

Shock-induced devolatilization from calcite in an open system using a two-stage light gas gun

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We investigated shock-induced decarbonation of non-porous calcite in an open system at a wide range of peak shock pressures using a two-stage light gas gun and a quadrupole mass spectrometer. A new experimental technique that avoids chemical contamination from the acceleration gas from the gun was developed. We also conducted high-speed imaging and spectroscopic observations simultaneously to investigate the validity of our experimental procedure. We newly found that the decarbonation efficiency along the Hugoniot curve changes around 50 GPa, which is close to the predicted pressure for incipient decarbonation by ANEOS. Although shock-induced decarbonation was detected at the pressure lower than 50 GPa as well as the previous experimental studies, decarbonation may be caused by local energy concentration due to shear banding, resulting in low decarbonation efficiency. We constructed a simple theoretical model for shock-induced decarbonation during isentropic release based on the entropy method and the lever rule under our experimental condition. The predicted CO₂ amount as a function of peak shock pressure agrees well the experimental results at >50 GPa, strongly suggesting that the shock-induced CO₂ amount is determined only by the entropy for the peak shock state, incipient and complete decarbonation at the ambient pressure. We can use the new method for the quantitative measurements of the chemical composition of impact-induced gases from solid materials without any modification. The new technique is very useful to investigate the required peak shock pressure for vaporization/devolatilization of geologic materials and the final chemical composition in impact-induced vapor clouds.

Keywords: Impact-induced devolatilization, Gas-phase chemical analysis, Open system, Two-stage light gas gun, Mass spectrometry, Carbonate