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Geology of Precambrian rocks, Ironwood-Ramsay area, Michigan

By Robert G. Schmidt

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Field mapping of the Ironwood-Ramsay area in western Gogebic County, Michigan, was done in the years 1965-1970, and studies of the area are being completed. This work was done in cooperation with the Geological Survey Division of the Michigan Department of Natural Resources.

The geology of the Precambrian W[1/] "crystalline basement" rocks has been little studied before and most of the information on these rocks presented here is new.

The Precambrian X sedimentary rocks in the area are a simple north-dipping succession. Much high-grade iron ore has been produced from the Ironwood Iron-Formation in this succession, and in contrast to the older crystalline rocks, the geology of the whole Precambrian X section has been rather well known for many years. For this reason, the geology of the iron ores is not treated in this provisional report.

Precambrian W Rocks

The geology of the rocks of Precambrian W age in this area is exceedingly complex. Even after much detailed field and office study, the interpretation of the relationships of rock types and the geological history are still provisional. Additional study in the areas to the east and west may provide answers to several of the geologic questions that remain.

1/ Time subdivisions of the Precambrian:

Precambrian Z--base of Cambrian to 800 m.y.
Precambrian Y--800 m.y. to 1,600 m.y.
Precambrian X--1,600 m.y. to 2,500 m.y.
Precambrian W--older than 2,500 m.y.

There are crystalline rocks of at least four ages within the Precambrian W complex of this area. Certain rather commonplace lithic types occur in more than one age group which makes unraveling the geology much harder. Metamorphism of all these crystalline rocks to the amphibolite grade later modified by metamorphism of a great range of intensity has produced pervasive mineral changes and perhaps destroyed some criteria of relative age that existed earlier. The migmatites of the Ironwood-Ramsay area are granite gneissic mixed-rock complexes in many of which distinct separate rock phases can be recognized. The term, migmatite, is used here much as it was originally used by Sederholm (1907, p. 110). The genetic implication of Sederholm's original usage is appropriate here, for the mixed rocks ordinarily consist of an old rock type, or paleosome, invaded or engulfed by a newer one, or neosome. Sometimes more than three rock-types are found in single outcrops but it could not be established that the additional types represented distinctly separate additional intrusive phases. The scale of some of the migmatite features and of some of the patches of banded gneiss are so large that only part of a single feature can be seen in one exposure and the whole textural picure can be obtained only by synthesizing data from many outcrops. Foliation is mostly northeast to east, parallel to phase boundaries, but some foliation is crosscutting.

The homogeniety of mineralogic detail in all quartz monzonitic and granodioritic intrusives and gneisses has made it necessary to depend mostly on macroscopic features--colors, textures, and radio-acitivity--plus structural relationships in the field for a system of classification. Modal analyses supported some but not all of the separate phase classifications. Many details of the microscopic mineralogical features are ubiquitous in the quartz monzonitic and gneissic rocks despite considerable differences in macroscopic appearance, perhaps largely as a result of pervasive early metamorphism of amphibolite grade.

The metamorphosed greenstone sequence, rf, a stratified unit of metasedimentary and metavolcanic rocks is probably the oldest rock unit. The intrusion of the porphyritic quartz monzonite, pqm, produced a fringe of highly modified country rocks, wcg, as the result of high grade contact metamorphism of the greenstone sequence, and the vbg by extensive injection of new pqm material into pre-existing layered rocks (whether rf or an older rock unit is not known). There are zones of migmatites up to a mile wide along part of the pqm-wcg boundary. Much of the vbg is migmatitic and the pqm-vbg boundary is mostly a rather arbitrary line drawn in a broad transitional migmatitic zone.

The gneissic rocks in the southeastern part of the area are perhaps somewhat different from the rest of the vbg and may have been derived from a different country rock or at another time. The southeastern gneisses may have existed in much their present form before the greenstone sequence, rf, was deposited, making these gneisses the oldest rock unit in the area; or perhaps they were formed by metamorphism of part of the greenstone sequence in an orogenic period preceeding the intrusion of the pgm. In any case, there are not sufficient field data to differentiate these gneisses as a separate rock unit and they are shown as single phase (ug-1) and two-phase (ug-2) undifferentiated gneisses.

The relationships between the pgm intrusive and the invaded country rock range from a simple planar contact in the community of Aurora (sec. 23, T. 47 N., R. 47 W.) to the broad zones of complex migmatites in the central part of the area. These wide variations are interpreted to relate to physical differences, such as depth of burial, in the different parts of the intrusive body; perhaps original differences in the country rock may have influenced the style of contact relationships.

All of the older crystalline rock units -- rf, pgm, wcg, and vbg -- are locally invaded by dikes and irregular masses of the leucocratic aplite-granite-pegmatite intrusives (sci). None of these sci intrusives was found in a narrow strip along the northern edge of the older rocks; and a line showing the northern limit of these intrusives is shown on the map. The sci intrusives occur at least as far as three miles east and five miles west of the mapped area in a variety of country rocks and the northern limit also continues east and west into adjacent areas, crosscutting metamorphic zones related to the pgm pluton. The sci intrusives are interpreted to be distintcly younger than the rocks related to the pgm event. (At least one group of older pegmatites is common in the area and positive age differentiation of every outcrop of aplite and pegmatite is not possible).

The Precambrian W crystalline rocks are cut by a pervasive lattice-work of diabasic and gabbroic dikes of diverse mineralogy and age none of which are shown on the map. The oldest dikes cut mainly the vbg, ug-1 and ug-2. Younger dikes cut both Precambrian W and X rocks, and the youngest cut the rocks of Precambrian Y age as well. The variety of original mineralogy, metamorphic changes, degree of sulfide mineralization, phenocrysts and magnetic characteristics also suggest that dikes of many different ages are present.

Precambrian X rocks

The sedimentary strata of Precambrian X age were deposited unconformably on the older crystalline rocks on a surface that appears to have been one of very low relief. The older Precambrian X formations, the Sunday Quartzite and the Bad River Dolomite, though present in other parts of the Gogebic district, are not found here.

Palms Formation.--The Palms Formation, mostly argillite and siltstone, and a layer of quartzite at the top, is a persistent unit with uniform characteristics. Though a basal conglomerate is described outside the mapped area, here only small discontinuous lenses of conglomerate are found at the base of the formation in crevices and depression in the pre-Palms surface.

The main part of the Palms Formation is a light gray and greenish gray laminated argillite and silty argillite with much interbedded fine quartzitic siltstone and little quartzite.

The upper quartzitic layer is thin- to thick-bedded and pink to red-brown. The quartzite is 80-105 feet thick in the Ironstone-Peterson mine vicinity in mine workings where a minimum of structural disturbance was noted by mining company geologists and engineers.

The Ironwood Iron-Formation.--The Ironwood Iron-Formation is the major iron-bearing unit in the Gogebic district and almost all of the high grade iron-ores have been derived from it by secondary alteration. A product of mostly chemical sedimentation, the unit has a rather complex internal stratigraphic sequence, and much of this sequence is persistent over tens of miles of the 60 miles of total strike-length.

The Ironwood Iron-Formation was divided into 5 distinctive members by Hotchkiss, (1919), and little refinement has been made by subsequent studies. These members are defined by predominance of one of two general types of iron-formation: thick, wavy bedded cherty iron-formation and thin, straight bedded chert-carbonate iron-formation. These types correspond generally to the types that make up the "cherty" and "slaty" members of the Biwabic Iron-Formation.

The minerals present in the Ironwood Iron-Formation in the area studied include only those found in unmetamorphosed iron-formation and in the lowest-grade metamorphic zones: quartz, siderite (including some magnesium, manganese, and calcium carbonate), hematite, magnetite, chamosite, and stilpnomelane. Aphrosiderite and greenalite are probably also present.

<u>Tyler Formation</u>.--The Tyler Formation is a thick sequence of light to dark gray plagioclase-rich fine sandstone, argillaceous siltstone, and argillite, with some ferruginous beds and lenses of iron-formation in the lowermost 600 feet.

The overall stratigraphic section of the Tyler Formation is fairly well known from many small exposures scattered from the base to the top, however surprising little is known about the lowermost 600 feet including the most ferruginous strata because this interval is represented by few exposures.

Ferruginous strata near the base.--The iron-rich beds at the base of the Tyler Formation and the iron-formation strata somewhat above the base are known from spoil piles, drill holes and mine workings, and a few small exposures. Some exposures in the bed of the Black River Ramsay are very good outcrops but the extent to which their true stratigraphic position has been modified by faulting is not known, thus diminishing their usefulness.

The basal 50 feet of the formation is iron-rich and was locally mined for iron ore; a layer of chert-carbonate iron-formation 450 feet above the base is known in at least 2 places where exploration has tested that particular stratigraphic interval, and some iron-rich lenses containing siderite and pyrite may occur up to 800 feet above the base.

The main part of the Tyler Formation.--The Tyler Formation above the interbedded iron-formation is a monotonous sequence of light to dark gray thinly bedded argillite, siltstone and quartzite. Combined ferrous and ferric oxide is probably under 10 percent. Fine quartzite is the most common rock in the natural outcrops, but that is because the argillite erodes more easily. The entire formation forms a wide topographic valley in which rock exposures are sparse but bedrock is mostly very shallow. The best natural exposures of Tyler Formation in the area are along the creek in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 8, T. 47 N. R. 46 W.

The dimunition of the thickness of the Tyler Formation is shown by the eastward narrowing of the outcrop belt. This thinning is the result of extensive erosion prior to the deposition of Precambrian Y strata.

Precambrian Y strata

<u>Bessemer Sandstone of Seaman</u> (1944).--The Bessemer Sandstone is a pink to reddish-brown quartz arenite with abundant matrix, about 300 feet thick. At many places in Wisconsin a coarse conglomerate is present at the base, but at no place in the mapped area are good outcrops of the lower contact exposed, and presence here of a conglomerate has not been confirmed.

<u>Lowermost Keweenawan Flows</u>.--The lowermost 5000 feet of the Keweenawan flow sequence consists of greenish-gray basalt and rare flows of intermediate composition. Many basal flows are pillowed. Lenses of arenite similar to the Bessemer Sandstone are interlayered between a few of the lower flows. For more information on the Keweenawan stratigraphic succession, the reader is referred to the work of Hubbard, in Schmidt and Hubbard (1972).

Economic mineral potential of the area, exclusive of iron ores.--

Detailed mapping of the Ironwood-Ramsay area provided little basis for further prospecting for economic mineral deposits except iron. Special features examined included zones of sericitic alteration and some sulfide in quartz-monzonite, disseminated sulfide in extensive thick mafic dikes, and syngenetic sulfide in the Tyler Formation. Sulfide deposits in the greenstone sequence were looked for but none found.

Extensive zones of seritic alteration in quartz-monzonite are exposed in the old railroad cut at the abandoned Newport Mine (NE$\frac{1}{4}$ sec. 24, T. 47 N., R. 47 W.) and east of the Black River in the SW$\frac{1}{4}$ sec. 26, T. 47 N., R. 46 W. A small patch of alteration, this one with some associated sulfide, is in a small rock knob in the NE$\frac{1}{4}$ of the same sec. 26. These sericitized rocks now consist of quartz, muscovite and microline, the plagioclase having been mostly altered to sericite, perhaps subsequently coarsened and recrystallized by metamorphism. No K_2O analyses were made but the mineral composition suggests considerable increase in potash over the original rock. One sample from each place was analysed and the base metal content was negligible.

The old (Precambrian W) mafic dikes of the area contain under 0.5 percent of visible sulfide. Of 30 samples analysed, 21 samples contained 25-200 ppm copper, 8 contained 200-500 ppm, and 1 contained 700 ppm. Most of the dikes are under 100 feet thick and simple, but in sec. 15, T. 46 N. R. 46 W., one large northeast trending dike seems to be as much as 600 feet thick. At two places this dike contains alternate light and dark mineral layers that suggest a cumulate texture.

Minor pyrite is a common constituent of the Tyler Formation, but abundant pyrite in elongate and oval structures 2-10 cm. long occurs locally on the west bank of the Black River just south of the U.S. Highway 2 bridge. The sulfide is believed to be primary and it occurs close to a small exposure of granular siderite-pyrite iron-formation. None of the sulfide has been analysed.

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EXPLANATION

kpm Keweenawan flows, similar to those along Powder Mill Creek

Near base, mostly thin basaltic flows with a few intermediate flows, and intercalated thin arenite lenses, pillow structures common. Only outcrops near base are shown

kbs Bessemer Sandstone of Seaman (1944)

Quartz arenite with abundant matrix; probably a conglomerate layer at the base. About 300' thick

——— Erosional Unconformity ———

bt Tyler Formation

Light- to dark-gray, plagioclase-rich, fine-grained sandstone, argillaceous siltstone, and argillite. Lowermost 1000' is partly ferruginous and has lenses of lean cherty iron-formation. Maximum thickness (in Wisconsin), 9500'

mi Ironwood Iron-Formation

Thick wavy bedded cherty iron-formation and interbedded layers of thin-bedded cherty carbonate iron-formation. In the eastern part of the area there is one tuff bed; it thickens eastward and probably pinches out between Bessemer and Ironwood. Thickness 450-950'

Precambrian X

mp Palms Formation

Sericitic argillite; red-brown quartzite at top.

Thickness 360-560'

Erosional Unconformity

sci Late, generally leucocratic intrusives like those near Sunset Creek

Pegmatitic, granitic and aplitic quartz monzonite, mostly in small commonly multitextured masses. Younger than all other Precambrian X rocks except old mafic dikes (not shown here), and present throughout except in narrow strips near Ironwood and Ramsay as shown by northern limit line. In some places not distinguishable from multitextured phases of pqm and perhaps older rocks

Precambrian W

pqm Porphyritic quartz monzonite like that ½ mile south of Puritan School

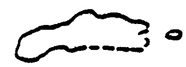
Generally homogeneous in texture and composition in the area without inclusions; gradational southward into one- and two-phase striped gneisses. Phenocrysts/poikiloblasts mostly 1-3 cm long

Precambrian W

Age relative to adjacent units not known

ug-2 Undivided two-phase gneisses

Generally consist of foliated or layered paleosome and less structured, commonly porphyritic, quartz monzonite or quartz diorite neosome. Perhaps partly or entirely equivalent to vbg



Outcrop area

Dashed where bedrock is inferred from abundant

boulders or edge of area is not well defined.

Line encloses area of abundant but not

continuous outcrop

Contact

Dashed where approximately located

Gradational contact

Fault

Location determined from subsurface data and

examination of aerial photographs

Inferred fault or lineament

Location selected by examination of aerial

photographs