

**THE REACTION OF CARBONATES IN CONTACT WITH SUPERHEATED SILICATE MELTS:
NEW INSIGHTS FROM MEMIN LASER MELTING EXPERIMENTS.**

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Introduction: Carbonates are present in about one third of the known impact structures on Earth [1]. In contrast to silicates, they are believed to decompose into CO₂, CaO, and MgO upon impact (e.g., [2]). Recently, the formation of carbonate melts has been postulated on the basis of petrographic observations for several impact structures (e.g., [1,3,4]). The salient point of these studies is the presence of round blebs and globules of calcite disseminated in silicate impact melt. These textures have been interpreted as being formed by liquid immiscibility, seemingly proving the coexistence of carbonate and silicate melts. However, evidence from terrestrial craters has been discussed quite controversially, as exemplified by contrasting studies on Meteor Crater [4,5]. Moreover, results from shock experiments and numerical modeling (e.g., [6,7]) suggest that both processes can occur. Here, we discuss the results of four laser melting experiments involving carbonates in contact with silicates, performed in the Multidisciplinary Experimental and Modeling Impact Research Network (MEMIN).

Methods: We used a ytterbium fiber laser (8 kW, 1070 nm wavelength, operated in continuous-wave mode) at Fraunhofer-Institut für Kurzzeitdynamik, Freiburg, Germany, to rapidly melt and partially vaporize targets made of a silicate layer (sandstone or basalt, 0.5–1 cm thickness) attached onto a carbonate layer (Carrara marble or Savonnières limestone, 2 cm thickness). The laser penetrated through the silicate layer into the carbonate layer below, and the laser–matter interaction zone was recorded with a video camera, an infrared camera, and a high-speed camera. The reaction products were investigated after the experiments using a combination of optical microscopy, SEM, EMPA, and Raman spectroscopy.

Results: In the sandstone experiments, the laser formed a pool of siliceous melt that quenched within ~18 s from >2100 to 500 °C ($dT/dt \approx 89$ °C) to a transparent to milky glass. The glass is mainly a mixture of SiO₂ and CaO that generally shows increasing CaO contents towards a carbonate reaction zone that lies below the silicate melt pool. Locally, silicate emulsions formed as the melt passed through a miscibility gap in the system SiO₂–CaO. Moreover, pseudowollastonite, CaSiO₃, crystallized close to the carbonate reaction front in the siliceous melt.

In the basalt experiments, the laser formed a pool of basaltic melt on top of a carbonate reaction front as well, but penetrated much further into the carbonate layer. The basaltic melt in the marble experiment quenched within ~36 s from 1900 to 500 °C ($dT/dt \approx 29$ °C/s) to a brown glass, whereas the marble at the irradiation area cooled within ~12 s from >2100 to 500 °C ($dT/dt \approx 133$ °C/s). The basaltic melt is thoroughly homogenized, mimicking the bulk composition of the original basalt. However, it is distinctly enriched in CaO towards the carbonate reaction zone. Moreover, at the contact between basaltic melt and carbonate reaction front exists an assemblage of quenched, Ca,Fe,Al-rich silicate melt, equant, idiomorphic, Si,Al-bearing calcite crystallites, lath-shaped, Ca,Si-rich, volatile-bearing quench crystals, and MgO. This assemblage resembles quenched immiscible silicate and carbonatite liquids known from quenching experiments (e.g., [8,9]). Moreover, merwinite, Ca₃Mg(SiO₄)₂, crystallized in the basaltic melt close to the carbonate reaction front.

Discussion: The formation of CaO-enriched silicate glasses and crystalline phases such as pseudowollastonite and merwinite document high-temperature reactions between the silicate melts and the molten or decomposed carbonates. Similar reaction products are known from the Houghton [10] and Chicxulub [11] impact structures. However, some textures observed in the basalt experiments are reminiscent of emulsion textures in silicate–carbonatite quenching experiments [8,9], suggesting the action of an immiscible carbonate melt phase that precipitated upon quenching so far unidentified Ca,Si-rich, volatile-bearing crystallites and equant, idiomorphic calcite crystallites.

References: [1] Osinski G. R. and Grieve R. A. F. 2008. *GSA Special Paper* 437:1–17. [2] Kieffer S. W. and Simonds C. H. 1980. *Reviews of Geophysics* 18:413–181. [3] Graup G. 1999. *Meteoritics & Planetary Science* 34:425–438. [4] Osinski G. R. et al. 2015. *Earth and Planetary Science Letters* 432:283–292. [5] Hörz F. et al. 2015. *Meteoritics & Planetary Science* 50:1050–1070. [6] Langenhorst F. et al. 2002. *High Pressure Shock Compression in Solids V*. Springer, pp. 1–27. [7] Ivanov B. A. and Deutsch A. 2002. *Physics of the Earth and Planetary Interiors* 129:131–143. [8] Lee W. and Wyllie P. J. 1997. *Contributions to Mineralogy and Petrology* 127:1–16. [9] Brooker R. A. and Kjarsgaard B. A. 2011. *Journal of Petrology* 52:1281–1305. [10] Martinez I. et al. 1994. *Earth and Planetary Science Letters* 121:559–574. [11] Deutsch A. and Langenhorst F. 2007. *GFF* 129:155–160.