GEOLOGY

The Great Ice Age

"A Classic of Science"

Swiss Glaciers Taught Agassiz to Read Records of the Ice Cap that Once Covered Northern Europe and America

ÉTUDES SUR LES GLACIERS; par L. Agassiz. Neuchatel, Jent et Gassmann, 1840. Translated for the SCIENCE NEWS LETTER *by Helen M. Davis.*

SINCE it can be shown by comparative study of fossils and by our knowledge of conditions under which we find animals buried in ice in the North, that the so-called diluvian formation of the North is not only contemporaneous with, but identically the same as, the deposits of bones of the *Elephas primigenius* of central Europe, and since no doubt remains that the catastrophe which froze them was sudden and accompanied by an abrupt change in temperature, it seems to me evident that the animals whose fossil bones are buried in the diluvian soil perished by the same cause, that is to say, by the cold and that consequently they came to be buried in the ice. But since it has been shown that the ice containing the mammoths is older than the lifting of the Alps, because formations with the bones of *Elephas primigenius,* which are contemporaneous with ice which Kotzebue called primitive, were dislocated when the Alps rose, I conclude that there was once a sheet of ice over the soil of Europe, which prevented the complete dispersion of alluvial soil, the filling up of lakes, and all inequalities already existing or formed by the lifting of the Alps. The ice sheet must be understood to be older also than the scattered boulders. The nature and the origin of those boulders themselves become themselves a new proof of the fact, so long ignored, and now so well proved, that the Alps are the youngest mountains in Europe, because the boulders resulting from fractures which they have suffered are always found resting on top of the alluvial soil, and never beneath it.

The formation of this great ice sheet must have swept away as its consequence all organic life from the surface of the earth. The surface of Europe, ornamented only a short time before by a tropical vegetation and inhabited by troups of great elephants, enormous hippopotami and gigantic carnivora, suddenly was buried under a vast mantle of ice which covered alike the plains, the lakes, the seas and the plateaus. After the commotion of a powerful creation came the silence of the dead. The springs dried up, the rivers ceased flowing, and the rays of the sun, rising upon this shore of ice (if indeed they reached it), were greeted only by the whistling of the north wind and the booming of crevasses which opened at the surface of this vast ocean of ice.

Interior Boiled Up

But this state of things had an end, a reaction took place: the fluid masses of the earth's interior boiled up again with great intensity; their activity showed itself in the principal chain of the Alps, whose rocks were altered in many ways and elevated to their present heights, with the crust of ice which covered them; which was itself dislocated like an ordinary rock formation. Enormous falls of rocks detached themselves at that time from the crests which dominated the ice sheet, for example, from Mont Blanc, whose elevation was earlier than that of the eastern Alps, and folds were caused by the appearance of the principal chain of the Alps at the extremity of the mass of Mont Blanc and in all the central and eastern part of the chain. Once strewn on the surface of the mass of ice which filled the space comprised between the Alps and the Jura, this debris remained there as on the surface of a great glacier.

While the appearance of the chain of the Alps had suddenly modified the climatological conditions of Switzerland, the temperature rose again and the alternation of the seasons, making itself felt anew, must have caused continual oscillations of heat and cold there which were necessarily recorded in the ice at the time of the oscillations, as they are exhibited by glaciers in our time. The surface of the great ice sheet of Switzerland must first have taken on a slope conforming to the general inclination of the earth from the Alps to the Jura: if this was of névé, it would be transformed into ice by the alternating effects of freezing and thawing: later its level would be gradually lowered; then would begin that long series of phenomena of withdrawal, analogous to that which certain of our glaciers show: boulders carried on the surface of the glacier depositing themselves the length of the Jura at lower and lower levels, down to that where the soil is uncovered; then organized life commencing to reappear where local circumstances were favorable to their development.

So long as the great ice sheet which covered Europe remained motionless, it must have been covered with snow, like the fields of ice which feed our glaciers in our day; but in retiring into narrower limits, this same ice cap determined its centers of movement in conformity with the highest accidental topography. Thus the Swiss Alps must have been the center of phenomena of transportation of the scattered boulders which are strewn over the great Swiss plain, upon the Jura and in the north of Italy. The appearance of Switzerland at the time of autumnal fogs, when the Alps and the highest summits of the Jura alone rise above the snows, seems to me to give an approximate idea of conditions at the beginning of the retreat of the glaciers, when these had not reached farther than the level of the first ledge below the high peaks of the chain before the Jura.

The moraines properly speaking did not begin to form until the ice began to retire into the valleys. The form and the arrangement of these moraines

prove to us that this retreat of the ice, far from having been instantaneous, was on the contrary accomplished in a gentle and gradual manner; from which I conclude that the epoch of greatest extension of the ice must have lasted a long time.

The retreat of the ice into more and more narrow limits also began from centers of movement in chains where there are no glaciers in our day: this is shown by observations of MM. Renoir and Hogard on the polished rocks and moraines of the Vosges, and those which I have already reported concerning the Dent de Vaulion, which was a glacier surrounded wholly by Jurassic rocks, undoubtedly from a time when the alpine glaciers had attained no greater height than the slopes of the Jura.

The scattered boulders, which differ so markedly from the moraines in their general arrangement, cannot therefore be in any way confused with the latter; since they were strewn before the formation of the moraines, that is to say, while the ice still occupied the entire Swiss plain.

On the other hand, when we consider that all our scattered boulders are so many splinters broken off from the mass of the Alps since their elevation, and that consequently they must have been transported to the places they occupy after this uplift, we are naturally led to ask how it is that they did not fill up our lakes. There are only two possible causes: either the lakes were protected in some way from invasion by the boulders, or else they did not exist when this transportation took place. But we have already seen earlier that this last supposition is contradictory to the facts, since we have observed on both their banks moraines arranged like those of a glacier which undergoes oscillations. I believe in consequence that our lakes are due to the uplifting of the Alps, or at least to dislocations produced by that cataclysm.

The north of Europe is the center of another region of boulders, which are scattered over England, Germany, Poland and Russia, about which M. Pusch has published very interesting general observations. The polished rocks which accompany them have been described by M. Sefstroem.

The north of America, with its scattered boulders and its polished rocks present repetition of the same phenomena in that part of the world.

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MINING

Airplanes Enable Geologists To Survey Arctic Copper

FLYING in a few hours over sections of the Barren Grounds of the North West Territories of Canada, which could be crossed by dog team or canoe only in weeks or months, aerial prospectors have found valuable deposits of copper within the Arctic circle.

This discovery, a recent achievement of man's newest mode of travel in one of the world's most inaccessible and undeveloped regions, is described in reports to the Canadian Mining and Metallurgical Institute by J. P. Norris and Gordon G. Duncan, each a member of geological parties that made extensive surveys with both plane and canoe.

The territory in which the newly-found copper deposits were surveyed lies along the Coppermine River between Great Bear Lake, Canada's largest inland body of water, and Coronation Gulf on the Arctic Ocean—in a land that is practically barren of trees and where in the winter the temperature falls under 50 degrees below zero and in the summer rises to more than 90 degrees Fahrenheit.

Yet the geologists who visited this region believe that when the world demands it, copper can be satisfactorily sent from this distant land of contrasts, either across Great Bear Lake, down Great Bear River to the Mackenzie River and hence to the Arctic Ocean, or directly to the Arctic at Coronation Gulf. Some deepening of rapids would be necessary in the rivers, but no difficulty is expected by ocean-going vessels rounding Alaska and coming into the Arctic Ocean as far as Coronation Gulf, for this has been done in the summer for a number of years.

Some high-grade copper ore has been found, but during the short time the parties were in the field they could not determine how extensive the deposits are. If this ore is in sufficient quantity, it can be profitably moved, Mr. Duncan explained in his report.

"The exploitation of the lower-grade deposits," he said, "is dependent upon the opening up of the area by the successful development of the higher-grade ore. Undoubtedly, other important ore bodies will yet be found."

Although all the flying done by the survey parties was far inland, they never found it necessary to use airplanes on wheels. In fact, it would have been almost impossible to find a suitable landing place for wheels, while myriads of lakes and rivers provided the best of runways for pontoons in summer and skis in winter.

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ARCHAEOLOGY

Air Gun Used to Dust Delicate Artifacts

ARCHAEOLOGISTS have discovered a new use for compressed air. They use it when working at ancient Indian sites to blow the dust of centuries from fine, delicate specimens, such as fur robes, burned matting, or badly disintegrated wood or bone.

The apparatus which has been successfully used by the Van Bergen-Los Angeles Museum Expedition in its work at caves and old village sites is simple. It consists of a small, portable air tank ordinarily used in spraying vineyards and orchards. The tank has a trigger-controlled nozzle through which air, instead of the spraying compound, is directed upon archaeological material too delicate to stand the touch of hands or even a fine camel's-hair brush.

In deposits such as debris of the old Basket Maker Indians, in which perishable materials are found, the air tank and hose with its readily controlled nozzle are most useful. Often, the fine dust of the centuries which has settled upon the artifacts left by these people who died some 1500 to 2000 years ago is soft and fluffy as ashes. Trenching is difficult. Even such tools as the ever-present and easily wielded trowel, the main digging tool of every well-trained archaeologist, prove too heavy.

When such difficulties are met the air gun is brought into play. Steady, gentle air currents are directed at the layers of dust, chaff, light straw and such debris, whisking them to one side, quickly and evenly, leaving the specimen or specimens bare, ready for photographing and, if necessary, treatment for future preservation.

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