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Perspective

Interaction between Vapour Clouds Caused By Impacts and the Surrounding Atmosphere

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DESCRIPTION

The evolution of planets may be significantly influenced by the interaction between vapour clouds caused by impacts and the surrounding atmosphere. A series of impact tests were undertaken in the companion study to provide detailed observations of this contact mechanism. Diatomic molecular spectroscopy laboratory investigations offer very precise observational limits on this mechanism. In this study, they test these observational restrictions against five distinct physical models of the interaction process. The findings of the calculations show that neither the impact-induced vapour nor the shock front between the impact vapour and the surrounding atmosphere could have produced the high-temperature radiation that was observed. The radiation is really due to vapour ablation from the surface of tiny, extremely fast projectile pieces that were entrained in the impact vapour cloud. Calculations using a straightforward ablation model show that a relatively high heat of vaporization is necessary to explain the observed tiny ambient-pressure dependence of the initial radiation temperature.

The predicted heat of vaporization is comparable to the energy required for the dissociation of the polymer that makes up bullet pieces into carbon radicals. The fact that the temperature of radiation is only little influenced by atmospheric composition strongly suggests that the majority of radiation originates from very small impact fragments that are similar in size to the mean free path of ambient atmosphere, or the "free-molecular flow regime." These findings could have a wide range of effects on planetary science, such as increasing the amount of impact vapour and melt produced in dense atmospheres, producing metastable chemical compounds in the ablation vapour around high-speed impact fragments, and causing an oblique impact to produce extremely strong downrange radiation. In the evolution of planets, the interaction between an atmosphere and a vapour cloud caused by an impact is crucial.

At the NASA Ames Vertical Gun Range (AVGR), a series of impact tests were done under various atmospheric pressures and compositions in order to investigate these events under controlled conditions. To generate the high degrees of vaporization anticipated in planetary-scale impacts of melts and silicates, plastic projectiles were fired into targets that were liquid water in those studies. High-speed spectrometers were used to study the interaction between impact-induced vapour clouds and the surrounding atmosphere. The spectrometers in the studies conducted by were concentrated on the leading edge of downrange-moving vapour clouds, which are mostly produced by projectiles. Blackbody continuity and strong molecular band emission of carbon compounds are both visible in the observed spectra. Several clearly defined constraints on the source of the observed molecular radiation are provided by analysis of the observed emission spectra. Between 4500 and 5500 K, the temperature of molecular radiation is particularly high. At high ambient pressures, the initial radiation temperature is higher. At higher ambient pressures, the decline of radiation temperature happens more quickly. At higher ambient pressures, the intensity of the radiation is greater. The initial few to twenty microseconds see an increase in radiation power followed by a decline. All of the observed spectra had similar molecular band emission and blackbody continuum strengths. The predicted temperatures of molecular radiation and blackbody radiation are essentially equivalent.

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