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"In-Place" Fossils by Chance: A Simple Statistical Analysis

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Abstract

Considering the fact that most fossils are not "in-place", how often do those that appear to be "in-place" come up that way by chance? Application of the binomial theorem shows that this can often happen. For instance, if an organism has a 50:50 probability of being deposited in life orientation, 4 of 5, or 11 of 15, will end up that way 1% of the time. Since a geologist visits many outcrops, he has a 50% likelihood of encountering one such 1-in-100 assemblage after 70 visits.

Keywords: binomial theorem, statistical analysis, probability, chance, fortuitous, "in-place", in-situ, life orientation, fossils, paleontology, paleoecology, Flood problems, deep time

According to standard uniformitarian thinking, marine fossils found in the Phanerozoic record were commonly buried in ancient seas, and a significant fraction of these were entombed in the location and orientation in which they had lived (hereafter "in place") on the ancient sea bottom. In contrast, given a global Flood causing nearly all of the world's fossils, one should not expect to find numerous marine fossils in place. Yet such occurrences are commonly cited.

Is another explanation possible? It has long been known that a transported organism may end up buried and then fossilized in life position owing to the fact that the life position is the most hydrodynamically stable orientation (for example, Woodmorappe 1999, p. 85), or even solely by chance. But, while this may account for a single "in-place" fossil, could it ever account for multiple "in-place" ones? Obviously, a combination of hydrodynamic factors and chance must come into play.

Fortuitous "In-Place" Possibilities

Assuming that the density of an organism is fairly uniform, the probability of its "in-place" deposition will depend primarily on its geometry. A hemisphere-shaped organism has a better than 50:50 chance of landing on its flat side, which is likely to be the "in-place" position owing to its hydrodynamic stability. A cube-shaped organism has a 1 in 6 chance of "in-place" deposition. A slab-shaped or sheet-shaped one has a 1 in 2 chance of the same. For a rectangular

Table 1. Probability trials by John Woodmorappe. To facilitate comparison, the probability of success in each situation is set at or near 0.01.

Total number of fossils (Y)	Number of fossils "in place" (X)	Probability of single fossil deposited "in place"	Probability of failure	Probability of success
2	1	0.1	0.9900000000	0.01
3	2	0.2	0.9920000000	0.008
4	3	0.33	0.9881407900	0.01186
5	4	0.5	0.9687500000	0.03125
10	3	0.1	0.9872048016	0.0128
10	5	0.2	0.9936306176	0.00637
10	6	0.33	0.9814510506	0.01855
10	8	0.5	0.9892578125	0.01074
15	4	0.1	0.9872795164	0.01272
15	6	0.2	0.9819411930	0.01806
15	9	0.33	0.9921440272	0.00786
15	11	0.5	0.9824218750	0.01758
20	5	0.1	0.9887468658	0.01125
20	8	0.2	0.9900182137	0.00998
20	11	0.33	0.9880983676	0.0119
20	15	0.5	0.9940910339	0.00591
50	10	0.1	0.9906453984	0.00935
50	17	0.2	0.9937392254	0.00626
50	24	0.33	0.9905679637	0.00943
50	33	0.5	0.9923266611	0.00767

Table 2. Probability trials by John Woodmorappe. If there is 0.01 chance of a fortuitous "in-place" fossil assemblage, then there is a 10% chance the geologist will encounter one of them after going to 11 fossil assemblages; 25% chance after going to 29; and 50% after going to 70.

Number of failures (visits-Z)	Threshold success	Probability of one success	Overall probability	Cumulative probability
1	1	0.01	0.0099	0.0099
2	1	0.01	0.009801	0.0197
3	1	0.01	0.00970299	0.0294
4	1	0.01	0.00960596	0.03901
5	1	0.01	0.0095099	0.04852
6	1	0.01	0.009414801	0.05793
7	1	0.01	0.009320653	0.06726
8	1	0.01	0.009227447	0.07648
9	1	0.01	0.009135172	0.08562
10	1	0.01	0.009043821	0.09466
11	1	0.01	0.008953383	0.10362
12	1	0.01	0.008863849	0.11248
13	1	0.01	0.00877521	0.12125
14	1	0.01	0.008687458	0.12994
15	1	0.01	0.008600584	0.13854
16	1	0.01	0.008514578	0.14706
17	1	0.01	0.008429432	0.15549
18	1	0.01	0.008345138	0.16383
19	1	0.01	0.008261686	0.17209
20	1	0.01	0.008179069	0.18027
21	1	0.01	0.008097279	0.18837
22	1	0.01	0.008016306	0.19639
23	1	0.01	0.007936143	0.20432
24	1	0.01	0.007856781	0.21218
25	1	0.01	0.007778214	0.21996
26	1	0.01	0.007700431	0.22766
27	1	0.01	0.007623427	0.23528
28	1	0.01	0.007547193	0.24283
29	1	0.01	0.007471721	0.2503
30	1	0.01	0.007397004	0.2577
31	1	0.01	0.007323034	0.26502
32	1	0.01	0.007249803	0.27227
33	1	0.01	0.007177305	0.27945
34	1	0.01	0.007105532	0.28655
35	1	0.01	0.007034477	0.29359
36	1	0.01	0.006864132	0.30055
37	1	0.01	0.006894491	0.30745
38	1	0.01	0.006825546	0.31427
39	1	0.01	0.00675729	0.32103
40	1	0.01	0.006689718	0.32772
41	1	0.01	0.00662282	0.33434
42	1	0.01	0.006556592	0.3409
43	1	0.01	0.006491026	0.34739
44	1	0.01	0.006426116	0.35381
45	1	0.01	0.006361855	0.36018
46	1	0.01	0.006298236	0.36647
47	1	0.01	0.006235254	0.37271
48	1	0.01	0.006172901	0.37888
49	1	0.01	0.006111172	0.38499
50	1	0.01	0.006050061	0.39104
51	1	0.01	0.00598956	0.39703
52	1	0.01	0.005929664	0.40296
53	1	0.01	0.005870368	0.40883
54	1	0.01	0.005811664	0.41465
55	1	0.01	0.005753547	0.4204
56	1	0.01	0.005696012	0.42609
57	1	0.01	0.005639052	0.43173
58	1	0.01	0.005582661	0.43732
59	1	0.01	0.005526835	0.44284
60	1	0.01	0.005471566	0.44831
61	1	0.01	0.005416851	0.45373
62	1	0.01	0.005362682	0.45909
63	1	0.01	0.005309055	0.4644
64	1	0.01	0.005255965	0.46966
65	1	0.01	0.005203405	0.47486
66	1	0.01	0.005151371	0.48001
67	1	0.01	0.005099857	0.48511
68	1	0.01	0.005048859	0.49016
69	1	0.01	0.00499837	0.49516
70	1	0.01	0.004948387	0.50011

stick-shaped organism, the probability is 1 in 4. In the case of a spheroid, assuming that a deviation of 30° or less from vertical passes for "in-place" deposition, the probability is 1 in 6 (60/360). The same holds for a cylindrical organism under the identical assumption.

If the density of an organism isn't uniform, the less-dense half will more likely be deposited upright than the more-dense half. This can be called the "hydrometer effect" or the "fisherman's bob effect." A classic example of this phenomenon is uprooted trees getting buried upright in a flood. The trunk and branches are less dense than the root-soil mass.

Using Probability

One must recall that improbable events become increasingly probable when an ever-larger population is sampled. For example, a *given* individual winning the lottery is extremely improbable, but *any* member of a large city winning the lottery is not so improbable. Likewise, given the fact that most fossil assemblages are obviously not in place, and the geologist visits many of these before encountering a single "in-place" assemblage, a fortuitous "in-place" assemblage becomes increasingly probable.

To quantify the foregoing considerations, the binomial theorem was used to quantify the probability of (X) out of (Y) fossils being deposited "in place" by chance, given the probability of a single fossil ending up deposited "in place" varied from 0.1 to 0.5 (Table 1). To facilitate the comparison of one assemblage with another, the group probability was set at a constant 0.01.

A different set of probability calculations were performed to determine the chances of a geologist encountering even one such 0.01 assemblage given (Z) assemblages visited (Table 2).

Results

When a specific organism has 0.1 chance of ending up buried "in place", then each of the following assemblages has an approximately 0.01 chance of arising: 1 of 2 "in place", 3 of 10, 4 of 15, 5 of 20, and 17 of 50. When the individual probability rises to 0.5, then the corresponding figures become 4 of 5, 8 of 10, 11 of 15, 15 of 20, and 33 of 50 (Table 1).

If there is an 0.01 overall chance of a fortuitous "in place" fossil assemblage, then there is a 10% chance the geologist will encounter one of them after going to 11 fossil assemblages; 25% chance after going to 29; and 50% after going to 70 (Table 2).

Conclusions

Chance alone can account for many "in-place" fossil assemblages. This study should be extended to actual numbers/fractions of "in-place" fossil assemblages, and actual numbers of fossil-bearing sites visited by geologists.

Up to now, the phenomenon of fortuitous "in-place" organisms has generally been treated haphazardly by researchers, and relegated to an anecdotally-reported situation. Detailed flume-based studies should be conducted on the burial of "in-place" organisms. Such a study should be expanded to assemblages of benthic organisms held together by algae or other normally non-fossilizable material.

Reference

Woodmorappe, J. 1999. *Studies in Flood Geology.* ICR, El Cajon, CA, 231p.