celestial x-ray sources were identified, especially by Naval Research Laboratory (NRL) workers. Hirsh sees the decade of the 1970's as the next stage of development, from the satellite Uhuru in 1970 until satellite Einstein in 1978. Utilization of these platforms allowed a major expansion both of equipment and of observing time. The evolution of x-ray astronomy is examined along several axes: political, sociometric, and intellectual. X-ray astronomy received its first instrumental boost from post-World War II rocket development and its second boost from post-Sputnik developments. The growth of government laboratories (such as NRL and, especially, NASA) is presented in the climate of civil and military national objectives. Hirsh shows the complexity and pluralism of support for modern American science: civil, military, industrial, and university groups competed, collaborated, and contributed to the growth of x-ray astronomy.

Like ionospheric physics and radio astronomy, x-ray astronomy began as a subject heavy in instrumentation. Equipment, methods, and data searched for a theoretical community. The work was done not by astronomers but mainly by physicists familiar with balloon and rocket experiments, Geiger counters, and electronics. Early theoretical models (synchrotron radiation, the neutron star) for energy generation and conversion provided only limited success in application to x-ray astronomy until the evolving subject itself became of greater conceptual interest to other fields such as galactic astronomy, nuclear physics, and cosmology. Hirsh highlights a competition between Herbert Friedman at NRL and Riccardo Giacconi at American Science and Engineering (an MIT spin-off company). Very much as in earlier radio astronomy, there was also competition in x-ray astronomy between the sky-survey approach and the single-star approach.

Portions of this book will be heavy going for those not literate in physics, but the treatment of theory chasing data chasing theory is nicely done. An unsolved problem for historians is how best to tell the intellectual history of a highly technical field while treating the social and political aspects and still give at least cameo roles to individuals. Several persons are subjects of mini-biographies, especially Friedman and Giacconi, but Hirsh could profitably have given us more. Even hilarity has ties to intellectuality. For example, although this isn't mentioned in the book, a few years ago near NASA's Goddard lab there was a "Riccardo Giacconi Look-Alike" costume party. Although Hirsh treats the topic, this reviewer wished for a more extensive discussion of the relationships between scientific development and military needs and contributions. Military-scientific operations (for example, the Argus tests in 1958 or the Vela Hotel satellites in the 1960's and 1970's) have often made scientific contributions, but their design and implementation have not usually been maximized for cooperation with or contribution to science. One suspects there is more than meets the eye with respect to the ensemble of U.S. military and civilian work in satellite and ground-based x-ray astronomy.

This volume is generally well written, proofread, and printed and is a welcome contribution to the history of modern science.

C. STEWART GILLMOR
Centre de Recherches
en Physique de l'Environnement
Terrestre et Planétaire,
94107 Saint-Maur des Fossés, France

Quaternary Geology

Glacial Lake Agassiz. JAMES T. TELLER and LEE CLAYTON, Eds. Geological Association of Canada, Toronto, 1983. vi, 451 pp., illus. C$34; to members, C$28. Geological Association of Canada Special Paper 26. From a symposium, Winnipeg, May 1982.

This book uses glacial Lake Agassiz as the focus for a synthesis of the Late Quaternary history of a large segment of central North America. Agassiz was the largest of the North American glacial lakes and occupied as much as 950,000 square kilometers of the area that is now Manitoba, Northern Ontario, Saskatchewan, North Dakota, and Minnesota during the melting of the last ice sheet, 12,000 to 8,000 years ago. The papers in the book describe Quaternary geology and deal with such matters as vegetation colonization, Holocene climate, dispersal of lower vertebrates, and archeological development.

One group of papers covers regional aspects of Quaternary geology and paleoecology. Some of these papers, such as ones on the stratigraphy and history of the southern part of the Lake Agassiz region by M. M. Fenton, S. R. Moran, J. T. Teller, and L. Clayton, Lake Agassiz in Saskatchewan by B. T. Schreiner, and the paleoecology of the southern part of the Lake Agassiz basin by A. C. Ashworth and A. M. Cvancara, are largely syntheses of data already available. Others, such as ones on the development of northern Lake Agassiz and its relation to Keewatin and Hudsonian ice regimes by L. A. Dredge and Lake Agassiz and the late glacial history of northern Manitoba by R. W. Klassen, present data and interpretations not previously published. Other groups of papers take up specific problems or present Quaternary histories of limited areas—for example, there are papers on the Sheyenne River and its effects on Lake Agassiz by J. A. Brophy and J. P. Bluemle, the Lake Agassiz-Lake Superior connection by J. T. Teller and L. H. Thorleifson, the origin of reticulate and oblicular patterns on the floor of Lake Agassiz by J. D. Mollard, and the postglacial dispersal of lower vertebrates in the Lake Agassiz region by K. W. Stewart and C. C. Lindsay.

Although considerable research has been devoted to Lake Agassiz and general agreement has been reached concerning the events that occurred during its formation and drainage, agreement has not been reached on the age of all events. The paper by Fenton *et al.* is an excellent summary that correlates glacial and lacustrine stratigraphic units within the southern part of the lake basin and provides an integrated history—complete with paleogeographic maps—of Lake Agassiz. The chronology in the paper is based on radiocarbon dates for wood; the authors reject dates for other types of organic material because of the danger of errors due to contamination. The history they outline has the lake forming on the north side of the Red River–Minnesota River drainage divide as the Late Wisconsinan glaciers retreated. Two and possibly three readvances of the ice occurred before ice retreat opened spillways in Ontario that permitted drainage of Lake Agassiz into Lake Superior and abandonment of the Minnesota River spillway. Readvance of the ice caused the lake to rise to its former outlet before retreat again opened the outlet to Lake Superior. According to these authors this sequence of events occurred between 11,700 and 9,500 years ago. Disappearance of the lake took place about 8,000 years ago when ice retreat permitted drainage directly into Hudson Bay.

In another paper, Klassen disagrees with the rejection of all radiocarbon dates other than those for wood and uses dates for all types of organic material to develop a longer history that has Lake Agassiz coming into existence more than 13,000 years ago.

In 1985 W. Upham established the geological significance of glacial Lake Agassiz in his United States Geological Survey Monograph 25, *The Glacial Lake*

Agassiz. The proceedings of a 1966 conference on environmental studies of the glacial Lake Agassiz region tied the biological story of lake basin history to the geological story. This new volume provides the Quaternary story as it was known in 1982. It is an excellent book that will stand as the definitive reference for the Quaternary of the heart of North America for many years.

R. J. FULTON

Geological Survey of Canada, Ottawa, Ontario K1A OE8, Canada

Elements of an Orogen

Regional Trends in the Geology of the Appalachian-Caledonian-Hercynian-Mauritanide Orogen. PAUL E. SCHENK, R. T. HAWORTH, J. D. KEPPIE, W. E. TRZCIENSKI, P. F. WILLIAMS, and G. KELLING, Eds. Reidel, Boston, 1983 (distributor, Kluwer Boston, Hingham, Mass.). xiv, 398 pp., illus. $53.50. NATO ASI Series C, vol. 116. From an institute, Fredericton, N.B., Canada, Aug. 1982.

This book is a collection of papers presented at a meeting of geologists many of whom have worked together on the International Geological Correlation Programme Project 27 to compile geologic data from the Appalachian (eastern North America), Caledonian (British Isles and Scandinavia), Hercynian (France, Spain, and Portugal), and Mauritanide (West Africa) orogens and to combine these data to obtain a better understanding of the orogen as a whole. The book is divided into six sections. The first five are summaries concerning geophysics, stratigraphy and sedimentology, volcanism and plutonism, metamorphism, and deformation. Included in the sixth are studies of mineralization and tectonics in the Canadian Appalachians.

Several thought-provoking interpretations are made from maps of geophysical data (section 1). For example, in the U.S. Appalachians two bands of gravity highs apparent on residual Bouguer maps for wavelengths shorter than 250 kilometers are interpreted by Kane to represent rifting environments, which is consistent with the presence of bimodal volcanic rocks reported by Fyffe *et al.* along the Blue Ridge and Green Mountains (section 3). In contrast to several papers published previously, both Roy *et al.* and Seguin and Fyffe conclude that paleomagnetic data do not support extensive left-lateral faulting within the northern Appalachians during Carboniferous time. From gravity and magnetic data Lefort *et al.* identify structures beneath the U.S. Atlantic Coastal Plain that they interpret to be the same as those in the Mauritanide orogen and propose that a prong of the African plate has been left behind. Schenk (section 2) interprets the Meguma terrane in Canada as part of that plate.

Poole *et al.* (section 2) give an excellent overview of the stratigraphy of the orogen. Tables, schematic maps, and text speak to the distribution of rock type in the geologic record. Other papers in section 2 provide more details of the stratigraphy of Scandinavia, Morocco, Nova Scotia, and Avalonian terranes. An interesting suggestion made by Kennan and Kennedy (section 6) is that coticules (manganese garnet quartzites) may be used for long-range correlation.

Succinct summaries of igneous rock type, age, intrusive morphology, distribution, and inferred tectonic setting are presented for the Appalachians, the Caledonides, and France (section 3). However, the lack of maps and, in several papers, references is frustrating. Metamorphic rocks from these areas are discussed in terms of metamorphic facies, grade, facies series, and age (section 4). Small-scale maps are extremely informative; Robinson nicely distinguishes each metamorphic event in southern New England on separate maps. Fisher suggests that a metamorphic facies series is correlated with the composition of magma formed during the same "event" and supports this hypothesis with data from New England. Tables and maps are used effectively in section 5 to summarize deformation type, plutonism, metamorphism, isotopic data, and fossil occurrences in time and space. Osberg suggests that plutonism continued beyond deformation in the Appalachians.

The book is an important reference for anyone interested in the bedrock geology along the margin of the North Atlantic Ocean. Though it lacks an integrated overview of the orogen as a whole, it does, as is stated by Schenk, emphasize the importance of a multidisciplinary study. It is the only reference I know of that brings together summaries of so many aspects of the geology of the orogen. Most of the papers are well referenced for those wishing to delve into further details. The authors are well versed in the subjects they address, and the data compilations they present will save the reader countless time wading through the literature.

JO LAIRD

Department of Earth Sciences, University of New Hampshire, Durham 03824

Books Received

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