FORMATION OF ANTIPODAL TERRAINS ON ICY SATELLITES;
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It has been proposed (Schultz and Gault, 1975) that seismic energy from a major impact could cause extensive crustal fracturing and surface disruption on the portion of the planet directly opposite the impact. Disrupted terrains of this type have been identified on Mercury antipodal to the Caloris impact and on the Moon antipodal to Imbrium. Although some analyses have assessed the focusing of seismic energy at the planetary antipodes (Schultz and Gault, 1975; Hughes et al., 1977; Rial and Cormier, 1985), an in-depth analysis of the problem has not been performed for icy satellites nor for a layered body of any composition. Schultz and Gault (1975) calculated the seismic effects from a major basin formation on a homogeneous silicate Moon. This study did not include the effects of either attenuation or layering, but showed clearly that some degree of seismic focusing of both body waves and surface waves should occur at the antipode. In 1977, Hughes, App, and McGetchin re-evaluated the problem using a finite difference computer code.

The study in progress extends the work of Hughes et al. (1977) to include the effects of layering (especially in the form of a high density core), and composition (both icy and silicate). Calculations are performed on a two dimensional half circle grid; three dimensional interactions and deviations from a homogeneous concentric shell model are beyond the scope of the current phase of this study. The calculated disruptions are then compared to those areas on icy satellites which are antipodal to major impacts. The presence or absence of an observed "antipodal terrain" in an area where models predict disruption may make it possible to constrain models of satellite interiors at the time of impact.

The initial impact energy distribution models are produced using a modified SALE (Simplified Arbitrary Lagrangian Eulerian) computational code written by A.A. Amsden et al. (1980). This code is used to calculate the development of a material flow. The code is initialized as a computational grid with the desired pressures, material characteristics, and initial velocities defined for each grid element. The calculation begins at the time of impact. An energy equivalent to the desired impact energy is deposited in the form of a compressed, high temperature 'impact site', and then the movement of material and of the subsequent shock wave is calculated in short timesteps until the pressure wave has dissipated.

A series of calculations has been performed for planets with a range of compositions and core sizes. It has been found that in a planet with a high density core surrounded by a lighter mantle material (ice over a silicate core, or silicate over iron), the incident pressure wave splits when it strikes the core. The part which passes through the core moves more rapidly and is refracted away from the antipode. It strikes the surface at some distance from the antipode and may overlap with the second part of the wave, which, missing the core, has traveled directly through the mantle. Refraction of the wavefront through the core may, therefore, decrease the pressure generated at the antipode and redistribute some of the pressure front to the surface adjacent to, but not at, the antipode. Antipodal and near antipodal calculated pressures have been plotted as a function of core size (Fig. 1). It can be seen that the redistribution is minimal for the smallest and largest core sizes, and largest for a core with a radius of about 1/3 the planetary radius.

Table 1 lists the highest antipodal pressures generated for the models run thus far. The initial energy listed is the total impact energy required to form the observed crater. This energy has been calculated with the Holsapple-Schmidt crater scaling law. The compressive strength of ice is approximately 5×10^7 Pa, slightly greater than the pressure generated at the Tethys/Odysseus antipode. The tensile strength (4.0×10^6 Pa) is exceeded by the pressure generated by all impacts run to date except the Tirawa impact on Rhea. Spallation will occur on surfaces where the tensile strength has been exceeded, and the surface material undergoes acceleration.

This project has produced a versatile code which can be used to calculate antipodal disruptions for a variety of planetary models and impact types. We have found that while antipodal focusing should occur on icy satellites the presence of a core may inhibit the antipodal focusing effect and may even redirect the focusing to an area away from the antipode.

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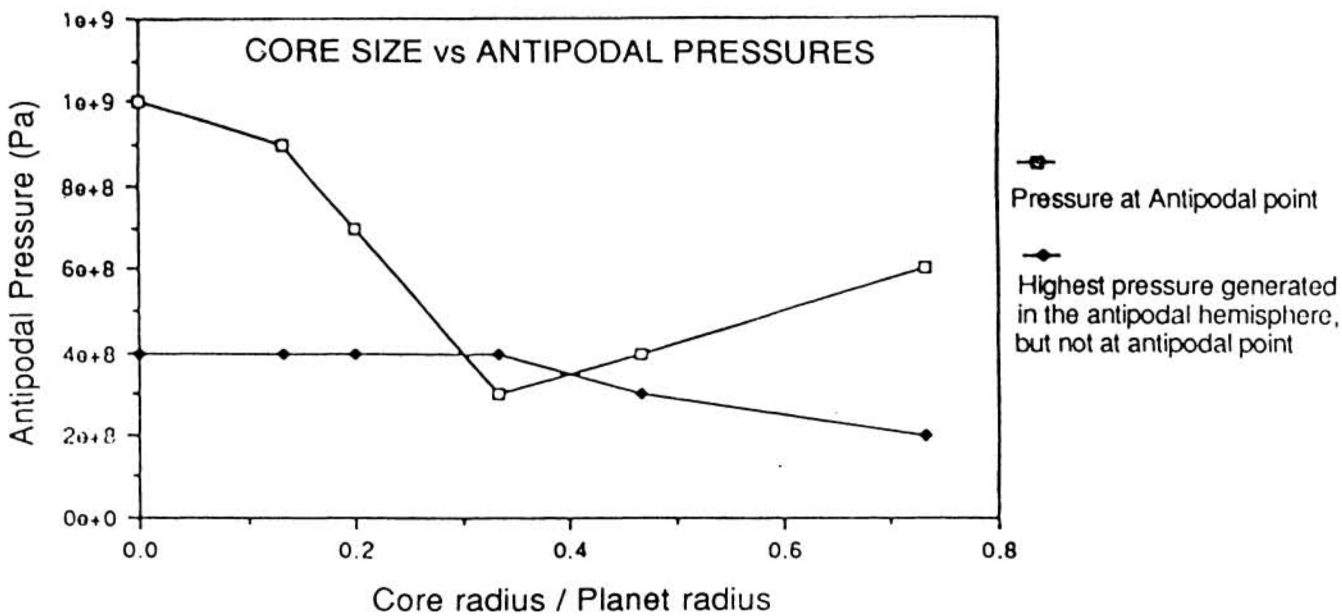

Fig.1. Core radius vs antipodal pressure in a 3000 km ice planet with a variable size anorthosite core. Impact energy is 3.7E24 Joules, equivalent to an impact approximately 400 km in diameter.

PLANET	PLANET (km diam)	CRATER	CRATER (km diam)	Eimp (J)	PRESSURE (Pa)
Tethys	1060	Odysseus	400	3.2E24	7.1E7
Tethys w/core					4.5E7
Rhea	1530	Tirawa	350	5.4E23	4.0E6
Rhea w/core					3.1E6
Mimas	394	Hershel	130	3.0E21	4.2E7
Callisto	4800	Valhalla	400	1.0E25	9.0E6
Moon	3480	Imbrium	600	6.1E27	1.9E9
Moon w/core					1.9E9

Table 1. Antipodal pressures computed for several impacts.