Progress report for 1947

Geology of a part of the Felch Mountain iron range, Michigan

By Carl A. Lamey

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Illustrations

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Extension of work

During the summer of 1947, mapping in the Felch Mountain iron range was continued eastward for 3 miles, and included the area around the abandoned Groveland mine (pl. 1). The methods used were the same as those described in previous reports.[1] As heretofore, dip-needle observations were made at 40-foot intervals along traverses spaced about an eighth of a mile apart. Control was maintained by taping section lines and by means of air photographs.

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[1] Geology of an area southwest of Randville, Dickinson County, Michigan: U. S. Geol. Survey open file report, 1945; Geology of an area near Randville, Michigan: U. S. Geol. Survey open file report, 1946.

Exposures and pits mapped

Numerous exposures of Sturgeon quartzite, Randville dolomite, and Vulcan iron-formation were mapped, as well as some exposures of ferruginous quartz-mica schist, mica-garnet-grunerite schist, gneiss, granite, a granite pegmatite and diorite of post-Huronian age, and sandstone of Cambrian age. Also numerous test pits, trenches, and a few abandoned shafts were located. Only those pits and trenches that reached bedrock are shown on the map. The distribution of exposures, pits, trenches, and shafts is shown on the geologic map (pl. 1).

Outcrops of the Sturgeon quartzite form a discontinuous belt from the south boundary of sec. 7, T. 41 N., R. 30 W., into sec. 35, T. 42 N., R. 30 W., a distance of about 5 miles; but granite and gneiss outcrops are present near the south quarter-corner of sec. 35, T. 42 N., R. 30 W., and are closely associated with the quartzite. East of this long belt there is a gap of about a mile, followed by a short strip of quartzite in sec. 31, T. 42 N., R. 29 W., which is apparently offset from the longer belt. Tentatively this small strip also is designated Sturgeon quartzite.

A series of test pits, trenches, and a few shafts near the east side of sec. 31, T. 42 N., R. 29 W., and extending about 500 feet into sec. 32 (not shown on the map), explored a ferruginous zone along the northern side of the quartzite. The material on dumps and exposed in a few outcrops is chiefly schistose specular hematite. The ferruginous zone appears to have a maximum width of about 100 feet, but the richest part of it, in which 3 shafts were sunk, has a width of only 30 feet. The streaks of hematite are intermingled with mottled red and white vitreous quartzite, gray quartzite, and mica schist. Generally the northernmost exposures are muscovite schist, considerably sheared, at some places characterized by muscovite flakes 1/2 to 1 inch across. These eastern outcrops of schistose specular hematite, quartzite, and schist have the same position with respect to the vitreous quartzite south of them as do outcrops of sugary magnetite-bearing quartzite and some schist that are present at a few places in the five-mile belt farther west.

Three belts of Randville dolomite crop out in the eastern part of the area: a principal northern one extending through secs. 34, 35, and 36, T. 42 N., R. 30 W.; a well exposed but shorter southern one extending for about three-fourths of a mile through secs. 35 and 36, T. 42 N., R. 30 W.; and a short, narrow, and poorly exposed belt just north of the center of sec. 36, T. 42 N., R. 30 W. The dolomite in all of these exposures has been considerably metamorphosed, and there are conspicuous tremolite crystals on weathered surfaces.

There is dolomite in a few pits north of State Highway M-69 in the eastern part of sec. 31, T. 42 N., R. 29 W., which tentatively is classed as the Randville dolomite. However, because only loose material from the pits could be examined, and this material apparently contains no tremolite and is only slightly metamorphosed, the age determination is uncertain.

It is of great interest and importance to observe that along the projection of the strike of the northernmost belt of Randville dolomite, the outcrops in the southern part of sec. 30, T. 42 N., R. 29 W., consist of gneiss cut by granite pegmatite. On a previous map of this area the Randville dolomite extends continuously throughout sec. 30.[2]

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[2] U. S. Geol. Survey Mon. 36, pl. 3, 1899.

Other outcrops and pits of particular importance are those south of the Groveland mine in sec. 31, T. 42 N., R. 29 W. The exposed rocks are in part a ferruginous quartz-mica schist, which in places is highly quartzose and contains well crystallized magnetite, and in part a reddish quartzite. These rocks appear to be different from anything described in former preliminary reports on this area, although to a slight extent they resemble the poorly exposed sugary magnetite-bearing quartzite along the north side of the Sturgeon quartzite. Some of this material mapped in 1947 bears a striking resemblance to exposures of Middle Huronian Ajibik quartzite in the Marquette district.

The mica-garnet-grunerite schist that crops out sporadically throughout the area is present in some good exposures near the west quarter-corner of sec. 36, T. 42 N., R. 30 W., and in one small outcrop in the north central part of that section, a short distance south of a test pit that exposes the Vulcan iron-formation. The material is similar to that exposed farther west, in secs. 5, 7, and 8, T. 41 N., R. 30 W. A dioritic type of rock is associated with the schist, as in the more westerly exposures. However, it does not clearly show intrusive relations with the schist, and on preliminary microscopic examination, although amphibole is abundant, the rock contains much quartz, and some specimens of it contain only a very small amount of feldspar.

Two belts of Vulcan iron-formation in the eastern part of the area are shown on the geologic map (pl. 1). The southern one is well exposed in the vicinity of the Groveland mine and westward through the central part of sec. 36, T. 42 N., R. 30 W. The northern belt, however, is exposed only in outcrops near the center of sec. 5, T. 41 N., R. 30 W., and in a test pit in sec. 36, T. 42 N., R. 30 W., and its position has been determined chiefly by magnetic attraction.

One other group of pits, in sec. 34, T. 43 N., R. 30 W., is of considerable interest. These expose a gray quartz-mica slate, part of which is somewhat schistose. At one of the pits some discarded drill core was obtained. The core material is essentially the same as the rock thrown from the pits. Preliminary microscopic examination shows that the composition varies from dominantly quartz and mica, to quartz and feldspar in about equal amounts along with much mica. The feldspar consists of plagioclase and microcline, and the mica of muscovite and biotite, either one of which may predominate. Some of these rocks contain a considerable amount of epidote, and all of them contain tourmaline.

A few outcrops of sandstone of Cambrian age are present in sec. 31, T. 42 N., R. 29 W., north and northeast of the Groveland mine; but sandstone in pits and trenches indicates that it covers the pre-Cambrian rocks throughout much of this section. The base of the sandstone is conglomeratic and contains many angular fragments of iron-formation, but also some angular fragments of slate and quartzite, and some rounded cobbles of quartzite.

Age relations

The age relations as presented in the progress report for 1948[3]

[3] Geology of an area near Randville, Michigan, op. cit.

remain essentially the same, but tentatively they are modified by the addition of rocks that appear to belong in the Middle Huronian, in part possibly equivalent to the mica-garnet-grunerite schist, in part below it and possibly equivalent to the Ajibik quartzite of the Marquette district. Also, tentatively the Sturgeon quartzite is subdivided into a lower vitreous quartzite and an upper quartz-mica slate. This latter rock is thought to be represented by the material exposed in test pits in sec. 34, T. 42 N., R. 30 W., and by schistose material along the northern side of the southern belt of Sturgeon quartzite. At present it also seems probable that schists or slates may underlie the vitreous quartzite in part of the area, as indicated by some mica schists in sec. 35, T. 42 N., R. 30 W., but as yet there is very little direct evidence to support this concept. The revised table showing age relations follows.

Table showing probable age relations

Cambrian		Sandstone and conglomerate
	Unconformity	
	Post-Huronian	Granite pegmatite and diorite; possibly some granite gneiss.
	Middle Huronian	Vulcan iron-formation.
		Mica-garnet-grunerite schist. (Possibly equivalent to the Siamo slate of the Marquette district or the Brier slate member of the Vulcan iron-formation.)
		Ferruginous quartz-mica schist.
Pre-Cambrian		Red to mottled red and white vitreous quartzite, possibly in part equivalent to the Ajibik quartzite of the Marquette district.
	Unconformity	
	Lower Huronian	Randville dolomite
		Sturgeon quartzite. Quartz-mica slate or schist in upper part; vitreous quartzite in lower part.
	Unconformity	
		Part of the granite gneiss.

Some additional information was obtained regarding the extent of the granite pegmatite of post-Huronian age. In previous reports it was described as cutting gneiss, Sturgeon quartzite, and Randville dolomite. In 1947 it was noted that narrow dikes of it cut the Sturgeon quartzite at several places in the southeastern part of sec. 35, T. 42 N., R. 30 W., and that a small stringer cut slates thrown from the pits in sec. 34, T. 42 N., R. 30 W. Also a number of dikes and small irregular intrusions cut the Vulcan iron-formation near the Groveland mine in sec. 31 and the gneiss outcrops to the north in sec. 30, T. 42 N., R. 29 W. Although there is no direct proof of the post-Huronian age of the granite pegmatite that cuts the gneiss, the location and general relations indicate that it is the same rock that cuts the Vulcan iron-formation, and that a large exposure of it is present farther north, probably in sec. 19 or 20, T. 42 N., R. 29 W. (not shown on the map).

No proof could be obtained regarding the age of the granite and gneiss exposures in sec. 2, T. 41 N., R. 30 W., and sec. 35, T. 42 N., R. 30 W., because at no place could a contact be found.

Magnetic anomalies

The magnetic anomalies may be divided into four principal groups for convenience of reference: (1) high, 30° and above; (2) moderate, 16° to 29°; (3) low, 12° to 15°; (4) very low, below 12°. The first three of these groups are represented in the entire area, but the fourth one is almost entirely confined to the eastern end of it (see pl. 2). Throughout much of the area it has been possible to establish from outcrops the cause of the high and moderate anomalies, but not with certainty the cause of the low and very low anomalies. The high anomalies, 30° and above, are characteristic of and almost entirely confined to the Vulcan iron-formation, but in a few places values up to 37° were obtained on the mica-garnet-grunerite schist. The moderate anomalies, 16° to 29°, characterize either the mica-garnet-grunerite schist or the sugary magnetite-bearing quartzite that crops out in places north of the vitreous Sturgeon quartzite. The low anomalies, 12° to 15°, are characteristic of most exposures of granite, pegmatite, gneiss, vitreous quartzite, and dolomite except where the latter is underlain by the Vulcan iron-formation. The very low anomalies, below 12°, are present in part where sandstone of Cambrian age is exposed, but there seems to be no reason to ascribe these very low anomalies to the presence of sandstone, because observations as low as 0° were noted on exposures of ferruginous quartz-mica schist in sec. 31, T. 42 N., R. 29 W., south of the Groveland mine, and erratic very low readings, 0° to 10°, were noted on exposures of mica-garnet-grunerite schist.

The principal high magnetic anomaly, caused by the Vulcan iron-formation, is strong and rather persistent nearly to the northeast corner of sec. 36, T. 42 N., R. 30 W., except for some decreased magnetism at places along the magnetic crest (pl. 2). In the northeast part of sec. 36, T. 42 N., R. 30 W., it ends abruptly, but a similar anomaly, along which there are numerous exposures of the Vulcan iron-formation, begins about half a mile south of the northern one and continues eastward nearly to the eastern boundary of sec. 31, T. 42 N., R. 29 W., where it ends abruptly. These two belts show an overlap of about a quarter of a mile. In addition to this continuous southern high anomaly, several discontinuous moderate to high anomalies are present to the west of it and south of the northern high anomaly. These discontinuous ones may represent, at least in part, somewhat isolated blocks of iron-formation. The definite break and displacement in sec. 36, T. 42 N., R. 30 W., of the principal belt of high anomalies, the location of the discontinuous high anomalies, and the shape of the magnetic contours, all indicate a fault of considerable magnitude, along which there has been drag folding.

Several minor breaks are present along the principal crest in sec. 31, T. 42 N., R. 29 W. These appear to be caused in part by minor faults and shattered zones, and in part by granite pegmatite intrusions. In those places where the pegmatite is exposed, decided drops in magnetic anomalies were observed. However, in other places where the pegmatite probably intrudes the iron-formation at a slight distance below the surface and is overlain by the iron-formation, exceptionally high anomalies were observed. Normally this would be expected, as the intrusion of the pegmatite should convert some of the overlying iron-formation into magnetite.

A break in the crest of the principal high anomaly was established by additional work in secs. 33 and 34, T. 42 N., R. 30 W., which indicates the position of a fault trending northeast.

A narrow moderate anomaly is caused by a magnetite-bearing sugary quartzite exposed in some places along the northwestern and northern side of the vitreous Sturgeon quartzite. The chief characteristic of this anomaly is its range from 16° to 19°, diversified by occasional values slightly higher than 20° but rarely more than 28°. This anomaly has been traced, with some interruptions, from the south boundary of sec. 7, T. 41 N., R. 30 W., to the east boundary of sec. 35, T. 42 N., R. 30 W. Farther east, in sec. 36, T. 42 N., R. 30 W., and in sec. 31, T. 42 N., R. 29 W., it was not found, unless it is represented by a very weak crest shown in the southern part of sec. 36 and the southwestern part of sec. 31, along which the dip needle shows a maximum of 14°.

It seems unlikely that this weak crest represents the magnetic quartzite anomaly, as the distribution of outcrops (pl. 1) and a second short belt of moderate anomalies in the southeastern part of sec. 31 (pl. 2) indicate that the Sturgeon quartzite should be farther south than this weak crest and perhaps is present in secs. 1 and 6, T. 41 N., Rs. 30 and 29 W., respectively. The trend of the outcrop belt, the moderate anomaly in the southeastern part of sec. 31, and the location of the latter south of the quartzite outcrops, support this concept. This moderate anomaly in sec. 31, south of outcrops of vitreous quartzite, bears the same relation to the quartzite as the anomalies, along which no exposures exist, in secs. 7, 8, and 5, T. 41 N., R. 30 W. Furthermore, near the east boundary of sec. 31, and extending into sec. 32, sheared specular hematite is present along the northern side of quartzite exposures, which throughout the rest of the area mapped is the position of the principal magnetic anomaly associated with the quartzite. Dip-needle observations along this specular hematite zone show no increase in magnetism above that yielded by the vitreous quartzite.

Numerous short magnetic crests and troughs are present in secs. 36 and 31. It is difficult to interpret these because of the faulting and intricate folding of the rocks in this area, which is well shown at the Groveland pit and by blocks of the iron-formation from test pits.

Structure

The structure of the area still is not well known, but the additional magnetic and outcrop data obtained during 1947 indicate rather clearly the presence of at least one major fault and several minor ones. It now seems apparent that the Vulcan iron-formation is cut by faults in secs. 4 and 5, T. 41 N., R. 30 W., and in secs. 33, 34, 35, and 36, T. 42 N., R. 30 W. These are clearly shown by the displacements of the magnetic crest (see pl. 2). Faulting of considerable magnitude, accompanied by drag folding, is indicated by magnetic contours in secs. 36 and 31, at the eastern end of the area. Moreover, much displacement by faulting is indicated by the location of iron-formation outcrops in secs. 36 and 31, and by the appearance of gneiss outcrops in sec. 30, T. 42 N., R. 29 W., along the projected trend of the iron-formation and dolomite exposed in sec. 36, T. 42 N., R. 30 W. The exact positions of faults are difficult to fix, but a combination of the information furnished by magnetic anomalies and outcrops indicates the probable location of the faults shown on the maps (pls. 1 and 2).

It will be noted that the Randville dolomite persistently accompanies the high magnetic anomalies that represent the Vulcan iron-formation in secs. 34, 35, and 36, T. 42 N., R. 30 W. The iron-formation is known to cause these anomalies, and its presence was again established by a test pit in sec. 36 a short distance south of a dolomite outcrop (pl. 1). Magnetic contours indicate that the iron-formation dips to the north, and outcrops show that the dolomite also dips to the north. Although the evidence is not yet complete, the conclusion seems almost inescapable that the northern belt of Randville dolomite has been thrust over the Vulcan iron-formation. If this is so, this thrust fault that brought up the Randville dolomite was displaced along the fault that cuts off the iron-formation near the northeast corner of section 36.

Some structural complexity is indicated by the schist and quartzite immediately south of the Groveland pit in sec. 31, T. 42 N., R. 29 W. If these rocks are in part the stratigraphic equivalent of the Middle Huronian Ajibik quartzite as seems likely, they may represent the material immediately underlying the Vulcan iron-formation. However, the only contact between this material and the Vulcan iron-formation found by the writer is in the southeast corner of the Groveland pit, and is a fault contact along which the schist has been much sheared. Further, the small belt of iron-formation within the schist presents some difficulties. Its relations to the schist could not be observed, as its presence is known only from material from test pits, but apparently its location results from faulting. It seems likely, therefore, that several faults showing somewhat the same trend as the formations are present south of the Groveland pit.

Some additional indication of faulting in this area is furnished by the character of the formations. The schist is finely foliated except where most intensely sheared, and the dolomite from test pits, although crystalline, is not coarse textured and contains no visible tremolite or other silicates, although granite pegmatite cuts the iron-formation a short distance north of these pits, and much magnetite, some grunerite, garnet, and other silicates are present in iron-formation on the dumps of the Groveland mine. This relatively low grade metamorphism of the dolomite in close proximity to higher grade metamorphism of iron-formation and to pegmatite intrusive into the latter, indicates that the dolomite may have been brought to its position along a fault after the intrusion of the pegmatite and the metamorphism of the iron-formation.

No additional information was found regarding the structural relations of the Sturgeon quartzite, except a few more exposures which show that the top of the formation is toward the north and that it is overturned. The disappearance in secs. 36 and 31 of both the quartzite and the magnetic belt along its northern edge, and the reappearance of the quartzite in sec. 31 with a trend indicating that it may be present some distance south of the gap in secs. 36 and 31, suggest displacement by faulting. The direction of any such fault is not apparent at present.

Possible distribution of ore

Discussions in previous reports regarding the possible distribution of ore have indicated that distribution may depend on whether concentration took place before or after folding and faulting, or before or after metamorphism and the formation of magnetite. It was stated that if the main period of concentration was before the development of magnetite, the places of high magnetism along the crest of the iron-formation anomalies might indicate greater ore concentration, provided that there is relatively little variation in the degree of metamorphism and depth of burial of the iron-formation throughout the area, and provided that post-magnetite faulting had not so shattered the iron-formation as to reduce the magnetism materially. On the other hand, if concentration were later than the formation of magnetite, the areas of lower magnetism along the crests of anomalies might result from post-magnetite faulting and later concentration of hematite along shattered zones.

Very little can be added to the statements in previous reports regarding the general distribution of ore, but some distinction might be made regarding high- and low-grade material. The high-grade ore pockets at the Groveland pit, so far as could be ascertained from present exposures, were associated with faults and shear zones, and the ore apparently consisted of schistose specular hematite. Several small piles of coarse-grained specular hematite were noted around the Groveland pit. Also, specular hematite and relatively coarse-grained magnetite were noted on the dumps.

The scarcity of outcrops in the area, except in the vicinity of the Groveland mine, prohibits detailed discussion of the general characteristics of the iron-formation. However, because these characteristics will determine to some extent the likelihood of using the iron-formation as low-grade or concentrating ore, it may be well to summarize some of the features noted in the vicinity of the Groveland mine. Some of the material contains magnetite octahedra as much as 0.08 inch across, rather uniformly distributed through siliceous iron-formation. Other material is more massive magnetite, and some is siliceous slaty iron-formation. In general, it might be stated that the magnetite observed is relatively coarse grained.

If conditions throughout the area are similar to those around the Groveland pit, the areas of high magnetism might yield relatively good concentrations of moderately coarse magnetite associated with pockets of specular hematite. It is possible that such material, if sufficiently coarse, might yield to concentrating processes, as it would not require extremely fine crushing to liberate the magnetite from the siliceous material.