MODEL OF TERRESTRIAL IMPACT CRATERS PRESERVATION

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Crater counting method for estimating the age of a planet's, based on the idea that density of craters on a planetary surface is determined by the age of the surface and the average crater production rate surface was calibrated for moon [1, 2 etc.].This method is not applicable for the Earth because craters are effectively destroyed by geological processes.

To describe the relationship between the apparent decrease in the number of craters and age, Dabizhei and Zotkin [3]) suggested that during any time interval a fixed fraction of craters of a certain diameter (D) is lost and the process of extinction of the crater population is described by the formula F (T, D) = C * exp (-T/D2Q), where D2Q is the relaxation time. L.V. Masaitis and co-authors [4] estimate of the minimum duration of the crater's existence, depending on depth of the crater and rate of denudation. The first model predicts the exponential, the second - linear, the decrease in the number of craters, with the increase in age, whereas the observed ratio is better described by the power law and this disparity requires an explanation or a new model of crater preservation.

There are two reasons, why crater became geologically undetectable: it may be overlaid by the younger rocks or disappear in geological processes. Since most of the detected craters are surface exposed we will assume that the crater is detectable, if at least some part of it is exposed on the surface

Analytical solution: let's denote by H crater's depth (the depth at which changes resulting from impact cease to be noticeable), denote by H_0 the initial crater's depth, by t - time since the crater formation, by h – the vertical movement during this time, compensated by denudation or sedimentation and denote by d the thickness of deposits overlaid the crater.

It is obvious that the time from the formation of the crater can be divided into n periods of length Δt, in each of which the crater was raised or lowered with an average speed of v and territory may be eroded or buried on the thickness Δh = v * Δt. Suppose that in a global terrestrial surface does not experience directional uplift or descent, then the distribution of Δh is characterized by the zero mathematical expectation and the standard deviation $\Delta t{*}v$. The full moment during the time t is h $= \sum_0^n$ Δh $= \sum_0^n$ Δt*v is a random quantity distributed according to the normal law with zero expectation 0 and standard deviation $\Delta t * v * \sqrt{n}$. Then the probability that the h does not exceed H_0 can be estimated as

$$P=\frac{1}{\Delta t * v\sqrt{2\pi}}\int_{-\infty}^{Ho} e^{-\frac{h2}{2n*(\Delta t*v)}}dh=\frac{1}{\Delta t*v\sqrt{2\pi}}\int_{-\infty}^{Ho} e^{-\frac{h2}{2t*\Delta t*v2}}dh$$

If we assume that at each step the surface is displaced by ± $\Delta t * v$, the thickness of the overlapping deposits at step n can take the values d = x * ($\Delta t * v$), where x is from 0 to n, with probabilities Px, n. P_0,n = ($P_{0,n-1}$ + $P_{1,n-1}$)/2 for x= 0 and $P_{x,n}$ = ($P_{x+1,n-1}$ +$P_{x-1,n-1}$)/2 for x> 0. For large values of n, the probability that x=0 (the crater will be exposed on the earth's surface) is very close to $0.8*\sqrt{n+1}$

The resulting probability that the crater will not be eroded and will not be blocked by the later sedimentary cover is equal to the product

$$P=\left(\frac{1}{\Delta t*v\sqrt{2\pi}}\int_{-\infty}^{Ho} e^{-\frac{h2}{2n*(\Delta t*v)}}dh\right)*0.8*(n+1)^{-0.5}$$

Step-by-step model was realized by MS Excel. For the first moment of time, for population of crater's was set equal initial depth (H_0), average vertical speed v and Δt. At each step, for the each crater variable h was randomized with zero mean and standard deviation $\Delta t*$, and the displacement is calculated, it is determined whether the crater leaves the surface, what is its depth of base and residual thickness. The probability of finding a crater for each of the steps is calculated as the ratio of the number of cases when at this step the crater comes to the surface to the number of repetitions of the calculation.

Both analytical solution and step-by-step model calculation show that dependence of the probability of the conservation of the crater decrease by the power law from time. For geologically reasonable parameters of the model, the slope of the approximating line is close to that observed for the distribution of terrestrial craters.

References:

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