news and views

Earth's cratering rate

from David W. Hughes

THE hysteria over Skylab's return to Earth and the unease engendered by the fact that about 600 of the 4,500 or so orbiting pieces of space hardware re-enter the atmosphere every year pales into insignificance against the shock that would follow the impact of an asteroid and the subsequent cratering event. How often are these impact craters produced? Well, a body capable of forming a crater with a diameter over 1 km hits the Earth every 1,400 years. Craters of 10 km diameter and more can be produced every 140,000 years assuming the impacting object hits land and not sea. These figures come from two reviews of the subject by R.A.F. Grieve and P.B. Robertson and Grieve and M.R. Dence of the Canadian Department of Energy, Mines and Resources and published in a recent issue of *Icarus* (**38**, 212; 230; 1979).

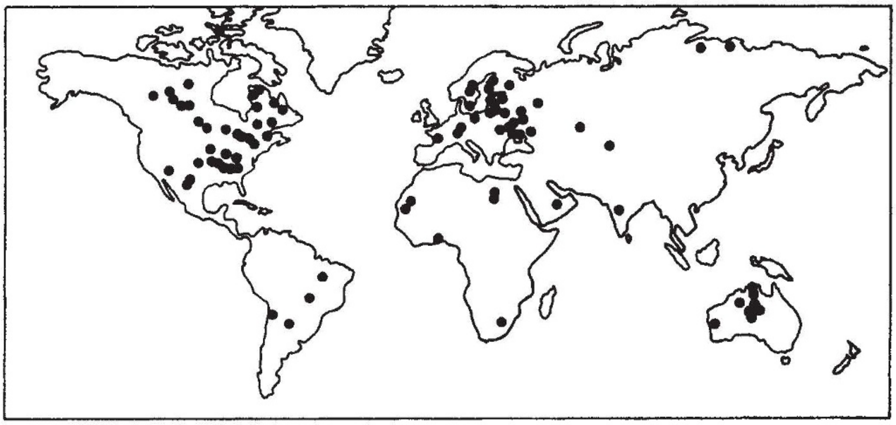

Fig. 1 The world wide distribution of impact craters (after Grieve and Robertson).

Terrestrial impact craters are fairly common and Fig. 1 shows their world wide distribution. Twelve of the structures shown in Fig. 1 are classified as proven meteorite craters because meteorite fragments have been found in their vicinity. The remaining 75 are 'probable' meteorite craters recognised as such because the target rocks have suffered shock metamorphic effects. It is obvious from the uneven distribution that the probability of their preservation and detection varies considerably from place to place. The majority occur in North America and Europe, areas with relatively stable geology and also with an active population of crater searchers. Erosion and geological processes progressively erase craters. For example a 20 km structure is only recognisable as a probable impact crater for a maximum of 600 million years whereas a 10 km structure usually has a lifetime of only 300 million years.

Morphologically there are simple bowl-like craters with an uplifted and overturned rim and complex craters with uplifted central peaks and slumped or depressed rims. Normally the simple craters have diameters of less than 4 km, the larger ones being complex.

Plotting the number of craters, N, which have diameters D greater than D as a function of D it can be seen that $N \propto D^{-2}$ for D larger than 20 km. The curve departs from linearity below this size because small craters have a shorter lifetime and are less likely to be recognised. It is highly probable that the $N \propto D^{-2}$ relationship actually extends down to crater diameters of about 1 km. Martian craters obey an $N \propto D^{-2}$ law. Large lunar craters lie between $N \propto D^{-1.8}$ and $N \propto D^{-2}$. This law can also be justified by combining the mass distribution of the causative asteroids (the number of asteroids more massive than M is proportional to $M^{-0.6}$) with the relationship between the crater diameter and the kinetic energy, E, of the impacting body ($D \propto E^{0.29}$).

To calculate the cratering rate one needs ideally a large area of the Earth's landmass which has a single age of origin, preferably as old as possible, and which has undergone a minimal and uniform level of subsequent modifying geological activity. Two areas approximate to this. The first is the North American stable region that lies between the Rockies and the Appalachians and the Quachita and the Arctic. The area is 1.25×10^7 km^2 and the exposure age varies from 450 million years in the north to about 300 million years in the south. It contains 33 impact structures over 1 km in diameter, the estimated production rate being $(0.36 \pm 0.1) \times 10^{-14}$ km^{-2} yr^{-1} for craters with $D > 1$ km. The second area is the Northern European plain lying between the Scandinavian Caledonides, the Urals, the Carpathians and the Caucasus. Here there are 20 craters with $D > 1$ km. Over an area of 4.5×10^6 km^2. As with North America the exposure age varies from 450 million years in the north to 300 million years in the south resulting in a production rate of $(0.35 \pm 0.13) \times 10^{-14}$ km^{-2} yr^{-1} for craters with $D > 20$ km. Combining these two production rates gives the equation

$$\log_{10}\phi = -11.85 - 2\log_{10}D \qquad (1)$$

where ϕ is the production rate (km^{-2} yr^{-1}) of craters with diameters greater than D km. This equation is definitely valid down to diameters of 20 km and probably valid down to diameters of 1 km. The results can also be interpreted as indicating that this cratering rate has remained reasonably constant over the last 3.4×10^9 yr. Equation (1) shows that, assuming the Earth's surface was all land, a 1 km crater would be produced every 1400 yr and a 10 km crater every 140,000 yr.

We must be thankful that two-thirds of the globe is covered by water and, of the remaining land mass, the frozen wastes, jungles, deserts and mountains account for over 90% of the area. □

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