SPH MODELLING OF ENERGY PARTITIONING DURING IMPACTS ON VENUS ; T. Takata and T. J. Ahrens. Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

Impact cratering of the Venusian planetary surface by meteorites was investigated numerically using the Smoothed Particle Hydrodynamics (SPH) method. Venus presently has a dense atmosphere. Vigorous transfer of energy between impacting meteorites, the planetary surface, and the atmosphere is expected during impact events. We have concentrated our investigation on the effects of the atmosphere on energy partitioning and the flow of ejecta and gas.

The SPH method is particularly suitable for studying complex motion, especially because of its ability to be extended to three dimensions [1,2,3,4]. In our simulations, particles representing impactors and targets are initially set to a uniform density, and those of atmosphere are set to be in hydrostatic equilibrium. Target, impactor, and atmosphere are represented by 9800, 80, and 4200 particles, respectively. A Tillotson equation of state for granite is assumed for the target and impactor, and an ideal gas with constant specific heat ratio is used for the atmosphere. Two dimensional axisymmetric geometry was assumed and we modelled normal impacts of 10km diameter projectiles with velocities of 5, 10, 20, 40 km/s, both with and without an atmosphere present.

The resulting flow fields show that the atmospheric gas and entrained target particles above the crater move upward at close to the escape velocity of Venus, whereas a strong radial horizontal gas flow along the surface is observed around the crater at lower altitudes [fig.1], in agreement with the previous work of Ivanov *et al.*[5] and Roddy *et al.*[6]. Coupling to the atmosphere is strong, because the size of the impactor is comparable to the scale height of the atmosphere ($\sim$ 15km). Not only ejecta, but a large amount of the atmospheric gas is accelerated to escape velocity. Because of the surrounding high gas pressure, however, the upward flow of the target particles at the bottom of the ejecta curtain is slower than in the no atmosphere case. These results qualitatively agree with experimental data [7].

The transfer of the kinetic energy of the impactor to the atmosphere continues after the impact. Approximately 10% of the kinetic energy is transferred directly from the impactor to the atmosphere [fig.2,3]. In the case of low impact velocity (5km/s), a greater fraction of the impact energy is partitioned into internal energy of the impactor and atmosphere than in the high impact velocity case (40km/s). When the atmosphere is present, the ratio of the internal energy of the impactor to that of the target is slightly smaller than in the case of vacuum [fig.3]. This may imply that the direct energy transfer from the impactor to the target is more efficient with an atmosphere.

In conclusion, impact cratering in the presence of an atmosphere can modify the energy partitioning among impactor, planetary surface, and atmosphere. For 10km diameter impactors, the Venusian atmosphere obtains $\sim$10% of the impact energy directly. This quantity is more than twice as large as for the earth (<5% [8]).

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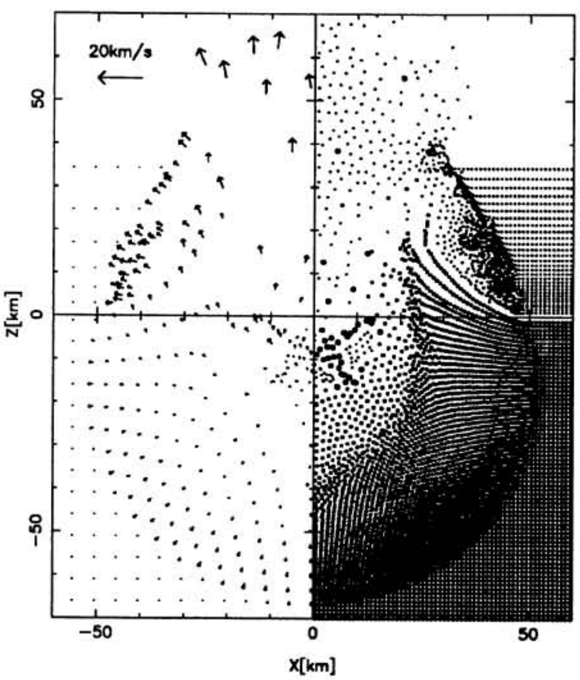

Fig.1. The particle positions (X>0) and velocities (X<0) for an impact on the Venusian surface with an atmosphere at t=7.7s after the impact. The impactor size is 10km and the impact velocity is 20km/s. The large, medium, and small dots represent the particles of the impactor, the target, and the atmosphere, respectively.

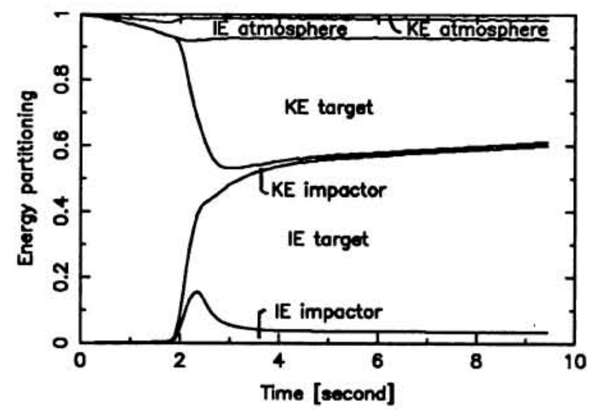

Fig.2. Energy partitioning (fraction of total) as a function of time in the same case as Fig.1. t=0 is set when the meteorite is at the altitude of 40km. The energy is normalized by the initial energy of the impactor. KE and IE denote kinetic and internal energy, respectively.

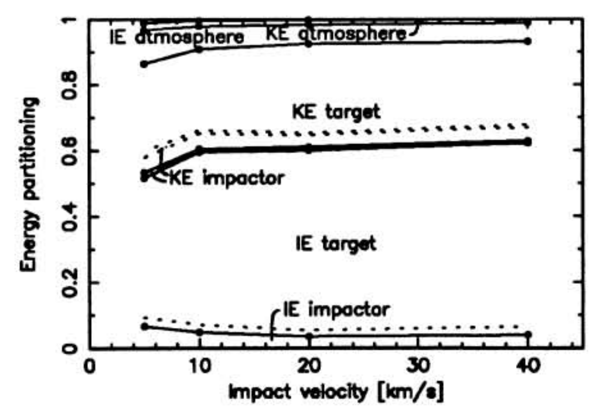

Fig.3. Final energy partitioning (fraction of total). Solid and dotted lines represent cases with and without atmosphere, respectively.