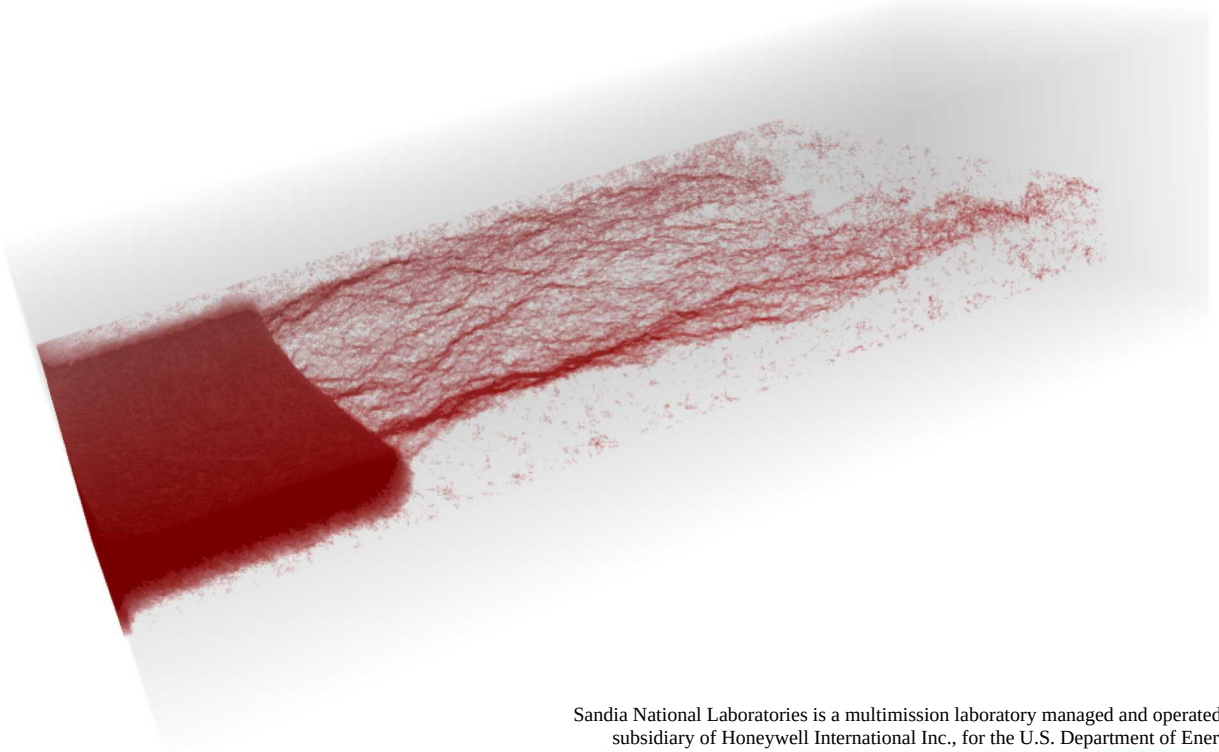
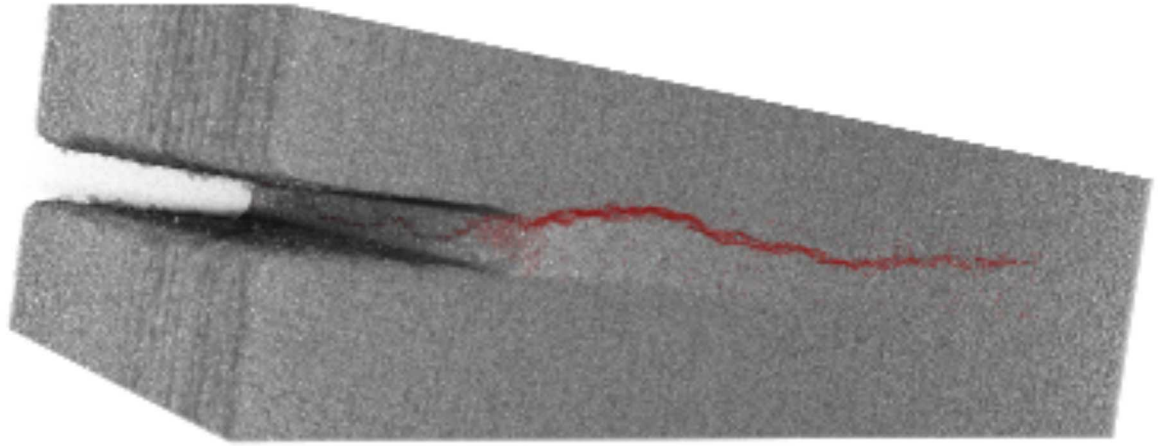
SAND2019-7272C

Effect of Mineral Orientation on Roughness and Toughness of Mode I Fractures

Liyang Jiang, Hongkyu Yoon, Antonio Bobet, Laura J. Pyrak-Nolte





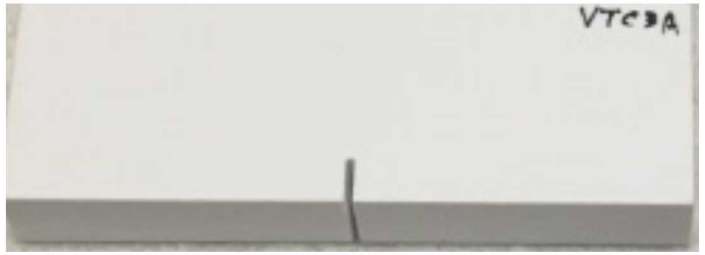
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

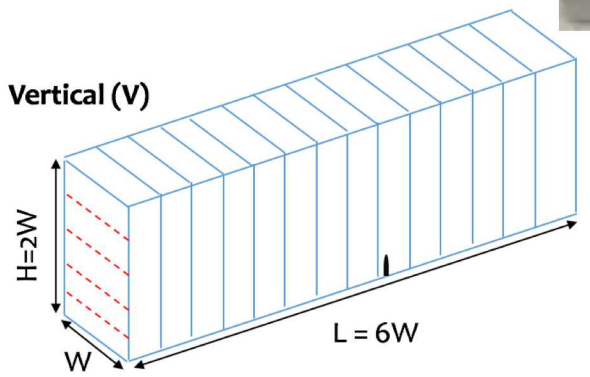
PURDUE UNIVERSITY

Sandia National Laboratories

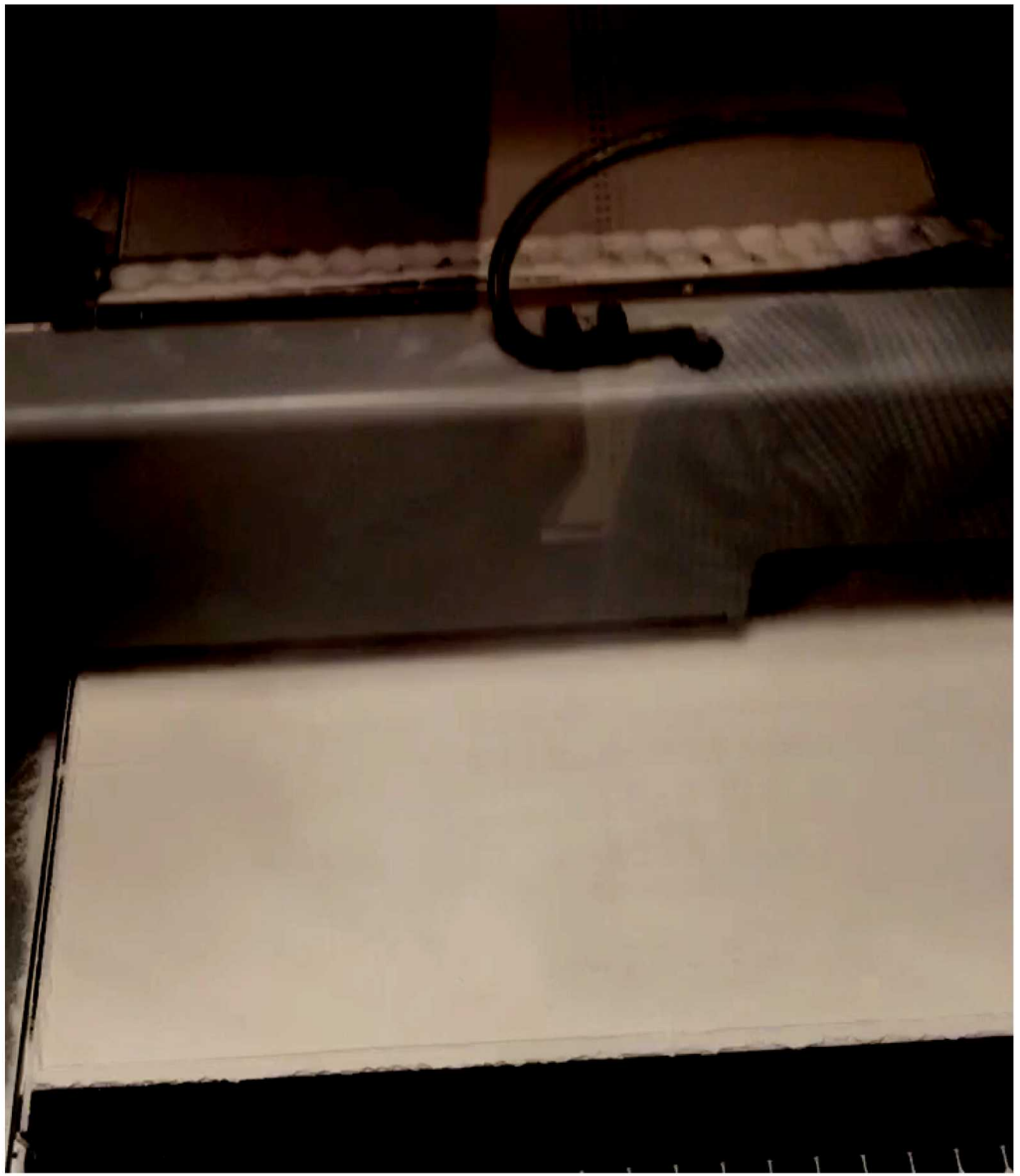
Background

- Analogue material to study tensile failure behaviors
- 3D printed samples do not have isotropic rock behaviors
- Sample layering presents anisotropy
- In-layer mineral orientation makes them orthorhombic

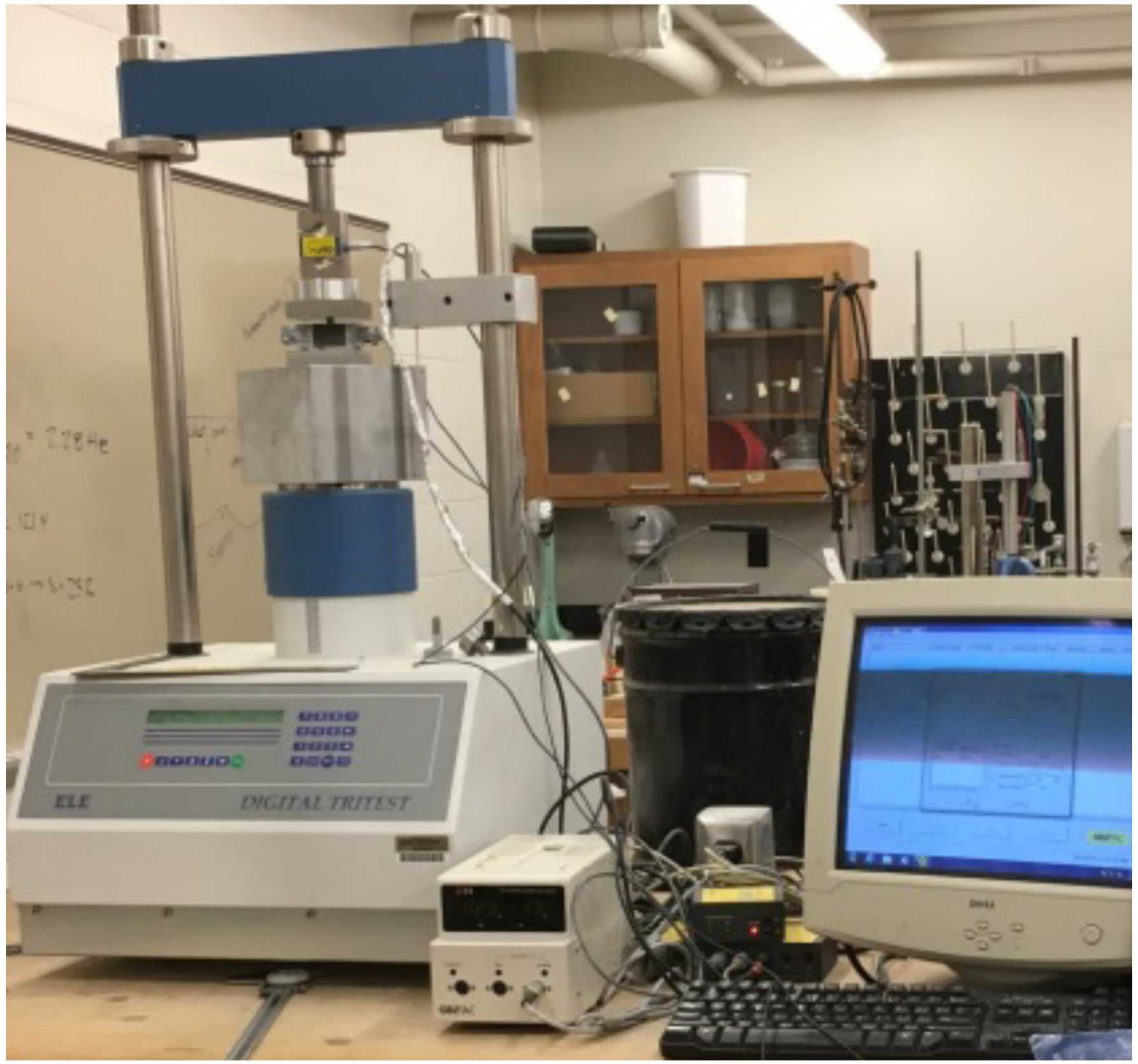




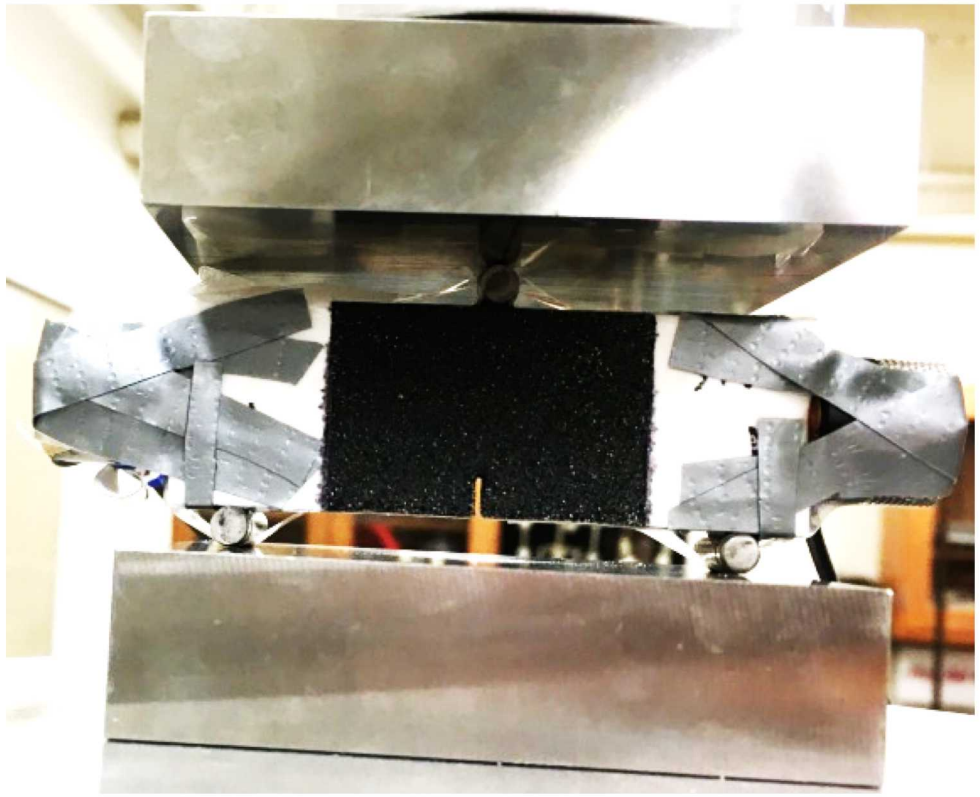
Blue lines:
bassanite layers
Red lines:
inkjet head direction
(gypsum texture)



Experimental Setup

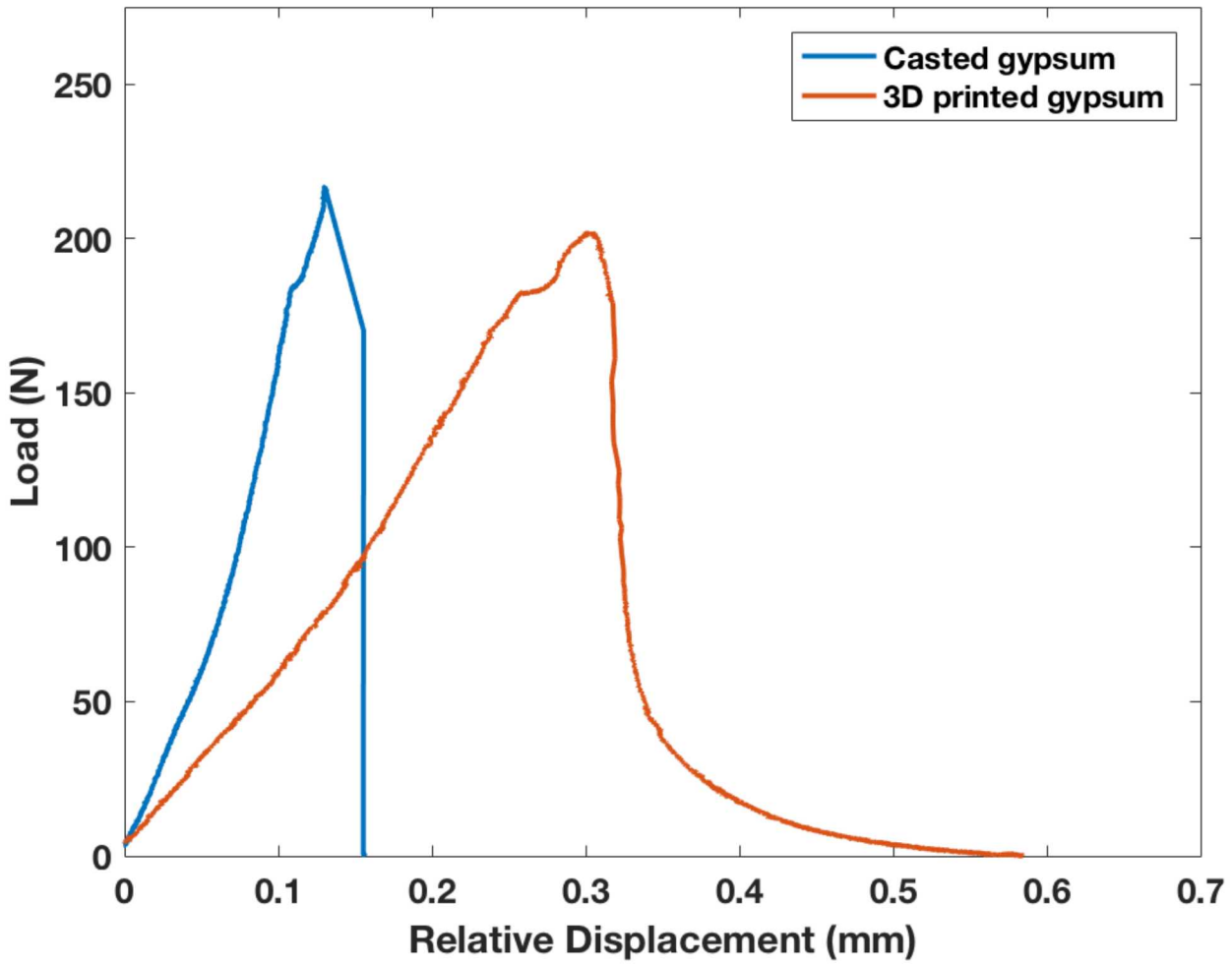


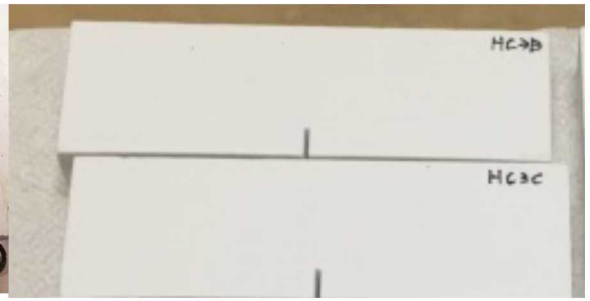
Height 25.4 *mm*
Length 76.2 *mm*
Thickness 12.7 *mm*
Middle Notch Height 5.08 *mm*



Rod diameter 4.76 *mm*
Rod length 19.05 *mm*

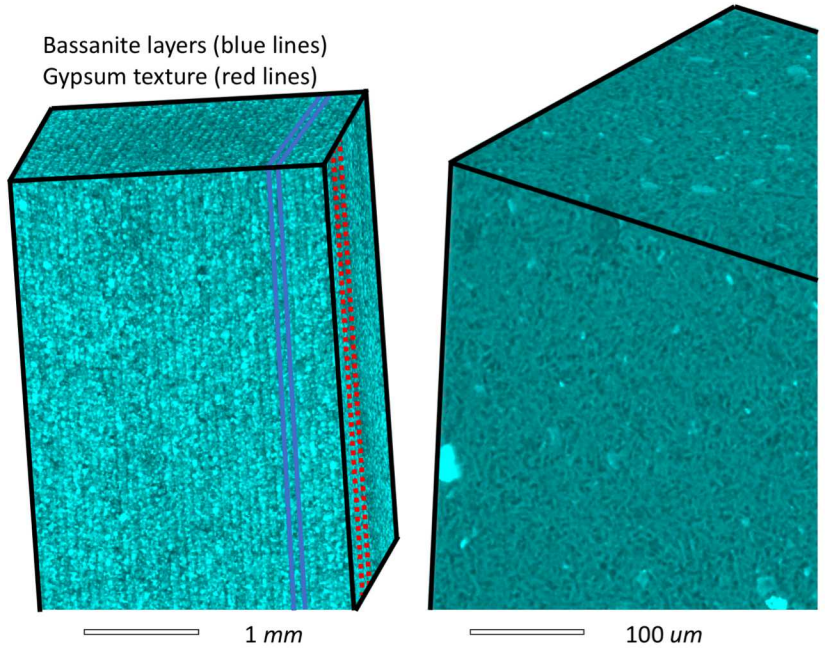
Casted Gypsum VS 3D Printed Gypsum



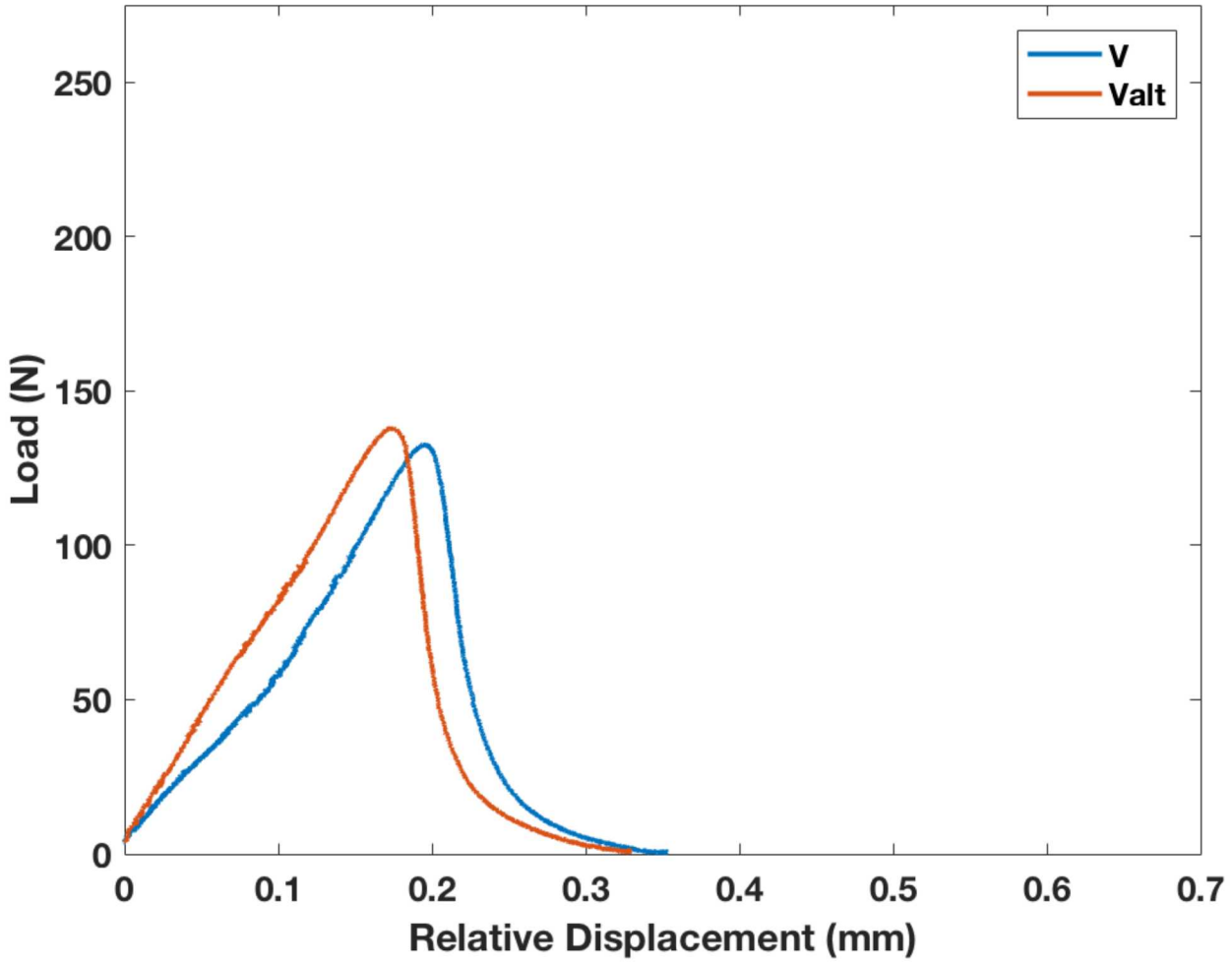


3D printed gypsum

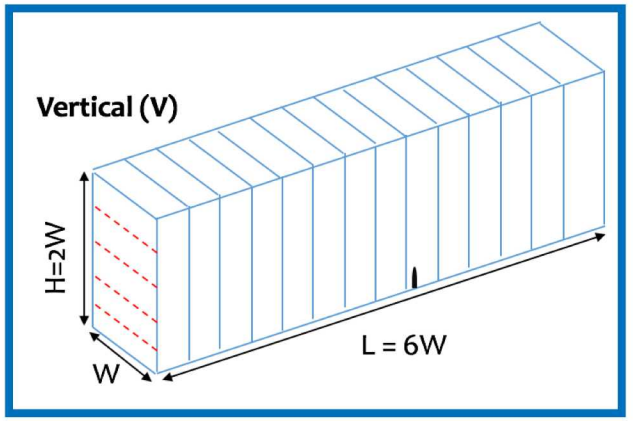
Casted gypsum

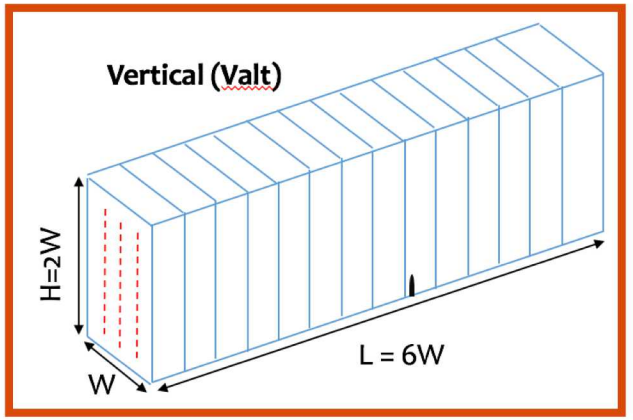


Weakest Samples

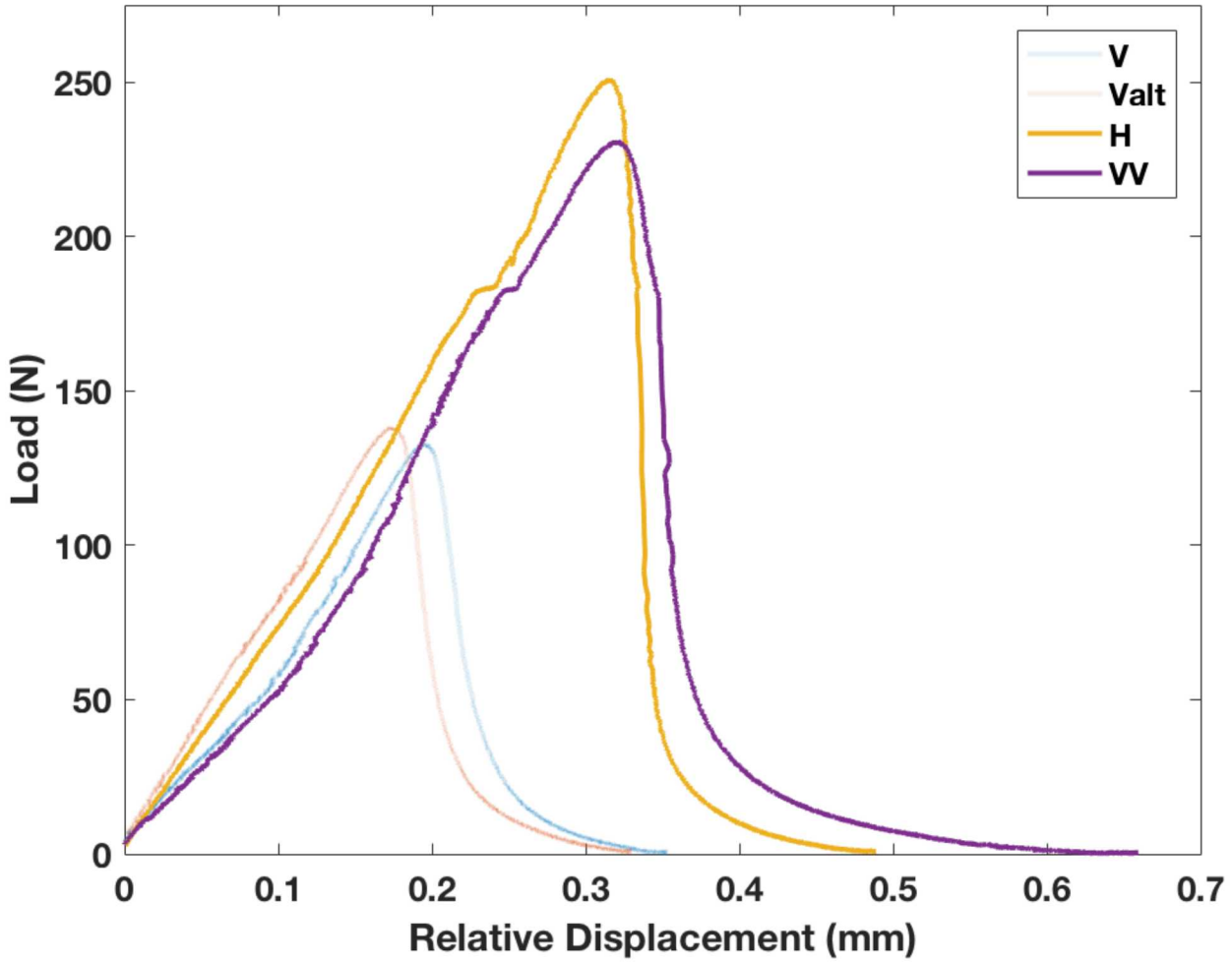


Blue lines:
bassanite layers
Red lines:
inkjet head direction
(gypsum texture)

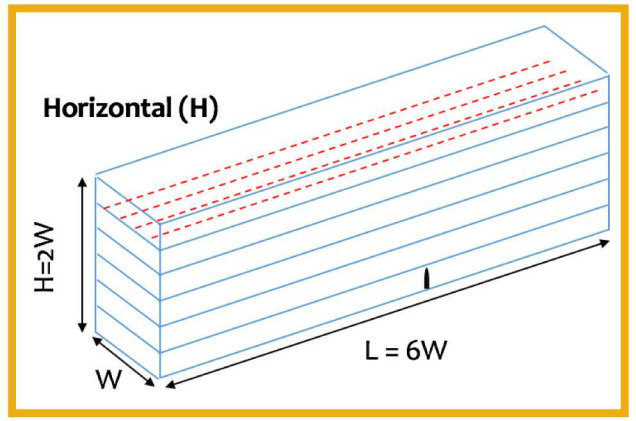


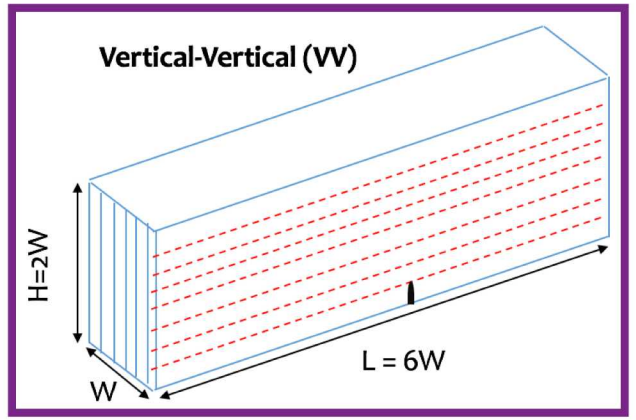


Strongest Samples

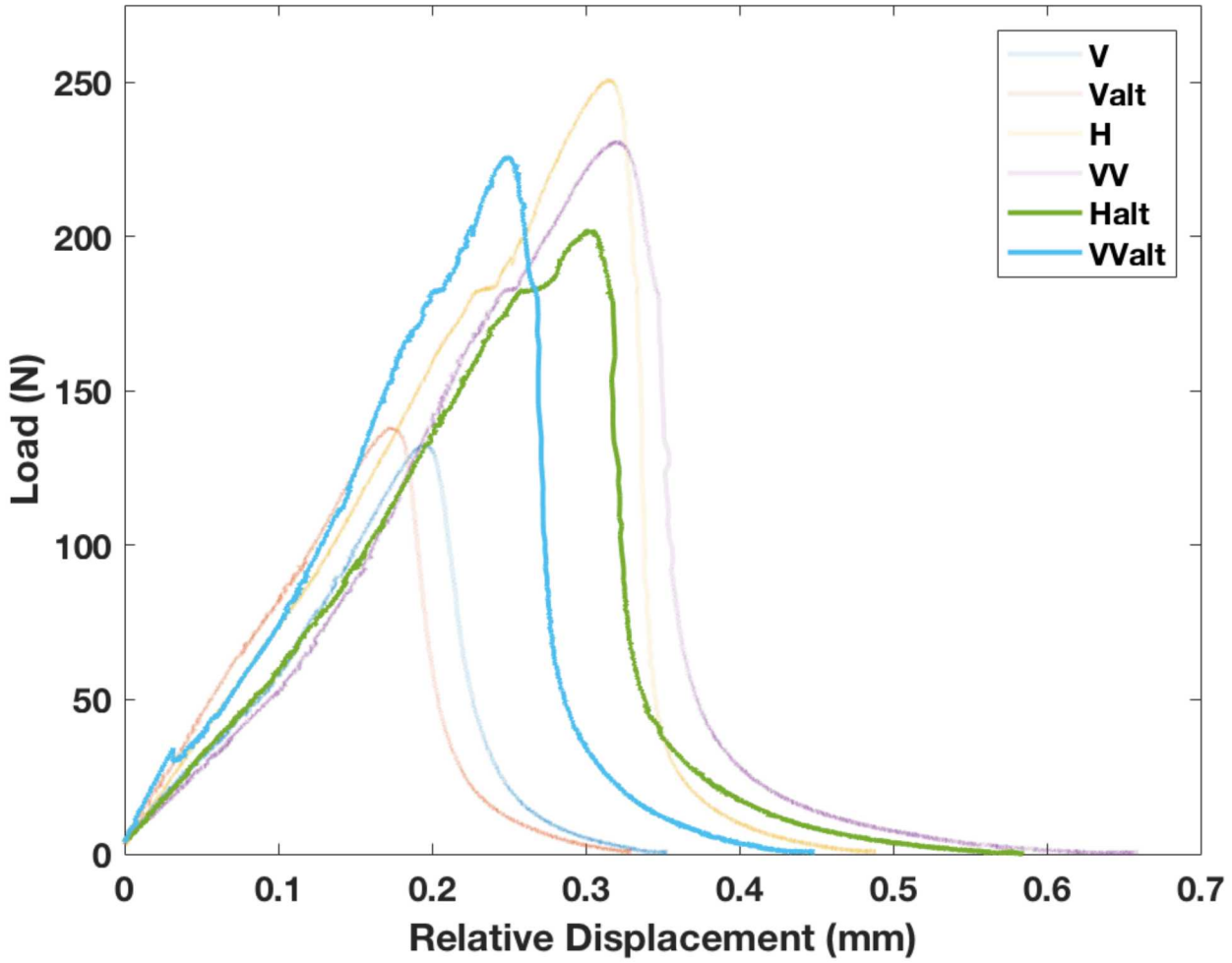


Blue lines:
bassanite layers
Red lines:
inkjet head direction
(gypsum texture)

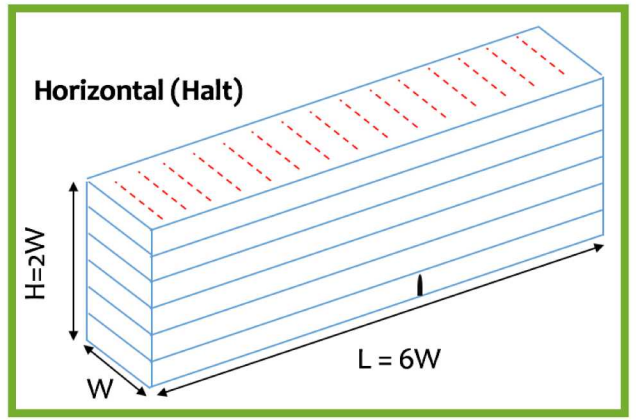


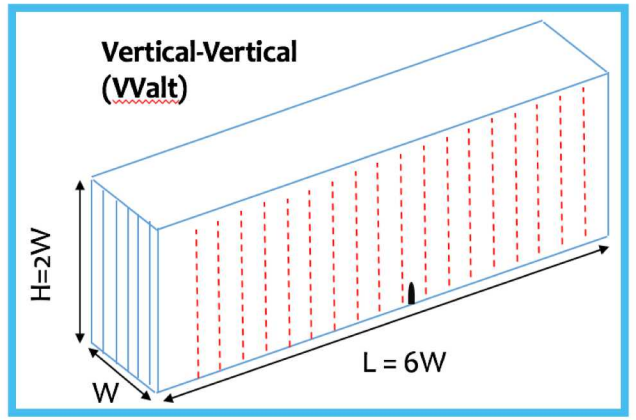


Same Layering, Altered Mineral Orientation Direction



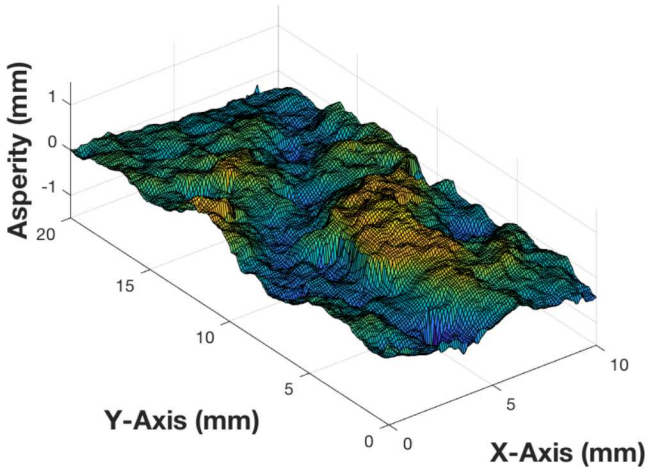
Blue lines:
bassanite layers
Red lines:
inkjet head direction
(gypsum texture)



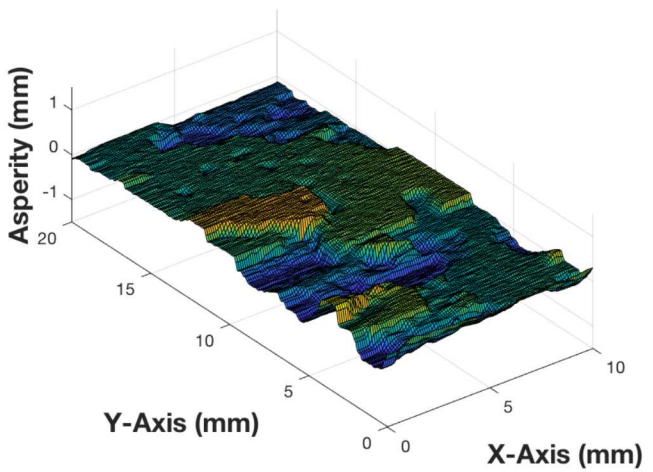


Surface roughness—Asperity 3D View

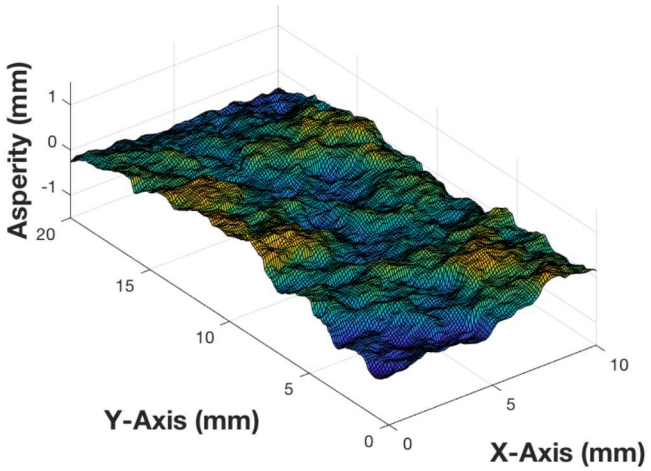
VV



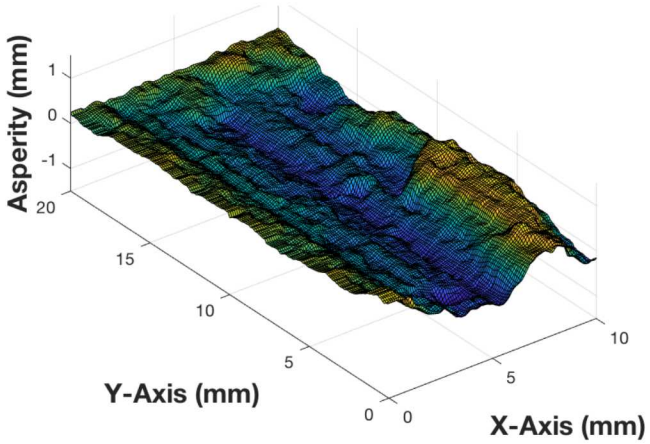
V



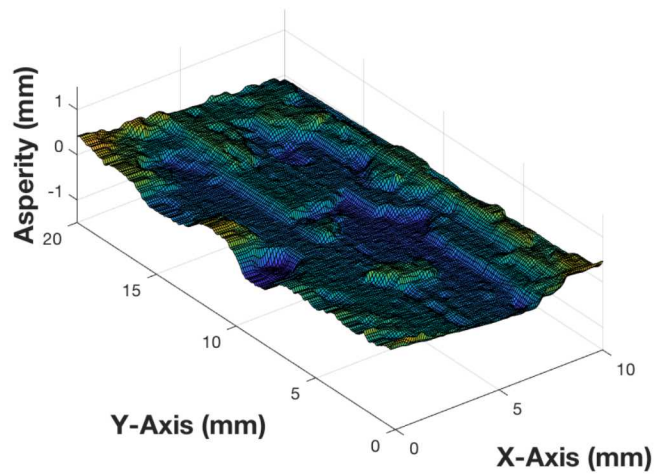
H



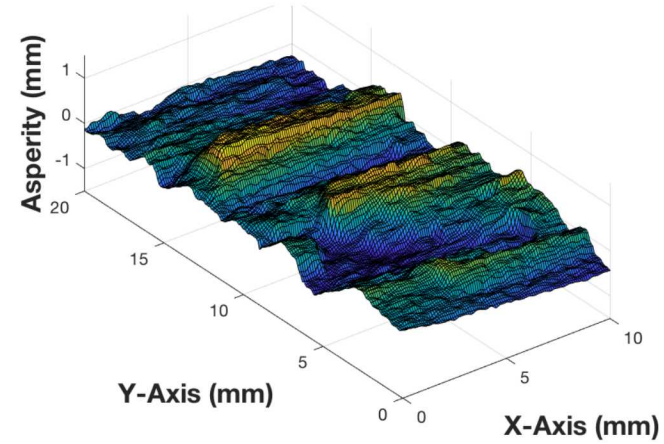
VVT



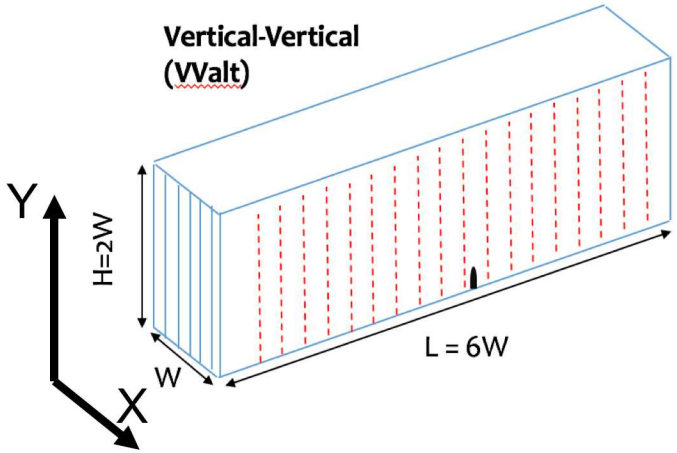
VT

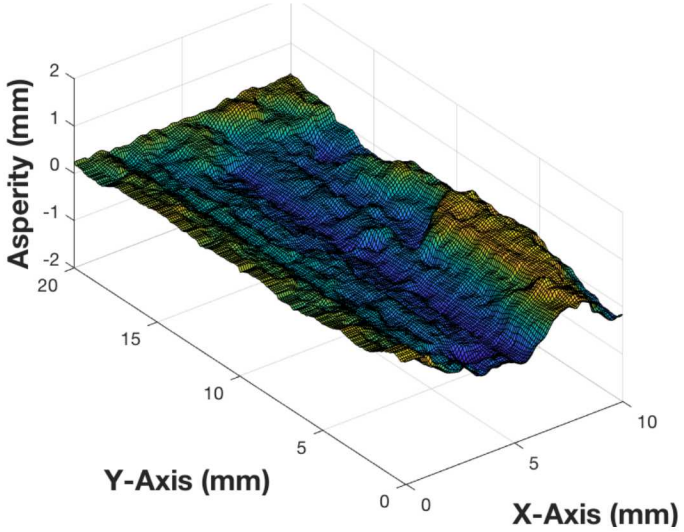


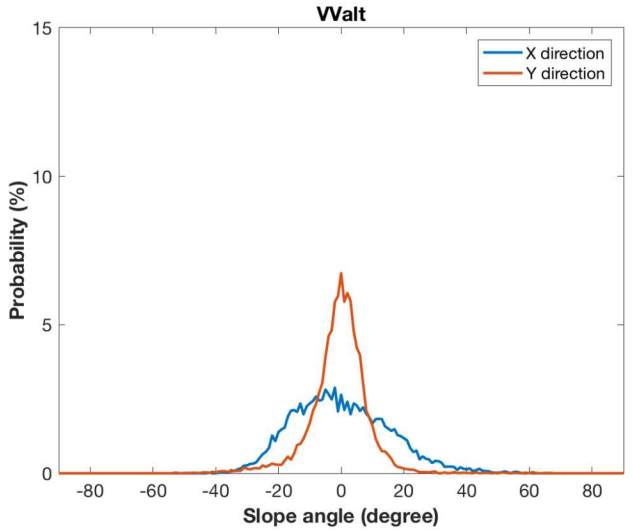
HT

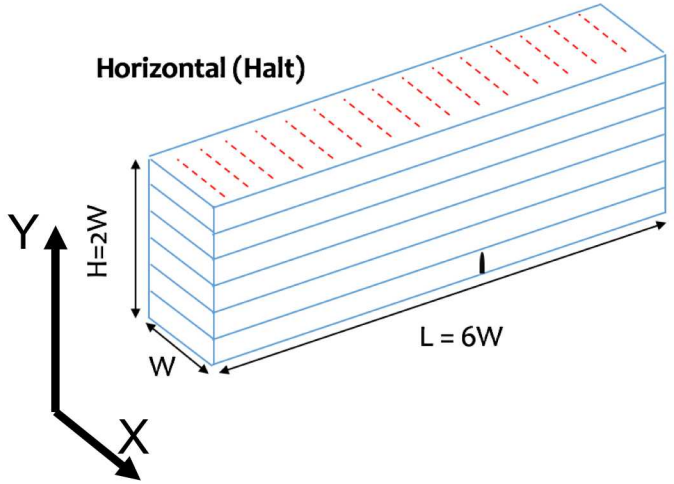


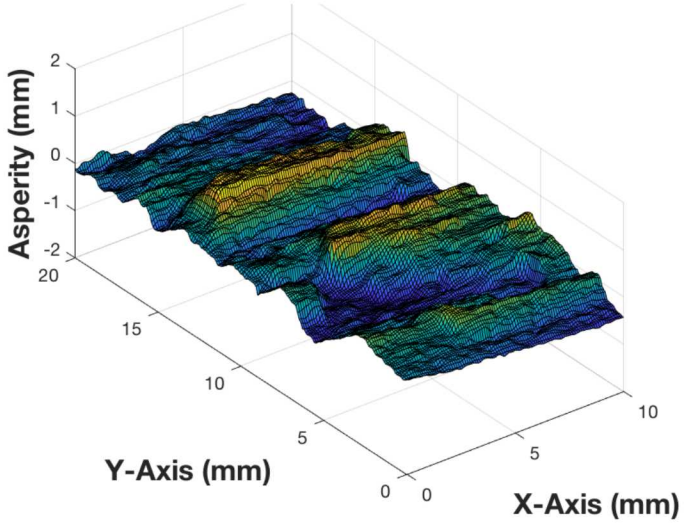
Surface Roughness Anisotropy

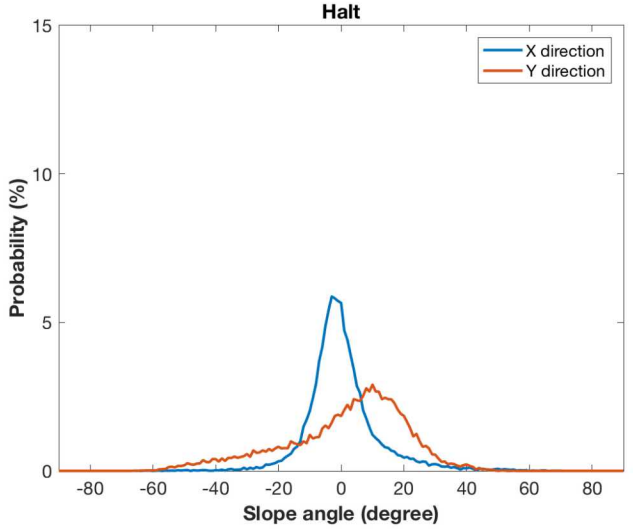












Conclusions

- Anisotropy in 3D printed rock can rise from two sources: layering and direction of mineral growth.
- Peak loading during tensile failure is the smallest when the layering is parallel to the fracture plane.
- Peak loading during tensile failure is the largest when the mineral growth direction is perpendicular to the fracture plane.
- Whether the surface roughness is isotropic or anisotropic depends on both the layering and mineral growth directions.

~Thank you~

Questions?

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. This work was also supported by the Laboratory Directed Research and Development program at Sandia National Laboratories.

We acknowledge the 3D X-Ray Microscope Facility in the Department of Physics for the images shown in this presentation, which were acquired on a Zeiss Xradia 510 Versa 3D X-ray Microscope that was supported by the EVPRP Major Multi-User Equipment Program 2017 at Purdue University.

Liyang Jiang
jiang352@purdue.edu