SOME MANGANESE DEPOSITS IN MADISON COUNTY, MONTANA.

By J. T. Pardee.

INTRODUCTION.

The deposits described in this paper lie along the west side of Madison Valley near Cherry and Wigwam creeks and in the foothills east of Jefferson Valley near Renova, localities that are, respectively, 70 and 30 miles southeast of Butte, Mont. Though they are small, these deposits yield ore that is almost free of silica and therefore very desirable for making ferro-alloys. They are also of interest because the manganese in them is primarily of sedimentary origin, and therefore they are different from most of the other manganese deposits known in this general region, which are related to metalliferous quartz veins. In August, 1917, the deposits on Wigwam Creek were being mined by W. L. Morrison, and the ore was hauled 30 miles by motor truck to Norris, the end of a branch line of the Northern Pacific Railway. Those near Cherry Creek were idle at the time of the writer's examination but had been worked intermittently during the previous year. No ore has been mined recently from the deposits near Renova, but formerly iron ore was shipped to the smelters at Butte and used as a flux.

On Wigwam and Cherry creeks irregular, lenslike bodies of manganese oxides, chiefly psilomelane and subordinately manganite and wad, are found in an ancient marbleized limestone that underlies the Cambrian Flathead quartzite. The principal impurities are calcium carbonate and oxides of iron. The percentage of silica is very low. Locally the limestone is brownish red and pink because of small amounts of iron and manganese oxides distributed through it. The ore is thought to have been formed in the Tertiary period by the weathering of this discolored limestone, the manganese and iron being in part dissolved and redeposited in open places.

Prior to August, 1917, about 100 tons of ore containing from 40 to 50 per cent of manganese had been produced, and a considerable amount of low-grade material remained on the dumps and in the stopes. In these small deposits virtually all the ore exposed is dug out as the exploratory work progresses; therefore little or no ore reserve is blocked out at any time. However, the unworked parts of the known bodies may be expected to yield a moderate amount of ore, and other bodies will probably be discovered.

In the Renova district a bed of iron ore that as a rule is steeply inclined and consists chiefly of hematite occurs a short distance above the top of the Flathead quartzite. Several exposures in an area of 2 or 3 square miles show the bed to range from 3 to 15 feet or more in thickness and at two places to contain a manganiferous streak from 1 to 4 feet thick. The bed of iron ore, together with the included streak of manganese, is thought to be part of an iron-bearing stratum that was primarily of sedimentary origin but was enriched during the Tertiary period by weathering. The quantity of manganiferous material exposed is small, but there is reason to think that further exploration of the iron bed will reveal more, and the development work so far indicates that a rather large tonnage of iron ore may be counted on. Because they are generally free from silica and contain lime and iron the ores from Wigwam Creek, Cherry Creek, and Renova are desirable for mixing with the siliceous manganese ores found at many places in Montana, particularly at Butte, where the ores contain even less iron than is needed in making high-grade ferromanganese.

As the deposits herein described are thought to be derived from the manganese and iron originally deposited as sediments in certain beds, it is believed worth while to prospect the same beds elsewhere in this general region for manganiferous ores. Because it crops out prominently the Flathead quartzite is a useful guide to the areas that should be prospected. It lies immediately above the limestone in which the manganese deposits on Wigwam and Cherry creeks are found and a short distance below the horizon of the deposit near Renova. The geologic map of the Three Forks quadrangle,[1] which covers large parts of Madison and Gallatin counties, shows that the Cambrian formations, including the Flathead quartzite at the base, crop out in the hills east of Three Forks, along the summits north and south of Jefferson River, on both sides of the Jefferson Range south of Ennis, and at several places in the Madison Range. In the Three Forks folio the Cambrian was divided into the Gallatin formation and Flathead formation, but in present usage the term Gallatin limestone is restricted to the three upper members of Peale's Gallatin formation, and Flathead quartzite is applied to only the lower quartzite member of Peale's Flathead formation. The limestone that lies below the Cambrian Flathead quartzite, however, is not shown separately but is included in the area mapped as Cherry Creek formation, which occupies the west side of the Madison Valley between Wigwam and Ruby creeks and a small area east of the valley and north of Indian Creek. The occurrence of the Flathead quartzite and overlying Cambrian rocks in the Renova district, which lies outside of the Three Forks quadrangle, has been previously referred to.

[1] Peale, A. C., U. S. Geol. Survey Geol. Atlas, Three Forks folio (No. 24), 1896.

These formations or their equivalents are known in the Helena region and at Philipsburg, where extensive manganese deposits are also found in Cambrian limestones, though according to available knowledge the deposits at Philipsburg are different in origin from those here described. The formations mentioned are known also to occur east of the Three Forks quadrangle and doubtless crop out in many places elsewhere in the general region.

DEPOSITS ON WIGWAM CREEK.

GEOGRAPHY.

Manganese deposits have been found in an area of about a square mile that lies south of Wigwam Creek at the western edge of Madison Valley and may be reached by an automobile road from Ennis and Norris, respectively 12 and 30 miles to the north. The general surface of the area and of the lands that adjoin it slopes gently eastward, merging on one hand into the extensive lowland of Madison Valley and on the other into the steeper but not abrupt slope of the Jefferson Range. In detail the surface is modified by low rounded hills and rather shallow valleys, the local relief being from 100 to 200 or 300 feet. Except Wigwam Creek, which heads near the summit of the Jefferson Range, no perennial streams cross the area, which is bare of timber and rather scantily covered with bunch grass.

GEOLOGY.

The manganese-bearing area is underlain by a white or light-gray limestone that in general resembles the upper Cambrian limestones, which are exposed a short distance farther west. Locally the limestone is colored brownish red and pink in areas or zones several feet wide that are roughly parallel to the bedding but irregular in detail. Under the microscope it appears as a coarse granular mass of calcite, in which virtually all the crystals are twinned. This feature presumably indicates that the rock has undergone severe strain. A few small flakes of colorless mica are inclosed in the calcite grains, and here and there a quartz grain is found between them. In the discolored areas a red dust, probably hematite, is partly scattered through the calcite and partly arranged in streaks along the cleavage lines. Manganese oxides are present also, in part forming a black dust associated with the iron but chiefly occurring as small irregular bodies scattered through the calcite. These are commonly associated with the mica, and the manganese is somewhat more widely and uniformly distributed than the iron.

Blowpipe tests of the discolored parts and of some of the white parts of the rock give distinct reactions for manganese, and a sample of similar appearing limestone from Cherry Creek yielded on analysis 0.47 per cent of manganese and 1.28 per cent of iron.

When stepped upon or struck with a hammer the surface in many places sounds hollow, the rock beneath having an extremely porous texture. In detail this porous rock is made up of somewhat irregular horizontal layers less than a quarter of an inch thick that show a vertical columnar structure and an open texture, and all the surfaces are coated with a brown dust. Rock masses of this character are commonly as much as 50 feet across but of irregular form. So far as they are exposed by the mine workings they merge gradually into the normal compact limestone at depths of 1 to 10 feet. The brown dust is chiefly iron oxide and subordinately manganese oxide, and the columns are composed of calcite that shows a concretionary or stalactitic structure. Specimens from the boundaries of these masses clearly show that they were derived from the compact discolored limestone by the solution of calcium carbonate. Apparently all the calcite of the original rock was dissolved, and part of it was redeposited in columnar forms that resemble little stalagmites and stalactites. Not all of the iron and manganese oxides went into solution, part of them being released from the limestone as a fine powder that was left loosely adhering to any surfaces available. Locally, however, the manganese oxide appears to have been dissolved and concentrated in the open spaces.

Although the limestone is wholly crystalline, it shows distinctly a rather closely spaced bedding that strikes about northwest and dips 5°–25° SW., the beds being conformable in attitude to the overlying Flathead quartzite. The limestone is approximately 1,000 feet thick and lies upon the uneven eroded surface of a group of severely deformed and metamorphosed rocks that consist chiefly of pink and red gneiss and quartz-mica schist. The geologic map of the Three Forks quadrangle[1] shows that the area under consideration is underlain by a group of Algonkian rocks, mapped as Cherry Creek formation, considered to be older than the Algonkian Belt series. As the name suggests, Cherry Creek, a short distance south of the area, is the type locality of this group, which is described as a "series of marbles, or crystalline limestones, and interlaminated mica schists, quartzites, and gneisses * * * highly inclined and perfectly conformable to one another. * * * Between Cherry Creek and Wigwam Creek * * * the unchanged beds of the Cambrian rest upon the upturned edges of this group." The appearance, structural conformity with the Flathead quartzite, and general field relations of the limestone under consideration suggest that it is much younger than early Algonkian. At any rate, the great differences in structure and metamorphism between the limestone and the underlying gneiss and schist show that a long period elapsed

[1] U. S. Geol. Survey Geol. Atlas, Three Forks folio (No. 24), 1896.

between the times when those members of the Cherry Creek group were laid down.

North of Wigwam Creek the limestone and associated formations are overlain by basalt, and a short distance south of the manganiferous area there are patches of rhyolite. These rocks, which are regarded as of middle Tertiary age, are evidently the remnants of formations that were formerly more extensive and probably covered the manganiferous area. On the east the limestone and the gneiss and schist pass beneath Tertiary lake beds and Pleistocene alluvial deposits.

PHYSIOGRAPHY.

The eastern slope of the Jefferson Range, including the area under consideration, shows a rather smooth general surface of erosion that now forms the west side of the broad basin known as Madison Valley. This surface has no very conspicuous features and evidently was not produced under the conditions prevailing at present, which, in fact, are destroying it. For some time past the streams that cross it have been deepening their valleys and thus accentuating its relief. The area may therefore be roughly divided into parts characterized by younger and older surfaces, the rugged valleys of the present streams being examples of the former and the rather smoothly contoured interstream areas examples of the latter. As the older surface passes beneath the middle Tertiary lavas its development must have been completed by middle Tertiary time. It is thought to be correlated with similar surfaces elsewhere in this region that are cut across folded rocks of late Cretaceous age, and it was therefore probably developed during the early part of the Tertiary period. Since the lavas were stripped away the manganiferous area has apparently been reduced somewhat by erosion, but it is still characterized by the smooth forms of the older surface. Near the middle the old surface is trenched from west to east by a rather broad, shallow valley which is floored with washed gravel and was apparently occupied by a considerable stream at a time somewhat earlier than the later Pleistocene.

ORE BODIES.

Distribution and occurrence.—The manganese deposits are found in an area about 1½ miles long and two-thirds of a mile wide that has a general northwest direction, parallel to the strike of the rocks. About 20 pits and shafts have been dug on nearly as many different ore bodies, most of which are in the hillsides north and south of the gravel valley and from 50 to 100 feet above its floor. No ore bodies have yet been found in the lowlands. Most of them reach the surface, and all extend within a few feet of it. The outcrops are inconspicuous and as a rule much narrower than the widest parts of the deposits. A little float that consists of fragments of the harder varieties of the ore is scattered about. In general the ore is found below or near masses of the porous limestone described on page —, though it does not appear that the presence of these masses necessarily indicates the proximity of ore.

Character and composition.—The ore bodies are irregular, but most of them approach flat lenslike or pipelike forms. The largest one accessible, though not explored to the limits, is at least 50 feet long and 9 feet wide at one place, but not more than half of this width is high-grade ore. It is narrow at the surface, widens a few feet below, and becomes narrow again at a depth of 20 feet. Most of the ore bodies show more or less distinctly a zoned or layered structure, and the richest ore is generally found in a more or less distinct middle streak or core. One body that is exposed in a 10-foot pit was evidently deposited in a solution cavity in the limestone and consists of a core of manganese oxides from 1 to 3 feet thick around which is a 2-foot layer of very coarse textured calcite. The limestone surrounding this body is partly replaced by iron oxides and also contains streaks and nodules of manganese oxides. As a rule the ore bodies are somewhat loose and open because of joints and therefore can be mined without much blasting. The deepest working, 25 feet below the surface, has not reached water.

Psilomelane forms the bulk of the ore. It is generally massive but in places shows porous and concretionary structure. In the poorer grades of ore it forms small nodules. It is hard, black, and homogeneous but not crystalline, though some of it shows a satiny luster on fractured surfaces. Manganite is rather common, and most of it shows arborescent forms with a bright metallic luster and is considerably softer than the psilomelane. Wad is distributed widely as a brown dust and in places forms soft feltlike masses that have a somewhat greasy feel. Commonly the minerals are arranged in rather indistinct layers, manganite being deposited upon psilomelane and wad upon manganite. Cavities in ore of this description are filled with calcite, which was the last mineral to form.

Analyses of ore selected for shipment as reported by the operator run from 40 to 50 per cent of manganese, 1 to 3 per cent of iron, 3 to 4 per cent of lime, and generally less than 2 per cent of silica. The material rejected in sorting the ore consists of limestone partly replaced by iron and manganese oxides. Considerable of it apparently contains between 15 and 40 per cent of manganese.

Perhaps 50 tons of high-grade ore and several hundred tons of manganiferous material high in lime and iron can be safely estimated as in reserve, and there is reason to think that further development work will discover additional ore bodies.

Origin.—The general features of these deposits clearly show that they were deposited in solution cavities and have also made room for themselves by replacing the limestone. There is nothing to suggest that, like the metalliferous quartz veins of this general region, they were formed by solutions that rose through fissures from a deep-seated source. On the other hand, their composition and structure suggest that they were deposited by surface waters circulating through joints or other openings in the limestone. Under these conditions the only apparent source of the manganese is the limestone itself, which, as previously described, contains small proportions of manganese and iron oxides. Under present conditions solution and concentration of the manganese oxides do not appear to be going on in any part of this area. According to available data, manganese oxides dissolve with difficulty except in acid waters, such as are produced by the weathering of sulphide minerals or the decomposition of vegetation in humid regions. There is no evidence that sulphides have ever existed in the limestone, either as disseminated particles or in veins, and the present climate is unfavorable to the production of vegetable acids. The occurrence of the manganiferous bodies near the early Tertiary surface described on page 135 suggests, however, that they were formed when conditions may have been more favorable to the growth of vegetation and the production of vegetable acids than at present.

There is little to be said concerning the ultimate source of the manganese or the processes by which it became distributed in zones through the limestone. The most probable supposition is that both the manganese and the iron were precipitated with the limestone as sediments, some changes in the form and distribution of their minerals being caused afterward by the regional metamorphism that recrystallized the limestone.

DEPOSITS NEAR CHERRY CREEK.

GEOGRAPHY.

Several manganese ore bodies have been found a short distance south of Cherry Creek about a mile west of Madison Valley, and some manganese claims have been located along Johnny Gulch, about 3 miles farther south. Cherry Creek is about 12 miles south of Wigwam Creek and 42 miles south of Norris. Automobile trucks can be driven within half a mile of the deposits. The surface between Cherry Creek and Johnny Gulch is similar to that of the area surrounding the deposits on Wigwam Creek, except that the relief is somewhat greater. South of Cherry Creek a slope rises steeply about 500 feet to a moderately hilly but smooth surface that extends southward to Johnny Gulch and beyond. Except Cherry Creek there are no perennial streams in this area. It is practically bare of timber, though it is covered in places by rather dense thickets of low shrubs.

GEOLOGY.

Most of the area between Cherry Creek and Johnny Gulch is underlain by a limestone that is similar in texture to that at Wigwam Creek but is much more extensively discolored. Zones that show dark brownish-red to pink shades range from 20 to 500 feet in width and persist along a general course of about N. 20° E. for at least 3 miles. A deep reddish-brown marbleized limestone exposed along the north side of Johnny Gulch is shown by the microscope to consist chiefly of calcite clouded with oxides of iron. Manganese oxides occur rather sparingly as streaks and small masses, distributed mainly along the cleavage lines. In addition there are a few small aggregates of quartz grains and here and there flakes of colorless mica. An analysis of a representative specimen, made in the laboratory of the Geological Survey, shows this rock to contain 0.82 per cent of manganese, 9.48 per cent of iron, and 4.06 per cent of insoluble matter. From Johnny Gulch at Louis Clark's upper claim to Cherry Creek, a distance of 3 miles, the zones of discolored limestone are very extensive and persistent and for the most part show rather deep red or pink shades that merge with purple and brown. Specimens from an outcrop half a mile north of Johnny Gulch that are rough and gritty on the weathered surface and finer grained than the common variety are shown by a qualitative examination to contain small amounts of iron and manganese and apparently enough magnesia to make the rock classifiable as dolomite. At the Dodge, Dougan, and Grove claims, on top of the hill south of Cherry Creek, the limestone shows a rich reddish-brown color, and a representative specimen of it yielded by analysis 0.47 per cent of manganese, 1.28 per cent of iron, and 2.86 per cent of insoluble matter.

At Cherry Creek no bedding was seen, but the limestone shows closely spaced parting planes that strike about northeast and are nearly vertical. This structure is thought to have been caused by deformation. The limestone gives place to gneiss and schist on the east and to the Flathead quartzite on the west. These relations, together with its appearance, indicate it to be the same formation as the limestone at Wigwam Creek.

The smooth surface mentioned as characterizing the area between Cherry Creek and Johnny Gulch passes beneath rhyolite lava in places and is apparently a continuation of the Tertiary surface occurring at Wigwam Creek. Both areas evidently have had a similar physiographic history.

ORE BODIES.

Eight or ten pits, shafts, and tunnels, none of which reach a depth greater than 40 feet, have been dug here on bodies of manganese ore that are essentially similar in form, composition, and occurrence to those at Wigwam Creek. The largest accessible body is about 3 feet wide and has been explored about 50 feet. Most of them are developed along fissures or joints that have a general easterly course. The workings have not reached water.

Psilomelane, which is the chief ore mineral, occurs in compact masses and as botryoidal crusts that surround cores of softer oxides. In a tunnel near the top of the hill a small lens of iron ore that consists largely of hematite showing concretionary and botryoidal forms is associated with the manganese. The limestone adjoining the ore bodies is thickly clouded with iron oxides and partly replaced by small nodules of psilomelane.

Between Cherry Creek and Johnny Gulch fragments of a black flinty rock, some of which are fairly rich in manganese, are sparingly scattered over the surface. These are probably derived from siliceous or cherty bodies occurring in the limestone, none of which, however, were seen in place. On the slope north of Johnny Gulch at Clark's upper claim is a ledge several feet wide that projects through the limestone and apparently is a part of the underlying gneiss and schist series. It consists largely of magnetite and hematite but shows bands of granular quartz, some of which has a clear deep-red color, and the whole has the appearance and texture of a quartzite. Weathered surfaces of this rock are thinly coated with manganese oxides, and the analysis of an unweathered specimen gave 1.25 per cent of manganese.

So far as shown by the development work less than 50 tons of high-grade ore and not more than 100 tons of low-grade ore which is evidently high in lime and iron can be definitely estimated as in reserve. It is believed, however, that the areas of discolored limestone between Cherry Creek and Johnny Gulch are worth careful prospecting in the expectation of finding other ore bodies.

DEPOSITS NEAR RENOVA.

GEOGRAPHY.

Iron ore and manganiferous iron ore are exposed by several workings in an area of 2 or 3 square miles about 3 miles southwest of Renova, a station on the Alder branch of the Northern Pacific Railway. The area is also about 5 miles southwest of Piedmont, on the Chicago, Milwaukee & St. Paul Railway. Most of the mine workings are reached by wagon roads that in places have steep gradients and are out of repair. The area described lies south of the Renova

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mining district, described by Winchell,[1] which contains several formerly productive gold and silver mines. It is near the north end of the Tobacco Root Range and in the foothills at the eastern edge of Jefferson Valley, near Gaylord, the site at which the building of a large smelter for the reduction of copper ores from Butte was begun at one time but never completed. The surface has a general northeasterly slope and is rather rough in detail, the local relief being as much as 1,000 feet. A short distance south of Renova a bold, steep slope that forms the east wall of the valley is so regular in form that from a distance it strongly suggests a plane that strikes N. 25° E. and dips about 30° W. For 2 to 3 miles eastward from the summit of this slope the surface, which has an average altitude of about 5,800 feet above the sea, is hilly or undulating and rather smooth except where it is broken by several deep, narrow gulches. Farther east this surface gives place to a slope that rises to the summit of the range at an elevation of about 8,000 feet. South of this area a deep transverse valley extends well back toward the divide, and south of the valley the hills recede eastward 2 or 3 miles, but their steeply dipping front slopes for many miles farther south coincide with a plane parallel to that of the front slope near Renova. North of the area the surface is hilly and moderately rough, and the slope facing the valley is irregular.

Springs are fairly plentiful, and the area is also crossed by several perennial streams that have their sources near the main divide. Up to an altitude of 6,000 feet there is little or no brush or timber. In general the rock exposures are good on the steep slopes facing Jefferson Valley, but in the rather smooth elevated areas east of these slopes the surface mantle is deep and the exposures poor.

GEOLOGY.

A dark-gray to green mica schist that is probably to be correlated with the Algonkian Belt series as described in the Three Forks folio[2] is exposed at several places along the north side of the area under consideration. This formation is overlain unconformably by Paleozoic rocks, which in this general region include in part a succession of Cambrian limestones and shales with the Flathead quartzite at the base, overlain by the Threeforks shale and the Jefferson limestone (both of Devonian age), and these in turn overlain by the Madison limestone (early Carboniferous). The Flathead quartzite is from 100 to 200 feet thick and crops out boldly, forming the summit of the steep slope mentioned as facing Jefferson Valley a short distance south of Renova. Above the quartzite a few feet of soft variegated shale and micaceous sandstone are poorly exposed.

[1] Winchell, A. N., Mining districts of the Dillon quadrangle, Mont.: U. S. Geol. Survey Bull. 574, pp. 99-101, 1914.

[2] U. S. Geol. Survey Geol. Atlas, Three Forks folio (No. 24), 1896.

The overlying Paleozoic limestones mentioned form rough and conspicuous light-colored outcrops that occupy the slopes facing Jefferson Valley south of Renova for at least 10 or 15 miles. The hills north of the particular area under consideration are underlain in part by a somber-colored andesite lava that rests upon the eroded edges of the rocks mentioned and is regarded as of Cretaceous or early Tertiary age.

On the steep valley wall south of Renova the Paleozoic rocks strike a little east of north and dip about 50° W., or 20° more steeply than the slope. East of the summit of this slope the strike changes somewhat abruptly to N. 75° E.; the dip is southward and rather moderate. The structure suggested is an anticline that leans eastward and plunges steeply southward. The position of the upper Cambrian limestones, which at a point just east of the summit are somewhat lower than the adjacent outcrops of Flathead quartzite, suggests that faulting has occurred along the axis of the anticline.

Although the east wall of Jefferson Valley pitches in the same direction as the bedded rocks, it is not strictly a dip slope following a particular stratum but a surface that cuts across several different beds. The alinement of the surfaces that compose the front wall of the valley with two or more parallel planes suggests that they represent a great fault or zone of faults of a north-northeasterly direction, Jefferson Valley being the downthrown block. The elevated rolling and soil-mantled areas east of the front slope are evidently the remnants of a surface of erosion produced when the drainage level was relatively much higher than at present.

ORE BODIES.

Occurrence and character.—On the Iron King claim, near the top of the steep slope east of Jefferson River, a short distance south of Renova, an adit has been run 80 feet north on a bed of iron ore that rests on the Cambrian shale overlying the Flathead quartzite. The ore body ranges from 4 to 8 feet in thickness and is overlain by Cambrian limestone; the average dip of the rocks and the ore bed is 48° W. An irregular streak that ranges from a few inches to 2 feet in width and generally occupies a position near the middle of the iron bed is rich in manganese oxides. The streak is in part rather hard and compact and in part soft and porous; the hard portions consist chiefly of psilomelane, and the soft portions of pyrolusite and wad. In places adjoining this streak small masses of earthy iron ore are coated with thin curved and glazed crusts of manganese oxides. A sample of the manganiferous streak in the face of the tunnel, where it is 18 inches wide, contains, according to an analysis made in the laboratory of the Geological Survey, 32.73 per cent of manganese, 17.84 per cent of iron, 1.71 per cent of insoluble matter, and traces of phosphorus and sulphur. The remainder of the deposit consists of hematite and limonite in which little or no impurity is visible. Several years ago a moderate amount of the iron and manganiferous ore was mined, hauled down a very steep road to the valley, and thence shipped to Butte. The outcrop of this deposit is said to be traceable for several hundred feet north and south of the working described.

On the Iron Blossom No. 3 and Iron Blossom No. 1 claims, 1½ and 2 miles respectively east of the Iron King, similar deposits of iron ore are exposed. At the Iron Blossom No. 3 the workings, which consist of pits only, do not reveal the size of the deposit but show that it is at least 10 feet thick throughout an area 40 or 50 feet wide. This body is covered by a deep surface mantle containing fragments of limestone and quartzite, and although its walls are not exposed by the workings, the rock outcrops near by show that it lies above the shales that overlie the Flathead quartzite. The ore is a massive and compact to rather porous mixture of iron oxides, chiefly hematite, some of which show platy crystal forms that are pseudomorhpic after magnetite. Certain compact portions of the ore are magnetic, but they give a brown to red streak and probably are partly altered magnetite or the mineral known as martite. Earthy yellow and hard brown varieties of limonite are moderately plentiful. No manganese oxides were observed except as rather thin coatings on seams in the iron ore. At the Iron Blossom No. 1 claim an open cut partly exposes a bed of iron ore that lies upon the variegated Cambrian shale overlying the Flathead quartzite. Above the shale, which dips 45° SE., there is about 15 feet of hematite and limonite, then a 4½-foot streak of manganiferous iron ore, above which is more iron ore. The hanging wall of the deposit is not exposed. The manganiferous streak is somewhat earthy and impure and contains a mixture of manganese oxides, the mineral species of which, except perhaps wad, could not be positively determined. A few small but perfectly formed cubes of hematite pseudomorphic after pyrite are scattered through the mass. An analysis of the manganiferous streak, made in the laboratory of the Geological Survey, gave 14.59 per cent of manganese, 39.81 per cent of iron, 0.07 per cent of phosphorus, a trace of sulphur, and 14.44 per cent of insoluble matter. From the Iron Blossom claims, which are reached by a fairly good wagon road, considerable iron ore was formerly shipped to Butte for use as a flux in the copper smelters.

From the available data it is difficult to determine the amount of ore in reserve, but the exposures so far made warrant the expectation of at least several hundred tons of manganiferous iron ore and several thousand tons of iron ore.

Origin.—The deposits show no marked structural features and do not in themselves offer much evidence as to their origin. The presence of magnetite suggests they may be a result of contact metamorphism, but that idea is not supported by the local geology. No intrusive bodies are known very near this locality, and the sedimentary rocks do not show any contact-metamorphic minerals or other evidences that intrusive bodies are present below. The localization of the deposits at the top of shales overlying the Flathead quartzite and their close association with an old surface of erosion suggest that they are portions of an iron-bearing stratum enriched by weathering when the land was being worn down to the level of the old surface and therefore are to be regarded as primarily of sedimentary origin. If this is the true explanation, other similar ore bodies are to be expected at the same geologic horizons in the neighboring districts.

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