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THE surface of the earth holds within its layers of deposits, like the pages of a book, the untold history of the past, a story which, preserved by natural processes, can be deciphered by the student from exposures on the earth's crust. Unfortunately, no single exposure contains a complete record; exposures of sedimentary rocks that contain fossils must be searched for at all points of the earth. These scattered pages or chapters of earth history, when found, are pieced together and used to reconstruct past events.

The history of life is gathered from data accumulated from two sources, first, from the fossils, which are evidences of past life, and second, from the rocks or materials in which the fossils are found. Specialists study the fossil evidence of plant and animal life from their knowledge of living forms and attempt to reconstruct those that lived long ago. By studying the deposits in which the fossils were found, they venture to reconstruct the conditions under which the plants and animals lived and were buried.

It is estimated that the lapse of time since the first preservation of life as recognizable fossils has been at least 450,000,000 years. In Michigan, no deposits are known

that were laid down from the end of Pennsylvania time, approximately 240,000,000 years ago, until near the close of the Ice Age, about 100,000 years ago. The fossils known from the Ice Age deposits in Michigan are the remains of plants and animals that lived in the state during the last 10,000 years.

SUBTROPICAL conditions existed in Michigan during Cretaceous time, with the last of the "ruling reptiles" struggling for existence. Cretaceous time was brought to an end about 75,000,000 years ago by a gradual uplift of the North American continent and the withdrawal of the large shallow sea that had extended from the southwestern part of the Gulf of Mexico northward and westward over the region of the present Rocky Mountains to the Arctic Ocean. As the continent was gradually uplifted and the continental sea withdrew, the Rocky Mountains came into existence, followed by the later uplift of the Pacific Coast Range, and along with these phenomena there came about a gradual change in the climatic condition from subtropical to temperate. The development of distinct and sharply marked tropical, temperate, and arctic climatic zones occurred during glaciation. The climatic conditions which prevail at the present time in the temperate and polar regions are exceptions in geologic history.

Along with the cooling climate in North America that occurred in the Pliocene ahead of glaciation, there was a slow change in the animal life, involving especially the

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extinction of the rhinoceroses, of most of the different kinds of mastodons, and of the last of the oreodons.

The plants and animals that lived in the high mountain regions and the polar regions during the Pliocene possessed, in some measure, a tolerance for the extreme cold that followed during glaciation and were, in part, the forms that lived nearest the ice fields. As a rule plants and animals have a wide range of tolerance to climatic conditions and, therefore, a wide geographical range. As the mountain and continental glaciers began to develop and areas became covered with ice and snow, those that had lived in these regions shifted their ranges away from the ice fields by population spread. The rate of development and advance of a continental glacier is slow enough to permit the plants and snails to reproduce, grow to maturity, and reproduce again and again so that there is a very gradual population shift into new areas in front of the glacier.

THE Pleistocene, commonly known as the Ice Age, is thought to include approximately the last 1,000,000 years of earth history. During that time, ice accumulated in the polar regions and in the high mountains to produce mountain glaciers, and other ice fields formed in high upland areas of continents near the poles to produce continental glaciers.

These ice masses were the result of atmospheric conditions associated with continental uplift which allowed snow to accumulate throughout the year, in the high altitudes of the mountains and in the north and south polar latitudes. These tremendous snowfalls were compacted under their own weight, probably with some sleet and rain included, to form glacier ice. It is estimated that at its maximum the continental glacier ice reached a thickness of at least two miles, if not as much as four miles, in the areas of origin. Owing to the great weight of the overlying ice and the

readjustment of the ice mass because of its weight, the upper part pushed the underlying ice out (by ice flow) around the edges across the earth's surface, irrespective of hills. This adjustment and movement of the ice mass is known as glaciation. That part of the earth's surface beneath the center of the large continental glaciers slowly settled. It took a long time for the ice to form and to move out from the centers of origin to its farthest extent and then to melt and disappear. The melting of the ice mass is called glacier retreat, and the time needed for the spread of the glacier and its melting is spoken of as glacial time. There is evidence that at least four great ice sheets developed and spread out upon part of the North American continent and then melted away. Each glaciation is separated, one from the next, by a long period of time, called interglacial time, when climatic conditions were similar to the present or even warmer.

Following is a list of the glacial and interglacial times recognized in North America:

<i>Glacial Times</i>	<i>Interglacial Times</i>
	Written history, 6,000 years
	Michigan fossil mammals, 8,000-10,000 years ago
	Last advance of Wisconsin ice, 10,000 years ago
WISCONSIN (4th) Lasted 80,000 years; 10,000-90,000 years ago	SANGAMON Lasted 160,000 years; 90,000-250,000 years ago
ILLINOIAN (3rd) Lasted 90,000 years; 250,000-340,000 years ago	YARMOUTH Lasted 270,000 years; 340,000-610,000 years ago
KANSAN (2nd) Lasted 110,000 years; 610,000-720,000 years ago	AFTONIAN Lasted 160,000 years; 720,000-880,000 years ago
NEBRASKAN (1st) Lasted 120,000 years; 880,000-1,000,000 years ago	

During all four major glaciations Michigan was completely covered with glacier ice (see map). The first three glaciations (Nebraskan, Kansan, and Illinoian) moved southward as far as the Ohio River. The last (Wisconsin) reached nearly as far. At four separate and distinct times, Michigan lay for thousands of years in an arctic belt covered with many feet of ice and snow.

THERE is no fossil record of vertebrate life in Michigan just prior to the Pleistocene or during the Pleistocene until the last ice sheet (the Wisconsin) began to shrink. It is doubtful whether any mammals lived on the ice fields that covered the state during any of the four major glaciations at the time the glaciers reached their maximum southern limits. The recession of the ice was probably as slow as its advance, since the plants and animals were able to follow its slow retreat by an extension of their ranges northward by population spread.

Statements about early Pleistocene life in Michigan can be drawn only by inference from knowledge of Pleistocene life in other parts of North America. Only a few of the vertebrates (fishes, amphibians, reptiles, birds, and mammals) that are known to live in Michigan at the present time have been found in Pleistocene deposits, though these forms possess a long geologic history. The reason that so little is known of most of

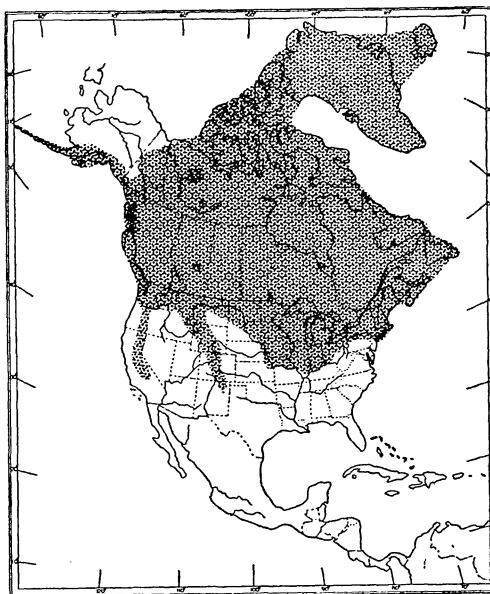
them is that they are small and their remains go unnoticed in the deposits.

As far as is known the Pleistocene fishes, amphibians, and reptiles differed but little from present-day forms except for the large land turtles, many of which were as large as those found on the Galápagos Islands. There is evidence that the bird life was slightly different, in that it included some forms now found in Central and South America. A few of these birds have become extinct.

Large herds of zebras roamed the grasslands to the west, together with bands of a small fleet horse about the size of the Shetland pony. How far east of the Mississippi

River these early Pleistocene horses ranged is unknown.

The ancestor of the American mastodon was one of the first mastodons to reach North America from Eurasia by the Alaskan-Siberian land bridge. The ancestral stock arrived here approximately 10,000,000 years before the Ice Age. The American mastodon browsed along the edges of the wooded streams, especially in eastern North America. These early Pleistocene mastodons were slightly smaller than their descendants which lived in Michigan after the retreat of the last ice sheet. The "short-jawed" mastodon, a distant cousin of the American mastodon and a close relative of the mastodon stock from which the mammoths (elephants)

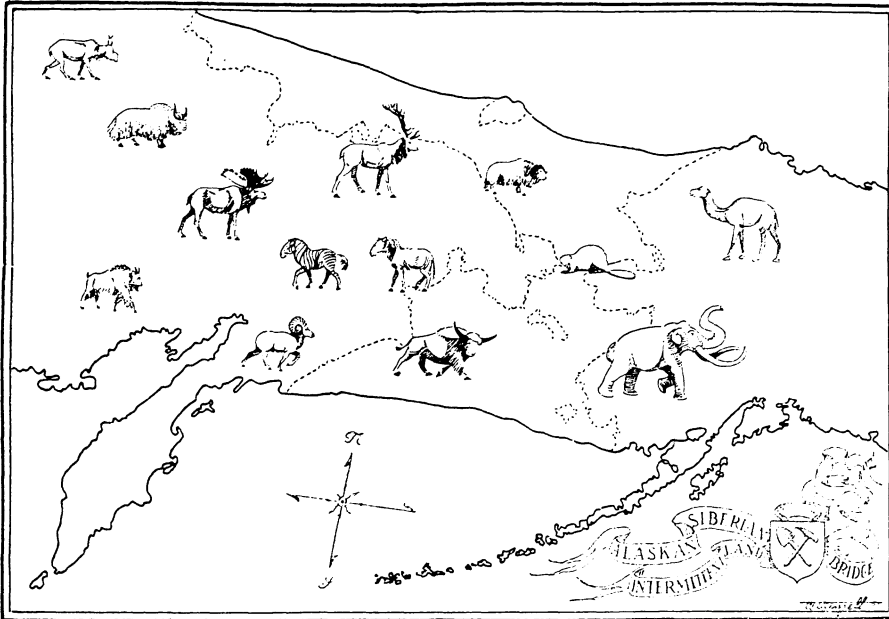


THE ICE AGE IN NORTH AMERICA
Maximum extent of mountain and continental glaciers during the Pleistocene in North America

descended, browsed along the more sparsely wooded streams of the West and Southwest during the early part of the Pleistocene. This species became extinct in early Pleistocene time.

Large sloths lumbered along the valleys browsing on the tender branches of shrubs and trees. The camel originated in North

cat cut down the large and slow-moving mammals. The large jaguar and panther preyed upon the swifter forms. A large bear as big as the grizzly but related to the spectacled bear of South America ranged from Alaska to Mexico and from California to the east coast. The small carnivores, rodents, moles, shrews, bats,



THE ALASKAN-SIBERIAN LAND BRIDGE

Illustrating the intermittent exchange of some of the larger land mammals

America. Many and varied forms lived on this continent, from which they were able to spread both to Asia and South America, later becoming extinct in North America. Bands of peccaries fed along the edge of the forests and meadows on roots, tender plants, fruits, nuts, and smaller animal life. The herbivorous mammals had a common meeting-place, the "water hole," where the sick came to die, the old and weak became mired, and the unalert fell easy prey to the larger carnivores.

Packs of large wolves roamed the open and woodland country. The saber-toothed

and rabbits, were nearly the same as they are at the present time.

A noticeable change in the Pleistocene mammalian fauna took place at middle Pleistocene time after the second glaciation (Kansan). First, certain forms died out, such as the zebras and small fleet ponies, which were unable to survive the changing environmental conditions or were unable to compete with more progressive animals for food and home sites. Second, new forms, such as the elephants (mammoths), musk ox, bison, etc., arrived from Eurasia via the Alaskan-Siberian land bridge.

This land bridge between Alaska and Asia in the region of the Bering Strait existed intermittently during geologic time. When it was present during the Pleistocene, it was broad and high enough above sea level to support a good grassland, shrubbery, and some trees along the grassland border. The mammals that came from Asia to North America or went from North America to Asia either grazed and browsed their way across or preyed upon other animals that lived in this area as they moved from one continent to the other by population spread.

Because of the successive glaciations over a long period of time (approximately 1,000,000 years) certain mammals became well adjusted to arctic, temperate, or tropical environments. Mammals like the woolly mammoth, the woolly rhinoceros, the polar bear, and the present-day musk ox became highly specialized for life in the Arctic and became "chained" to living in the polar region. The present-day musk ox would be doomed if all of the glacier ice melted and the climate moderated, since he could not shed his shaggy coat and replace it with short hair in order to live in a mild climate. Other forms during the Pleistocene became adjusted by Wisconsin time to a cool condition and lived chiefly in the northern temperate region. Some examples of these are the now-extinct northern woodland musk ox, the American mastodon, and the giant mooselike *Cervalces*.

NO PLEISTOCENE vertebrate remains are known from Michigan prior to the last advance of glacier ice. The deposits laid down by the shrinkage of the previous glaciers and during interglacial time were either pushed or carried away down to bedrock by the succeeding glacier or such deposits were overridden and so deeply covered by the last glacier that no Pleistocene fossil evidence has been found in Michigan that is pre-Wisconsin in age. All of the Pleistocene vertebrate fossils discovered in Michigan to date have come

from a surface that was developed as the last ice sheet melted northward. Fortunately, it is possible to date rather closely the shrinkage of the last ice sheet (the Mankato) that covered Michigan. By the study of radioactive carbon recovered from the trunks of trees that were overridden by the advancing ice to the west of Michigan, it has been established that its movement southward occurred approximately 10,000 years ago. This event helps to date the reinhabitation of southern Michigan by plants and animals.

As the Wisconsin glacier receded northward from near the Ohio River, a small belt was left along the edge of the ice that resembled the wide tundra region to the north beyond the timber line. Adjoining this to the south was the timber line, and because of the closeness of the Gulf of Mexico, the Boreal zone was greatly narrowed in width. Between the northern woodland and the Gulf the climate was milder and temperate. The continental life that had existed from the Gulf of Mexico to the Arctic Ocean and from the Rocky Mountains to the Appalachian Mountains had been crowded between the front of the ice sheet and the Gulf.

The shrinkage of the glacier ice was by melting, not only along its southern margin but also on the entire surface of the ice field. The land thus exposed was barren, but it was invaded by plants as soon as they could take root.

In southern Michigan much stagnant ice (large blocks) lay deeply buried on the bedrock in the debris which had been brought down by the glacier. Whether or not the ground was deeply frozen is not known, but sometime after the withdrawal of the ice northward these large pieces melted and thereby permitted the overlying materials to sink. In this way the molds of the former ice blocks were exposed and the many lakes for which southern Michigan is noted were brought into existence.

The Wisconsin ice sheet shrank to the

North across the divide in northern Ohio that separated the southern from the northern drainage system. The thick ice sheet to the north of the divide constituted a dam which prevented the water from flowing northward, so that the melt water from the glacier was ponded between the divide and the southern border of the ice. It filled the large depressions and overflowed

ward. The melt waters allowed them to gain entrance into the lakes that were being formed, as well as to the new water courses (the present streams) that were being developed on the land surface. The rivers carrying the excessive melt water were much wider and deeper than they are at present. The Mississippi was at least five miles wide near the mouth of the Ohio



A MICHIGAN LAKE AT THE CLOSE OF THE WISCONSIN GLACIATION

The giant beaver (Castoroides) and the mooselike Cervalces were to be seen in such surroundings.

through the lowest outlets to reach the Mississippi River. These large ponded bodies of water were the beginnings of the Great Lakes.

The only escape for the melt waters from the ice sheet that lay between the Appalachian Mountains and the Rockies, and for the waters from some mountain glaciers, was by way of tributaries of the Mississippi River into the Gulf of Mexico. After the glaciers began to recede, these swollen streams during late spring, summer, and early fall afforded a pathway for fishes to follow the receding ice north-

and was deep enough to float a large ocean liner. This water was cold, deep, and not too swift.

The oceanic waters to the north had become chilled, and life that had existed in the Arctic Ocean and the northern Atlantic along the coast of North America and Greenland had moved southward along our eastern coast. The chilled water of the Mississippi cooled the water in the Gulf of Mexico. Some of the whales that were roaming the waters of the Gulf entered the flow of the Mississippi. They ascended that river to the junction of the Chicago River,

traveled up it into Lake Chicago, on northeast through Grand River into Lake Saginaw, and thence into Lake Whittlesey. The remains of two of these whales have been found buried well beneath the surface in the beach sands of old Lake Whittlesey. One was found in Genesee County, and the other southwest of Detroit in Lenawee County. As the ice receded farther northward it uncovered two outlets to the north, and the melt water was allowed to flow northeastward. One route was by the way of Niagara Falls, and the other route, known as the North Bay outlet, was well to the north and entered the St. Lawrence River just west of Montreal. A third whale made its way up the St. Lawrence, through the North Bay outlet, and into the large body of water known as Lake Nipissing. The bones of this whale were found buried in the beach sands of Lake Nipissing near Oscoda in Iosco County.

A few have questioned the age of the remains of these whales and suggest that they were carried in by the Indians or by the early settlers. If such is the case, the Indians, or the settlers, possessed a good knowledge of the prehistoric Wisconsin lake beaches in which to bury their discarded whale bones.

AS THE ice receded northward over the divide, the ponded waters encroached upon the tundra zone. The latter accordingly was reduced in area and came to exist only as small isolated patches close to the ice where the land was not covered by water. Herds of the barren-ground caribou, which fed on the tundra, were indistinguishable from those living today. Their remains have been found in the bogs of southern Michigan. It is likely that many tundra plants and animals in the Great Lakes region south of the ponded waters were trapped by the ancestral Great Lakes system, when the tundra zone shifted northward, leaving the plants and animals in an area of a changing climate.

The northern woodland frog moved northward with the barren-ground caribou. Whether it was able to bridge the waters of the Great Lakes system of that time or filtered laterally round them is unknown. This frog is adapted to a frigid climate. At present its range extends from Michigan northward past the timber line into the Arctic and westward into Alaska.

No remains of the musk ox that is now found in the tundra region are known from Michigan. It is an animal of the open country, and its remains are common in Pleistocene deposits of the "High Plains."

Adjoining the tundra on its southern border were the forested and intermittent grassland areas with their successive faunas working their way northward. The hairy American mastodon lived in large numbers along the wooded areas and browsed on the shrubs and trees. It is safe to say that there is at least one mastodon skeleton, or part of one, in every fair-sized bog in southern Michigan. The mastodons lived for a considerable time in Michigan. Their remains have been found in the blue clay below the marl, in the marl, above the marl in the peat, and in the muck above the peat. These skeletal materials have not been confined to any one bog which would definitely indicate their recent extinction, but have been taken from bog areas developed over very different periods of time. It seems quite possible that the mastodon was living in Michigan as late as 6,500 years ago.

The giant mooselike *Cervalces*, a late arrival from Asia or the northwest part of our continent, fed along the edges of the lakes with the American mastodon. Its remains have not been recognized from bog deposits of Michigan, but they are known from similar deposits of New York, Ohio, Indiana, and Illinois that were formed after the ice receded from these areas. Its bones have probably been confused many times with those of the moose, which it closely resembles.

"Timber!" was the word of those days, when, outdoing the exploits of Paul Bunyan, the giant beaver, as large as a black bear, felled trees for its lodge and food. Living at the same time, though taking a back seat, was its smaller cousin, *Castor*, the present beaver which is found along the streams and lakes.

Foraging along the edge of the lakes and forests were the woodland musk ox

Grand Rapids, Michigan, in a bog deposit along with remains of the American mastodon. Its horns are more like those of the cow than those of the other musk oxen. The niche this bovid filled in the late Pleistocene fauna is unknown.

The Jefferson mammoth, a large hairy elephant, stood about eight feet at the shoulder, being slightly larger than the American mastodon. It was a distant cousin



AN UPLAND SCENE IN MICHIGAN AT THE CLOSE OF GLACIATION

In the foreground is a band of peccaries, and at the right the hairy Jefferson mammoth is approaching.

(*Symbos*) and the woodland caribou. Little is known of the woodland musk ox, but its remains are found in the bogs with those of the American mastodon. Could the development of the large lakes to the north have trapped the woodland musk ox and the American mastodon so that, unable to move northward, they found themselves left in an area of changing environment which may have contributed to their extinction?

Sargent's musk ox, *Boötherium*, is known from only one skull, which was found near

of the woolly mammoth that lived to the northwest in the tundra, and it grazed in the meadows around the lakes and between the timbered areas. Because of the absence of extensive grasslands, it was not as abundant as the American mastodon. At the same time there lived in the warmer Southwest a closely related form, the Columbian mammoth. Artifacts of very late Pleistocene man have been found associated with the remains of the Columbian mammoth.

The peccaries, a very distant relative of the domestic pig, roved in small bands

along the edge of the hardwood timbers and the intermittent grasslands. They stood about twenty-six inches high at the shoulder and weighed about a hundred pounds. They were larger than their living relatives, the collared peccary of Texas, New Mexico, Arizona, and Mexico, or the white-lipped peccary of Central and South America. The disappearance of this large peccary from North America after the recession of the last ice sheet is one of many mysteries connected with the extinction of animal life.

It is not known why all of these forms became extinct; their ancestors had weathered four major ice advances and three interglacial environments. Some forms, the woolly mammoth, for example, and also the musk ox, which is living today, had become highly specialized for a life in an extremely cold climate. Such animals, subjected to a very restricted range or a sudden climatic change, are doomed. Our knowledge of many of the extinct forms reveals no such degree of specialization as existed in the woolly mammoth to which their extinction could be attributed.

Along with the extinct mammals known

from Michigan during the late Pleistocene were the forms found living at the present time as far north as the Arctic Ocean. The present-day flora and fauna, together with the forms of life that became extinct during Wisconsin glaciation and up to the present time, constitute the last Pleistocene flora and fauna. These plants and animals lived south of the last ice cap and slowly shifted northward following the shrinkage of glacier ice to become the present-day flora and fauna.

We are still living in the Pleistocene. More than 12,000 years have passed since the last continental glacier began to recede northward. This is between one-twelfth and one-twentieth of the time estimated as occurring in the interglacial ages of the Pleistocene. Time will tell whether we are now living in an interglacial cycle or at the close of the Ice Age. The conditions that brought about the development of large ice caps which allowed great snowfalls to accumulate in those areas are as unknown as are the reasons why and how the climate changed so as to melt the ice caps and permit the interglacial climatic conditions to exist.

