HYDRODYNAMIC MODEL OF CENTRAL MOUND FORMATION AT METEORITE CRATERS.

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At impact events of large scale the stresses induced by gravity are much larger than the rock strength. Moreover the formation of large meteoritic craters is accompanied with a dynamic reduction of the internal friction of rock material. So one can simulate some important features of crater formations using the hydrodynamic model of incompressible fluid.

As the first step of this simulation the gravity collapse of a hemispheric crater on the fluid surface has been studied. The dimensionless coordinates have been used, in which the initial crater diameter, D, the gravity acceleration, g, and fluid density, ρ, have the unit value. The Laplace equation in the region with moving boundaries was integrated using a cylindric coordinate system. The potential function was presented as the sum of a series on the Bessel functions.The coefficients of the series were calculated numerically at the number of points on the boundary (up to 50 points).

Fig. 1 show the crater profile evolution from an initially hemispheric cavity to a shallow complex structure with a prominent central mound. When the top of the central mound crosses the initial fluid level, the pressure in fluid regions near the top point becomes negative. Thus the condition arises to spallation of the target material near the top of the moving central mound. To take this process into account, the new surface of zero pressure has been determined at each time step. The material above this surface has been treated as the cloud of fragments, which are in free flight in the gravity field. This effect is the well known plum formation in the case of explosion on water surface.

It is interesting to note that the spalled material removes about 50 % of energy from the region of the hydrodynamic flow (Fig.2). This effect must be taken into account in the simple models of crater modification stage, proposed by Melosh [1].

The above mentioned result may be interpreted as indication on a possibility of the dynamic disruption of material near to top of the growing central mound during the modification stage of large scale craters formation. Much more sophisticated calculations are needed to investigate this process for more realistic models of target mechanical properties. Melosh [1] made the simple estimations of changes in the style of crater modification in dependence of the scale of the event. He introduced the flow parameter $FP = g^{1/2} \cdot \rho \cdot D^{3/2} \cdot \eta^{-1}$ which controls the final morphology of a crater (η is the effective dynamic viscosity). It seems to be obvious that above mentioned dynamic failure (or spallation) of the top of the central mound would be controlled with the same flow parameter FP. For large value of FP the viscous dissipation is low and the dynamic failure of the mound occurs. The value of the FP exists when the viscous dissipation would brake the flow before the dynamic spallation. It is interesting to note that in the case of constant values of density and viscosity the critical crater diameter would be scaled as $D_* \sim g^{-1/3}$.

Conclusions. At large scale events the effect of dynamic disruption of central mound may be prominent. It may be responsible for such natural phenomena as the transition from central peak craters to multiring structures along with the crater size growth and the origin of central pits in the craters on icy planetary bodies.

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Reference: 1. Melosh H.J. J Geophys. Res., v. 87, 371-380.

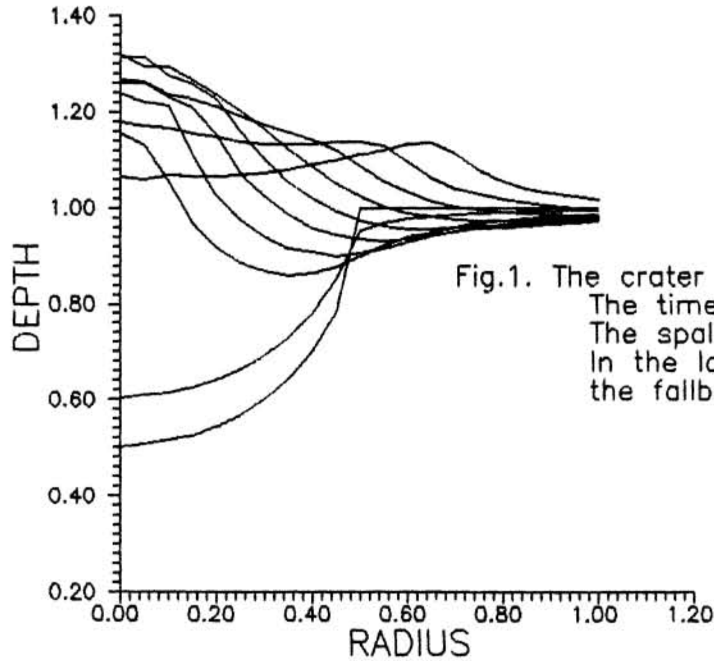

Fig.1. The crater profile changes in time. The time step equals to $.3*(D/g)^{1/2}$. The spalled material does not shown. In the later moments of time the fallback of this material begin.

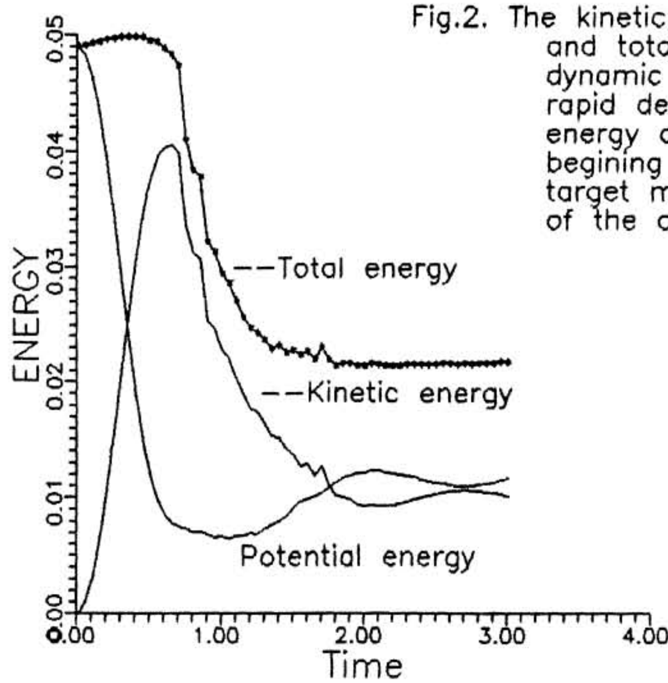

Fig.2. The kinetic, potential and total energy of hydrodynamic flow v.s. time. The rapid decreasing of total energy at t=.7 reflect the begining of spallation of target material from the top of the central mound