble

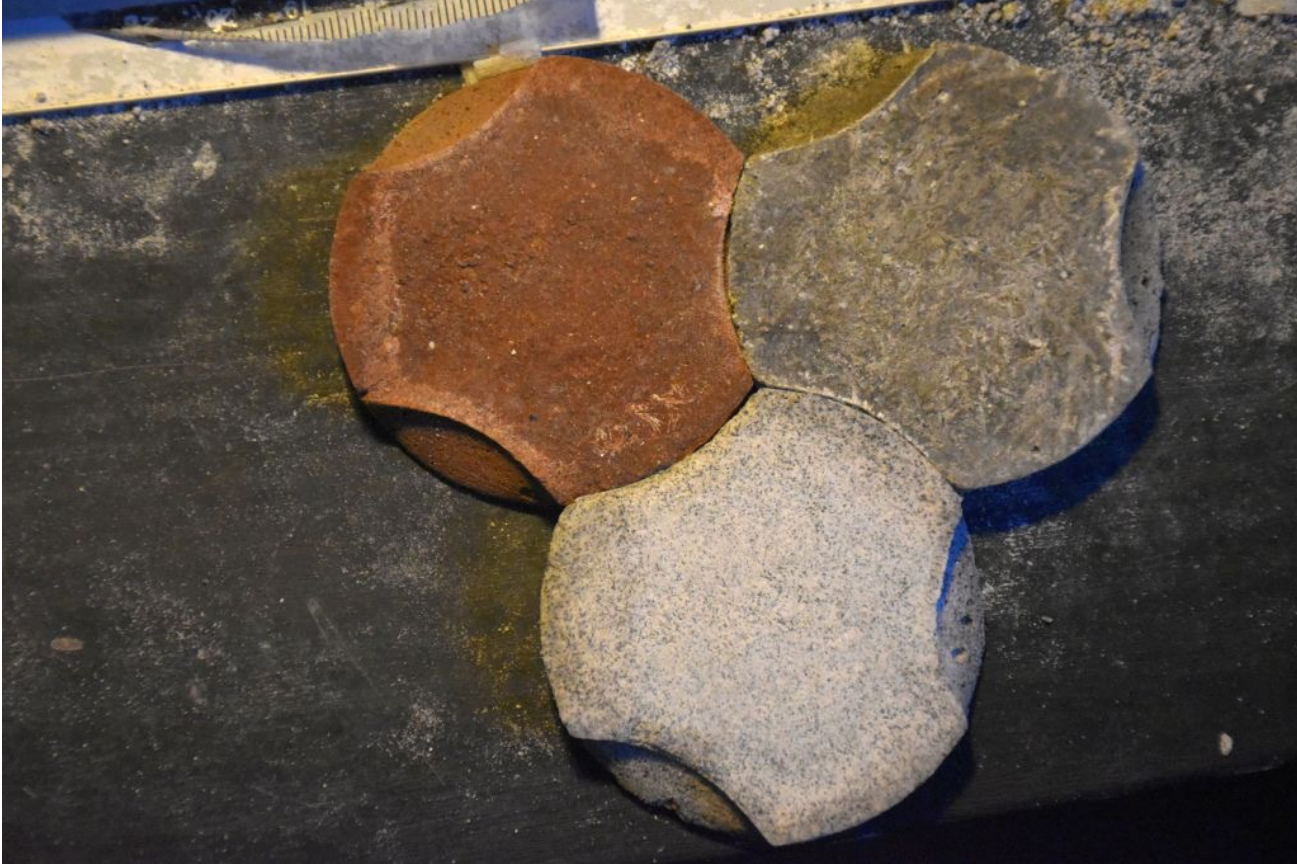




# Two concrete cylinders made of the same mixture welded with a lens



**With the same process, MGS-1 (brown), basalt (black), LHS-1 (white)**





**The same composition but heated directly**



**The same composition after 16 days in the air**





**After more than 2 months in the water**



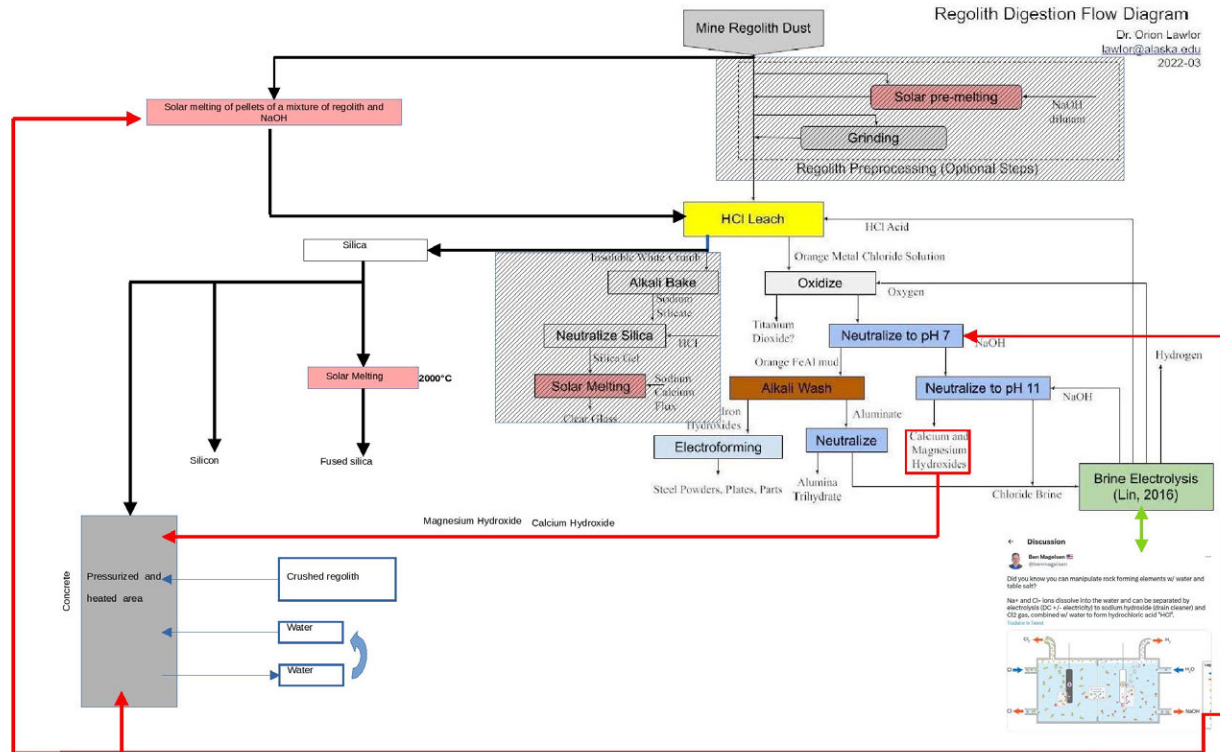
**Result obtained by Orion from a welding test of 2 Portland cement cubes with a Fresnel lens**





# Process to obtain silica as well as magnesium hydroxide from lunar regolith

Overall Regolith Processing Architecture (Plan)

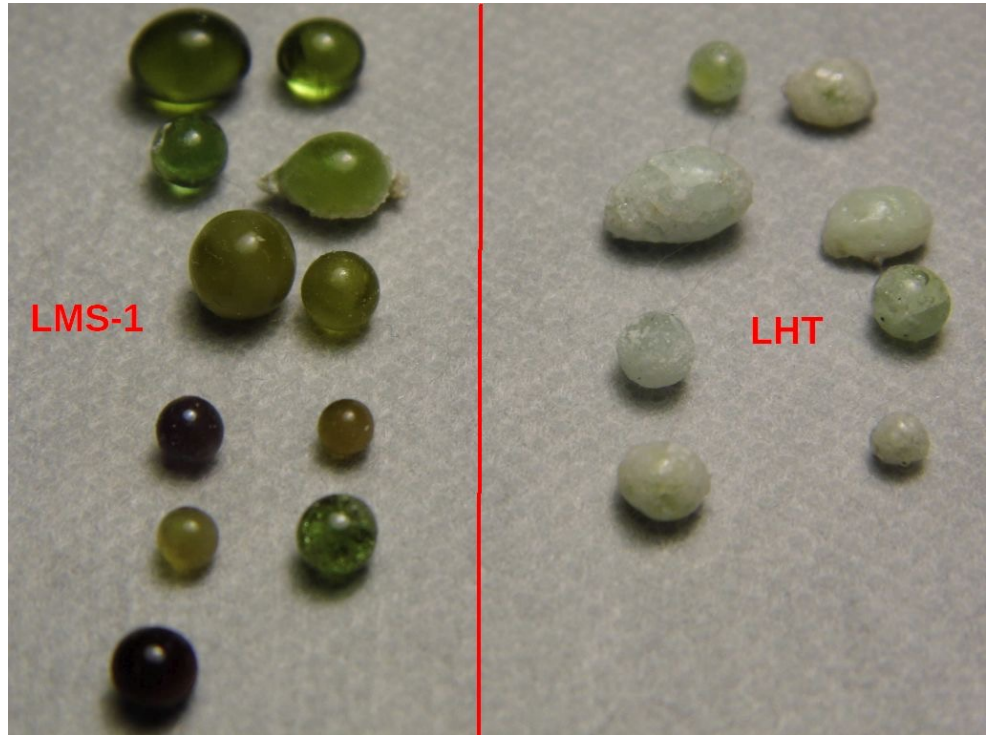


# Silica obtained with this process





# Glass spheres obtained by melting silica extracted from different lunar regolith simulants



# Conclusion

- With this process, it is possible to obtain heat-weldable geopolymer concrete.
- We believe that this process is innovative and that it would be interesting to be able to further our research.



# Contacts

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- **Thank you**