

Laser processing regolith for lunar base construction: Implications of experimental trials

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- Lunar base development
- SoMR
- Laser regolith processing for construction
 - SLM
 - DLS
 - Welding
- Experimental trials
- Outcomes
- Viable end-uses

Permanent lunar base and ISRU

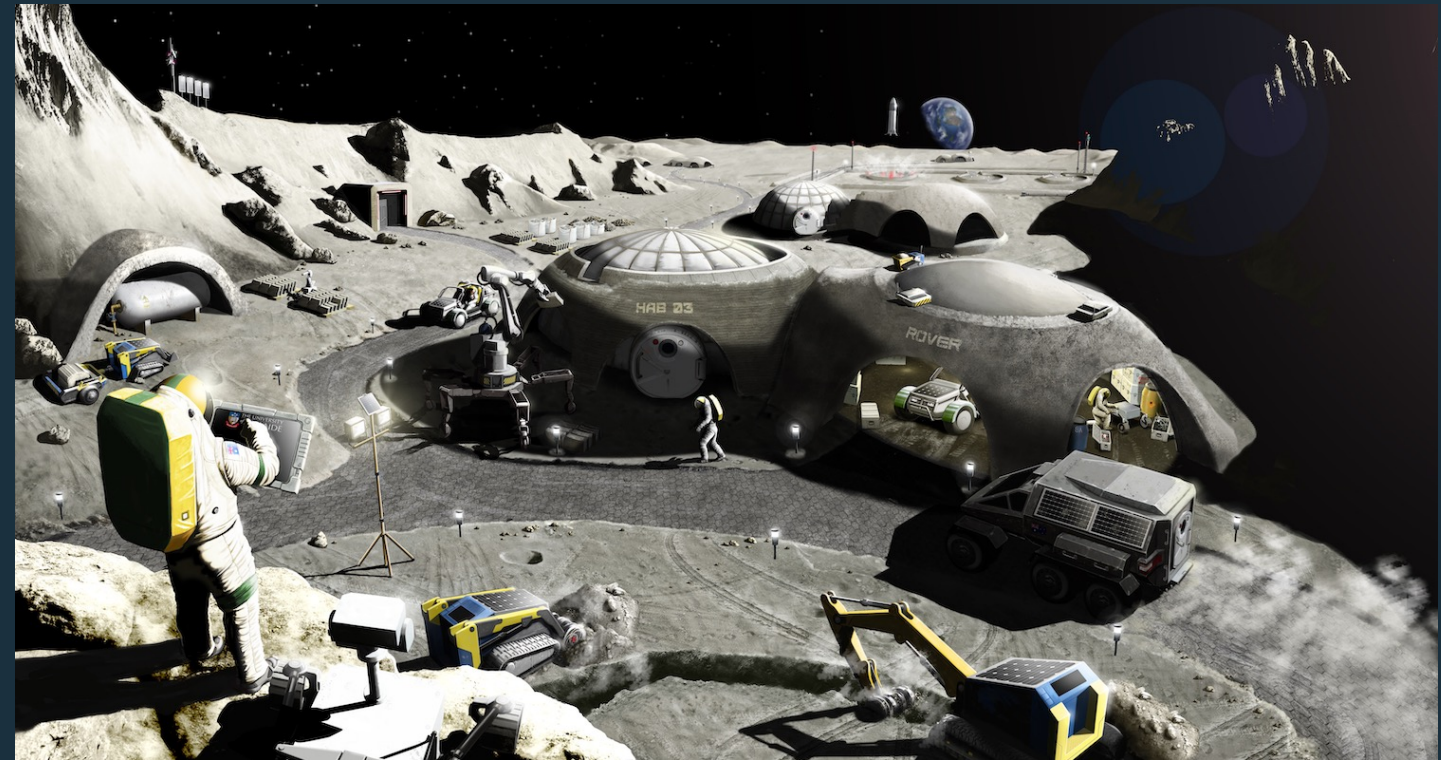
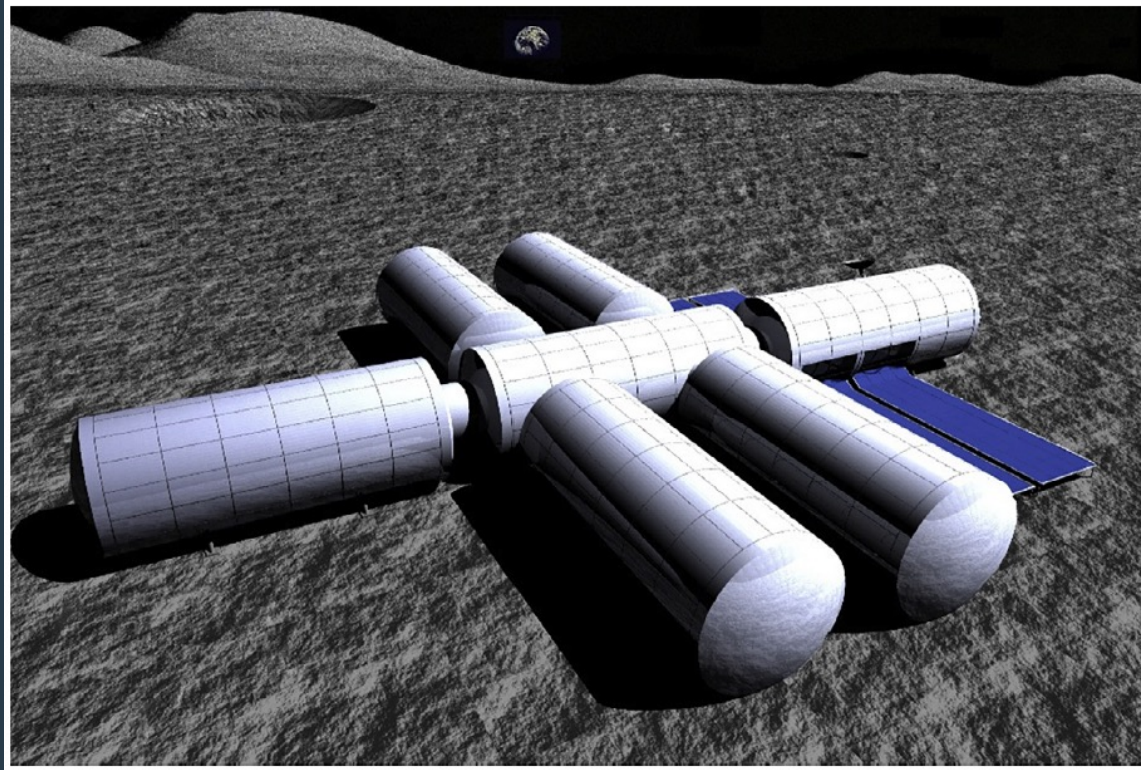


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Permanent lunar base and ISRU

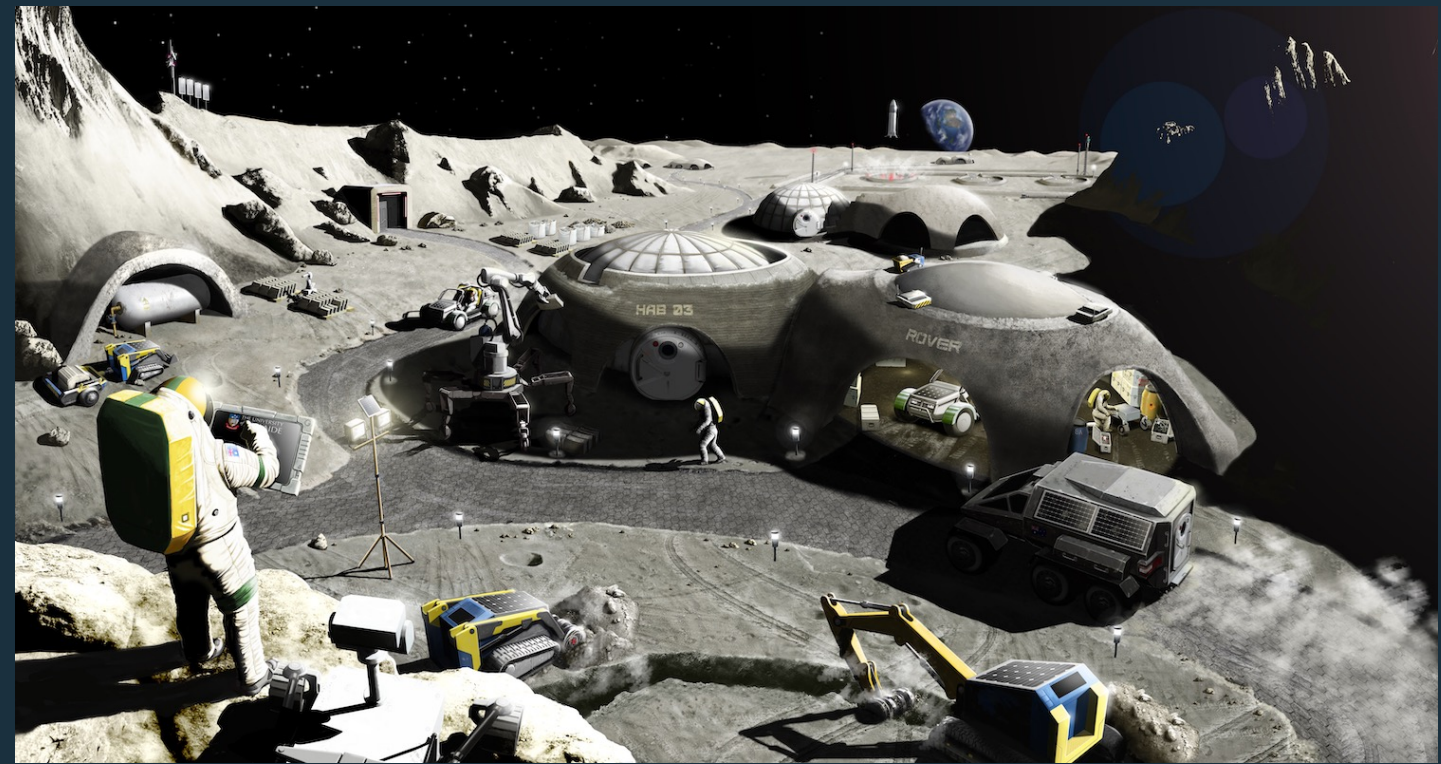
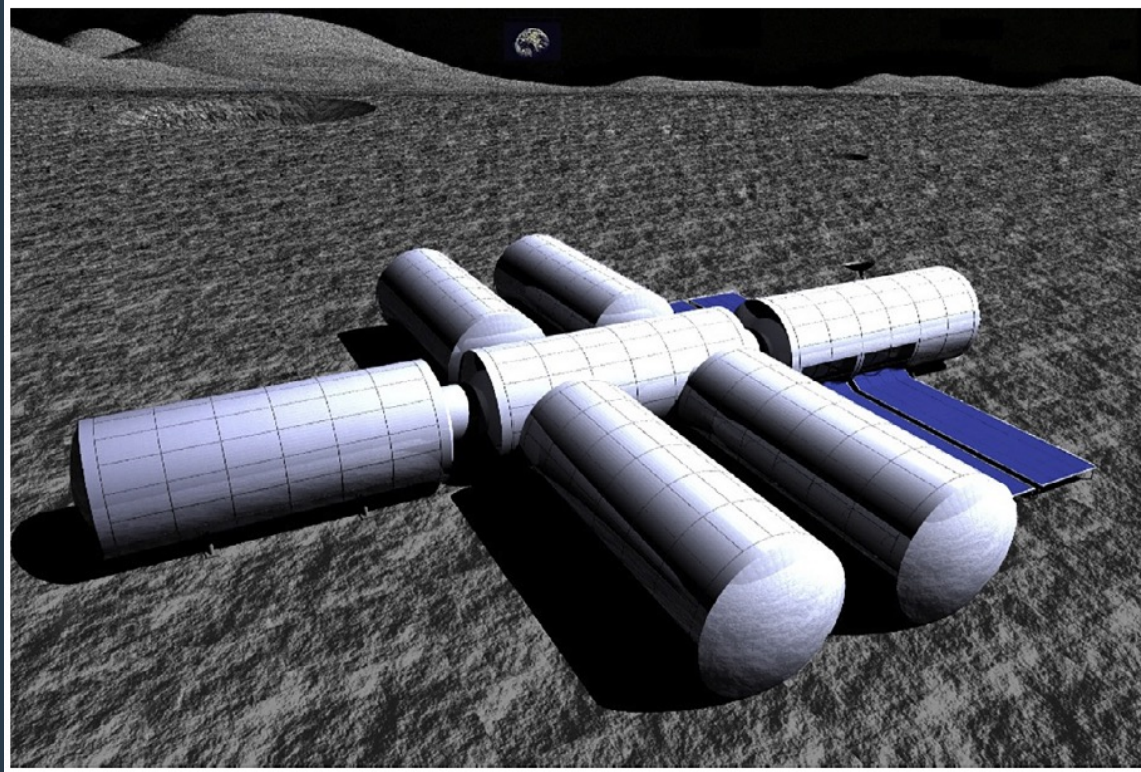


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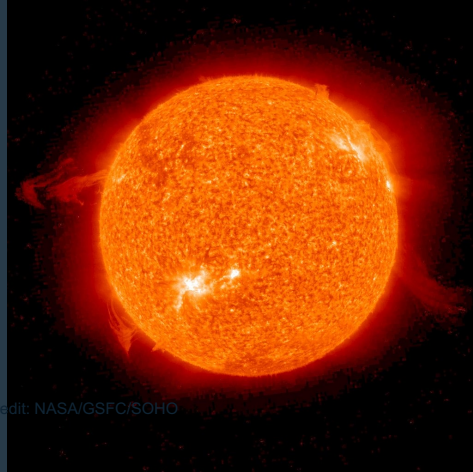


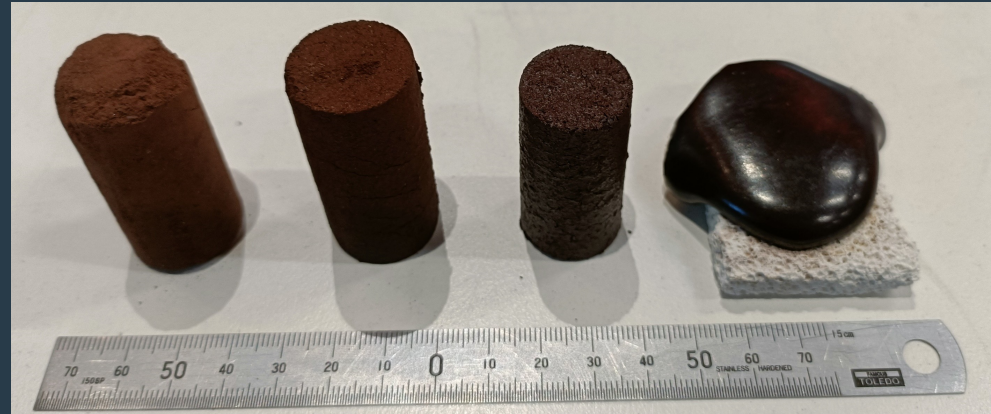
Image credit: NASA/GSFC/SOHO



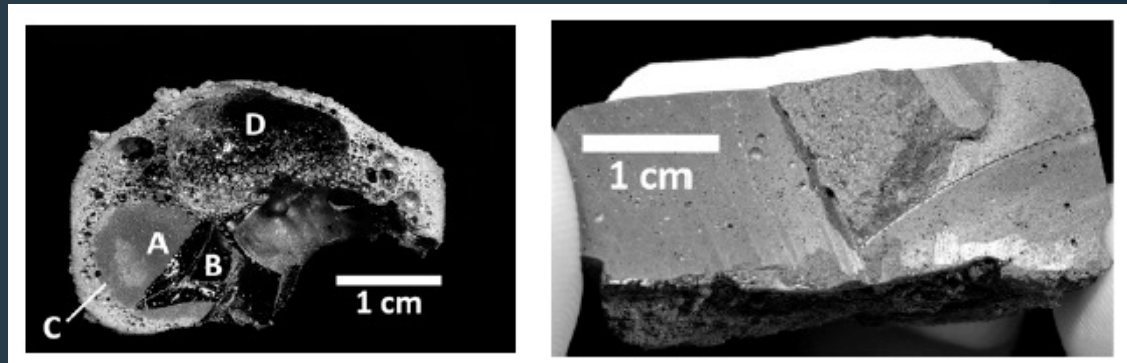
Sinter
or
melt



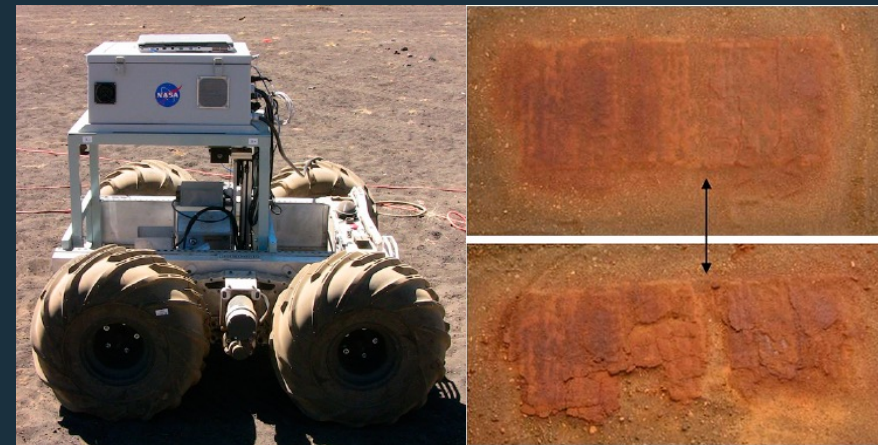
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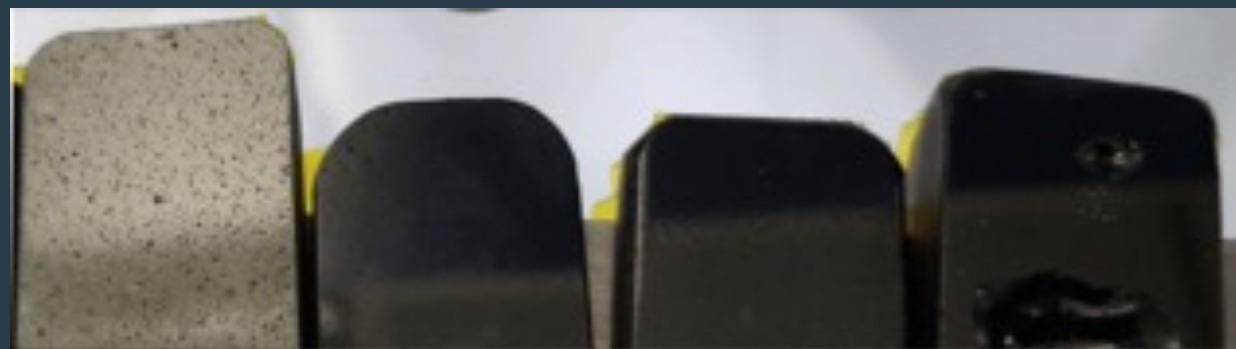
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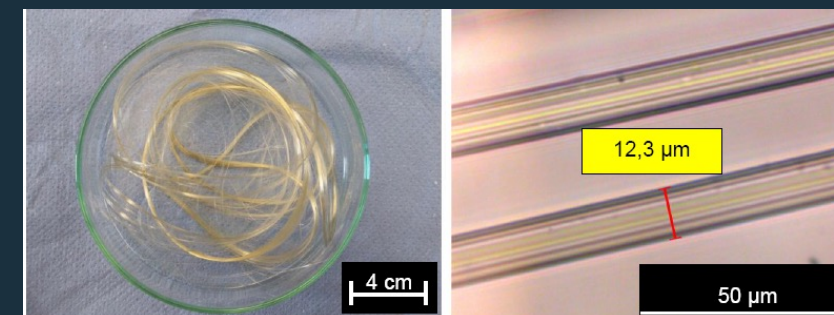
Allan, S. M., et al. (2013). "High-temperature microwave dielectric properties and processing of JSC-1AC lunar simulant." Journal of Aerospace Engineering **26**(4): 874-881.



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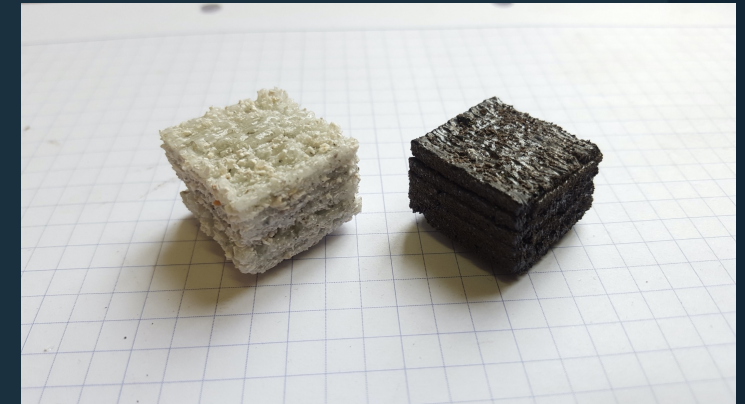
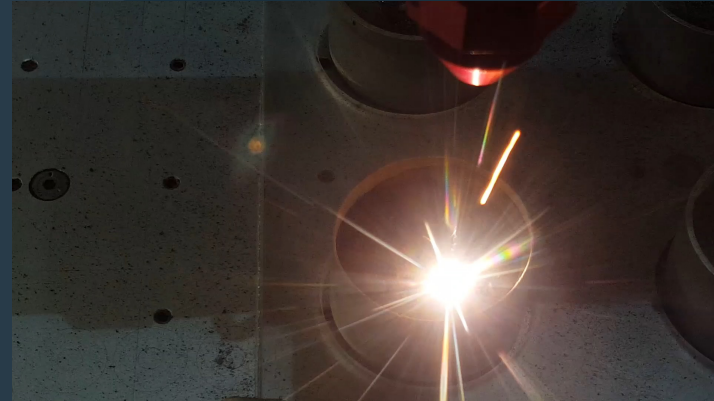
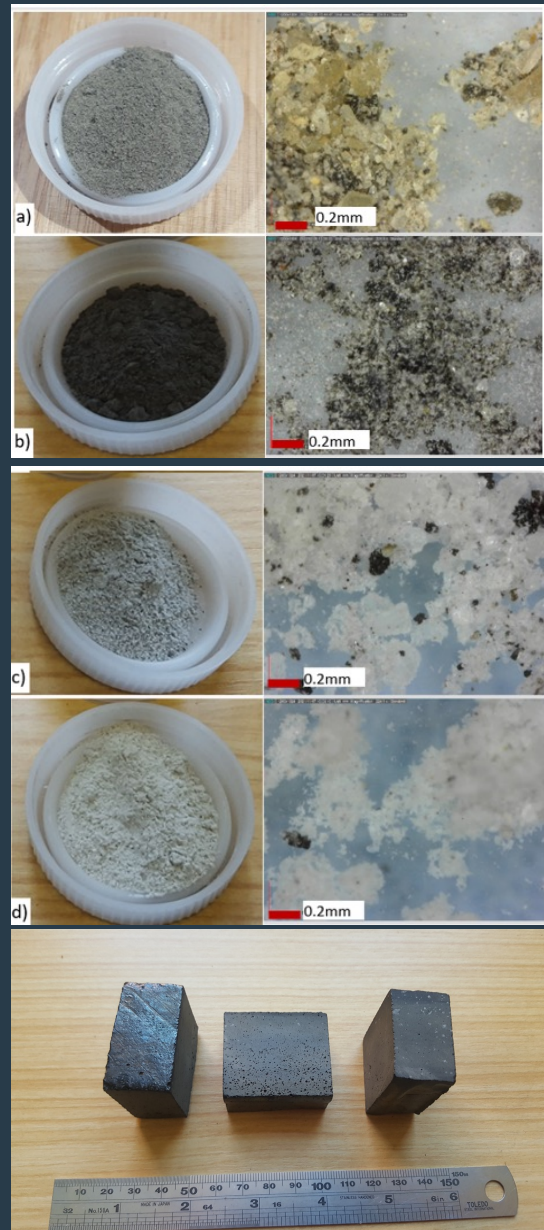


Schleppi, J., et al. (2019). "Manufacture of glass and mirrors from lunar regolith simulant." Journal of Materials Science **54**(5): 3726-3747.

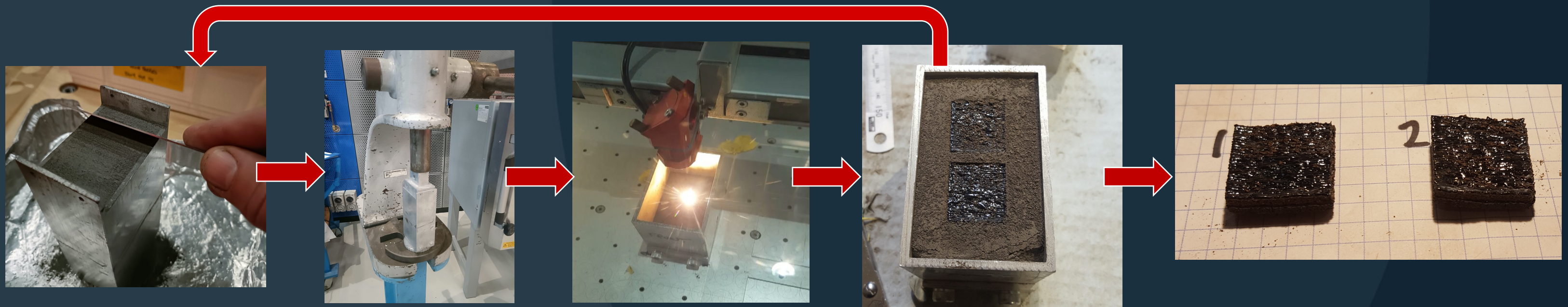


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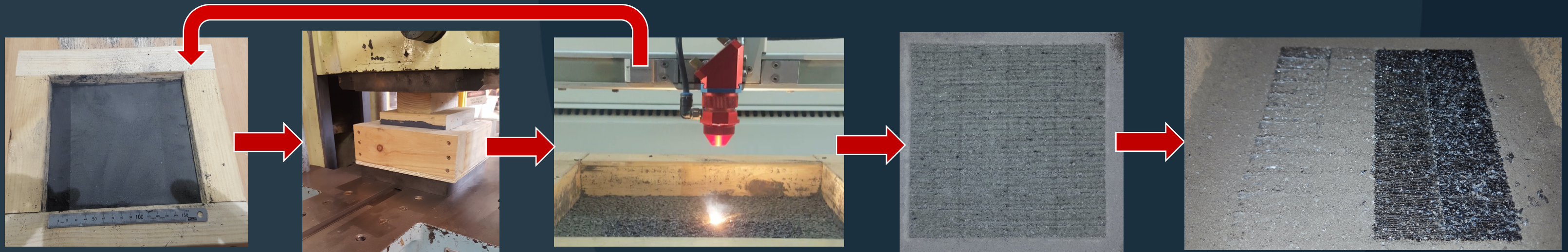
Can laser processing of regolith by SLM, DLS and welding be scaled to a level where they are useful for lunar civil construction?



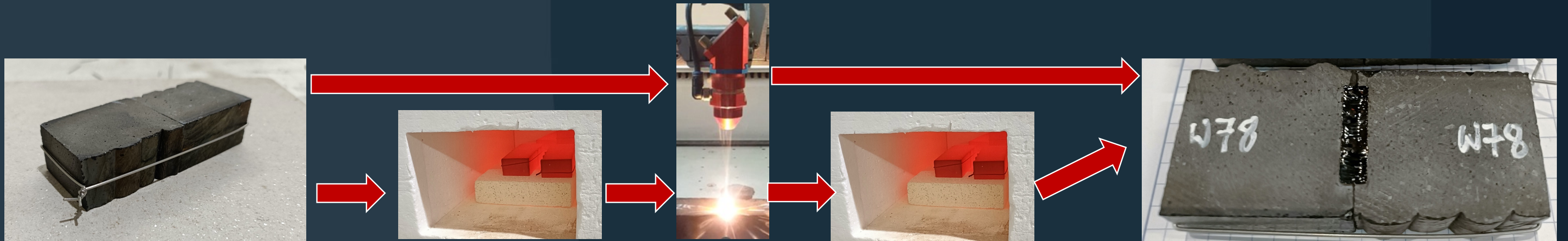
SLM

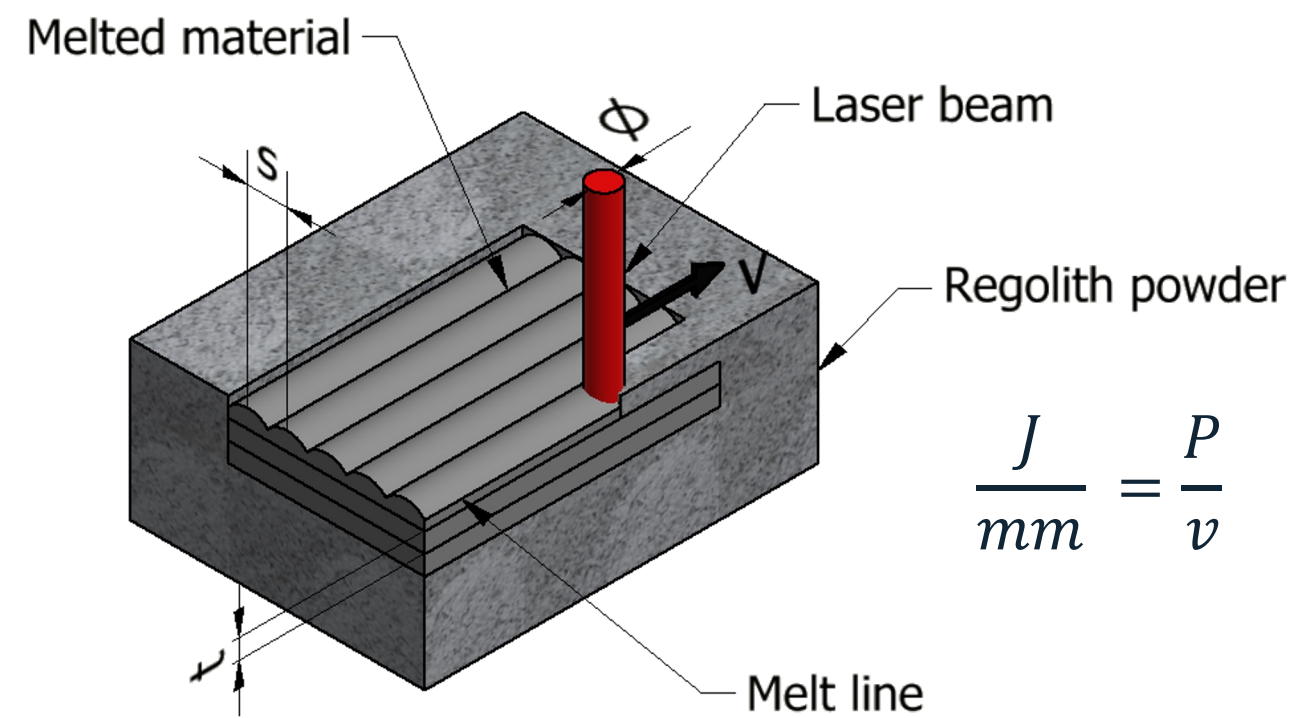


DLS

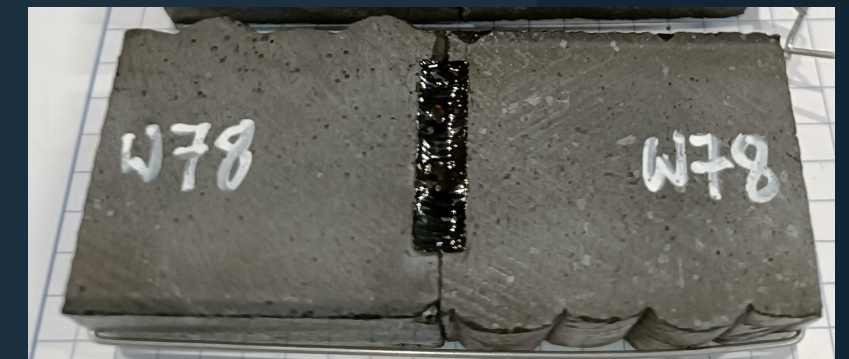
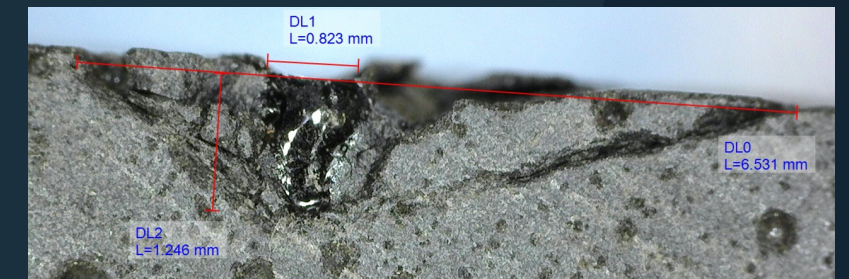


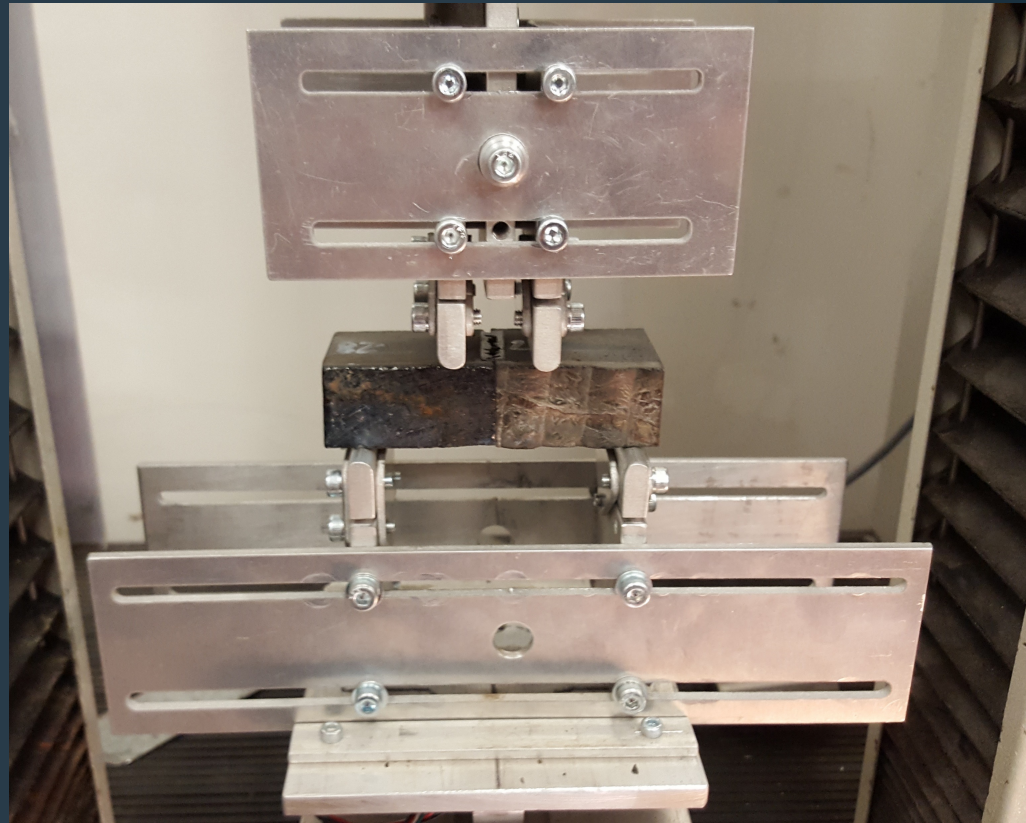
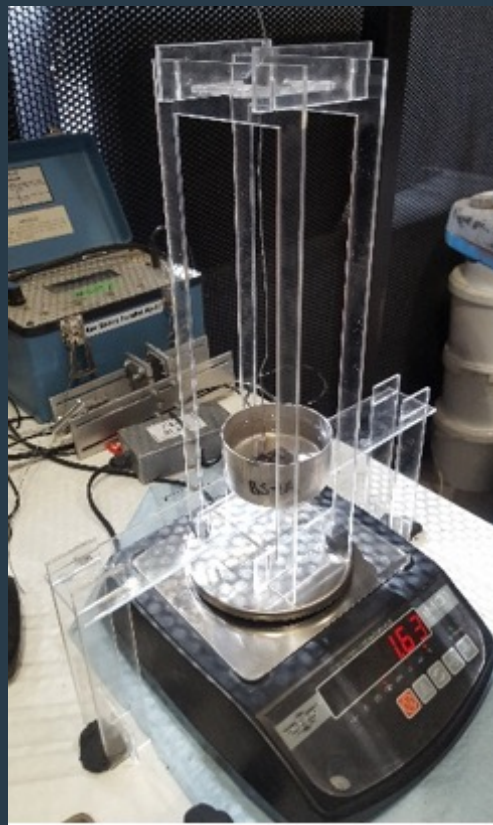
Welding





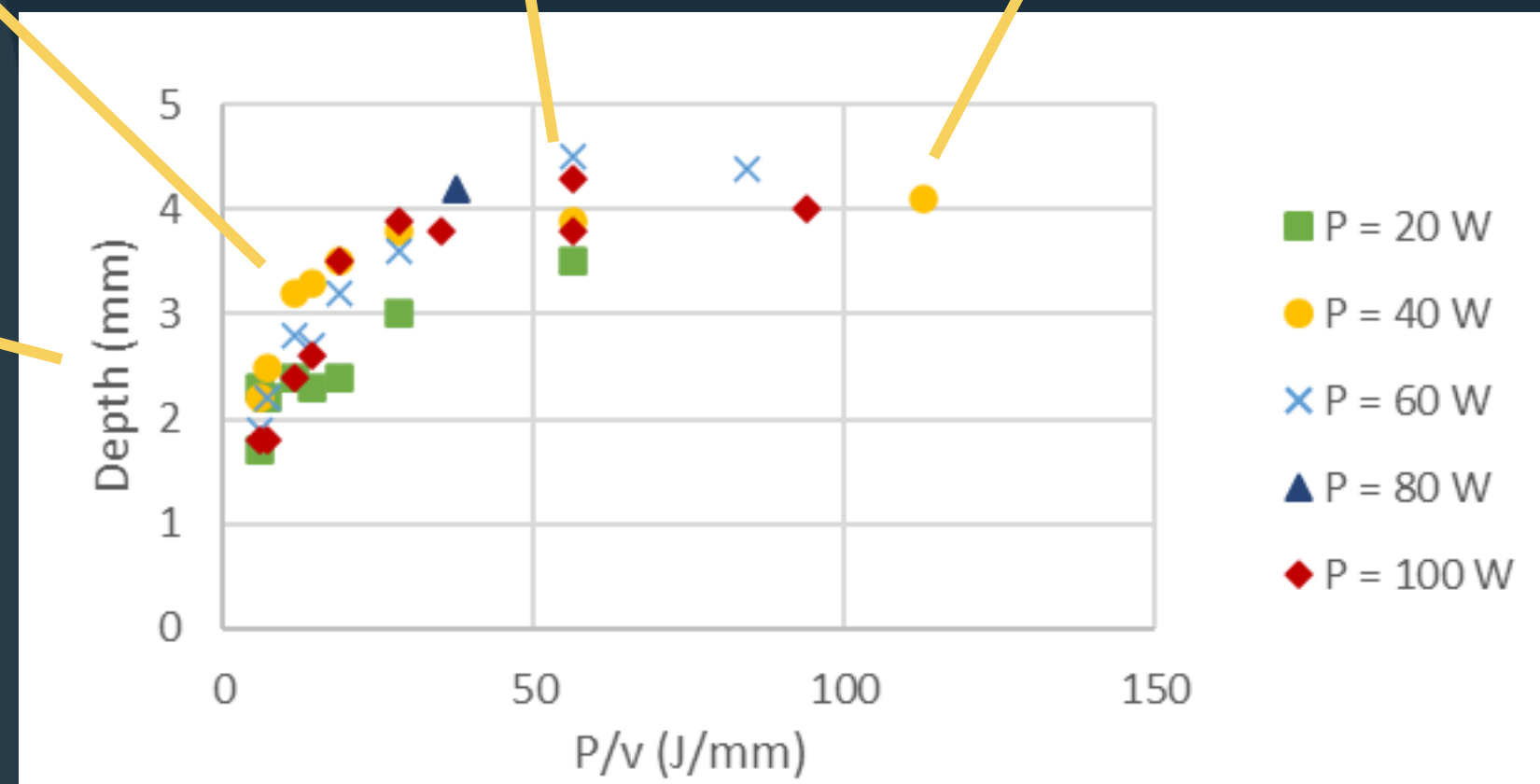
$$\frac{J}{mm} = \frac{P}{v}$$

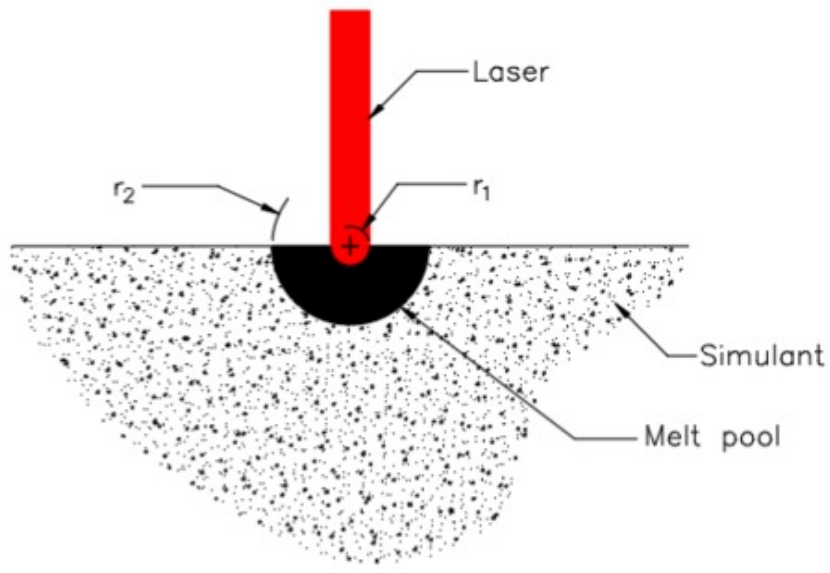




Outcome 1 – Penetration depth is limited by material thermal properties





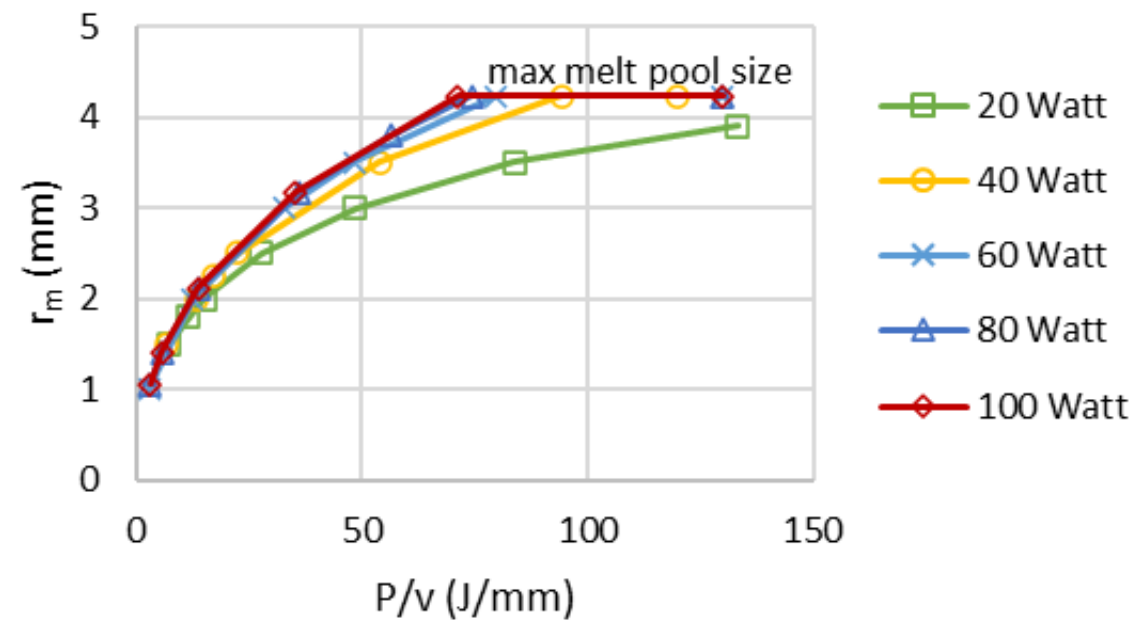


$$r_m = r_{sp} \left(1 + \frac{T_{sp} - T_m}{T_m - T_0} \times \frac{\lambda_m}{\lambda_s} \right)$$

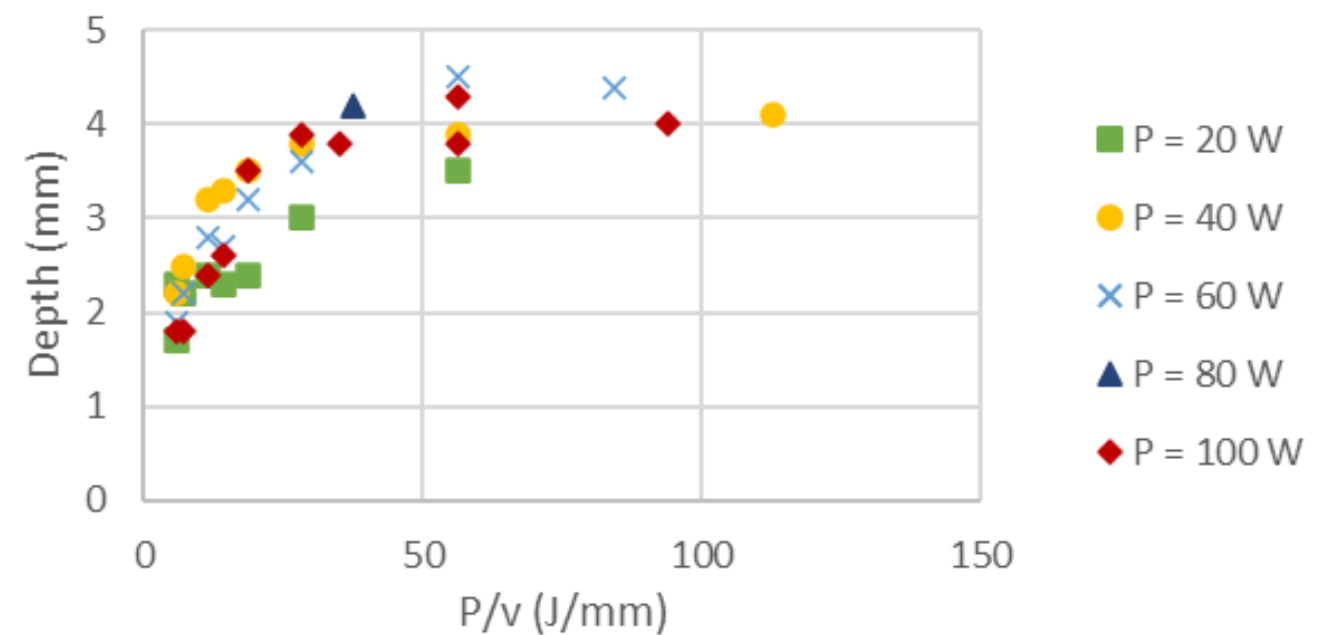
$$P_{cond} = 2\pi\lambda_s r_m (T_m - T_0)$$

$$P_{enth} = \frac{\pi\rho_s v}{2} (r_m^2 - r_{sp}^2) (C_{p,s} [T_m - T_0] + \Delta H) + \frac{P_{cond} C_{p,m} \rho_m v}{\lambda_m} \left(\frac{(r_m^2 - r_{sp}^2)}{2} + \frac{r_m^3 - r_{sp}^3}{3r_m} \right)$$

Theoretical

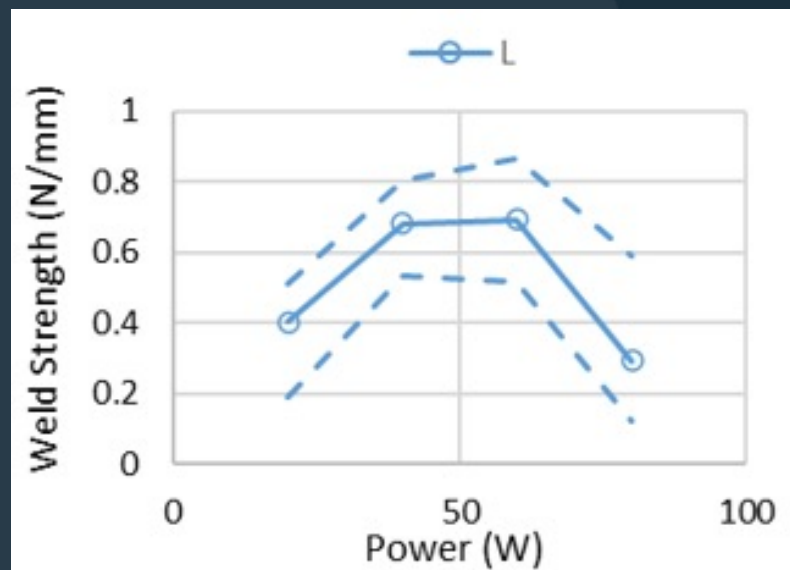
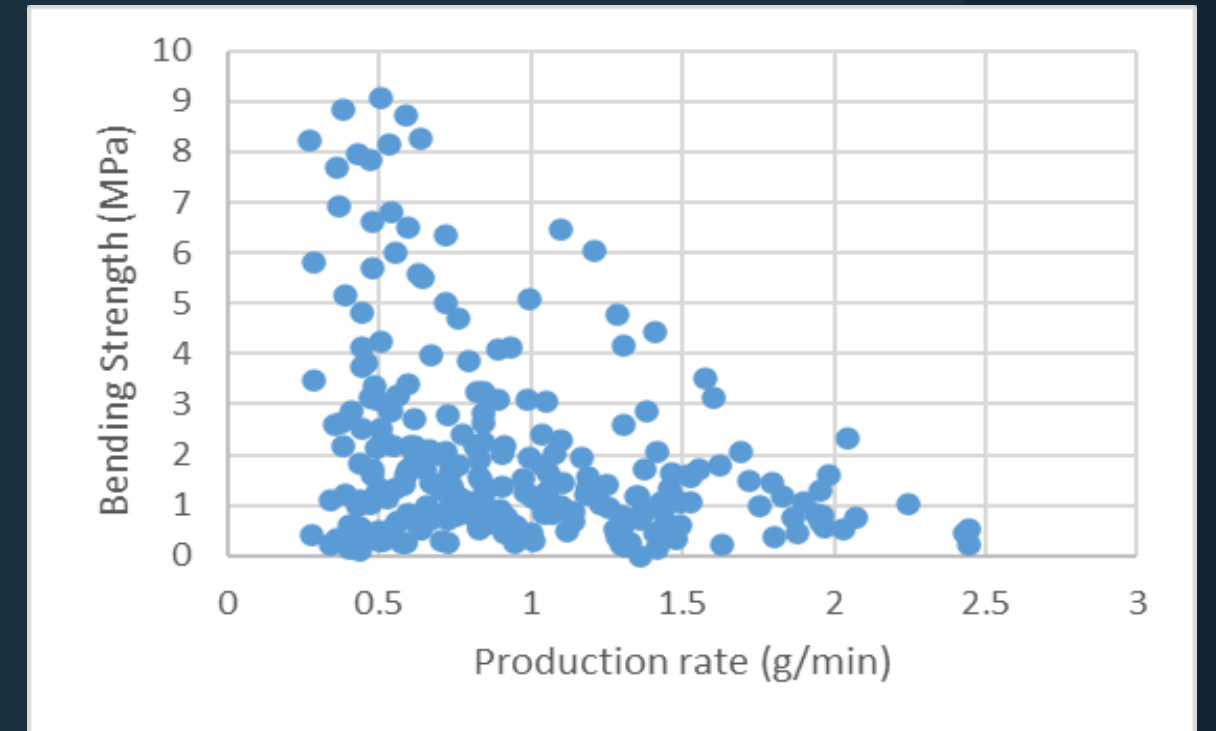
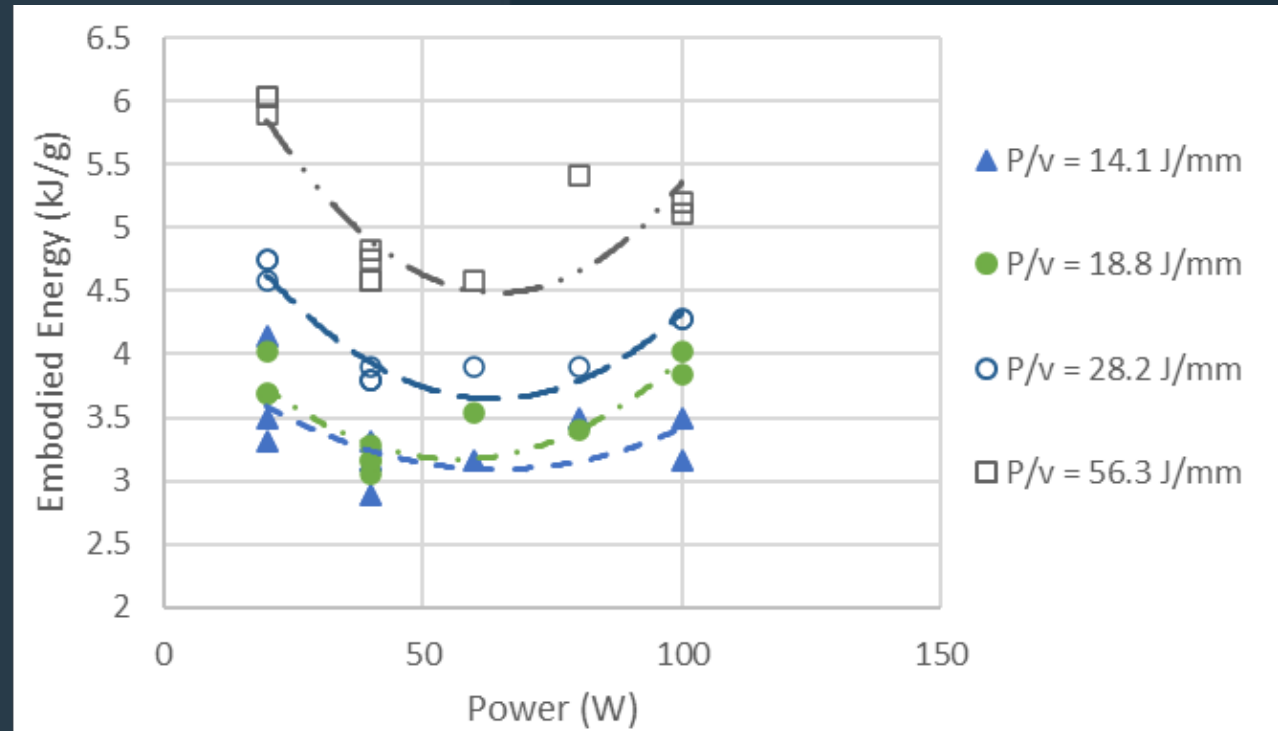


Experimental

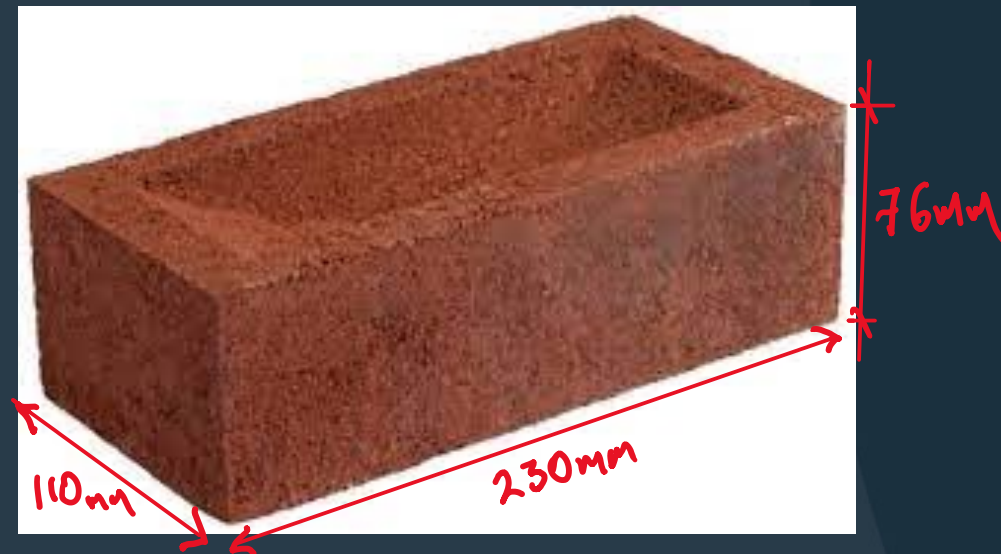


Outcome 2 – SLM and DLS production rates are low

Power↑ Velocity↑ Production rate↑ Strength ? Efficiency ?



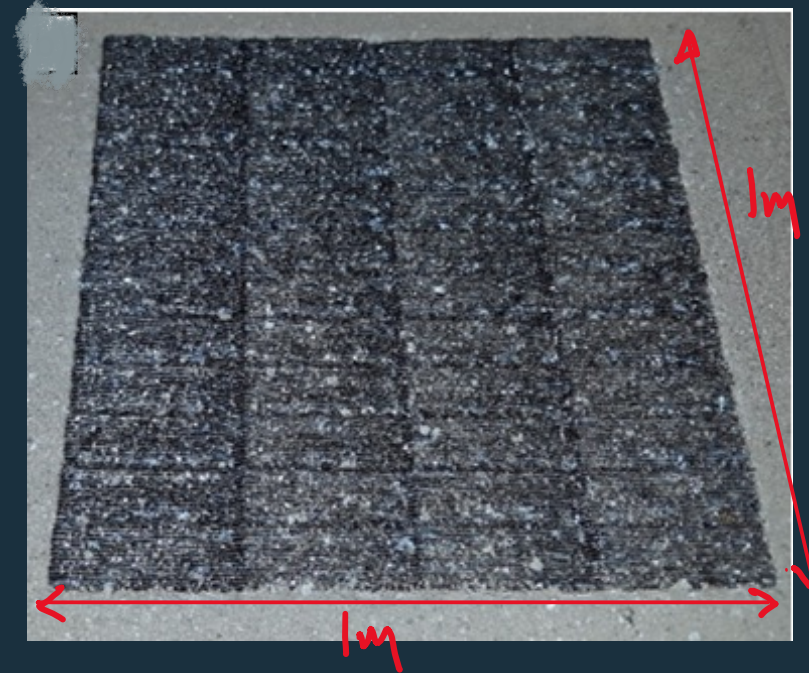
SLM



Standard brick (3.5 kg)

Production time > 1 day

DLS

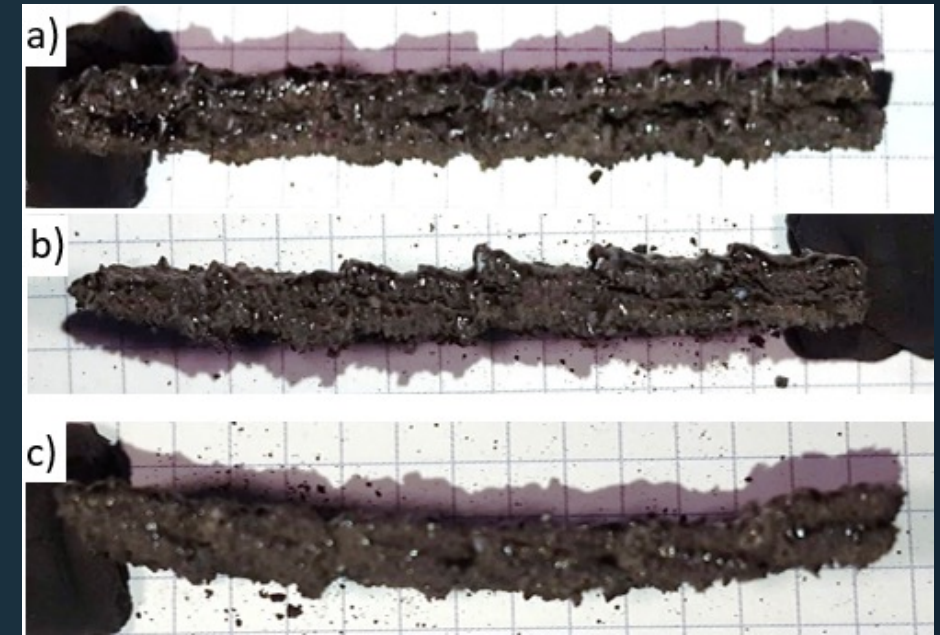
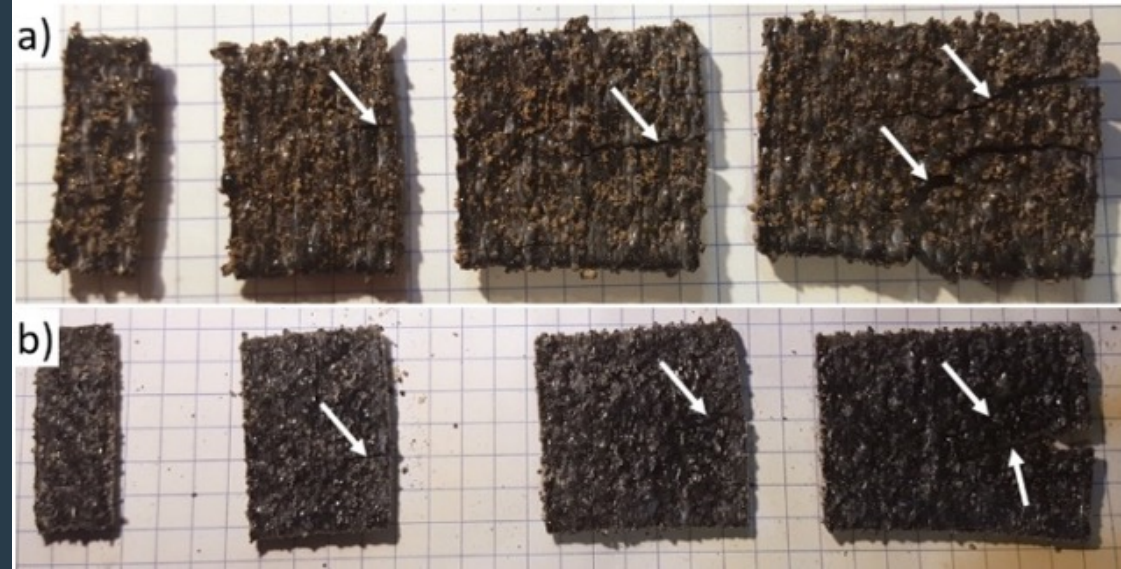


1 m² DLS area

Production time > 4 days

**Outcome 3 – Product size can only be increased by
optimising the scanning strategy**



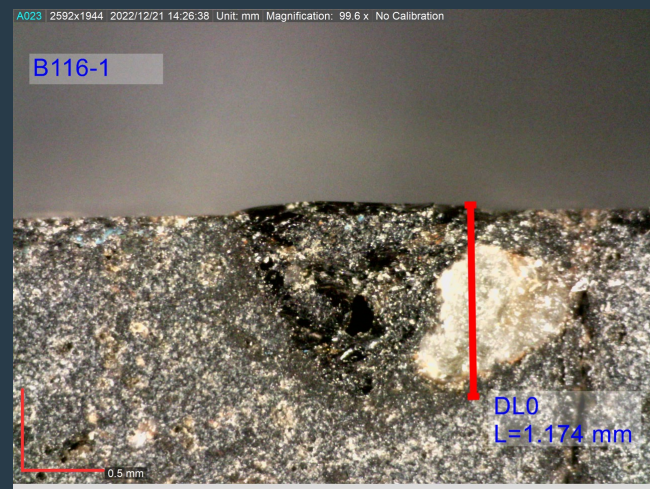
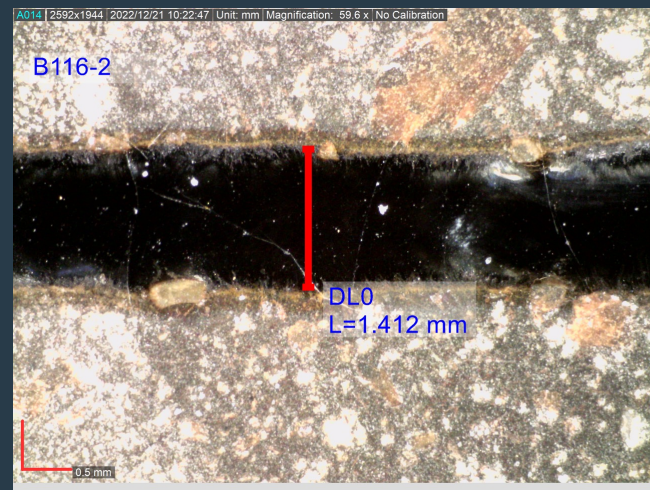
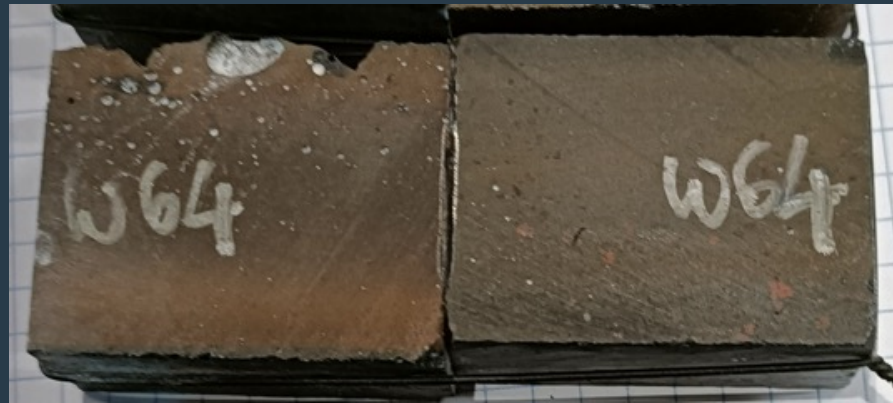


Tile dimensions (mm)	Flexural strength (Mpa)
15 × 30	7.2 MPa
30 × 30	1.5 MPa
30 × 60	0.34 MPa

Outcome 4 – Without preheating, cast basalt welds crack but have some residual strength

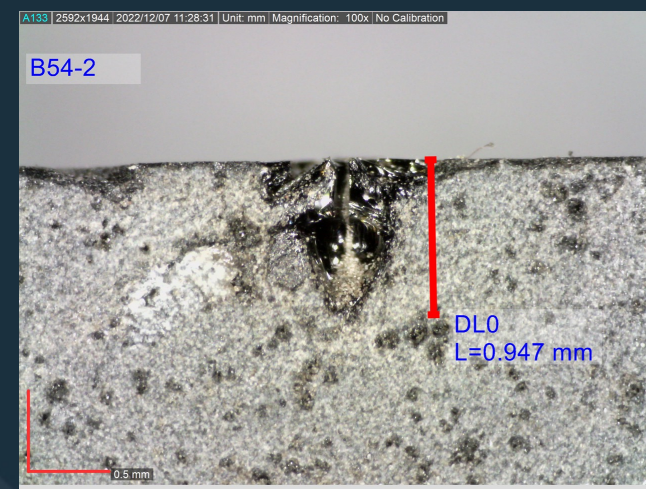


With preheating and annealing



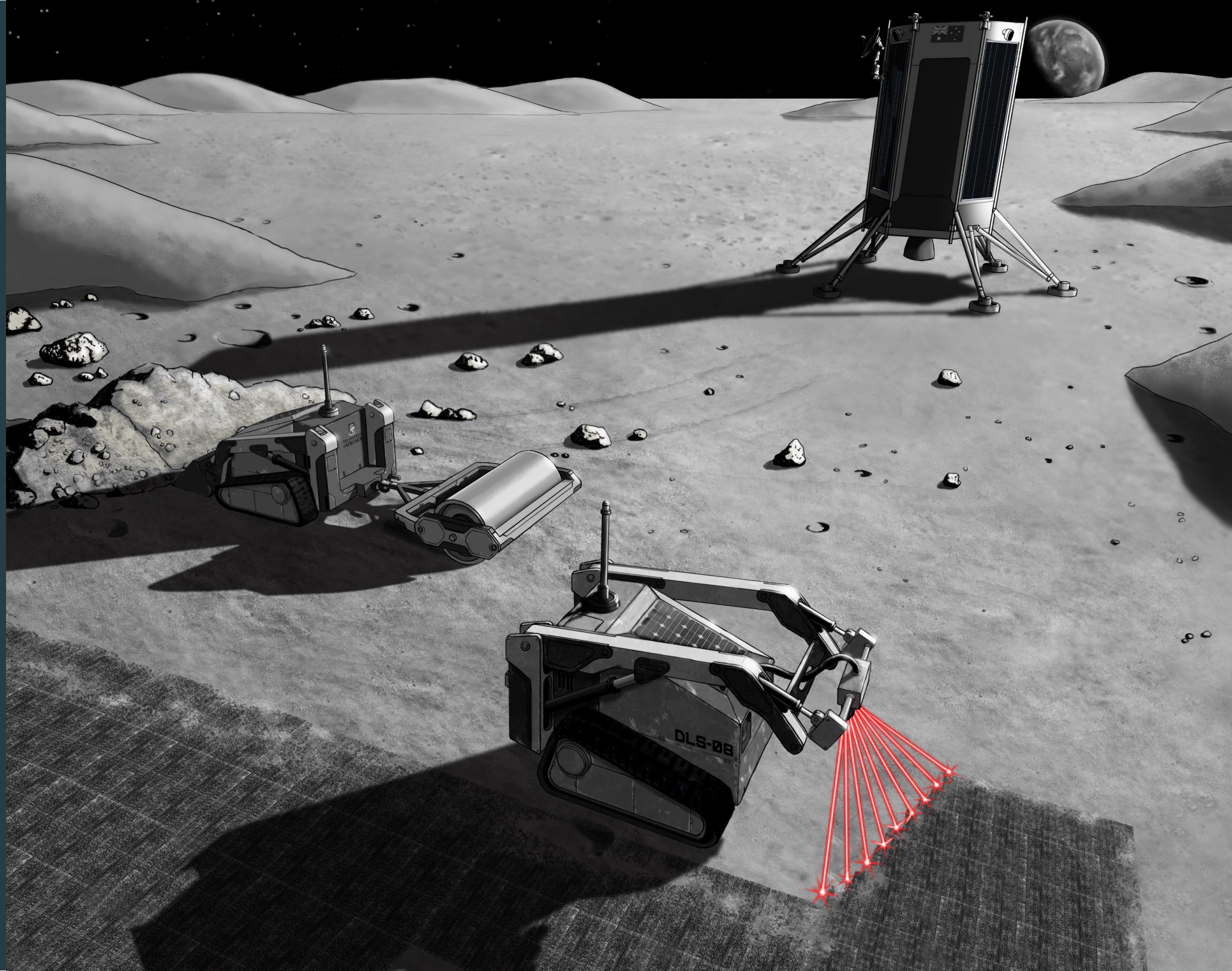
Max strength ≈ 12 MPa

Without preheating and annealing



Max strength ≈ 0.9 MPa





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Any questions?

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