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The establishment of the Minnesota Geological and Natural History Survey was brought about by a law drafted by Pres. W. W. Folwell, and introduced by Sen. J. S. Pillsbury, which passed the legislature of Minnesota on March 1, 1872. The purposes of this Survey were to carry on a geological and natural history survey of the state, and to prepare a geological map of the state on which the various geological formations should be shown. Prof. N. H. Winchell was appointed State Geologist in July, 1872, and his service began September of that year. On December 31, 1872, the first annual report appeared and in it was presented a brief summary of the then existing knowledge of the geology of Minnesota. Following this for 24 years, begun 1872, and ended 1895, annual reports, in all 24, were issued. Besides these reports, bulletins were issued as follows: No. 3, botanical, in '86; No. 2, on petrology and No. 4 on aphidae, in '87; No. 5, on natural gas, in '89; No. 6, on the iron ores, in '91; No. 7, on Minnesota mammals, in '92; No. 8, on igneous rocks, in '93; No. 9, botanical, in '98; and No. 10, on the geology of the Mesabi Range, in '94.

Along with the series of 24 annual reports and the 10 bulletins, six great quarto volumes were issued, entitled the Final Report of the Geological and Natural History Survey. Of these Vol. 3, on Paleontology, was divided in two parts; Part 1, 474 pages and Part 2, 607 pages, both illustrated with plates and figures. While the annual reports and bulletins treated all parts of the state and some of them the geology as a whole, the Final Reports included a regional treatment of groups of counties.

Material for the first report was gathered from 1872 to 1882 and the report, Vol. 1, was issued in 1884. This treated about three tiers of counties along the south border of the state, including Houston, Winona, Fillmore, Olmsted, Mower, Dodge,

Freeborn, Steele, Waseca, Blue Earth, Faribault, Watonwan, Martin, Cottonwood, Jackson, Murray, Nobles, Pipestone, Rock, Brown, Redwood, Yellow Medicine, Lyon, Lincoln, Big Stone, Lac qui Parle, Le Sueur, and Rice Counties. In Vol. 1 there was also a comprehensive treatment of early explorations, also a treatment of building stones and of the physical features of Minnesota.

The second volume of the Final Report appeared in 1885. This treated the counties in the central part of the state, including Wabasha, Goodhue, Dakota, Carver, Scott, Sibley, Nicollet, McLeod, Renville, Swift, Chippewa, Kandiyohi, Meeker, Wright, Hennepin, Ramsey, Washington, Chisago, Isanti, Anoka, Benton, Sherburne, Stearns, Douglas, Pope, Grant, Stevens, Wilkin, Traverse, Otter Tail, Wadena, Todd, Crow Wing, Morrison, Mille Lacs, Kanabec, Pine, Becker, and Clay counties.

In Vol. 4 of the Final Report, 1896-1898, was treated the geology of the north part of Minnesota, including the counties Carlton, Aitkin, Cass, and part of Crow Wing, Hubbard, Norman, Polk, Marshall, Rosseau, Kittson, Beltrami, Itasca, St. Louis, Lake, and Cook; the Pokegama Lake; Grand Rapids and Swan Lake plates; the Hibbing, Mountain Iron, Virginia, Partridge River, and Dunka River plates of the Mesabi Iron Range; the Gabbro, Snowbank, Fraser, Akeley, Gunflint, Rover, and Mountain Lake plates; the Pigeon Point, Vermilion Lake, Carleton, and Duluth plates.

In this volume the geology of the iron ranges is discussed and also the economics of iron ores are summarized. Of the Final Report, Vol. 3, as already stated, treats the Paleontology of Minnesota, Vol. 5 treats the Petrology, and Vol. 6 is an atlas in which maps of each section of the state are brought together with a brief discussion of the geology of each.

Iron ore was first produced in Minnesota in 1884, when the Duluth and Iron Range Railroad was completed from Two Harbors to Tower. That year the Minnesota Iron Co. began shipments at a rate of 15,000 tons a month.

The Mesabi Iron Range lies south of the Vermilion Range and the road to the latter crosses the Mesabi at the town of that name. Valuable iron deposits were found in this region in 1890 and shipments began in 1892. Iron had been noted at

Gunflint Lake by J. G. Norwood, as early as 1852, and by E. Whittlesy in 1866. In 1866 also Eames stated that bodies of iron ore were to be found in the northern part of the state. The reports of these explorations made, however, only casual mention of the iron ores. In 1878, Professor Winchell reported the occurrence of iron in R. 14 W., and published two analyses of ores from Towns. 59 and 60, R. 14, showing them to be non-titaniferous Bessemer ores. In 1881 he recorded the results of a trip from Embarrass Lake east to Range 14, where he described the "Gunflint beds" or iron formation. These descriptions antedated the opening of the first Mesabi iron mines about ten years.

The 10th Report, 1881, calls attention again to the existence of iron ore in Minnesota in large quantities and in this Professor Winchell predicted that a great industry would be developed in the northern part of the state because of them. Says he: "The blast furnace which is now in operation at Duluth, using ore from Marquette, should be supplied from Minnesota." The 11th Report, 1882, contains a note on the age of the rocks in the Vermilion and Mesabi Ranges. The 13th Report gives an account of the opening of mines of the Minnesota Iron Co. at Tower, the first mine opened in the state. The 15th Report takes up the geology of the iron-bearing rocks, giving the detailed field observations of 1886 and includes a map of the region from Vermilion Lake to Pigeon Point and one of the region of Vermilion Lake. The 16th Report, 1888, has a map of the area between Rainy River and the headwaters of the Mississippi. The 17th Annual Report summarizes work on the crystalline rocks, and the 18th Report takes up the area east of Pokegama Falls and the region about Tower and Ely.

As early as 1884 Professor Winchell stated that the ore occurs at three horizons: (1) the titaniferous ores of the gabbro belt; (2) the magnetites and hematites of the Mesabi area; and (3) the hard hematite of the Vermilion Range.

In 1890, November 16, the first body of rich iron ore of economic importance was discovered on the Mesabi Range. This was in a pit dug by J. A. Nichols, in charge of the crew working for the Merritts of Duluth. About this time also John McCaskell, an explorer, noted iron on the roots of an upturned

tree near the present site of Biwabik. Test-pitting there by W. J. Merritt soon disclosed the Biwabik ore body.

Up to the time of these discoveries all accounts of the Mesabi region refer principally to the east end of the range, where the ore formation is changed to hard magnetite rocks by the Duluth gabbro and the Embarrass granite. There, on account of its indurated character, the ore formation does not concentrate to iron ore by weathering as does the greenalite in the central and western part of the range. As soon as the rich ore at Biwabik and Iron Mountain was discovered prospectors rushed to the district and for several years explorations were carried on vigorously. The Geological and Natural History Survey represented by Profs. N. H. and H. V. Winchell, aided by new data gained from test pits, attacked the problem vigorously at the very beginning of the new development. In 1892 a report was published showing the distribution of rocks and ore formation, including the discovery of Merritt.

In 1894 the Survey published a report and detailed maps of the Mesabi Range. This report was by J. F. Spurr of that survey, and brought knowledge of the new range down to date. The maps of the report which include the greater portion of the district, show the Virginia-Eveleth loop, the relations to granite and gabbro at the east part of the range, and the essential geological features and boundaries of the ore formation. As new data were accumulated these delineations of the boundaries of the ore formation proved to be remarkably accurate. Maps of the entire region were published later in Vol. 4 of the Final Report, 1898. The reports early and late contain comprehensive discussions of the origin of the ore and analyze extensively current opinions of iron ore genesis.

Regarding the genesis of the Minnesota iron formations, Prof. Winchell maintained that the iron was precipitated in ancient seas, but that there were contributions to these seas from igneous material probably while the latter was in a heated condition. This theory includes some novel features, and, so far as I am aware, was presented by Prof. Winchell for the first time.

Concerning Prof. Winchell's interpretation of the geologic structure of the iron region, we find in his earliest reports that they are of pre-Cambrian age and the recognition of deposits of

the two great geologic series. Notwithstanding the drift which covers the outcrops at many places, Prof. Winchell seems to have recognized the essential features of the structure long before exploration began. From the beginning his statements concerning the value of the ore bodies and the future of the industry were optimistic. They were doubtless a source of encouragement to prospectors and operators throughout the early years when the value of the deposits must have appeared at times problematical.

Summarizing Prof. Winchell's contributions to the development of the iron industry of Minnesota, his greatest services were (1) repeatedly calling attention to the presence of the ores and ore formations in the period before the ranges were brought to a producing stage, and (2) delineating the geologic boundaries of the ore formations so that they could be intelligently prospected for concentrations of iron.

I quote from John Birkenbine, statistician of the United States Geological Survey, in a report of 1896, the following: "The Geological Survey of Minnesota is to be congratulated upon having pointed to the region now known as the Mesabi Range as a probable iron producing district prior to active exploration and the limits in which workable bodies of commercial ore have been found correspond closely with conclusions arrived at by the geologists as to the probable existence of this material." (Seventeenth Annual Report, U. S. Geol. Survey, Pt. III, p. 33.)

Prof. Winchell was a man of tireless energy and methodical habits of study. To both these qualities, or rather to their combination, is due his great productiveness as a scholar, extended over a long term of years. The geological museum which was built up by Prof. Winchell and his associates, contains collections of Minnesota fossils, minerals, and rocks, determined and labeled with minute attention to details. Among its other valuable collections will be found one of the best collections of meteorites in the world. As founder and editor of the American Geologist, and as a frequent contributor to it, Prof. Winchell stimulated the study of geology throughout the world. For many years this was the only publication exclusively devoted to geology in the United States, and today its successor, Economic Geology, is the world's leading exponent of applied geology.

As a broad student and scholar and as editor of the American Geologist, Prof. Winchell had an unusual opportunity to build up a collection of geologic books and periodicals, which was one of the most valuable private libraries in the country. This priceless collection, which could not have been obtained by purchase from dealers at any price, Prof. Winchell, with characteristic generosity, gave to the University of Minnesota in 1911.

As bearing on his contributions to science, there should be mentioned also the contributions of the men who were trained on the Geological Survey of Minnesota. These men, most of them at an early age, were employed by Prof. Winchell, in the Minnesota work and thus they received inspiration and guidance from him. Of those who have had distinguished careers in geologic work we may mention W. M. Harrington, Warren Upham, M. Wadsworth, J. E. Todd, U. S. Grant, A. N. Winchell, E. O. Ulrich, H. V. Winchell, J. E. Spurr, A. H. Elftmann, H. V. Hoveland, and Charles Schuchert. Many of these men are now the leading authorities in their particular fields.

Great men may pass away, but their works are imperishable, and their influence is carried down the ages by those whom they have instructed and inspired. Their contributions to knowledge are our heritage and the heritage of countless generations that are to come.