SERIAL IMPACTS OR RANDOM ALIGNMENT? MONTE CARLO SIMULATIONS OF THREE 38TH PARALLEL IMPACT STRUCTURES

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Introduction: The 38th parallel structures across Kansas, Missouri, and Illinois alternately have been regarded as crypto-explosive structures [1,2] and serial impacts [3]. Decaturville and Crooked Creek are accepted impact structures [4]. The recovery of abundant shocked quartz grains from breccias associated with the Weaubleau structure makes it a third viable impact structure along this trend. Currently, we regard other structures as having uncertain affinities. Nevertheless, the three known impact structures are aligned and stratigraphic age constraints cannot exclude the possibility that they are temporally related as products of serial impact. We used Monte Carlo simulations to test the hypothesis that these three impacts were unrelated temporally and aligned randomly across the 200 km distance that separates them.

Model Parameters and Simulations: Of the 174 currently accepted terrestrial impacts, most have been found on land [4]. Many are small, and others are double impacts, so model values of 200 and 300 incidents assume that some impacts remain undiscovered. The model also assumes a rectangular surface area of 148,939,100 km^2 (12,204 km x 12,204 km) to represent the present-day land area with an additional 200 km buffer to avoid edge effects. Tectonism (i.e. subduction, sea-floor spreading, mountain building, and reconfiguration of landmasses) was not addressed.

Monte Carlo simulations were programmed in MatLab. A series of 10,000 random impact simulations were completed for 20 runs using various parameter combinations to estimate the standard deviation of N_{event}. A search algorithm identified clusters of three or more impacts within 100, 200, or 300 km radius, and the routine further identified those aligned in one cluster, allowing for angular discordance up to ±2°. These parameters are conservatively estimated, and they can be used to generate an upper limit of the probability for random narrowly aligned impacts.

Results and Discussion: With 100 km radius and 200 impacts, N_{event} were only 6.6±2.5 for 10,000 simulations. N_{event} increased to 25.3±3.4 with 300 impacts. Thus, random alignment within 100 km radius is highly improbable with $P<0.003$. This model returned a probability an order of magnitude lower than those derived by Rampino and Volk [3]. Their equation assumed that third and subsequent impacts must align with the first two that constituted a linear trend. Suppose the length D is 200 km and a zone of width, w, is 5 km, the probability of the third crater falling along this strip is about 0.03. However, our results also indicated that the probability would increase dramatically when the search radius became larger. With 200 impacts, N_{event} was 124.8±10.9 when radius was 200 km, and 668.1±34.7 when radius was 300 km. With 300 impacts, N_{event} was 439.8±17.3 when radius was 200 km and 2,315.0±57.9 when radius was 300 km. Therefore, based on simulations and our current knowledge of impact rates, it is highly unlikely that the 38th parallel structures resulted from random, temporally unrelated impact events.

References: [1] Snyder F. G. and Gerdemann P. E. 1965. *Am. Jour. of Sci.* 263:465-493. [2] Luczaj J. 1998. *Geology* 26:295-298. [3] Rampino M. H. and Volk T. 1996. *Geophys. Res. Let.* 23:49-52. [4] Earth Impact Database. 2007. <*http://www.unb.ca/passc/ImpactDatabase/*> accessed 10 May, 2007.