TRANSIENT CAVITY CALCULATIONS OF CENTRIFUGE CRATERING EXPERIMENTS AT TWO DIFFERENT VALUES OF GRAVITY, M.G. Austin, J.M. Thomsen, and S.F. Ruhl, Physics International Co., 2700 Merced St., San Leandro, CA 94577

The relationship of transient cavity depth to final crater depth is important for understanding impact craters on planetary surfaces. In general this relationship may depend on many different factors. Some light may be shed on the role that gravity plays by looking at two continuum mechanics computer calculations performed to simulate laboratory-scale explosion cratering on a geotechnic centrifuge at two different values of acceleration.

The experiments were Boeing Aerospace Company Shots 25-0 and 25-X (1). 4.08 gm PETN high explosive charges were half-buried in Permaplast clay test beds which were spun on the centrifuge to 10 and 517 times earth gravity (1g) for shots 25-0 and 25-X, respectively, and then the charges were detonated. Figure 1 shows the experimental crater profiles and the original position of the PETN. The 10 g crater produced was nearly hemispherical and about 6 cm deep, whereas the 517 g crater was saucer-shaped, a little less than 3 cm deep, and almost 6 cm in diameter.

The two-dimensional axisymmetric finite difference calculations (2) used the appropriate values for the gravitational acceleration (10 g and 517 g) and also initialized the stress distribution in the clay target to the correct overburden pressures. The clay has an initial zero pressure density of 1.53 gm/cm^3 , a cohesion of 11 kPa and an angle of internal friction of 1.2 degrees. The hydrostatic loading-unloading relationship used is that of a similar clay, plasticene modeling clay (3). The experimental test bed was about 15 cm deep but for these calculations the target was treated as an infinite half-space. The PETN has a Chapman-Jouguet pressure of 32 GPa and a detonation velocity of 8300 m/s.

The calculated work done against gravity in the first 100 μs after the PETN detonates is shown in Figure 2. It is much less than the kinetic and internal energy imparted to the Permaplast clay shown in Figure 3. The transient cavities for both calculations at 100 μs are hemispherical and about 3.5 cm deep as shown in Figure 4. At this time the calculated transient cavity in the 517 g calculation is only very slightly smaller than the one for 10 g, but is already deeper than the experimental 517 g crater depth and still growing deeper. At 400 μs the transient cavity growth has slowed greatly but both cavities are still hemispherical and about 5.5 cm deep, almost the depth of the experimental 10 g crater and about twice the depth of the experimental 517 g crater.

Since the computed work done against gravity was much smaller than the kinetic and internal energy in the cratering flow field during the time of growth of the transient cavity, the calculated crater growth is very similar for the first 400 μs for both the 10 g and the 517 g calculations. Comparison of these calculated early transient cavities to the experimental final crater profiles implies that late time inward material motions or late time adjustment to overburden pressure may have dominated the final crater shape in the 517 g experiment, but not in the 10 g experiment. These results provide some support for the idea that, in the gravity dominated regime, planetary impact craters may have formed large transient cavities before assuming their final shallower depths. Acknowledgement- This analysis was partially supported by NASA under contract NASW 3168. Calculations were done for Defense Nuclear Agency, DNA 001-77-C-0211. Refs-1.) Schmidt & Holsapple, DNA 4999,May 1979. 2.)Thomsen et al.,PI Co. Report PIFR-1059,(1980).3.)Thomsen et al.(1979)Proc.LPSC.10th.

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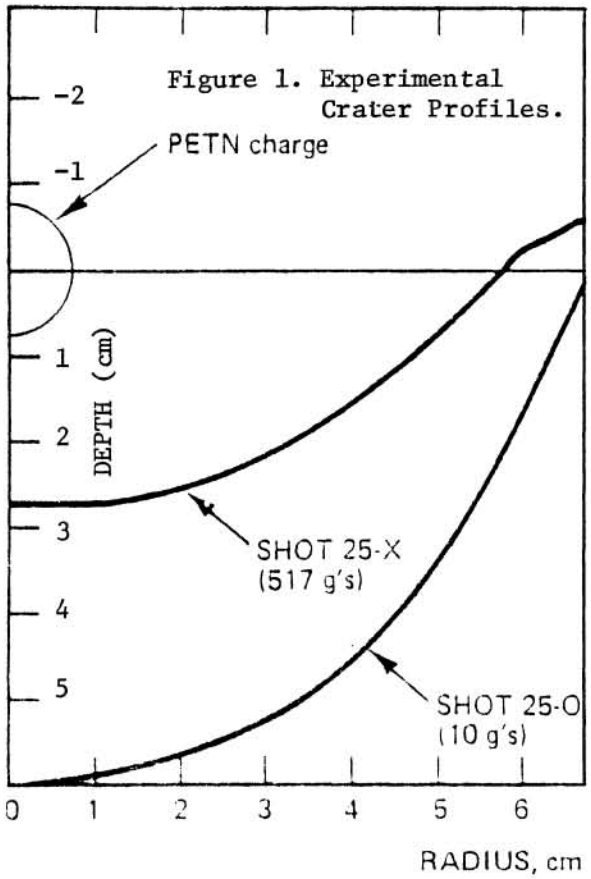

Figure 1. Experimental Crater Profiles.

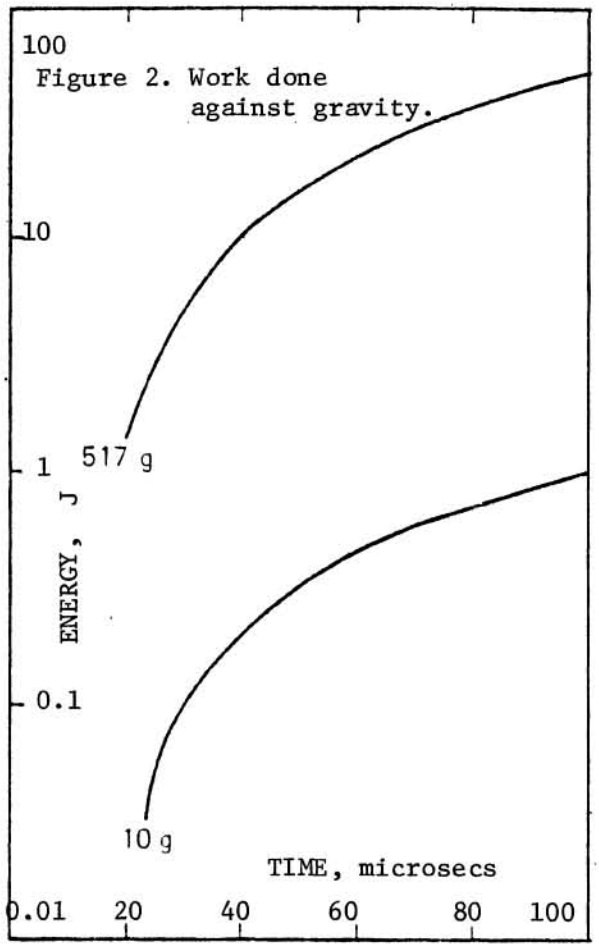

Figure 2. Work done against gravity.

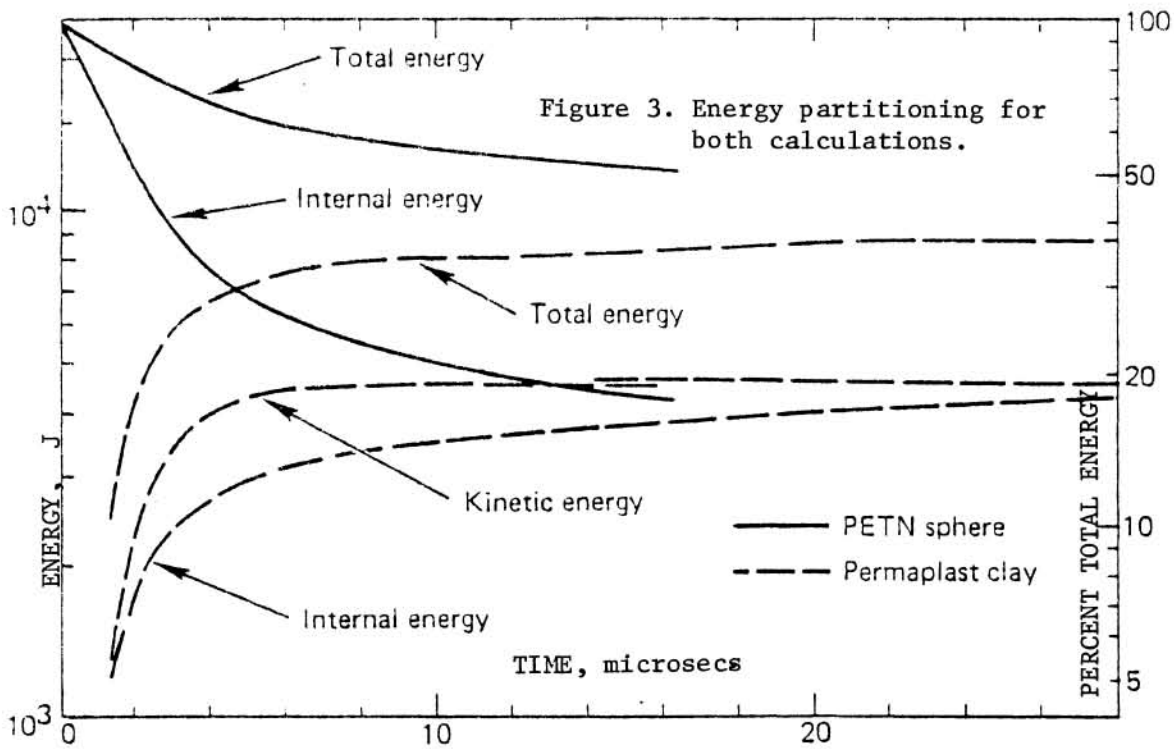

Figure 3. Energy partitioning for both calculations.

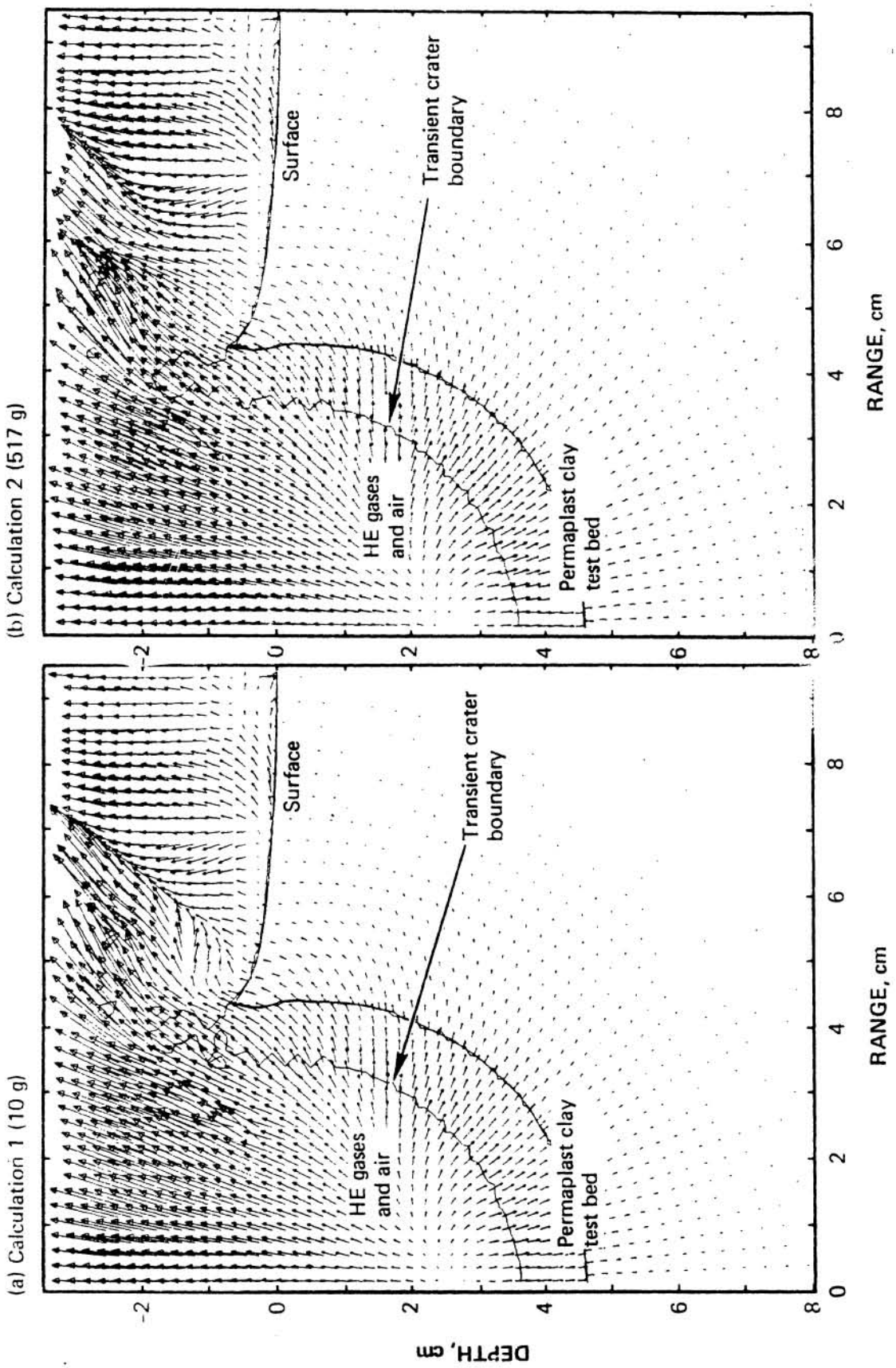

Figure 4. Vector velocity and material boundary plots at 100 μs, for 10 g and 517 g calculations.