

The Seismic Effect of Impacts on Asteroids: Preliminary Results

James Richardson, H. Jay Melosh, & Rick Greenberg

Introduction: Crater counts made from the NEAR spacecraft images of the asteroid 433 Eros have revealed a paucity of small craters on this small body. Seismic 'shaking' from impacts has been cited as a potential means of small crater erasure, and we present here some preliminary work in investigating this hypothesis.

The Impact Seismic Signal: An impact can be modeled as an impulsive point source acting on a free surface. The displacement field consists of a downward, vertical singlet component and two orthogonal, horizontal dipole components, to create an expanding, hemispherical pressure pulse within the medium. The resulting seismic waveform is shown in Fig. 1, consisting of a small P-wave displacement and a much larger Rayleigh wave displacement. This is quite similar to the waveform of the 'classic' Lamb pulse (vertical singlet source only). Fig. 2 shows an amplitude spectrum of the impact seismic waveform, displaying a broad frequency peak between 1 and 200 Hz (max. at 50-80 Hz). This agrees well with the experimental (missile impact) results reported by Lathan *et al.* in 1970, in which a mean peak frequency of 26 \pm 13 Hz was obtained. The surface effects of this waveform are described below.

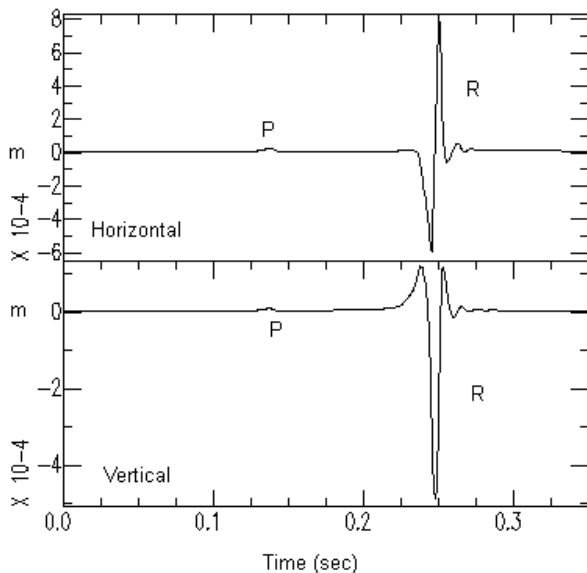


Figure 1: Synthetic seismograph for a small impact on a free surface, with the receiver at 0.5 km distance. Body pressure wave (P) and surface Rayleigh wave (R) displacements are labeled.

Seismic Pulse Effects: This is surface modification due to the passage of discrete seismic pulses over the surface of the asteroid shortly after impact. These effects are magnified due to the very low surface gravity of these bodies (on the order 1/1000 or less Earth g 's). In this case, relatively small impacts can have 'global' seismic effects. For example, an impact producing a 1 km diameter crater on a 20 km diameter asteroid will generate a magnitude 4 quake, impart surface accelerations of over 10g out to an angular radius of 50° from the impact site, and disrupt all slopes on the surface of the asteroid to varying degrees.

Seismic Reverberation Effects: Due to their small size and potentially high seismic quality factor (Q) values, asteroids can experience a seismic reverberation lasting for several minutes following the dispersion of the initial seismic pulses. These reverberations will cause additional accelerations on the surface, primarily at the peak frequencies injected by the impact (1-200 Hz), and can cause further surface modification in areas of high surface relief. These effects are currently under investigation.

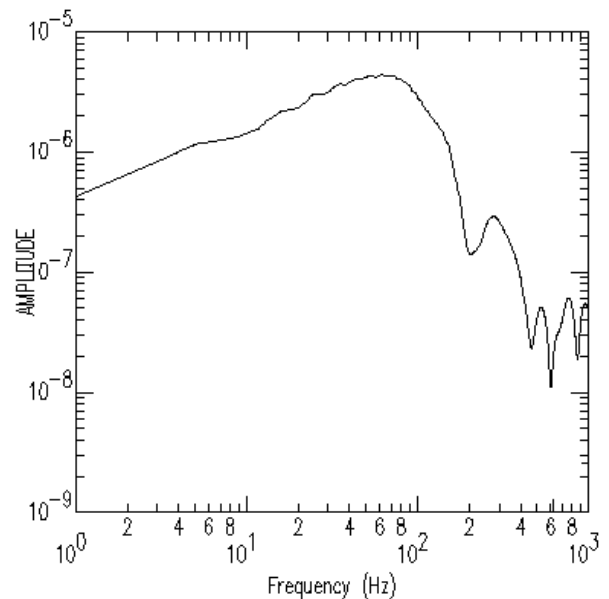


Figure 2: Amplitude spectrum for the synthetic seismic waveform shown in Fig. 1. The highest amplitude frequencies are generally between 1 and 200 Hz, with a flat peak at about 50-80 Hz.