WEB-BASED PROGRAM FOR CALCULATING EFFECTS OF AN EARTH IMPACT.

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Introduction: Periodically, stories concerning the possibility of a large extraterrestrial impact on earth enter the mainstream media. During these times, both scientists and non-scientists alike become interested in determining the effects that this impact would cause on earth, often with a particular impact site and distance from impact in mind. For scientists, the trouble with determining these effects is merely the time it would take to find all of the equations and data necessary to calculate the effects. For non-scientists, these calculations are all but impossible.

Presently, there is no reliable place where the interested person may obtain a clear and concise summary of the general effects created by an impact on earth. We currently maintain a popular crater diameter calculator online at http://www.lpl.arizona.edu/tekton/crater.html. This program uses scaling laws to derive crater size estimates from impact parameters such as impactor size, velocity and density. The goal of the Earth Impact Effects Program is to provide a similar, easy-to-use web-based program to calculate various pertinent environmental consequences of a given impact event on Earth at a specified distance away. So far, the environmental effects that we have considered are crater size, seismic effects (including Richter magnitude and damage assessment), and the thickness and average fragment size of the ejecta deposit. In the future, we intend to extend the program to include the effects of the shock wave and thermal radiation. In addition, the web page will include a description of our algorithm with citations to the scientific sources used. It is our intention for this program to be useful for not only casual users, but also those who require a deeper understanding of how the results were obtained.

Crater Size: The Earth Impact Effects Program finds both the transient and final crater diameters caused by an impact. The equations used to determine the transient crater diameter, D_{tr}, are taken from Melosh [1]. The program then determines whether the final crater is simple or complex. For a simple crater the final crater diameter D_f is given by:

$$D_f = 1.56 D_{tr}$$

For a complex crater the final crater diameter is given by:

$$D_f = 1.17 D_{tr}^{1.13} / D_c^{0.13},$$

[2], where D_c, the diameter at which the transition from simple to complex crater occurs, is taken to be 3.2 km on Earth.

Seismic Shaking: When an impact occurs, the most pertinent information to the program user is the intensity of the seismic shaking at the input distance and the time it takes for the shaking to reach that distance. For the purposes of the program, the major seismic shaking is assumed to be due to the surface waves, which travel at a velocity of ~5 km/s. To determine the extent of seismic shaking at the input distance, the program first calculates the Richter scale magnitude M of the seismic disturbance created by the impact. From Melosh [1]:

$$M = 0.67 \log_{10} W - 5.87$$

W is the energy of the impact. After this magnitude is found, the program determines the resulting ground acceleration at the specified distance. This calculation is made using curves fit to empirical seismic data from Richter [3]. The ground acceleration is then mapped to an intensity of shaking, using the modified Mercalli scale [3].

Ejecta: Our program also outputs the ejecta thickness, arrival time, and the average size of the ejecta produced by the impact. We use scaling laws derived from crater measurements on the Moon [1] to calculate the rim height of the final crater, which we assume is the thickness of the

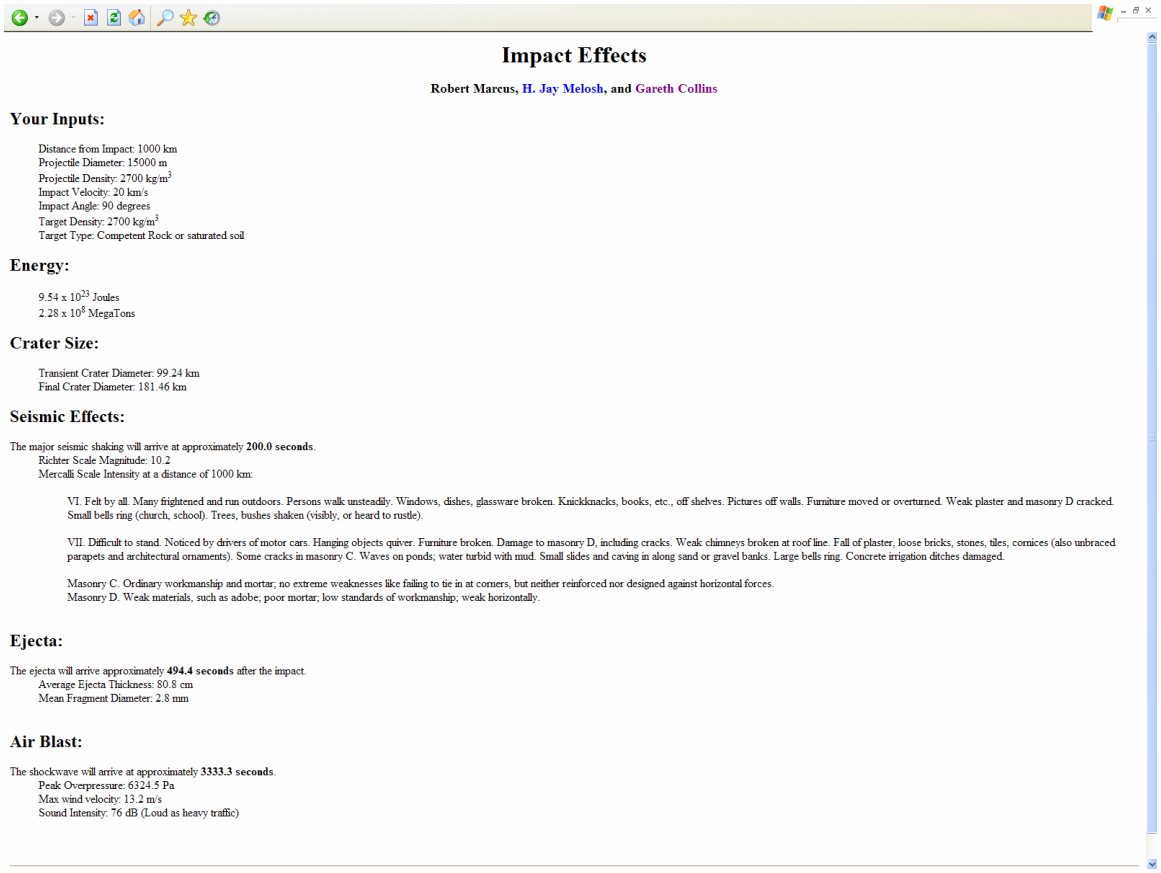
ejecta blanket at this point. We further assume that from the rim outwards the average ejecta thickness falls off as one over the distance from the crater rim cubed. The ejecta arrival time is determined using ballistic travel time equations for a spherical planet assuming all ejection is at a 45° angle to the planet's surface [4]. The mean fragment size is determined using an empirical law for the mean diameter of impact ejecta on Venus as a function of distance from the crater center [5].

Future additions and Feedback: We intend to extend our program to calculate the effects of the air blast and of thermal radiation. The air blast effects are in the draft stages, while the thermal radiation effects have yet to be considered.

If any other useful information seems to be missing, feedback would be greatly appreciated.

References: [1] Melosh H.J. (1989) *Impact Cratering*. Oxford Univ. Press. [2] McKinnon and Schenk (1985) *LPSC XVI*, 544-545. [3] Richter C. (1958), *Elementary Seismology*. [4] Ahrens T.J. and O'Keefe J.D. (1978), Proc, Lunar and Planetary Science Conference 9th, 3787-3802. [5] Shaller C. J. and Melosh H. J. (1998) *Icarus, 131*, 123-137.

Figure 1. A sample output of the Earth Impact Program. The results show the effect felt near Houston, TX for the Chicxulub impact.



Impact Effects

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Your Inputs:

Distance from Impact: 1000 km
Projectile Diameter: 15000 m
Projectile Density: 2700 kg/m^3
Impact Velocity: 20 km/s
Impact Angle: 90 degrees
Target Density: 2700 kg/m^3
Target Type: Competent Rock or saturated soil

Energy:

9.54 x 10^{23} Joules
2.28 x 10^{8} MegaTons

Crater Size:

Transient Crater Diameter: 99.24 km
Final Crater Diameter: 181.46 km

Seismic Effects:

The major seismic shaking will arrive at approximately **200.0 seconds**.
Richter Scale Magnitude: 10.2
Mercalli Scale Intensity at a distance of 1000 km:

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

Masonry C. Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.
Masonry D. Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Ejecta:

The ejecta will arrive approximately **494.4 seconds** after the impact.
Average Ejecta Thickness: 80.8 cm
Mean Fragment Diameter: 2.8 mm

Air Blast:

The shockwave will arrive at approximately **3333.3 seconds**.
Peak Overpressure: 6324.5 Pa
Max wind velocity: 13.2 m/s
Sound Intensity: 76 dB (Loud as heavy traffic)