Keweenawan geology of the North Ironwood, Ironwood, and Little Girl Point Quadrangles, Gogebic County, Michigan

by

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Abstract

Volcanic and sedimentary rocks of late Precambrian age include four formations of volcanic rocks (three newly recognized) and four formations of sedimentary rocks, with a total apparent thickness of more than 60,000 feet.

The Siemens Creek Formation, composed of thin basalt flows, and the overlying Kallander Creek Formation, composed predominantly of intermediate flows, are both of Lower Keweenawan age. They were folded before the Portage Lake Lava Volcanics of middle Keweenawan age were deposited on them. An unnamed formation of volcanic rocks conformably overlies the Portage Lake Volcanics and is overlain by reddish sandstones and conglomerates of the Copper Harbor Conglomerate. The Copper Harbor Conglomerate is conformably overlain by the dark gray siltstones and fine sandstones of the Nonesuch Formation of Upper Keweenawan age. These are overlain by the reddish, cross-bedded sandstones of the Freda Formation. Folding occurred after the Freda was deposited. Significant copper mineralization occurs near the base of the Nonesuch Formation.

General geology

Much of the area (see figure 1) is covered by glacial till and outwash. These deposits consist of unconsolidated silt, clay, and gravel deposited from glaciers and periglacial streams and lakes. The surficial deposits were not mapped in detail and are not shown on the geologic map.

Keweenawan volcanic and sedimentary rocks of Precambrian Y age underlie the mapped area but bedrock outcrops are uncommon (Plate 1). Some occur on pre-glacial hills that project through the till, but many occur where streams have cut through glacial deposits that mantle the hilly pre-glacial topography. In most places except on hills, exposures occur ten to fifty feet or more beneath the general upper level of the glacial till. No outcrops occur in a band more than two miles wide between the lower and middle Keweenawan outcrop area. In this band all water wells, which have maximum depths of 200 feet, penetrate only unconsolidated materials.

Formerly, the volcanic rocks were interpreted as a single conformable succession, but detailed mapping indicates two series of volcanic rocks. The older series formerly was called the South Range Traps (Irving, 1883, p. 201) and correlated with part or all of the overlying middle Keweenawan rocks (see White, 1966, p. E2). Powder Mill volcanic rocks differ from younger volcanic rocks in rock type, regional geographic distribution, structural attitude, magnetic intensity, and orientation and polarization of the residual magnetic field. The Powder Mill Group (Hubbard, 1975) probably was deposited in a basin that was mostly south of the Ironwood area, as suggested by: (1) The dips of the Powder Mill Group and older layered rocks diverge or fan southward: the dips of the uppermost rocks are vertical to overturned and each older formation dips less steeply northward. Similar relations occur to the east and west (Van Hise and Leith, 1911, pls. V, VI, VIII, X, XII). The fanning of the beds is inferred to be caused by continued subsidence of the area to the south during deposition. (2) The oily dikes in the older rocks to the south are feeders for Siemens Creek lava flows.

The Powder Mill rocks were metamorphosed and tilted before the middle and upper Keweenawan rocks were deposited in an overlapping basin that was mostly north of the area. The middle and upper Keweenawan basin was filled in part by lava flows that probably were extruded from vents to the north and in part by sediments derived from a mountainous or hilly terrain to the south. The sedimentary rocks are mostly lithic sandstones, although they commonly have been called arkoses. Generally, the proportion of volcanic detritus decreases and the proportion of quartz increases in successively younger formations.

Sedimentary structures show that the detritus in the upper Keweenawan rocks was derived from south of the outcrop belt. The large volume of Powder Mill-type detritus in the upper Keweenawan sediments indicates that a large volume of Powder Mill-type rocks were south of the area.

The Freda has been interpreted as grading upward into the Bayfield Group in Wisconsin (Thwaites, 1912), but these units are probably unconformable. The Freda is folded and the rocks are vertical in places, whereas Bayfield is nearly flat-lying; the Bayfield rocks are more quartzose, have lower specific gravities, and have a different heavy-mineral suite (Tyler and others, 1940, p. 1479).

Structure

The Keweenawan rocks form northward-facing homoclinal sequences. The lower beweenawan rocks dip steeply all across the area, the dips increase northward, and the uppermost exposed rocks are overturned. The middle and upper Keweenawan rocks are strongly warped. In the east, these rocks decrease northward in dip from about 45^{o} to about 20^{o}. The dips generally increase westward and are nearly vertical in the western part of the area. The middle and upper Keweenawan rocks are probably on the southern limb of a syncline whose axis is north of and nearly parallel with the shore of Lake Superior. Folding took place after deposition of the Freda Formation.

A few normal faults cut the lower Keweenawan rocks along the southern part of the area. The largest displacement is 1500 feet on a fault north of Bessemer. Normal faults in the middle Keweenawan are less abundant; the largest displacement seen is at Algonquin Falls where the rocks are offset horizontally more than 150 feet. A bedding-plane fault occurs north of a felsite on Powder Mill Creek. The Keweenaw fault (Irving, 1883, p. 231) was postulated to cross the area, but no evidence for the fault was found in the Ironwood area. Joints are prominent in the middle Keweenawan lava flows; two sets, one parallel with and one perpendicular to the bedding occur on most outcrops, and another set trending roughly north-south is usually present.

Metamorphism

The metamorphic grade of the Keweenawan rocks of the Ironwood area is lowest greenschist facies at the base of the section and decreases to pumpellyite-epidote facies at the top of the section. The metamorphic grade of the lower Keweenawan rocks increases westward. In Wisconsin, hornblende is very rare in the Siemens Creek Formation at Eagle Bluff, about half a mile west of the Ironwood area, and increases in abundance westward toward Mellen, about 25 miles west of the Ironwood area, where the rocks are of amphibolite facies. The metamorphic grade of the middle Keweenawan rocks is uniform throughout the region from 120 miles north of Ironwood on Keweenaw Point and as far as 20 miles west of the Ironwood area on the Potato River in Wisconsin. The metamorphic grade of the middle Keweenawan rocks farther west was not studied in thin sections.

No rock sampled by the writer contains more than 500 ppm copper, and most rocks contain less than 100 ppm. Semiquantitative spectrographic analyses of 24 samples of flows exposed on Chippewa Hill (Copper Peak) and on strike with them along the Black River contain 15-100 ppm and average 56 ppm; 28 samples from the highlands in secs. 33 and 34, T. 49 N., R. 46 W., and secs. 3 and 4, T. 48 N., R. 46 W., contain 50-500 ppm and average 85 ppm; and 12 samples from flows along the Black River near Algonquin Falls contain 15-100 ppm and average 48 ppm copper. Flows from the lower keweenawan Kallander Creek Formation contain more copper; 12 flows along Powder Mill Creek contain 10-200 ppm and average 123 ppm copper.

These samples are not representative of the copper content of rocks of the stratigraphic section, because most exposed rocks are the more resistant massive parts of flows. On Keweenaw Point, the copper mineralization is mostly in flow tops and sedimentary rocks between flows. Exposures of such rocks are very rare in the Ironwood area, but copper-bearing rocks may be concealed by the thick glacial deposits.

Economic geology

Rock for crushed stone and rip-rap and sand and gravel have been mined commercially in the area. The Siemens Creek Formation has been the source of nearly all stone. Most of the sand and gravel has been mined from pits in the glacial deposits on the plain north of the outcrops of the Kallander Creek Formation.

The Nonesuch Formation contains copper east of the Black River. The copper-bearing rock was drilled by American Metals Climax, which also sank an exploration shaft about 1957. In late 1957, American Metals Climax announced that it had developed 50 million short tons of 1.52 percent copper and 54 million tons of 1.04 percent copper (Anon., 1958). The deposit has not been mined.

Very little copper occurs in the middle Keweenawan volcanic rocks. Equivalent rocks, however, are copper-bearing on Keweenaw Point. Prospect pits and short adits were dug on Chippewa Hill and in the highlands in secs. 33 and 34, T. 49 N., R. 46 W., and in secs. 3 and 4, T. 48 N., R. 46 W.

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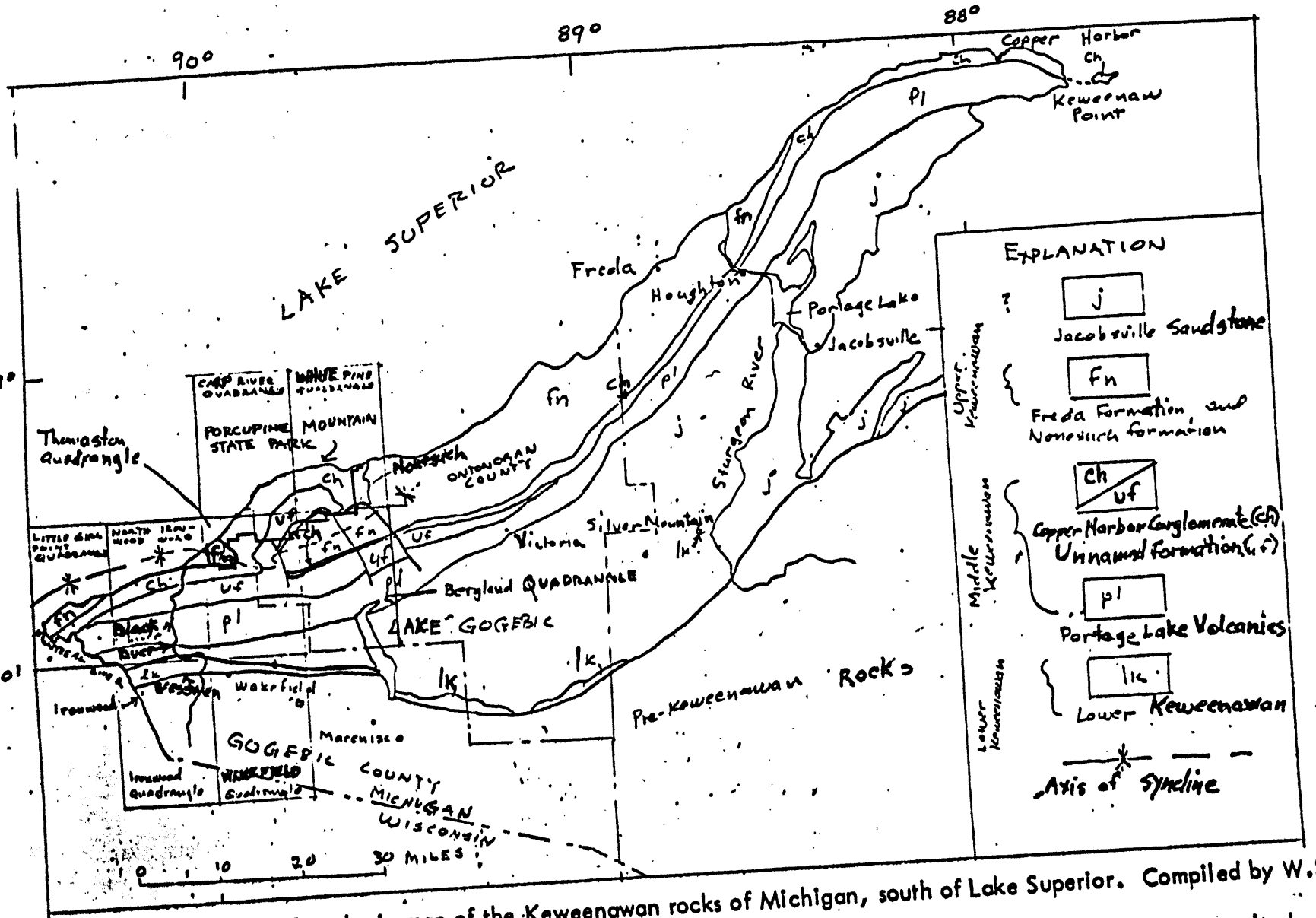

Figure 1 --Generalized geologic map of the Keweenawan rocks of Michigan, south of Lake Superior. Compiled by W.S. White from published maps except west of Victoria where unpublished maps of the following have been consulted: E. R. Brooks, H. A. Hubbard, R. W. Johnson, W. S. White, J.T. Wilband, and J. C. Wright.