Letters

Frozen Mammoths

In an earlier issue of *Science* [**133**, 729 (1961)] William R. Farrand made a valiant attempt to salvage the gradualistic position vis-à-vis the frozen mammoths. But these fossils of the Siberian permafrost present an insuperable difficulty for a theory of slow, gradual geology. Baron Cuvier, one of the most critical observers of these remains, insisted that they were frozen suddenly. He wrote: "It is well known that its tusks are still so well preserved in cold countries, that they are used for the same purpose as new ivory, and, as we have before remarked, individuals have been found with the flesh, skin, and hair, which had been frozen since the final catastrophe of the globe. The Tartars and Chinese have imagined it to be an animal which lives under ground, and perishes whenever it appears in daylight."

In the 1815 edition of Cuvier's *Essay on the Theory of the Earth* (pp. 258, 259), Jameson, the translator and editor, described the finding of a mammoth carcass (reported by Adams). "In the year 1799, a Tungusian fisherman observed a strange shapeless mass projecting from an ice-bank, near the mouth of a river in the north of Siberia, the nature of which he did not understand, and which was so high in the bank as to be beyond his reach. He next year observed the same object, which was then rather more disengaged from among the ice, but was still unable to conceive what it was. Towards the end of the following summer, 1801, he could distinctly see that it was frozen carcase of an enormous animal, the entire flank of which and one of its tusks had become disengaged from the ice. In consequence of the ice beginning to melt earlier and to a greater degree than usual in 1803, the fifth year of this discovery, the enormous carcase became entirely disengaged, and fell down from the ice-crag on a sand-bank forming part of the coast of the Arctic Ocean. In the month of March of that year, the Tungusian carried away the two tusks, which he sold for the value of fifty rubles; and at this time a drawing was made of the animal, of which I possess a copy.

"Two years afterwards, or in 1806, Mr. Adams went to examine this animal, which still remained on the sand-bank where it had fallen from the ice, but its body was then greatly mutilated."

Hundreds of thousands of these animals must have been suddenly killed and then preserved by freezing (Digby). Lydekker, in the *Smithsonian Reports* for 1899 (pp. 361–366), reported that about 20,000 pairs of tusks in perfect condition were exported for the ivory trade in the few decades preceding 1899. "Buried ivory" was apparently in world trade even in Aristotle's time. These tusks, Lydekker wrote, must have been buried or at least frozen "comparatively quickly as exposure in their ordinary condition would speedily deteriorate the quality of the ivory." Lydekker could not explain how these animals could have existed in such numbers in a region where their remains became so swiftly frozen.

Neither sudden freezing nor climatic change could make Farrand hesitate. After explaining the mammoth remains as fortunate accidents, he writes: "an apparent paradox remains—that the climate in northern Siberia was warmer than at present in late glacial time when climates elsewhere on earth were cooler than at present." He admits the animals died "in the warm season, probably in the late summer or early fall, . . . when melting and solifluction would have been at a maximum and, accordingly, locomotion would have been difficult." He concludes that the animals lost their footing in the melted tundra and were killed or drowned.

But according to the Russian expert on this subject (Tolmachoff, cited by Hapgood), the frozen remains are not found in rivers or holes but are often found on the highest points of the tundra. Analysis of the stomach contents of the Berezovka mammoth indicated a temperate climate vegetation. The mammoth was feeding itself in a forested area apparently in late summer. There was no swampy terrain. How, then, can we explain the preservation of flesh in frozen ground? No gradualistic process can result in the preservation of tens of thousands of tusks and whole individuals, even if they died in the winter. They must have been frozen suddenly.

Apparently in spite of this evidence, Farrand concluded: "Since only the heavy-footed giants of the fauna—the mammoths and woolly rhinoceroses—have been found in a frozen state, it is very unlikely that a catastrophic congelation occurred in Siberia. On the contrary, the frozen giants are indicative of a normal and expected (uniformitarian) circumstance of life on the tundra." Unfortunately for Farrand's thesis, the mammoths are no longer existing in the salubrious northern Siberian environment. Farrand's article explained nothing.

In his *Lost Americans* (Crowell, New York, 1946), Frank C. Hibben suggests a possible partial explanation: "One of the most interesting of the theories of the Pleistocene end is that which explains this ancient tragedy by world-wide, earth-shaking volcanic eruptions of catastrophic violence. This bizarre idea, queerly enough, has considerable support, especially in the Alaskan and Siberian regions. Interspersed in the muck depths and sometimes through the very piles of bones and tusks themselves are layers of volcanic ash. There is no doubt that coincidental with the end of the Pleistocene animals, at least in Alaska, there were volcanic eruptions of tremendous proportions. It stands to reason that animals whose flesh is still preserved must have been killed and buried quickly to be preserved at all. Bodies that die and lie on the surface disintegrate soon and the bones are scattered. A volcanic eruption would explain [this]."

Tremendous amounts of volcanic dusts could have cut off sunlight and accelerated the onset of extreme cold. Volcanism can bring into the atmosphere huge quantities of water vapor. Huge blizzards and rainstorms would therefore have accompanied the cataclysm. Slurries of soil and debris, volcanic ashes and dusts and blizzards combined could result in sudden freezing in "tundra." A shift in the location of the pole, possibly by means of the

mechanism suggested by Hapgood, could have resulted in extreme cold and could have ensured the permanent preservation of the destroyed animals in permafrost.

Whatever the precise mechanism, it is apparent than an unbiased observer must agree with what Baron Cuvier wrote well over a century ago: "[Sudden catastrophes] left, in the northern countries, carcases of large quadrupeds frozen in the ice, . . . preserved down to the present period with their skin, their hair and their flesh. If they had not been frozen as soon as killed, putrefaction would have decomposed them. And besides, this eternal frost did not previously exist in those parts in which they were frozen, for they could not have existed in such a temperature. The same instant that these animals were bereft of life, the country which they inhabited became frozen. This event was sudden, momentary, without gradation."

The extermination of the mammoths is part of a larger picture of geologic change that is impossible to reconcile with orthodox gradualism.

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Lippman's letter is typical of several which I have received since the article on frozen mammoths appeared. All these letters indicate that the writers prefer to retain their former ideas about woolly mammoths in spite of abundant evidence to the contrary. I will not reiterate here all the arguments which I have previously presented, but I wish to emphasize certain conclusions once more.

It is surprising to read that "the frozen mammoths are not found in rivers or holes but are often found on the highest points of the tundra." Certainly the best-studied mammoths have come from river banks—on the Berezovka, Mamontova, and Lena rivers. The Lena Delta discovery is the Adams mammoth, which Lippman himself cites.

The botanical evidence speaks for itself. Any treatise on plant ecology and distribution shows that these assemblages (Table 1 in my article) belong in the Tundra and high Boreal zones of northern Siberia, Alaska, and northern Canada. There is absolutely no evidence of forests; all the tree species are dwarf and scrub forms. Only a slight shift, if any, in vegetation zones

is indicated. People who have not been in high arctic areas appear to have little conception of the relatively luxuriant vegetation there—grasses, flowers, shrubs, and dwarf trees. It is amazing what 24 hours of sunshine a day will do!

It is unfortunate that such critics seldom dig back into *original* references. If Lippman had read Tolmachoff's 1929 paper (written in English), instead of reading only Hapgood's interpretation of Tolmachoff's ideas, he would realize that Tolmachoff's ideas on death and preservation are nearly the same as mine.

I would like to say something about Lippman's concept of "gradualism," which he has apparently confused with uniformitarianism. Uniformitarianism ("the present is a key to the past") is the geologist's concept that processes that acted on the earth in the past are the same processes that are operating today, on the same scale and at approximately the same rates. A catastrophe such as a river flood or a tidal wave could have happened in the past just as it does today. Also, the very slow downcutting of streams has always taken place, although the rates have been variable in time and space. It is not logically sound to postulate a major catastrophe on a scale far beyond anything we have experienced to explain geological phenomena which can be adequately explained by the everyday processes which we can observe around us.

Certainly the death (suffocation, in several cases) of the frozen mammoths was catastrophic, and they were frozen in a very short time, geologically speaking—probably in much less than 1 year. Decomposition of the mammoth carcasses was retarded by the cold climate and the very low bacteria count in the Arctic, and by burial of the beasts at the time they died. In at least some cases, decomposition of the flesh had begun before the carcass was completely frozen. Such catastrophes are in accord with the doctrine of uniformitarianism.

Finally, a word about volcanism as a cause of widespread glaciation. The volcanic theory fails on two main counts: it is both quantitatively and chronologically inadequate. The largest volcanic explosions we know—for example, that of Krakatau in 1883—had a very small and short-lived effect on world climate, whereas many decades and centuries of climatic cooling are required to build continental ice sheets.

In addition, the effects of volcanic dust are strongly restricted to areas close to volcanoes. There is little, if any, evidence of world-wide, or hemisphere-wide, volcanism, whereas glaciation *was* world-wide! Moreover, some periods of great volcanic activity, such as that which produced the tremendous lava fields of the Columbia River Plateau in Washington and Oregon in mid-Tertiary time, were not accompanied by glaciation. Many such examples could be cited. Furthermore, it is highly improbable that volcanic holocausts could account for the several fluctuations of the Pleistocene Ice Age: four major and numerous minor advances and retreats of continental ice sheets within the last 1 million years.

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On Planarian Behavior

Recently I have become more than a little interested in the problem of the extent to which learning may be demonstrated in lower invertebrates. As a result, the report of Best and Rubinstein entitled "Environmental familiarity and feeding in a planarian" [*Science* **135**, 916 (1962)] came to my particular attention. I have some doubts about this report and wish to ask whether the authors can resolve them.

The authors compare feeding times in two samples of the animal, one of which they say was "unfamiliarized" with respect to its environment, the other "familiarized." The "familiarized" animals were placed, with no food, for 90 minutes in a plastic test receptacle containing water from their home bowl. They were then removed and put back in their home bowl for 25 minutes. They were then put back into the Lucite test chamber, which now contained liver, and their feeding time was measured. The so-called "unfamiliarized" group were taken from their home bowl and placed in the Lucite test chamber with liver, and their feeding time was measured forthwith.

No doubt the data presented for the feeding times of the two samples, which show that the so-called "familiarized" individuals had a shorter latency period before feeding than the so-called "unfamiliarized" group, were accurately obtained, and the sample of animals, although small in each case, appears to have been adequate to give statistically