Journal of the Minnesota Academy of Science

Volume 21 | Number 1 Article 2

5-1953

Geologic Dating and the Time Scale of the Ice Age

H. E. Wright Jr.
University of Minnesota

Symposium

DATING THE PAST

GEOLOGIC DATING AND THE TIME SCALE OF THE ICE AGE

H. E. WRIGHT, JR.
University of Minnesota, Minneapolis

INTRODUCTION

The time scale for the Pleistocene is based on cyclic climatic changes. In the higher latitudes these resulted in advances and recessions of glaciers. In the lower latitudes they produced variations in the activity of streams, lakes, springs and other physiographic processes, as well as in the vegetation cover and soil-forming processes. At the latitudes along the sea coasts there were fluctuations of sealevel as water was effectively removed from the ocean basins and stored on the land in the form of glacial ice.

GLACIATED REGIONS

The basic subdivisions of the Pleistocene are founded on the history established for the glaciated regions. In both Europe and North America there are clear records of four major advances of the ice sheets, called the Nebraskan, Kansan, Illinoian, and Wisconsin. The deposits of successive advances are separated by weathering horizons or other indications of warm or interglacial climates. The record of the last or Wisconsin advance is of course most continuously exposed and least modified by later erosional processes, and there appear to be four distinct sub-ages recognizable in the last major age. These sub-ages, named the Iowan, Tazewell, Cary, and Mankato, were separated only by short intervals of moderate recession of the ice-margin (Flint, 1947).

Minnesota may be taken as an illustration of the Pleistocene history in glaciated regions. Here the records of the first three major glacial ages are confined to small areas in the southeastern and southwestern corners of the state, and are incomplete. The last or Wisconsin glacial age is represented by widespread deposits, and all four sub-ages are recognized. Most extensive are the deposits of the third or Cary subage of the last glacial age. These deposits were left by at least four different ice lobes which advanced into the state from different directions (Fig. 1). The drift of each lobe is characterized by distinctive pebbles from known areas of different bedrock, by distinctive color, and by certain patterns of moraines, drumlins, and eskers. Covering the deposits of the Cary sub-age in many places is the glacial drift of the Mankato sub-age. The interglacial interval between the Cary and Mankato subages is called the Two Creeks interval, named for a buried forest bed near Two Creeks in northeastern Wisconsin; the analysis of the radioactive carbon content of the wood at this site, by the technique to be described as part of this symposium, provides one of the firmest absolute dates (about 11000 years) for the late Pleistocene.

The areas freshly bared by retreating ice are generally marked by innumerable depressions. As vegetation gradually advanced and changed in character during the post-glacial or interglacial phases, records of the succession of vegetational changes are preserved in peat bogs in which

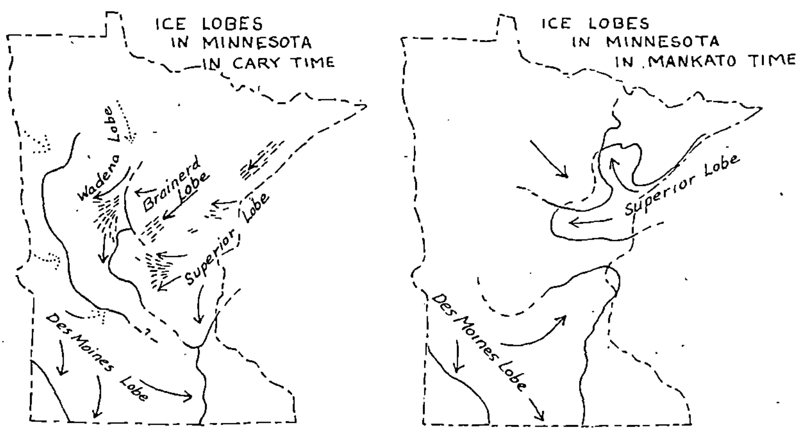

Fig. 1. Ice lobes in Minnesota during the Cary (3rd) and Mankato (4th) subages of the Wisconsin glacial age. Short lines show patterns of drumlins.

the pollens of surrounding trees accumulate. A following contribution in this symposium will deal with the technique of pollen analysis and its relation to interpretation of climatic fluctuations.

PERIGLACIAL REGIONS

In the so-called periglacial regions bordering the ice margin, where the climate was affected by proximity to the ice sheet, a similar succession of cold and warm climates is recorded. In streams draining the ice sheets the cold phases are represented by deposits of outwash gravels and sands, and the warm phases by dissection of these deposits to make terraces. In streams which have their sources not in the ice sheets but in the presumably barren lands bordering the ice sheets, the cold phases are also represented by deposition, brought about by intensified frost-action on the hill slopes. Intensified frost action is further recorded by stone rings, stone nets, contorted bedding, and ice-wedge structures. Interstream areas in the periglacial zone during the cold phases were mantled with loess (wind-blown silt), whereas the warm phases are represented by stabilization of the loess and the development of the weathering profile or soil. On the plains of Kansas, for example, there is a clear succession of loesses and buried soils which may be traced from the uplands into the stream valleys and thence up certain tributary streams to the glacial border (Frye and Leonard, 1952). Loess deposits may be further related to other features of the periglacial and glaciated regions by the study of the snail and mammal fossils which may be found in them.

ARID REGIONS

The succession of cold and warm phases as established in the glaciated regions on the basis of succession of glacial drifts and buried soils may thus be extended into the periglacial regions. Extension into still lower latitudes is based upon physiographic evidences for changes in the effective precipitation (pluvial vs. interpluvial climate). The pluvial climate in the southwestern United States, for example, or in the Mediterranean region, is recorded by changes in the behavior of streams, lakes, springs, and other geologic operators sensitive to water supply. In the arid regions of western United States or Northern Africa, the small existing salt lakes were represented during pluvial phases by greatly expanded water bodies which left distinct beach lines. The changes in stream activity may be seen in western New Mexico, for example, where the valley fillings contain lake deposits, fossils of large grazing animals,

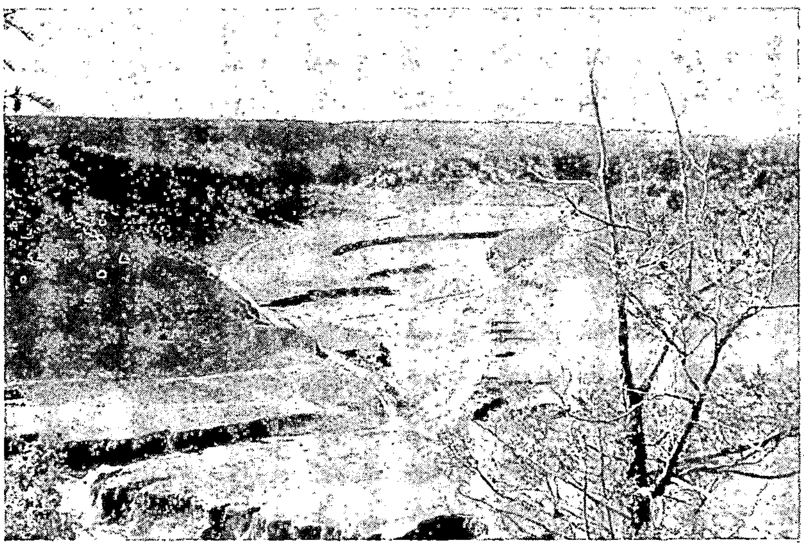

Fig. 2. Gully cut 20-30 feet deep into valley fill of river sands, silts, lake beds, and peat, Bonito Canyon, west of Fort Defiance, northeastern Arizona. Gully cutting started about 1880, and has been ascribed to decrease in vegetation cover as a result of climatic change and overgrazing.

and other indications of widespread vegetation and thus relatively wet climate (Fig. 2); the gully-cutting episodes are related to sand dune deposition and to valleys unprotected by vegetation (Bryan, 1941). Similarly in the foothills of Mesopotamia in the Middle East there is the record of valley filling and cutting which appears to be controlled by climatic fluctuations (Wright, 1951). In both of these examples the recorded climatic changes are all relatively recent; they post-date the last glacial age and are related to the development of early man in these areas. In the New Mexico illustration the climatic fluctuations are further represented by variation in the widths of tree-rings—a subject which will be discussed in detail by another speaker in this symposium.

COASTAL REGIONS

One further geologic method is available for establishing a sequence of cold and warm stages in the Pleistocene. This is confined to coastal regions, but extends to latitudes far beyond the glaciated regions. It is related to the lowering of sea level that is a result of transfer of ocean water to the land in the form of glacier ice. The high sea-level positions reached during intervening interglacial phases are recorded by wave-cut cliffs and terraces, many tens of feet above the modern sea level (Fig. 3). Terraces of equivalent date seem to be at a fairly uniform elevation above sea level, at least in coastal areas of crustal stability (Zeuner, 1952). Each terrace may be correlated with a specific interglacial phase. The coastal terraces may actually be extended up active tributary streams

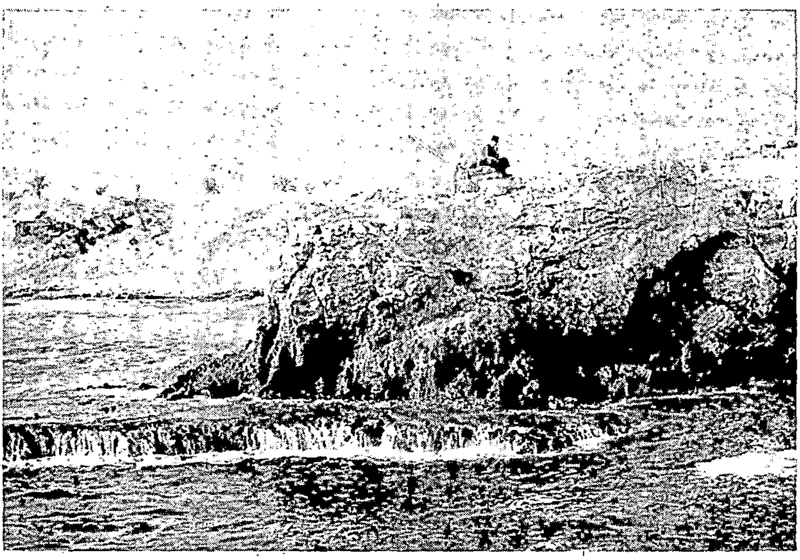

Fig. 3. Marine terrace cut across limestone during the last interglacial interval. Near Beirut, Lebanon. Modern terrace and sea cliff forming in foreground.

for some distance, and thereby the correlations may be extended inland. In some cases, as in the Susquehanna River or in the Thames River of England, the river may head in a glacial or periglacial region in which deposition is active during the glacial phases (with dissection in the interglacial phases) and extend to the sea where deposition was active during the inter-glacial phases.

The geologic field procedure in unglaciated regions, then, is to establish a sequence of climatic changes based upon the study of stream terraces, lake beds, wind-deposits, plant and animal fossils, or other physiographic and paleontologic features. This sequence may be tied to the standard subdivisions of the Pleistocene by direct tracing either to the glaciated regions or to coastal terraces. This is the most effective means of establishing the geologic age of human remains or archaeological materials which might be found in unglaciated regions. The reconstruction of the physiographic and climatic environment is useful as well in inferring the ecology of the landscapes of early man.

BASIS FOR THE TIME SCALE

The method of geologic dating in the Pleistocene provides only relative age, not absolute age. Until the introduction of radiocarbon analysis as a technique of absolute age determination, the date in years of a given deposit or early-man site could only be inferred from a rather inaccurate absolute time scale which had been set up for the subdivisions of the Pleistocene. This time scale was based on two measuring procedures. First, the length of post-glacial time was calculated to be about 25,000 years from a study of annual deposits (varves) formed in glacial lakes during retreat of the ice, and from extrapolation of historic rates of recession of Niagara Falls and St. Anthony Falls. The second precedure involves the degree of weathering of glacial deposits. The deposits of the last glacial age have been weathered to a certain depth during this 25,000 years of post-glacial time. Applying this yardstick of 25,000 years to the measurable depth of weathering of older glacial deposits, one can construct a time scale with absolute age applied to each of the subdivisions of the Pleistocene. On this basis the total duration of the Pleistocene has been estimated at about one million years. The development of the radiocarbon method has resulted in shortening the post-glacial from 25,000 to 10,000 years, and the absolute ages of earlier stages must therefore be adjusted.

The radiocarbon method has therefore added precision to the later stages of the Pleistocene time scale, but the geologic-paleontologic method still provides the framework for dating earlier materials, and may supply as well a reconstruction of the physiographic and climatic environment of interest in the study of the evolution, distribution, and migrations of plants, and animals, and especially Early Man.

LITERATURE CITED

BYRON, K. 1941. Pre-Columbian agriculture in the Southwest, as conditioned by periods of alluviation. Assoc. Am. Geogr., Annals, vol. 31, pp. 219-242.

FLINT, R. F. 1947. Glacial geology and the Pleistocene Epoch. Wiley, New York.

FRYE, J. C. and Leonard, A. B. 1952. Pleistocene geology of Kansas. Kans. Geol. Surv., Bull. 99.

WRIGHT, H. E., Jr. 1951. Geologic setting of four prehistoric sites in northeastern Iraq. Am. Sch. Oriental Research, Bull., No. 128, pp. 11-24.

ZEUNER, F. E. 1952. Dating the past—an introduction to geochronology. Methuen, London.