ARE LASER-INDUCED MELTING EXPERIMENTS SUITABLE TO SIMULATE METEORITE IMPACT PROCESSES?

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Introduction: Projectile and target material may get completely molten and mixed during the highly dynamic hypervelocity impact process [1]. This mixing is accompanied by significant element partition processes [2,3]. Laser-induced melting experiments (LME) were conducted in order to produce and analyze target and projectile melts and their mixtures under more idealized conditions.

Experimental setup: LME were performed with the Trumpf Haas HL 3006D welding facility at the Technical University of Berlin (Nd:YAG-Laser; output power 2kW). Centimeter-sized cuboids of sandstone (target) and iron meteorite or Cr-V-Co-Mo-W-steel (projectiles) were fixed either separately or laterally together on an Al plate. The laser beam was conducted along 1 cm lines across the two materials with robotic machinery. Samples were cut out from the melt tracks parallel to the laser beam trajectory and prepared for microprobe analyses (JEOL JXA-8500F field emission microprobe at MFN).

Results: The LME were able to produce features very similar to those of impactites from impact craters and cratering experiments [2,3]: formation of lechatelierite, partially to completely molten sandstone and injection of projectile droplets into the target melts. The target and projectile melts have experienced significant chemical modifications during the impact. Inter-element ratios of the projectile tracers Cr, V, Co, Ni, Mo, and W within the contaminated target melts are strongly modified from the original ratios in the projectile. This fractionation process is most likely the result of differences in the lithophile or siderophile character of the projectile tracer elements, or more precisely, of differences in their reactivity with oxygen [1] during interaction of metal melt with silicate melt. Fe, Cr and V of the projectile droplets nearly totally partition into the sandstone melt, whereas the siderophile Co, Ni, Mo and W almost entirely remain in the projectile droplets. In addition, emulsion textures, observed within the contaminated target melts, indicates phase separation into Fe-rich and Si-rich silicate melts during the quenching process. This liquid immiscibility phenomenon was recently described for the Wabar impact glasses [2].

Conclusions: The laser technique does not reproduce typical high-pressure shock effects, e.g. PDF in quartz, but it can be definitely used to simulate high-temperature effects of an impact, mainly for the investigation of geochemical processes. This method allows (i) separate high-temperature (partial) melting of target and projectile material to better constrain primary melt heterogeneities before mixing and (ii) the quantification of element partitioning processes between coexisting projectile and target melts.

References: [1] Gibbons et al. 1997. *Proceedings of the LPSC 7th*, 863–880. [2] Hamann et al. 2013. *Geochemica et Cosmochemica Acta* 121: 291–310. [3] Ebert et al. 2014. *Geochemica et Cosmochemica Acta* 133, 257–279.