



Roadside Geology of Minnesota, edited by Richard W. Ojakangas, 2009, Mountain Press Publishing Company, Missoula, Montana, 353 p., USD 26.00, paper, ISBN: 978087425624.

Having received part of my geology education in Minnesota, the opportunity to review *Roadside Geology of Minnesota* by Richard W. Ojakangas was a pleasure. The guidebook brought back fond memories of field trips to some of the sites covered in the book. Dr. Ojakangas is a native Minnesotan and professor emeritus in the Department of Geological Sciences at the University of Minnesota Duluth. He has written the book in an easy-to-follow manner that targets the novice interested in learning about Minnesota geologic history. Geologists and geology students will also find the book valuable as reference tool.

The book covers over 3.5 billion years of Earth's history, which includes a mountain building event at about 2.7 billion years ago, deposition of economically viable Proterozoic iron formations, igneous activity produced from abortive splitting of the North American continent during the Proterozoic, Paleozoic transgressions and regressions of shallow tropical seas, and the more recent events of the great ice age. In addition to the geologic story of the state, Dr. Ojakangas also provides interesting information on Native American Indians, explorers, and settlers in the region and discusses changes in the vegetative cover after the last ice age, as well as changes to the landscape as a consequence of farming and logging activities.

The book begins with an introduction of general geologic concepts on the origin of the three major rock types and concepts of plate tectonics to assist the reader in understanding the geology of the various road stops. This is followed by a detailed discussion on the geologic history of the state from Archean to present. The book is then divided into four sections—Northeastern, Northwestern and Central, Southwestern, and Southeastern—based primarily on the geologic history and rock types exposed in each region. Each section begins with a general introduction of glacial and bedrock geology, which should be read before embarking on any road trip, followed by a road guide for the various major highways dissecting each region.

A substantial part of the book focuses on northeastern Minnesota, because it contains abundant Precambrian outcrops exposed by erosive Pleistocene glaciers. The erosive effects of glaciation can be viewed at several road stops in the form of polished bedrock surfaces, concentric gouges, and glacial striations. The introduction to this section along with geologic

explanations for the various road stops highlights the development of a late Archean greenstone belt composed of volcanic and related sedimentary rocks metamorphosed and deformed during the Algonian orogenic event about 2.7 billion years ago. One stop in particular shows well-preserved pillowed basalts within the greenstone sequence. Also highlighted in this section is the Mesabi Iron Range, known for producing high-grade iron ore from the early Proterozoic Biwabik Iron Formation. The book includes stops to view the iron formation in road cuts along U.S. 53 near the town of Eveleth and a stop to view mining operations at an overlook near the city of Virginia. For a more close-up view of mining operations, Dr. Ojakangas recommends a visit to Soudan Underground Mine State Park. My family recently toured the underground mine, and it was one of the highlights of our vacation. The field guide also visits spectacular outcrops of basaltic lava flows that comprise the 1.1 billion-year-old North Shore Volcanic Group exposed along the scenic North Shore of Lake Superior, and he discusses the interesting origin of these flows as part of the Midcontinental Rift System that extends between Kansas and Michigan. For those of us who are native Minnesotans, learning that the state gemstone, the agate, is derived from secondary minerals filling vesicles at the top of some of these basaltic flows was interesting. Several stops provide the opportunity to search for agates on the beaches of Lake Superior. The book also visits the Duluth Complex: the intrusive equivalent of the North Shore Volcanic Group and one of the world's largest gabbroic complexes. After reading this section of the book, I am inspired to use the book as a guide for a field trip to introduce my students to the early geologic history of this part of North America.

The Northwestern and Central section of the field guide offers an excellent opportunity for the novice to learn more about the glacial history of Minnesota. This area of the state contains most of Minnesota's 10,000 lakes. The text discusses the formation of these lakes as well as the extension of Glacial Lake Agassiz into the northwestern corner of the state. The guide points out several locations where the traveler can view ancient beaches that formed along the shore of Glacial Lake Agassiz. The book includes a visit to Glacial Lakes State Park where one can see numerous glacial features, including esker, kames, and

kettles. There are also stops to see end moraine deposits from four glacial lobes that extended into central Minnesota during the last major ice advance. For those that do not suffer from motion sickness, the field guide includes a roller-coaster ride over the Wadena Drumlin Fields along MN 210 between the towns of Staples and Hewitt. Northwestern and central Minnesota is also home to the source of the Mississippi River at Itasca State Park. Dr. Ojakangas provides an excellent description of the glacial geology of the park and discusses interesting facts on the discovery of the source of the Mississippi River and on the Native American history of this area. Although exposures of bedrock are uncommon in this section, the book does include a few stops to view Precambrian bedrock exposures located along the Rainy River, south of Lake of the Woods, and in the St. Cloud area. Of particular interest are the Proterozoic granites that have been extensively quarried for building stone and crushed rock near St. Cloud.

The Southwest section of the book highlights some of the oldest rocks in the world—the 3.5-billion-year-old Morton Gneiss. The text indicates that the Morton Gneiss was considered to be one of the oldest rocks on Earth, which has since been replaced by 3.8- to 4.28-billion-year-old volcanic rocks located along Hudson Bay in northern Quebec. The field guide includes several stops along the Minnesota River in the vicinity of the towns of Morton and Redwood Falls to view the gneiss. Traveling further to the southwest, the road guide visits outcrops of the 1.7-billion-year-old Sioux Quartzite at Blue Mounds State Park, Pipestone National Monument, and the Jeffers Petroglyphs. In addition to providing information on the Sioux Quartzite, the book highlights the tall grass prairie preserved at Blue Mounds State Park and discusses the Native American history of Pipestone National Monument and the Jeffers Petroglyphs. Pleistocene glacial features outlined in the book consist mostly of moraine deposits, with deposition of deposits influenced by an elevated plateau extending from the northeastern corner of South Dakota to southwestern Minnesota. The road guide also includes stops along the Minnesota River valley to view the extraordinary

width of the valley, which was cut by Glacial River Warren when part of Glacial Lake Agassiz catastrophically emptied.

The final section of the book on southeastern Minnesota takes the traveler through a fascinating period of geologic time when warm shallow seas teeming with life periodically covered much of the North American craton. Part of this region escaped glaciation during the last ice age, and as a result, stream erosion has exposed over 1,500 feet (457 m) of sedimentary rock dating from 504 to 374 million years ago during the late Cambrian to Middle Devonian periods. The book contains a stratigraphic column and cross section to help navigate through the sedimentary rock stratigraphy. Numerous stops allow you to view sedimentary units and rock sequences that were deposited in a variety of near-shore and shallow marine environments. Some of the stops provide the opportunity to see such sedimentary structures as cross bedding and ripple marks and to collect marine fossils. Many of the fossils in my own collection are from this area. The guide also highlights karst features—caves and sink holes—that have formed in some of the carbonate units. A trip through this region is interesting not only for the geology but also for its spectacular scenery.

The book contains abundant photographs, maps, and diagrams to help orient travelers as they visit the various road stops. A glossary is also available to assist with any unfamiliar terms used in the text. The book is comparable to other volumes in the *Roadside Geology* series published by Mountain Press and is a valuable addition to this series. I have thoroughly enjoyed reading the book and highly recommend it to the Minnesota traveler interested in learning and experiencing the geology of the state. I will be taking my copy back with me to Minnesota when I visit my family this summer.

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