The quality of the figures and the clarity of the text are high. It is unfortunate that no map of the continent was provided for those unfamiliar with its geographical features and that no chapter was included to provide a hydrological and geographical perspective, given Australia's extremes in climate—its northern tip is like Bengal, the southernmost region is like Norway, but the greatest expanse is comparable to the Sahara Desert. Despite these shortcomings, this is a valuable book for students who require an introduction to various aspects of limnology and for researchers interested in data from Australian inland waters and advances in ecological theory derived from examination of Australia's many distinctive habitats.

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Northern Glacial Chronology

Quaternary Glaciations in the Northern Hemisphere. Report of the International Geological Correlation Programme, Project 24. V. SIBRAVA, D. Q. BOWEN, and G. M. RICHMOND, Eds. Pergamon, New York, 1986. x, 514 pp., illus., + loose charts and tables. Boxed, $110. *Quaternary Science Reviews*, vol. 5.

This large book and the accompanying collection of large charts and tables are the result of a massive international effort to summarize the stratigraphy and chronology of Quaternary glacial events throughout the Northern Hemisphere. For the United States 15 papers of variable length and detail summarize the features region by region, including Alaska and Hawaii. One paper is concerned with Mexico, four with Canada, 19 with Europe, four with the U.S.S.R., one with Japan, and three with China. Compiled by leading investigators in each region, the volume brings together most of the recent research on Quaternary glaciations in the various areas, and the several summary chapters attempt syntheses and correlations with the marine stratigraphic record. The book is published as volume 5 of the journal *Quaternary Science Reviews*, but in a much larger format.

Whereas recent review volumes have been concerned largely with the Late Wisconsin, the present book deals with the entire Quaternary. In the introductory chapter Richmond and Fullerton recognize the almost indecipherable complexity of the early and middle Pleistocene glaciations of the midcontinent and propose the elimination of the long-standing terms "Nebraskan" and "Kansan" in favor of the all-inclusive term "pre-Illinoian." A rationale for this major revision is presented in the chapter on the Central Plains by Hallberg. When the Pearlette ash, once the anchor for correlation of early glacial events in the Kansas area, was discovered to represent three ashes derived from a Yellowstone Plateau source with potassium-argon (K-Ar) dates of 0.61 million, 1.27 million, and 2.01 million years, the glacial chronology for the older Pleistocene fell apart. Paleomagnetic measurements, fission-track dating, recognition of multiple paleosols, deep drilling, and other stratigraphic techniques have revealed the complexity but have not deciphered it. Even the Illinoian till itself, as described in the chapter by Johnson on the Lake Michigan lobe, is considered to represent at least two major glacial fluctuations. The demonstration that the marine stratigraphy recorded many more than four major Quaternary glaciations has certainly been an incentive to reexamine the continental glacial record.

The term "Sangamon interglaciation" is used in a restricted sense to designate the interval of maximum warmth between the Illinoian and the Wisconsin glaciation and is correlated with stage 5e of the marine sequence; the term "Eowisconsin" is introduced for the incipient intervals of cooling (marine stages 5d through 5a) before the Early Wisconsin. It is recognized that the Sangamon soil itself is time-transgressive in both its lower and its upper boundaries: it continued to form in Illinois until buried by the Middle Wisconsin till.

Ever since the formalization of stratigraphic nomenclature in Quaternary geology, and with the introduction of radiocarbon dating, it has been mandatory for glacial geologists to establish synchroneity of regional events before correlation can be justified. This advisedly conservative approach has resulted in the presentation of local stratigraphic terminologies, so that it is difficult for one to obtain a broad historical picture of the Laurentide ice sheet and its fluctuations without remembering dozens of names. For example, Fullerton lists almost 70 named tills for the area from Indiana east to New Jersey, with more than 100 references. The myriad of names for each of the eight U.S. Laurentide ice-sheet areas treated in the book is put in chronological context in a series of very large but rather simply designed and easily understood charts, on which glacial formations, loess units, paleosols, volcanic ashes, and the important stratigraphic units are diagrammatically shown, along with many radiocarbon dates that allow the chronological control to be evaluated. The result is an impressive display of the glacial history as currently understood. Maps within the text provide a picture of the course of Late Wisconsin deglaciation for certain areas, but no overall glacial map of moraines and other features is provided—an almost impossible task in view of the remaining uncertainties in correlation from one area to another. Thus the colored "East of the Rockies" map of 1959 (Glacial Map of the United States East of the Rocky Mountains, published by the Geological Society of America) remains the only available wall map for the Laurentide ice sheet in the United States.

Separate chapters and correlation charts are provided for the Rocky Mountains, the Pacific Northwest, the Sierra Nevada, Alaska, and Hawaii, followed by a synthesis and comparison with other areas. In the Yellowstone Plateau the numerous volcanics associated with glacial features and dated by K-Ar provide the chronological control for events predating the radiocarbon range—so that even the Eowisconsin is divided by Richmond into early, middle, and late. The glacial history is also described by Richmond one by one for 22 other mountain areas in the Rocky Mountains, Colorado Plateaus, and Great Basin.

The summary chapters that conclude the U.S. section of the book, by Richmond and Fullerton, offer a chronology of dated glaciations: Pliocene Alpine glaciation, more than 1,650,000 years ago; early Pleistocene, between 1,650,000 and 788,000 years ago (taken to be the date of the Matuyama/Brunhes paleomagnetic reversal); middle Pleistocene, 788,000 to 132,000 years ago; Sangamon (restricted), 132,000 to 122,000 years ago; Eowisconsin, 122,000 to 79,000 years ago; Wisconsin, 79,000 to 65,000 years ago; middle Wisconsin, 65,000 to 35,000 years ago; and late Wisconsin, 35,000 to 10,000 years ago.

This chronology includes 11 glacial episodes (mostly documented in the Rocky Mountains with K-Ar dates) that match 11 marine oxygen-isotope "cold" stages during the last 900,000 years. The correlation chart shows that the Laurentide ice-sheet chronology has insufficient control to equal this match, because of the lack of radiometric dates as well as the paucity of exposed stratigraphic sections with paleosols and other materials indicating nonglacial conditions.

The synthesis also shows that the last glacial maximum for the Laurentide ice sheet occurred between 22,000 and 21,000 years ago, that for Alpine glaciers about 22,000 years ago, and that for the Cordilleran ice sheet about 15,000 years ago. The ice-volume maximum for North American ice appears to have predated the isotopic ice-volume maximum in ocean cores

(18,000 years ago) by a few thousand years.

The Canadian contributions to the volume are not so comprehensive, consisting of a general chapter and three short summaries for the eastern, western, and arctic sectors, but here also the evidence for glaciation prior to the Late Wisconsin is included, although the inadequate dating control makes a correlation chart impractical.

Europe is treated in two papers for Scandinavia; two for the British Isles; six for the Netherlands, Germany, and eastern Europe; two for northern and central France; five for the Alps, Carpathians, and Pyrenees; one for Corsica; and one for a summation. In Norway, Sweden, and Finland recent research has revealed a record not only of the last interglacial (Eemian) but also of Weichselian interstadial deposits that are correlated with the complex Weichselian stratigraphy of Denmark and the North European plain on the basis of radiocarbon dates and pollen analyses. For the Late Weichselian in Scandinavia, new ideas on the pattern and chronology of glaciation are summarized by Lundqvist, with numerous maps and diagrams.

For England, Ireland, Scotland, and Wales, the wealth of recent research (almost 500 references are cited) is summarized in separate sections, including extensive reference to early and middle Pleistocene events. Unfortunately radiometric dating and related techniques provide little control for time prior to the radiocarbon range, and even paleomagnetic-reversal chronology has not been applicable. The classification of glacial units is largely based on biostratigraphic correlations with the better-defined sequences in the Netherlands. Accordingly no comparison with the oceanic stratigraphy is feasible.

Most of the other European chapters are brief. In Poland the application of thermoluminescence dating provides a chronology to 788,000 years ago covering 11 glacial units correlated with marine oxygen-isotope stratigraphy back to stage 20. Here and elsewhere in Europe the paleobotanical record is sufficiently detailed to permit correlation of interglacial and even interstadial deposits on the basis of pollen stratigraphy and floristics—techniques not used in any American studies.

Of special interest is the loess stratigraphy of Lower Austria, in which the overlapping Stranzendorf and Krems sections with their multiple paleosols span the entire Quaternary back to the Gauss/Matuyama paleomagnetic reversal (2,840,000 years ago). Micromammal evolution provides support for correlation of the overlap of the two sections. Relations of the loess stratigraphy to the classical Günz/Mindel/Riss/Würm sequence of Alpine glaciation are uncertain, however, and in the summation for Europe no real attempt is made to correlate the Alpine glacial intervals with the complex glacial sequence of northern Europe, where the classical pre-Eemian glacial intervals (Saale, Elster) are now subdivided numerous times in an attempt to match the last 22 glacial/interglacial phases of the marine record.

The paper on Soviet Europe by Velichko and Faustova is packed with descriptions, tables, and stratigraphic sections. Correlations for the older glacial phases as presented in a large table in the text are based largely on fossil plants and both large and small mammals in interglacial deposits, especially their extirpations and evolutionary trends. For Siberia, thermoluminescence dating provides a basis for subdividing the earlier Pleistocene back to 630,000 years ago. A summary chapter shows in a table the correlations between eastern Europe, Siberia, and the northeastern U.S.S.R. and presents a map that shows the glacial limits of the various main stages over the entire country, indicating both the minimum version for the last glaciation and the maximum version, in which the ice sheets of northwestern Siberia were confluent and blocked the major north-flowing rivers to create a great proglacial lake that drained south to the Caspian Sea and thence to the Mediterranean.

For Americans in particular this impressive volume provides a convenient entry to the recent Quaternary research in Eurasia, which is proceeding at a rate equal to that in this country. The approach throughout is geared towards establishing correlations among regions in order to build up a grand chronology. This has always been the aim of much of Quaternary research, but the impetus to pursue it in greater detail has come from, first, the firm establishment of a master glacial chronology based on marine oxygen-isotope stratigraphy, so that the old quadripartite subdivision of the Pleistocene could no longer be valid, and, second, the development of new dating techniques in addition to radiocarbon analysis, for example paleomagnetics, thermoluminescence, K-Ar dating of volcanics, and the analysis of micromammalian evolutionary trends, so that the early and middle Pleistocene could be studied and correlated more objectively. Certainly the last word has not been presented on these problems, or on the terminology, but this volume should be a milestone in the history of Quaternary research.

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