DESCRIPTION OF THE FORT BENTON QUADRANGLE.

INTRODUCTION.

General relations.—The Fort Benton quadrangle is a square-shaped area covering approximately 300 square miles, distinctive in topography and geologic structure, and occupying a prominent position in the central part of the state of Montana. It is bounded on the north by the Little Belt Mountains, on the east by the Missouri River, on the south by the Yellowstone River, and on the west by the Highwood Mountains.

In general, the Fort Benton quadrangle is characterized by a series of intermontane basins and plateaus, with the Highwood Mountains forming a prominent feature on the east. The area is traversed by several streams, including the Yellowstone River and its tributaries, which have carved deep valleys through the rock formations.

The geologic map shows that the various rock formations in the region are well exposed and provide a detailed record of the earth's history. The oldest rocks are Precambrian in age, and the youngest rocks are Cenozoic in age. The intermediate rocks include theTriassic, Jurassic, and Cretaceous periods.

The climate of the region is continental, with cold winters and hot summers. The annual precipitation is generally low, averaging around 15 inches. The region is subject to extremes of heat and cold, with varying degrees of snowfall and frost.

The area is of great economic importance, with coal mining, agriculture, and livestock farming being the major industries. The region is also of scientific interest, with a wealth of geologic and archaeological sites.

In conclusion, the Fort Benton quadrangle is a valuable resource for both economic development and scientific research, and it plays a significant role in the history and culture of Montana.
Limestone ponds to the surface of the gneisses upon which planes are indistinct, and which is composed Park, whose gentle northerly inclination corres­
Archean. They underlie the surface of Belt hornblende-schist, whose rusty weathered outcrops -
inter­
Adakian. They are characterized by hornblende schists, whose rusty weathered outcrops are very conspicuous. Stringers or dikes of white quartz granite, which are usually much more rusty orange or red, are not uncommon. Some of the rocks are undoubtedly of igneous origin, but are obscured and metamorphosed.

Sedimentary Rocks

Beds of the Cambrian Period.

Barker formation. — The oldest sedimentary rocks of the quadrangle form a sequence, collectively called the Barker formation, as they can not be mapped separately on the scale of these sheets. They are characterized by thinly bedded red sandstone and shale containing fossil remains of early Cambrian age. The oldest and best bed is the Flathead sandstone, a coarse sandstone, which rests conformably on the Otter-sandstone and is made up of small pebbles and coarse grains of quartz and feldspar, with occasional pebbles of granite. This grade into incoherent sandstones, which are often finely cemented, hard, and resistant to weathering.

Beds of the Silurian and Devonian Periods.

Monarch formation. — The Monarch formation consists of red sandstone, alternated by thin beds of shale, which are coarse grained above but very fine grained below, with abundant pebbles of quartz and feldspar. These beds often show a fine striation, due to slight variations in color. Near Barker the lower beds contain light gray sandstones and gray shales.

Beds of the Permian Period.

Medicineimestone. — The Madison limestone is the most conspicuous single group of beds in the Little Belt Mountains. It consists of a thickness of from 1500 to 1600 feet of limestone, marl, siltstone and sandstone, and is divided into two members. The top member is a limestone of great thickness, which rests unconformably on the Madison sandstone. The lower member consists of siltstone and sandstone, of which the upper part is made up of coarse sandstone and gravel.

Glacial Drift and Till. — The entire northern half of the quadrangle is covered by a nearly continuous sheet of glacial drift. Near the southern limit of the area these forms are obliterated by a well-defined forest, with a scattered fringe of bowlders, and high montane ridges occur south of the Missouri River. The material is an unsorted mixture of sand and gravel in which bowlders of varying sizes are irregularly scattered. These bowlders consist of geologically different materials, very different from any rocks found within the quadrangle. The largest, especially south and west of the Little Belt Mountains, consist of glacial erratic boulders, which are in the process of being re-worked and recrystallized into the drift by the Corrasion of the Missouri River.

Till. — The river bottoms, more especially those of the Missouri and the Tetons, are occupied by flood-plain deposits of recent alluvium composed of the fine silts, clays, and gravels transported by the streams in times of high water and deposited by them. Such areas are commonly overgrown by thickets of willow, or groves of cottonwood trees.
Intrusions rocks of the Little Belt Mountains.

The igneous rocks of the Little Belt Mountains present many transitional varieties of well-known rocks, and even in the same rock mass they show considerable variation in character. For this reason the naming of the rocks forming the intrusive sheets and masses presents difficulties which are partly met by giving local designations to the principal varieties of granite-porphyry (the common rock), while other rocks are designated by the names of the groups to which they appear most closely related. The rocks of the various localities of the range belong to one well-marked structural type, with slight variations in mineral constitution and chemical composition. The most common form is a variety of granite-porphyry to which the name Barker porphyry is given.

In Steamboat Mountain the rock is a diorite-porphyry, but those rocks, which petrographically are distinct, are variations of the same kind of magma, and in hand specimens are strikingly similar and clearly belong to the same type.

Igneous rocks of the Highwood Mountains.

The igneous rocks of the Highwood Mountains are of various kinds and modes of occurrence. They are found as massive granular varieties, filling former volcanic conduits in the shape of central stocks or cones, as exist at Highwood, Midle, Skonk, and Union Peaks, with light-colored caps, as at Square Butte and near Mallard Lake in the Skonk Sag; as porphyritic types in the great mass of dikes, as the Bridger dikes, which are partly met by giving local designations.

Diorite-porphyry.

The diagnostic mass of Steamboat Mountain consists of a diorite-porphyry, which is composed chiefly of pyroxene, hornblende, and feldspar, and contains a greater proportion of plagioclase feldspar, so that it must be classed as a diorite-porphyry. The rock shows the same phenomena, orthoclase and plagioclase feldspars, hornblende, biotite, and iron ore as the Barker porphyry, in a microgranitic groundmass of plagioclase and orthoclase.

Syenite-porphyry.

The rock of Woodhouse Mountain is classed as syenite-porphyry, as it is the end of the Yogo stock. The rock is in appearances essentially similar to the Barker porphyry, but microscopically it contains so little quartz that it is no longer a granite-porphyry. The rock is composed of plagioclase, hornblende, and biotite, and is more or less nepheline and sodalite. The latter minerals are present in such abundance that the rock is granular, and varies in the coarseness of its grains in different localities.

White granite-porphyry.

The rocks of the same locality as the white granite-porphyry which forms the intrusive mass of this rock. It forms also the lower porphyry which extends from the large, gray quartz crystals or cores at the edges of a large number of the dikes.

Silica porphyry.

The intrusive sheets and masses of this rock are mostly rhyolite-porphyrpores, consisting of a white rock comprising chiefly of pyroxene and a small quantity of interstitial feldspar, so that it must be classed as a diorite-porphyry. The rock is composed of a white rock which is a sodalite-pyroxene granite-syenite-porphyry. At the borders of the masses it is then a rhyolite-porphyry (quartz-porphyry). In the Little Belt Range the dikes of this rock are mostly rhyolite-porphyry, consisting of a white rock which is a sodalite-pyroxene granite-syenite-porphyry. At the borders of the intrusive masses of this rock are composed chiefly of pyroxene, hornblende, and feldspar, and contains a greater proportion of plagioclase feldspar, so that it must be classed as a diorite-porphyry. The rock shows the same phenomena, orthoclase and plagioclase feldspars, hornblende, biotite, and iron ore as the Barker porphyry, in a microgranitic groundmass of plagioclase and orthoclase.

Barker porphyry.

The rock Barker porphyry, which is classed as a porphyry, is a light-colored rock, usually gray or pale yellow-brown, often weathering reddish. It shows large crystals, sometimes an inch across, of orthoclase, with very much more abundant and much smaller prisms of hornblende, pinkish gray, and smaller prisms of plagioclase feldspar in a groundmass that is recognized as finely granular, and is peppered with small, slender, glittering black prisms of a peculiar hornblende.

Lucite porphyry.

In the Highwood Mountains the trachytic rocks are mostly rhyolite-porphyry, consisting of a white rock comprising chiefly of pyroxene and a small quantity of interstitial feldspar, so that it must be classed as a diorite-porphyry. The rock is composed of a white rock which is a sodalite-pyroxene granite-syenite-porphyry. At the borders of the dikes of this rock are composed chiefly of pyroxene, hornblende, and feldspar, and contains a greater proportion of plagioclase feldspar, so that it must be classed as a diorite-porphyry. The rock shows the same phenomena, orthoclase and plagioclase feldspars, hornblende, biotite, and iron ore as the Barker porphyry, in a microgranitic groundmass of plagioclase and orthoclase.

Alkali porphyry.

The rock of Woodhouse Mountain is classed as syenite-porphyry, as it is the end of the Yogo stock. The rock is in appearances essentially similar to the Barker porphyry, but microscopically it contains so little quartz that it is no longer a granite-porphyry. The rock is composed of plagioclase, hornblende, and biotite, and is more or less nepheline and sodalite. The latter minerals are present in such abundance that the rock is granular, and varies in the coarseness of its grains in different localities.

White granite-porphyry.

The rocks of the same locality as the white granite-porphyry which forms the intrusive mass of this rock. It forms also the lower porphyry which extends from the large, gray quartz crystals or cores at the edges of a large number of the dikes.

Silica porphyry.

The intrusive sheets and masses of this rock are mostly rhyolite-porphyry, consisting of a white rock comprising chiefly of pyroxene and a small quantity of interstitial feldspar, so that it must be classed as a diorite-porphyry. The rock is composed of a white rock which is a sodalite-pyroxene granite-syenite-porphyry. At the borders of the intrusive masses of this rock are composed chiefly of pyroxene, hornblende, and feldspar, and contains a greater proportion of plagioclase feldspar, so that it must be classed as a diorite-porphyry. The rock shows the same phenomena, orthoclase and plagioclase feldspars, hornblende, biotite, and iron ore as the Barker porphyry, in a microgranitic groundmass of plagioclase and orthoclase.

Barker porphyry.

The rock Barker porphyry, which is classed as a porphyry, is a light-colored rock, usually gray or pale yellow-brown, often weathering reddish. It shows large crystals, sometimes an inch across, of orthoclase, with very much more abundant and much smaller prisms of hornblende, pinkish gray, and smaller prisms of plagioclase feldspar in a groundmass that is recognized as finely granular, and is peppered with small, slender, glittering black prisms of a peculiar hornblende.

Lucite porphyry.

In the Highwood Mountains the trachytic rocks are mostly rhyolite-porphyry, consisting of a white rock comprising chiefly of pyroxene and a small quantity of interstitial feldspar, so that it must be classed as a diorite-porphyry. The rock is composed of a white rock which is a sodalite-pyroxene granite-syenite-porphyry. At the borders of the intrusive masses of this rock are composed chiefly of pyroxene, hornblende, and feldspar, and contains a greater proportion of plagioclase feldspar, so that it must be classed as a diorite-porphyry. The rock shows the same phenomena, orthoclase and plagioclase feldspars, hornblende, biotite, and iron ore as the Barker porphyry, in a microgranitic groundmass of plagioclase and orthoclase.
feldspathic component that it is often impossible
to define its exact original nature. It may be
safely said, however, that in all cases they are
probably all alkali basalts with sodalite-feldspar as the chief compo-
nent of the base is either very rare or wholly
absent in the district.

RELATIONS OF ROCK MASSSES.

The Archean nucleus of the region is exposed
only in the southwest part of the quadrangle,
where it has been disclosed by the degradation
of the Little Belt upland. This area is the floor on
which the stratified rocks were laid down. This
nucleus is often impossible to define its exact original nature. It may be
safely said, however, that in all cases they are
absent in the district.

their normal nearly horizontal position a few
which the stratified rocks were laid down. This
only in the southwest part of the quadrangle,
different parts of the region, though and bandi "g-
and their dip and direction vary in dif- Schistosity
ferous beds. No well-marked unconformity other
and conformable sequence from Cambrian to Creta-
sedimentary rocks.

ious igneous masses intruded between it and the
waxing away, at 20° to 30°, from the buttes. The
troughs, in which areas of the younger rocks are
surrounded by older ones, as a result of the
decomposition of the bedrock, and the younger
region the flat summit and upper slopes of the

body of massive rock, about the borders of which
the baked sediments show five examples of
contact metamorphosis of clay shale and sand-
nosed, showing the breccia and breccia-like
that only the rocks immediately adjacent to the
contact are uplifted. Barker Mountain is an
example of an intrusion from which the
batholith has been partly removed, and the smoothed,
smoothed southerly slope of the mountain is the surface of
the mountain northeast of it is still covered by
stratified rocks, horizontal on the summit and dipping steeply on its slopes, but a branch of
Butte has cut deeply into the heart of the
is exposed by the session of the cover.

The great domeshaped hill near Kibbey is
believed to represent a laccolith from whose
surface a number of erosions have been
striped and the massive Madison limestones
are laid through by Little Otter Creek, but the
igneous core is probably still far below. A similar
dome is cut through by Dry Wolf Creek. A smaller
dome, forming the prominent rounded hill rising above the plains nearby, called Skull
Butte, is not yet stripped of its higher, softer
beds.

In the eastern part of the Highwood area, the
earliest volcanic disturbance resulted in the for-
mation of laccoliths in the stratified rocks.

These were greatly deformed by intrusions before the earliest breccias of the region
and may be regarded as the oldest of the igneous rocks of these mountains.

The Shonkin Sag is cut across two of these lacco-
liths, extending from the fringing ridge and
will be cut across by Dry Fork of Belt Creek
Barker Mountain area the breccias show a rude arrange-
ment, while the later ones are mostly chaotic and
breccias are common accompaniments of these bodi-

Volcanic cores.--In the Highwood Mountain
area the contact formed the core of a laccolith,
and the exposure of the laccolith differs from the
intrusive breccia by the thinning of the mass into a
lenticular body, over which the strata arch. A
breccia of this kind is called dome-shaped and is the
ideal form. The examples in the Little Belt Range are
not perfectly regular, but have broken in some parts and
are normal to the cooling surface, and rest upon
the height of which depends upon the amount of
the original melt and the degree of denudation.
Laccoliths in various stages of denudation are
seen in the quadrangle. The Little Belt Mount-
ain laccolith occurs partly denuded of the sedi-
mentary cover, and also in domes where the over-
strata have been partly removed or cut deeply into
the massive rock beneath, though the structure leaves
doubt as to its presence.

The laccoliths of the Little Belt Range are all
intrusive breccias at Highwood Peak masses of
Highwood syenite and basic rocks occur together.
At the latter locality the two forms are quartz-
syenite and monzonite. At Square Butte it is
sodalolite and shonkinite. The relations of these
discordant rocks is beautifully illustrated in the
Shonkin Sag locality. The walls of the
Shonkin Sag show sections cut through two of these
beds of breccias, showing the breccia-like
injection of intrusive igneous rocks, both the
ardent and the monzonite masses, and many of
these breccias show radiating dikes.

At East Peak the coarse-grained rock is seen
intrusive breccia of basic breccias, the younger
fragmental rocks. At the Shonkin Creek core, and those masses
are cut across by the old river course
of coarse grain but very unlike in appearance.
At East Peak the coarse-grained rock is seen
intrusive breccia of basic breccias, the younger
fragmental rocks. At the Shonkin Creek core, and those masses
are cut across by the old river course
of coarse grain but very unlike in appearance.
cut at one or two places by streams gorges, showing the internal features of the mass. The section thus presented shows that the liquid rock cooled rapidly about the main body and that the geyserlike flow in the intrusive sheets, consisting of albite-basalt.

In the center, however, where the liquid rock rapidly spread on the surface, the liquid was quenched to produce a large block of basalt. The Alpehine Mountains, consisting largely of sheared basalt, lies on the surface of the region. This block of basalt is composed of a syenite consisting chiefly of light-colored minerals, mainly feldspar. This is surrounded by a darker rock composed of the darker and basaltic iron-bearing minerals, angles, micas, and silicates, with little quartz and the dark iron-bearing minerals.

This differentiation is more strikingly illustrated in the large flat-topped mountains in and around Square Butte, which forms the extreme eastern member of the Highwood group.

RELATIONS OF POST-CAMBRIAN BODIES TO DEPOSITIONAL SEQUENCE.

The post-Cambrian rocks rest upon the eroded surfaces of the older rocks. The Stratton formation, of which only isolated fragments now remain, caps hills and interstream terraces which owe their prominence to the protection afforded by the Stratton surface. These terraces, which are generally marked with the characteristic triangular episode, are composed of a syenite consisting chiefly of light-colored minerals, mainly feldspar. This is surrounded by a darker rock composed of the darker and basaltic iron-bearing minerals, angles, micas, and silicates, with little quartz and the dark iron-bearing minerals.

The uplift shown was accompanied or followed by intrusion of the great body of limestones into the region beneath marine waters; the sea was not to separate this great body of limestones into emerged land, the impure limestones carrying more and more silicious sand, the last-formed beds consists of a mass of comminuted wave-worked and anabahedral cement.

CONTACTING FEATURES.

Early Cretaceous lavas.-At this epoch the region emerged from the sea, forming a tract of lowlying with shallow lakes or estuaries and tidal flats, in which a luxuriant vegetation of ferns and rushes furnished the material for the beds of coal now so extensively mined.

The beds which constitute the coal constitute the Cascade formation and are supplied with the same identity of the Eocene rocks of British Columbia. The coal beds, which are similar in stratigraphic position and the plant remains found with the coal show a similar flora. The beds of volcanic ash and tuff found interbedded with the Cascade strata, and seen also in the Cascade beds of the quadrant south of this, have not been observed here.

Formation of fresh water and marine waters.-There is no evidence showing the condition of the region during the long period intervening between the Cascade and Dakota epochs. After the formation of the coal the basins were covered by a varying thickness of sand which now forms the badlands and rock outcrop where seen on the coal. This was succeeded by the deposition of alternating beds of shale and redish and lilac-colored sandstone. The shales hold thin-stratified fossiliferous nodules and lenses that contain fresh water fossils at a horizon 160 to 190 ft above the sea level. The fossils found in the coal beds are of marine origin, and the true marine origin of the rocks, in distinction to the truly marine tracts of the succeeding epoch. This is illustrated by the Second voyage exploration around the borders of the main body and for some 15 or 20 miles. The eastern United States.

The observed facts do not prove the submergence of the region beneath marine waters; the sea was not to separate this great body of limestones into emerged land, the impure limestones carrying more and more silicious sand, the last-formed beds consists of a mass of comminuted wave-worked and anabahedral cement. Glaciation.

The uplift shown was accompanied or followed by intrusion of the great body of limestones into the region beneath marine waters; the sea was not to separate this great body of limestones into emerged land, the impure limestones carrying more and more silicious sand, the last-formed beds consists of a mass of comminuted wave-worked and anabahedral cement.
part of the quadrangle belonging to the Little Belt Range. Gold has been found in limited quantity in small areas of placer gravel, and it is not certain that gold has been found in a number of locations in quartz veins, but of these none have as yet been developed into mines. Quartz veins occurring on the slopes of the ridges, with the exception of the Little Belt Range, are not in great variety and are capable of taking a high polish. The symplectite of Burren furnishes a splendid material of any desired size, but is at present not in great demand.

Clays suitable for brick making abundantly occur in the alluvial areas along the streams of the Little Belt proper, or south of it, and less abundantly in the mountain district.

Artesian water.—The sandstones which underly the Big Baldy are the lower beds of the Little Belt Coal Fireclay, and these beds constitute so large a portion of the quadrangle as to be probably porous enough to hold water and so wide an area of arid soil are conducive to such use of the water. As there are many square miles over which even grazing is impossible, for lack of water, it is evident that this is worth the cost of testing.

Coal.—The coal lands of the quadrangle are shown on the Economic Geology sheet by a dark shade of green. The area so colored is not coincident with that of the Cascade formation, for which the coal seams belong, for the seams occur at the top of that formation, and the greater part of the area where these beds are exposed is not underlain by coal. For this reason the outcrop of the seam has been taken as one boundary of the area mapped, and, as the beds dip beneath the flat bench lands, a strip of country which the seam underlies is shown in the map. It is developed by a vertical two-com­partment shaft, with crosscut levels to the veins, which forms the west wall of the lode. The main ore shoot was not then reached. The Barker mine is one of the first discovered in the district, and it is said to have been opened about 1879, but remained unworked for several succeeding years. It is developed by a vertical two-com­partment shaft, with crosscut levels to the veins, and a drift level, but has made no considerable figures. The Barker mine was one of the first discovered in the district, and it is said to have been opened about 1879, but remained unworked for several succeeding years. A number of small mines, and not in great ones like Thunder Mountain are said to show $1.00 to $2.00 of the limestone with eruptive porphyry. In that part of the quadrangle belonging to the Little Belt Range. Gold has been found in limited quantity in small areas of placer gravel, and it is not certain that gold has been found in a number of locations in quartz veins, but of these none have as yet been developed into mines. Quartz veins occurring on the slopes of the ridges, with the exception of the Little Belt Range, are not in great variety and are capable of taking a high polish. The symplectite of Burren furnishes a splendid material of any desired size, but is at present not in great demand.

Clays suitable for brick making abundantly occur in the alluvial areas along the streams of the Little Belt proper, or south of it, and less abundantly in the mountain district.

Artesian water.—The sandstones which underly the Big Baldy are the lower beds of the Little Belt Coal Fireclay, and these beds constitute so large a portion of the quadrangle as to be probably porous enough to hold water and so wide an area of arid soil are conducive to such use of the water. As there are many square miles over which even grazing is impossible, for lack of water, it is evident that this is worth the cost of testing.

Coal.—The coal lands of the quadrangle are shown on the Economic Geology sheet by a dark shade of green. The area so colored is not coincident with that of the Cascade formation, for which the coal seams belong, for the seams occur at the top of that formation, and the greater part of the area where these beds are exposed is not underlain by coal. For this reason the outcrop of the seam has been taken as one boundary of the area mapped, and, as the beds dip beneath the flat bench lands, a strip of country which the seam underlies is shown in the map. It is developed by a vertical two-com­partment shaft, with crosscut levels to the veins, which forms the west wall of the lode. The main ore shoot was not then reached. The Barker mine is one of the first discovered in the district, and it is said to have been opened about 1879, but remained unworked for several succeeding years. A number of small mines, and not in great ones like Thunder Mountain are said to show $1.00 to $2.00 of the limestone with eruptive porphyry. In that part of the quadrangle belonging to the Little Belt Range. Gold has been found in limited quantity in small areas of placer gravel, and it is not certain that gold has been found in a number of locations in quartz veins, but of these none have as yet been developed into mines. Quartz veins occurring on the slopes of the ridges, with the exception of the Little Belt Range, are not in great variety and are capable of taking a high polish. The symplectite of Burren furnishes a splendid material of any desired size, but is at present not in great demand.

Clays suitable for brick making abundantly occur in the alluvial areas along the streams of the Little Belt proper, or south of it, and less abundantly in the mountain district.

Artesian water.—The sandstones which underly the Big Baldy are the lower beds of the Little Belt Coal Fireclay, and these beds constitute so large a portion of the quadrangle as to be probably porous enough to hold water and so wide an area of arid soil are conducive to such use of the water. As there are many square miles over which even grazing is impossible, for lack of water, it is evident that this is worth the cost of testing.

Coal.—The coal lands of the quadrangle are shown on the Economic Geology sheet by a dark shade of green. The area so colored is not coincident with that of the Cascade formation, for which the coal seams belong, for the seams occur at the top of that formation, and the greater part of the area where these beds are exposed is not underlain by coal. For this reason the outcrop of the seam has been taken as one boundary of the area mapped, and, as the beds dip beneath the flat bench lands, a strip of country which the seam underlies is shown in the map. It is developed by a vertical two-com­partment shaft, with crosscut levels to the veins, which forms the west wall of the lode. The main ore shoot was not then reached. The Barker mine is one of the first discovered in the district, and it is said to have been opened about 1879, but remained unworked for several succeeding years. A number of small mines, and not in great ones like Thunder Mountain are said to show $1.00 to $2.00 of the limestone with eruptive porphyry. In that part of the quadrangle belonging to the Little Belt Range. Gold has been found in limited quantity in small areas of placer gravel, and it is not certain that gold has been found in a number of locations in quartz veins, but of these none have as yet been developed into mines. Quartz veins occurring on the slopes of the ridges, with the exception of the Little Belt Range, are not in great variety and are capable of taking a high polish. The symplectite of Burren furnishes a splendid material of any desired size, but is at present not in great demand.

Clays suitable for brick making abundantly occur in the alluvial areas along the streams of the Little Belt proper, or south of it, and less abundantly in the mountain district.

Artesian water.—The sandstones which underly the Big Baldy are the lower beds of the Little Belt Coal Fireclay, and these beds constitute so large a portion of the quadrangle as to be probably porous enough to hold water and so wide an area of arid soil are conducive to such use of the water. As there are many square miles over which even grazing is impossible, for lack of water, it is evident that this is worth the cost of testing.

Coal.—The coal lands of the quadrangle are shown on the Economic Geology sheet by a dark shade of green. The area so colored is not coincident with that of the Cascade formation, for which the coal seams belong, for the seams occur at the top of that formation, and the greater part of the area where these beds are exposed is not underlain by coal. For this reason the outcrop of the seam has been taken as one boundary of the area mapped, and, as the beds dip beneath the flat bench lands, a strip of country which the seam underlies is shown in the map. It is developed by a vertical two-com­partment shaft, with crosscut levels to the veins, which forms the west wall of the lode. The main ore shoot was not then reached. The Barker mine is one of the first discovered in the district, and it is said to have been opened about 1879, but remained unworked for several succeeding years. A number of small mines, and not in great ones like Thunder Mountain are said to show $1.00 to $2.00 of the limestone with eruptive porphyry. In that part of the quadrangle belonging to the Little Belt Range. Gold has been found in limited quantity in small areas of placer gravel, and it is not certain that gold has been found in a number of locations in quartz veins, but of these none have as yet been developed into mines. Quartz veins occurring on the slopes of the ridges, with the exception of the Little Belt Range, are not in great variety and are capable of taking a high polish. The symplectite of Burren furnishes a splendid material of any desired size, but is at present not in great demand.

Clays suitable for brick making abundantly occur in the alluvial areas along the streams of the Little Belt proper, or south of it, and less abundantly in the mountain district.

Artesian water.—The sandstones which underly the Big Baldy are the lower beds of the Little Belt Coal Fireclay, and these beds constitute so large a portion of the quadrangle as to be probably porous enough to hold water and so wide an area of arid soil are conducive to such use of the water. As there are many square miles over which even grazing is impossible, for lack of water, it is evident that this is worth the cost of testing.

Coal.—The coal lands of the quadrangle are shown on the Economic Geology sheet by a dark shade of green. The area so colored is not coincident with that of the Cascade formation, for which the coal seams belong, for the seams occur at the top of that formation, and the greater part of the area where these beds are exposed is not underlain by coal. For this reason the outcrop of the seam has been taken as one boundary of the area mapped, and, as the beds dip beneath the flat bench lands, a strip of country which the seam underlies is shown in the map. It is developed by a vertical two-com­partment shaft, with crosscut levels to the veins, which forms the west wall of the lode. The main ore shoot was not then reached. The Barker mine is one of the first discovered in the district, and it is said to have been opened about 1879, but remained unworked for several succeeding years. A number of small mines, and not in great ones like Thunder Mountain are said to show $1.00 to $2.00 of the limestone with eruptive porphyry. In that part of the quadrangle belonging to the Little Belt Range. Gold has been found in limited quantity in small areas of placer gravel, and it is not certain that gold has been found in a number of locations in quartz veins, but of these none have as yet been developed into mines. Quartz veins occurring on the slopes of the ridges, with the exception of the Little Belt Range, are not in great variety and are capable of taking a high polish. The symplectite of Burren furnishes a splendid material of any desired size, but is at present not in great demand.

Clays suitable for brick making abundantly occur in the alluvial areas along the streams of the Little Belt proper, or south of it, and less abundantly in the mountain district.
The Belt Creek field embraces the coal lands on both sides of Belt Creek, extending from the mouth of Cora Creek northward to the confluence of Little Belt Creek, a distance of 7 miles, along which the seam is exposed in the canyon walls on both sides of the Belt Creek Valley. The coal lands belong to a number of owners, and are worked at nearly a dozen different points, but by far the largest production is from the mines of the Anaconda Mining Company, at Belt.

The coal of the field was first mined in 1877, when a few tons were shipped to Fort Benton. Since that time a few hundred tons a year have been mined. The product was 1900 tons in 1886, 600 tons in 1888, and 2000 tons from the various mines in 1888, but the opening of the mines at Sand Coulee, with railroad transportation, closed the market temporarily to the Belt Creek mines.

In the autumn of 1895, Mr. P. J. Shields leased a large tract on the west side of the creek. Convinced that the lower part of the seam, consisting of coking coal, would increase in thickness westward, he drove a drift entry and proved the correctness of his surmise. The property was acquired by the Anaconda Mining Company in 1896, and exhaustive tests having proved that the coal, though high in ash, could be washed and used as a roof. For 700 feet from the face of the bluff the entry driven through the level showed a bony, impure fuel, but beyond this the lower part of the seam showed 5 to 8 inches of coking coal, having a persistent 4-inch to 10-inch parting about one-third of the distance from the floor. The roof (which is really the middle seam parting) occasionally rolls, and for a few yards pinches up or even cuts off the coal. Sometimes the roof sends an outcrop into the coal forming a 4-inch to 12-inch parting.

The coal as mined runs about 20 to 30 per cent slack. The run of the mine averages 10 per cent of ash by analysis, but this is reduced to 7 per cent in the slack, by washing before it is coked.

Belt Creek coal is found in the open upland country lying north of the Little Belt Range. Openings from which coal has been mined are found at the forks of Otter Creek, Front Creek, Skull Butte, and Sage Creek. The Otter Creek seam is about 4 feet thick, but so far as exposed is too impure for shipment. The Front Creek openings show the usual separation of the bed into two seams, with 5 feet of shale between. Only the lower seam has been opened, showing 25 feet of good fuel in a total thickness of 33 to 4 feet. The beds dip 5° N., and are capped by a heavy bed of sand rock whose upper surface forms the bench land. At Skull Creek the coal seam is warped about the flanks of this dome-shaped hill and nearly encircles it. It has been prospected at several places, and is mined at the point where Skull Creek cuts through the coal measures. Both the upper and lower seams have been worked, the lower one showing the section illustrated on the Columnar Section sheet. The coal at this mine is flaky, and shows the effects of the uplift of the hill. The dip of the seam being 15° N.

The Sage Creek mines are situated on Spring Coulee, a fork of Sage Creek. The bed dips 5° N., and is covered by the heavy sandstones which form the surface of the surrounding bench land. The seam shows two benches found elsewhere, but the lower one alone is worked; it shows 44 feet of clean coal, dull with bright streakings, carrying occasional balls of pyrite. A section of the bench worked is shown in the Columnar Section sheet.

Near Woodhurst, on Running Wolf Creek, the seam shows 16 inches of coal.

The analyses below represent samples taken by the writer, not to show the average composition of the coal or the run of the mine, but to ascertain the variation in composition in different parts of the same seam at the same locality, and the variation at different localities. The analyses will be found, however, to give a very close approximation to the general composition of the coal from which the samples were taken.

Lignite.—Lignite beds are found at the head of Shookin Creek in the Highwood Mountains, as outcrops in the walls of the Shookin Bag, and are seen in the bluffs of the Missouri River near Eagle Creek. These lignites are inferior to coal in heating power, but being found in a treeless region they may prove valuable for local use as household fuel.

WALTER HARVEY WEED,
Geologist.

December, 1899.

| Analyses of coal from Belt Creek field, Sage Creek, and Skull Butte. |
|---|---|---|---|---|---|
| Locality | Name | Sampled | ash | Coke | Coke | Remarks |
| South tunnel, Armington's mine, west side of creek, Armington. | 1.08 | 36.95 | 49.15 | White | Poor | |
| Millard, top coal, belt, east side of creek. | 5.50 | 60.55 | 61.81 | Good | Good | Shanty, abandoned coal. |
| Millard, middle bench. | 3.75 | 45.00 | 66.59 | White | Good | A dull coal. |
| Millard, lower bench. | 5.08 | 61.45 | 66.47 | Good | Good | Blacksmith coal. |
| Wicton mine, east side of creek. | 4.99 | 61.35 | 63.35 | Good | Good | Poor. |
| Sage Creek. | 4.54 | 62.96 | 55.81 | Good | Good | Poor and middling. |
| Skull Creek mine. | 8.42 | 80.96 | 67.95 | White | Poor | L. H. Hamilton, owner. |
| Selected samples, Anaconda mine, belt. | 8.09 | 43.51 | 52.21 | White | Poor | Good | |

Fort Benton—7.

The Belt Creek field embraces the coal lands on both sides of Belt Creek, extending from the mouth of Cora Creek northward to the confluence of Little Belt Creek, a distance of 7 miles, along which the seam is exposed in the canyon walls on both sides of the Belt Creek Valley. The coal lands belong to a number of owners, and are worked at nearly a dozen different points, but by far the largest production is from the mines of the Anaconda Mining Company, at Belt.

The coal of the field was first mined in 1877, when a few tons were shipped to Fort Benton. Since that time a few hundred tons a year have been mined. The product was 1900 tons in 1886, 600 tons in 1888, and 2000 tons from the various mines in 1888, but the opening of the mines at Sand Coulee, with railroad transportation, closed the market temporarily to the Belt Creek mines.

In the autumn of 1895, Mr. P. J. Shields leased a large tract on the west side of the creek. Convinced that the lower part of the seam, consisting of coking coal, would increase in thickness westward, he drove a drift entry and proved the correctness of his surmise. The property was acquired by the Anaconda Mining Company in 1896, and exhaustive tests having proved that the coal, though high in ash, could be washed and used as a roof. For 700 feet from the face of the bluff the entry driven through the level showed a bony, impure fuel, but beyond this the lower part of the seam showed 5 to 8 inches of coking coal, having a persistent 4-inch to 10-inch parting about one-third of the distance from the floor. The roof (which is really the middle seam parting) occasionally rolls, and for a few yards pinches up or even cuts off the coal. Sometimes the roof sends an outcrop into the coal forming a 4-inch to 12-inch parting.

The coal as mined runs about 20 to 30 per cent slack. The run of the mine averages 10 per cent of ash by analysis, but this is reduced to 7 per cent in the slack, by washing before it is coked.

Belt Creek coal is found in the open upland country lying north of the Little Belt Range. Openings from which coal has been mined are found at the forks of Otter Creek, Front Creek, Skull Butte, and Sage Creek. The Otter Creek seam is about 4 feet thick, but so far as exposed is too impure for shipment. The Front Creek openings show the usual separation of the bed into two seams, with 5 feet of shale between. Only the lower seam has been opened, showing 25 feet of good fuel in a total thickness of 33 to 4 feet. The beds dip 5° N., and are capped by a heavy bed of sand rock whose upper surface forms the bench land. At Skull Creek the coal seam is warped about the flanks of this dome-shaped hill and nearly encircles it. It has been prospected at several places, and is mined at the point where Skull Creek cuts through the coal measures. Both the upper and lower seams have been worked, the lower one showing the section illustrated on the Columnar Section sheet. The coal at this mine is flaky, and shows the effects of the uplift of the hill. The dip of the seam being 15° N.

The Sage Creek mines are situated on Spring Coulee, a fork of Sage Creek. The bed dips 5° N., and is covered by the heavy sandstones which form the surface of the surrounding bench land. The seam shows two benches found elsewhere, but the lower one alone is worked; it shows 44 feet of clean coal, dull with bright streakings, carrying occasional balls of pyrite. A section of the bench worked is shown in the Columnar Section sheet.

Near Woodhurst, on Running Wolf Creek, the seam shows 16 inches of coal.

The analyses below represent samples taken by the writer, not to show the average composition of the coal or the run of the mine, but to ascertain the variation in composition in different parts of the same seam at the same locality, and the variation at different localities. The analyses will be found, however, to give a very close approximation to the general composition of the coal from which the samples were taken.

Lignite.—Lignite beds are found at the head of Shookin Creek in the Highwood Mountains, as outcrops in the walls of the Shookin Bag, and are seen in the bluffs of the Missouri River near Eagle Creek. These lignites are inferior to coal in heating power, but being found in a treeless region they may prove valuable for local use as household fuel.

WALTER HARVEY WEED,
Geologist.

December, 1899.

| Analyses of coal from Belt Creek field, Sage Creek, and Skull Butte. |
|---|---|---|---|---|---|
| Locality | Name | Sampled | ash | Coke | Coke | Remarks |
| South tunnel, Armington's mine, west side of creek, Armington. | 1.08 | 36.95 | 49.15 | White | Poor | |
| Millard, top coal, belt, east side of creek. | 5.50 | 60.55 | 61.81 | Good | Good | Shanty, abandoned coal. |
| Millard, middle bench. | 3.75 | 45.00 | 66.59 | White | Good | A dull coal. |
| Millard, lower bench. | 5.08 | 61.45 | 66.47 | Good | Good | Blacksmith coal. |
| Wicton mine, east side of creek. | 4.99 | 61.35 | 63.35 | Good | Good | Poor. |
| Sage Creek. | 4.54 | 62.96 | 55.81 | Good | Good | Poor and middling. |
| Skull Creek mine. | 8.42 | 80.96 | 67.95 | White | Poor | L. H. Hamilton, owner. |
| Selected samples, Anaconda mine, belt. | 8.09 | 43.51 | 52.21 | White | Poor | Good | |