Additive manufacturing using extra-terrestrial multi-component ceramic materials

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INTRODUCTION
The aim of this research was to investigate the application of Laser Additive Manufacturing to process ceramic multicomponent materials into 3D layered structures. These ceramic materials matched those found on the Lunar and/or Martian surface. These indigenous extra-terrestrial materials could potentially be used for manufacturing physical assets onsite (i.e., off-World) on future planetary exploration missions and could cover a range of potential applications including infrastructure, radiation shielding, thermal storage, etc. [Figure 1].

METHODOLOGY
An Ytterbium fiber laser (NIR) and a CO₂ (IR) laser were used to provide a range of thermal energies to selectively fuse regions of a powder bed containing the Lunar and Martian regolith materials and manufacture complex structures on a layer-by-layer strategy [Figure 5].

FINDINGS
• Identification of a suitable process window that allowed successful fabrication of three dimensional specimens from the multi-component Lunar and Martian regolith ceramic materials.
• Material Hardness for sintered Lunar regolith identified as 660 ± 2 VHN, harder than common soda lime glass.
• Internal relative porosity of 40% (Lunar) and 59% (Martian) was observed [Figure 4].
• Substantial change in the particular element concentration due to the laser processing was identified [Figure 6].
• Both materials showed better laser absorption characteristics when the NIR laser was used [Figure 7].