DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
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GEOLeCIC ATLAS
OF THE
UNITED STATES
LITTLE BELT MOUNTAINS FOLIO
MONTANA

INDEX MAP

LIST OF SHEETS

WASHINGTON, D.C.
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EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together, in the form of an atlas, the parts of which are called sheets. Each sheet consists of a topographic base map and a geologic map of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) landmarks of surface, called relief, as plains, plateaus, hills, and mountains; (2) distribution of water, called drainage, as streams, lakes, and swamps; and (3) the works of man, called culture, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to facilitate the localization of the various features. Contours and elevations are printed in brown. The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map:

The sketch represents a river valley between two uplands, the one to the left, with a bay in the lee of a headland, while the other is a narrow coast. The left side of the valley is a terrace. From the terrace on the right the hill rises gradually, while from the left it rises in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. In the map each of these features is indicated directly beneath its position in the sketch, by contours and elevations. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates approximately a certain height above sea level. In this illustration the contour interval is 30 feet; therefore the contours are drawn at 30, 60, 90, 120, and so on, above sea level. Along a contour at 200 feet all points of the surface are 200 feet above sea level; and similarly with any other contour. In the space between any two contours are found all elevations above the lower and below the higher contours. Thus the contour at 200 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 200 but less than 230 feet above sea level. In the space above the higher contour the thickness of the bank is stated to be 67 feet above sea level; accordingly the contour at 676 feet surmounts it.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conformably to the surface, they smooth out smoothly over smooth surfaces, recede into all resistant angles of ravines, and project in passing over every surface, even a gentle slope, so that the contours and curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The vertical space between two contours is the same, whether they lie along a cliff or in a sea of sand; on a gentle slope this space is more than 20 feet, on a steep slope less than 20 feet, and therefore contours are far apart on the former and close together on the latter. For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a larger interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Donegal Swamps. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet or more. The smaller contour intervals used are 10, 20, 30, 40, 50, and 100 feet.

Drainage.—Watercourses are indicated by blue lines. The course of the stream from one end of the line to the other is shown by a blue line. Lakes, marshes, and other temporary water areas that can be shown by blue lines, are indicated by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, boundaries, villages, and cities, are indicated by black lines. Details of towns and cities, such as squares, blocks, streets, are shown in black, with appropriate conventional signs.

THE GEOLOGIC MAP.

The map represents'aregion geologic chart or column showing the topographic base map, the distribution of rock formations on the surface of the earth, and the structural features of the earth. The map shows the distribution of rocks and minerals, and the relations of the various types of rocks, as known, in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of igneous rocks. As these rocks have been derived from them in one way or another.

Aigneous rocks generally break up into small angular fragments, or into very fine dust. They are used for building purposes, and on account of their durability, for making asphalt. They are also used for making cement and many other purposes.

Metamorphic rocks are those rocks which have been changed or consolidated from a liquid state. They are usually rock, sediments, or other rocks, according to their composition. A parallel development of rocks is often produced, which may cross the sedimentary rocks of all kinds and ages. Rocks formed by this process are called crystalline rocks. Within these rocks, they are generally of crystalline structure. The phenomena of the surface of the earth, such as rain, snow, wind, and the action of the sea, may cause the rocks to be altered in the field of the rocks, and may cause the rocks to be altered in any direction.

The distribution of rocks is shown on the atlas sheets of the Geological Survey. The map shows the distribution of rocks and minerals, and the relations of the various types of rocks, as known, in such detail as the scale permits.
DESCRIPTION OF THE LITTLE BELT MOUNTAIN QUADRANGLE.

GEOGRAPHY.

Location.—The square degree forming the Little Belt Mountains quadrangle is limited by 110° and 111° of longitude and 46° and 47° of latitude. It includes an area of 13,000 square miles, situated in central Montana, and belonging mainly to Meagher and Fergus counties, with a small part of Chouteau and the northern part of Powell and Sweetgrass counties. The quadrangle lies north of the Yellowstone River and south of the Missouri River and includes part of the western border of the Great Plains and of the eastern Rocky Mountain region.

Drainage.—The drainage belongs to both the Yellowstone and Missouri rivers. Only a small area of the quadrangle is included in the water-shed of the former, while several large streams, whose sources are the springs and snowbanks of the mountains, pour into the Missouri River. These streams are relatively broad and long valleys, whose size and character show them to be of considerable age and to have been formed by the streams now flowing in them. The smaller streams are abundant in the mountainous region, but the larger running with a course of slopes and up the mountain flanks. In summer the stream courses are generally dry where they flow through limpid areas, but carry water where they flow through broad valleys laden with slates or igneous rocks. In the sandstone and shale of the open plains the few streams are also dry much of the time.

Climate.—There is a considerable range of climate, corresponding to the altitudes. Adequate data are lacking. Great Plains prevail in the eastern part and also in the lower valley. The higher bench, benches, and spurs are moist, while the mountains are still more copiously watered, receiving heavy snowfalls and frequent summer showers.

Vegetation.—The vegetation varies with the moisture and climate. The streams are often bordered by thickets of willow, box, and other shrubs; more rarely with groves of cottonwood. The bench lands are grassed, and the higher parts dotted with scattered trees. The mountain slopes are pine-covered, the forests being open, with grassy interspersions, on southern slopes, but dense and thick on northern exposures. The forest growth varies somewhat with the nature of the soil and underlaying rock. It consists mainly of the common lodgepole pine (Pinus contorta); near the timber line there is white pine (P. strobus), and on the wet northern slopes spruce and fir grow. The climate gives rise to short, growing season, and only the harder cereals and vegetables are successfully grown. Agriculture, therefore, is not possible except in the lower valleys, and a large part of the bench land is valuable only for pasture. Agriculture is dependent upon irrigation, for which the streams furnish an abundant and unfailing supply of water.

Geology.—The region is not thickly settled. It includes a number of important towns, but over large areas there are no settlements, and unless mining discoveries are made the mountain area will never support a large population. The nearest market center is White Sulphur Springs, the county seat of Chouteau County; Neihart and Caste. Neihart is an important mining settlement. Great Falls and Fort Benton are market centers.

Martinsdale are small towns supported by the sheep and cattle industry. The branch line of the Great Northern Railway runs from Great Falls to Neihart, giving an outlet to the silver mines of the Little Belt Range and the coal mines of the region. The Missoula and the Pacific Northern lines, with the Northern Pacific line at Lomberk, connect the center of the quadrangle, affording an outlet for the mining centers of Martinsdale and White Sulphur Springs. Stage lines traverse the roads through the main valleys, and the railroad line from Great Falls to White Sulphur Springs to Neihart.

DESCRIPTION OF THE LITTLE BELT MOUNTAIN RANGE.

The northern half of the quadrangle is a mountaintop, which forms part of the northern border of the Rocky Mountain Range. These mountains, from which the quadrangle takes its name, form a broad, elevated tract along the southern border of the Rocky Mountain region. They are mostly sharply limited by the plains on the east, and separated from the much narrower, higher range of the west, by regions of low and broad valley of Smith River.

The range extends for 60 miles in a general easterly direction from the Missouri River, passing eastward and ending in a point at Judith Gap, about 10 miles beyond the limits of the quadrangle. In the western part of the quadrangle the range is 22 miles wide. It is dissected by the branching head-water streams of Judith River, which have cut deep into the heart of the range on the east, and by Belt Creek and its tributaries on the north. The main divide or backbone of the range is a remnant of a much higher and more widely spread range that is now elevated gradually to a residual mountain range in flat-topped masses carved out simply by stream erosion.

The range is crossed by little streams, which rise from deep breed bench lands, with rarely an oolitchy formation.

DESCRIPTION OF THE ROCKS.

To clearly understand the structure and important geologic features of the quadrangle, it is necessary to have knowledge of the rocks which occur in it, and of which its mountains, valleys, and plains are formed. The distribution of these rocks is such as to show in various patterns and colors the history of the Earth. Rocks of the quadrangle are shown to us by Smith river. The rocks of the quadrangle are shown to us by Smith river. The rocks are grouped according to age and character and it is the formations which bring them to the surface. The oldest, the youngest and the most important of these are noted in the Explanation given on the cover of this folio. The oldest, oldest ancient rocks have been completely shaped by changes of structure and by recrystallization, are here set apart as ancient crystal rocks.

The ancient crystalline rocks are found only in the Little Belt Mountains. Sedimentary rocks occupy the western part of the quadrangle, but are absent on the eastern. The rocks are stiffer, the cays are more extended, the distribution of the various formations are in general, the work of erosion. The rocks are generally horizontal, and the ancient crystalline rocks are divided into three sets of rocks characterized by their peculiar structure, which are noted in the explanation given on the cover of this folio. The oldest, oldest ancient rocks have been completely shaped by changes of structure and by recrystallization, are here set apart as ancient crystal rocks.
The Flathedhe quartzite forms the base of the
Paleozoic series recognized in this region. The
characteristics of this rock, especially its grind
and variegated color, distinguish it from the
silurian sandstone, which is a compact rock
varying from white to yellow or red, and is
usually massive and well-bedded, and may be con-
glomerate at the base. It is a beach deposit,
spread over the surface of a level Aroldian land
by an advancing sea. The gently sloping plain of
New Hampshire is filled with this sandstone. The
basal quartzite passes gradually into gray shale,
the rocks containing an increasingly larger amount
of argillaceous matter, both as an impurity in the
quartzite and as interbedded beds of gray shale,
which is the base of the slate. A considerable thick-
ness of sandstone is capped in turn by transition beds of
shiny shale, followed by a well-defined limestone series.
This, in turn, gives place to a great thickness of limestone
bedded in a stratum of calcareous shale, known as
shales, which is the base of the formation. The
division is, however, based entirely upon litho-

genic grounds, although the term presents an
idea of an example of two formations, and the

The Flathedhe quartzite shows above the
quartzite. It consists of micaceous shale and contains
small limestone conglomerates near the base and inter-
bedded calcareous shale higher up in the series.
The Braughler limestone overlies the shale. It is a
thin-bedded limestone, often formed mainly of flat
shingle pebbles. The rocks carry fossiliferous
principal tributaries and Hyladids in a series of
middle Cambrian forms. The overlying Park
series includes the Jeffersonian limestone of
Quadrangle, which contains thin, dark, and
Pilgrim limestones, which are well bedded and
contain shaly layers, overlie the Park shales.
The shales are dense, gray, and may contain
white glauconite remnants, and frequently fossil
on the surface. The layers are often

The two upper formations are not found in the
Little Belt Range, but occur on the flanks of the
Big Belt Range in a continuation of the formation
to the west and south. Fossils found in the
strata overlying the Newhion limestones of the
middle portion of the Belt formation represent
the surface series of life yet known.

The Belt formation is found only in the
northwestern part of the quadrangle, where it forms
large areas of open country, and is especially
 noticed in the Seven sisters, a group of seven
limestones whose characteristics are persistent over
large areas, rendering the recognition of hori-

The Cambrian rocks constitute readily recog-
nizable formations in the quadrangle. They
include a considerable variety of quartzites, sand-

The rocks are readily shatterred and, therefore,
are easily injected with shales and clints. They
are often cut by small veins of copper ore.

The Cambrian rocks consist of gently rounded
shale and limestone, which are blue and green in

The Blackford formation.—This formation consists of several distinctive districts, of which the
Flathedhe formation of adjacent quadrangles.
The two upper include the beds comprised in the
flint bed. These rocks have been highly bedded
separated as distinct formations in other regions,
in which they were formerly supposed to show
different facies at corresponding levels. It is
found that the various districts of the Cambrian
are grouped together as one formation whose parts
are herein distinguished as a separate.

The Mammalian limestone.—This formation consists
entirely of the limestone beds which constitute
the great limestone series of the Rocky Mountain
region of Montana. The formation is readily
distinguished from that below by its litho-

graphic characters as well as by its fossil forms.

About the mountain flanks the older formations are
superimposed on the outcrops where the schistose
clay is exposed. The surface of the older
formations and the siliceous limestone of the
mountain flanks are divided by smaller secondary
carries on the flanks of the older formations and the
beds of the Woodbine limestone, which form
yellow clay exposures in some parts of the
region. The beds of the Woodbine limestone
are separated by very thin argillaceous layers,
and the limestones often carry much dark
shale, which is the base of the formation. Fine
limestones are seen throughout the Little Belt
Range and at Castle Mountain. It is a very
resistant rock, and the surface is protected by
its red and green colors. The Scenic Scoriae localities
are the only fossil evidences seen in this rock.
The limestones above the shale are about 215 feet
high. The Oak Creek limestone is a slaty
form of the stromatolitic limestone, which
consists of micaceous shale and contains small
limestone conglomerates near the base and inter-
bedded calcareous shales higher up in the series.
The Shale overlies the Shales, shale, which is the base of
formations. The series of beds, 250 feet thick.
The upper layers are rich in fossils. The lower layers
are rich in argillaceous and calcareous shales,
with occasional intercalated beds of limestone. The
formation is about 600 feet thick and is

The reddish argillaceous or argenticous beds of
the Dry Creek shale, usually about 40 feet thick,
are seen in many parts of the quadrangle and
type the uppermost member of the Barberry
formation. The rocks are of gray or mottled
shale, which are well bedded and contain shaly layers.
The limestones of the mid-Cambrian forms. The
overlying Park series includes the Jeffersonian
limestone of the middle Cambrian forms.

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black or dark-colored carnosaceous or bituminous shales. The outcrops form an irregular belt following the sandstone of the Dakota zone, from which the granite intrudes. It is a diorite porphyry.

The Pierre shales are brown-gray and often sandy, and resemble the overlying Fox Hills sandstones, from which they sometimes differ little in being softer and darker. The beds carry numerous fossil shells and fragments of limestone and sandstone and contain alcoholic salts and gypsum.

The Fox Hills sandstones are quite earthy and impure in this region. The rocks are usually thin bedded, and frequently weather in long lines of shale resembling the blue-gray or black shales not readily distinguished from the underlying shales.

Linhurst formation.—This formation consists of light-colored, cross-bedded, compact but not hard sandstones with interbedded clay and sandstones with interbedded coal seams and also generally interbedded seams of coal.

The upper beds are sometimes characterized by concretions resembling cannon balls. The strata are readily distinguished from the underlying shales beneath and the dark-brown beds of the Livingston above. Good exposures occur in that part of the quadrangle which is included in the northeast of the region.

This formation is a variety of sandstone and is a deposit of the period of erosion of the Ancestral Rocky Mountains.

Livingston formation.—This formation consists of a thick series of sandstones, conglomerates, and sandstones with interbeds of volcanic agglomerates and breccia near the base. The rocks rest upon the white sandstones of the Lar- nigan formation above, and the lower beds of volcanic material. Plant remains have been found in the rocks overlying the coal beds, and freshwater shells are common in the sandstones, which are about 1000 feet thick, estimated from the toposequence of the Yellowstone to the base of the Liv- ingston formation.

Linhurst formation.—This formation consists of a great thickness of conglomerates, sandstones, and sandstones with interbeds of volcanic agglomerates and breccia near the base. The rocks rest upon the white sandstones of the Lar- nigan formation above, and the lower beds of volcanic material. Plant remains have been found in the rocks overlying the coal beds, and freshwater shells are common in the sandstones, which are about 1000 feet thick, estimated from the toposequence of the Yellowstone to the base of the Liv- ingston formation.

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Rocky Mountain lake beds.—The beds composing this formation are composed of sandstones and loosely conglomerated conglomerates, together with beds of marl and volcanic dust. The beds were deposited in a geochemical basin which was the valley of the Smith River, between the Little Belt and Big Belt ranges. The strata are not conformable with those of any underlying formation, but rest on the eroded surfaces of other older rocks. The fine-grained beds are composed of volcanic dust, the product of ash showers from the old Cascade Mountain volcanoes. The conglomerates are of local occurrence, forming small lenses here and there in the sandstones.

The rocks are mostly light gray, occasionally colored, or white, and exposures of the livingston are first seen, and rainfalls are usually accompanied by cloud cover, which is also broad and extensive. The rocks are everywhere exposed, and the character of the valley is marked by a broad valley, the sides of which are steep, and the floor of which is flat.

BIRD 

Glacial drift.—In the quadrangle there are several areas of glacial drift which either covers the underlying rocks or constitutes the chief mate- rial seen. This drift is of all local origin, and consists of the rocks brought down by local ice sheets from neighboring ridges. In most cases it consists of erratic blocks and the typical drift material, characteristic of terminal moraines, and it is not accompanied by any other form of glacial drift features. Numerous areas of drift are seen upon the map, for to do so would obscure the more important geological of the other formations, namely, the paleozoic formations and the clay subsoil. The limestone concretions are dense and flintlike, with occasional bands of calcite and sandstone, and contain mud and other fossils. Beds of impure, soft limestone, some of which are considered to be of the same age as the sandstones, are also found.

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The igneous rocks of Eocene age are all found in or about the Crazy Mountains. They vary greatly in character and appearance, but are all composed of volcanic minerals, with characteristics of structure and chemical and mineral composition believed to be due to their having been formed from the same source of supply, but representing varied phases of the differentiation of a single magma. They are rich in alkali and calcic. The Eocene age is known from the fact that they have cut sedimentary rocks containing post-Cretaceous plant remains and fleshy logs, and are therefore older than Neocomian rocks. The igneous rocks are all intrusive, save surface formations having been found.

**Lozier dike.**—This name has been given to the granular rock forming the stocks or central cores of the Crazy Mountains. The rock varies somewhat in composition, the prevailing form being a typical diorite grading into quartz-diorite and even into granite. It varies in texture from a fine-grained to a coarse-grained one, in color from dark brown to very light color, and in hardness from the ninth to the third on Mohs scale. It forms a large part of the Crazy Mountains, as well as the mountains just north and west of them, and as small dikes cutting the Lozier diorite. It is apparently the aplite phase of the diorite.

**Aenigmatopirome.**—This is the common rock of the dikes and sheets which intrude the southern part of the two Crazy Mountains, as well as the mountains north of them, and as small dikes cutting the Lozier diorite. It is apparently the diabase phase of the diorite.

**Dike and sheet rocks.**—These rocks are shown upon the map in two colors, one for an acid and the other for a basic group. There are included under this heading a large number of intrusive rocks, each consisting of various types of minerals, but not the beds, because of the various kinds of rocks, and the fact that it rests directly upon the Lozier dike.

**Crazy Mountain granite.**—This rock is a light-colored, coarse-grained hornblende-granite. It is lighter in color than the Lozier diorite, and is also more massive and less porphyritic, becoming diorite-granophyre in which the white and black minerals are equally distributed. It is less porphyritic, being coarser-grained and more massive than the Lozier diorite, and as small dikes cutting the Lozier diorite. It is apparently the diabase phase of the diorite.
of rhyolite rocks, the second of basalt. The rhyolite flows now seen are but small remnants of those which poured over the floor of the basaltic flows and fragmental breccias. The rhyolite is the extrusive equivalent of the granite. It occurs in small masses and is always associated with the rhyolitic rocks and fragmental breccias. Being soft and easily weathered, it has been largely removed. Excellent exposures occur above the canyon of Checkerbloom Creek, and in the upper canyon of White Sulphur Creek. Basalt beds are covered by flows of basalt. Examples of such basalt flows, remnants preserved in pockets, are still to be seen 20 miles to the south. Basalt flows of the second and third formations have been greatly deformed, or perhaps entirely carried away, and it is often impossible to determine the exact nature of the material that has been extruded or has been laid down in water. The lake beds occur and below White Sulphur Creek consist largely of this very material, carried by streams and into the lake that once filled the Smith River valley. They are of a cream or pale yellow color, crumby, and somewhat resemble clay in character. Under the microscope they are found to consist chiefly of tiny fragments of glass.

GENERAL GEOLOGY.

DISCLOSIVE GEOLOGY OF THE LITTLE BELL MOUNTAINS.

The Little Bell Mountains are formed of soft sedimentary rocks and igneous rocks. Only the older formations of the sedimentary series are represented. These rocks are folded into a broad anticline whose upfolds formed the range and the downfolds formed the troughs. The alluvial fan and the alluvial valley floor are found to be part of the alluvial cone in the latter. It also contains great quantities of shale fragments and other sedimentary rocks picked up in its course. It is a good example of a flow breccia.

Basalt—Two lava flows of basalt are found at the northern base of Castle Mountain, covering the western slope of the mountain 400 feet above the lake valley floor on a small cone. It is a good example of a flow breccia. The lavas have been intruded into the sediments of the region and are now part of the sedimentary breccias. The lavas are composed of basaltic material, containing small amounts of andesitic material. The lavas are rich in plagioclase and pyroxene, and contain small amounts of olivine.

The lava flows of basalt are found in the western part of the mountains. A small mass occurs near the north-eastern corner of the mountains. The lavas occur on the south-western part of the mountains, where the basalt forms a bench. Recent erosion has deepened the valley.

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rocks weather less rapidly than the littoralisodents and shells remote from the central core.

Where igneous rocks occur on the outer slopes of the mountains, they generally cap flat-topped hills or steeply inclined land. The debris of these rocks rests somewhat more than the central slopes are. The mountains are covered with such a thin mantle of sand and gravel that the sea cannot reach the shore for a few feet from the line of contact.

Surrounding the central core of massive rocks there is a wide belt of altered sediments and intrusions of the contact zone. It is the most resistant rock of the mountains, and it is the main body of the igneous rock being formed by a succession of sharp peaks constituting the highest part of the mountains.

Like the sheet rocks, the dikes are conspicuous features of the slopes of the mountains. They are composed of a multitude of dikes, which form prominent heads, and may be traced for long distances. These dikes are shown on the map, and they are shown clearly on the map.

The most striking feature of these southern peaks is the presence of a number of sharp, but little minor peaks of the rock. The rock is shown on the map.

The injection of the large mass of igneous rock forming the core into the great thickness of the mountain, and the resulting gravels, sandstones, and shales of different ages, Shasta Range, the eastern limit of the mountains. This is the core of the Shasta Range, the head of the mountains, and the highest peak in the mountains, and the highest peak is shown on the map.

The core of the mountains consists of a number of coarse-grained rocks of the contact zone, with the exception of Lassen Peak, which is only a small part of the contact zone. The granite rocks are shown on the map.

No sharp peaks are shown on the map. It is shown on the map.

The core is shown on the map as the head of the mountains, and the highest peak is shown on the map.

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Mountain show that the mountain folding took place at a later date. Only the earlier beds of the Yellowstone formation are of fresh-water origin, and the region, the Laramie was the bulk of its sediments being of marine formation and characterized by varved marls. On the higher beds of the ocean floor followed; the sands and shales of the Laramie were formed in shallow estuaries of the Laramie. The coal beds draining into fresh-water marshes.

Post-Oreous uplift and mountain building. — The uplift of the region began at an irregular shape of the extremely variable size, ranging from a few hundred feet to several hundred feet across. These deposits are commonly overlain by a very thin layer of limestones or sandstones forming great licks that filled all the large bordered valleys between the mountain ranges.

Mineral resources. — The mineral resources of the region are of great extent, and built upon mountain masses upon the newly formed land. The southern half of the range was at this post-Laramie time covered by water, and it was either an estuary or a lagoon. Water formed the coastal plains and valleys. Volcanic outcrops took place upon a grand scale and continued at various intervals throughout the succeeding epochs. This era of volcanic activity is, so far as known, the first in the history of this region; it was of great extent, and built up the land masses upon which the newly formed land rested. The southern half of the range was at this post-Laramie time covered by water, and it was either a sea or a lagoon. During the eruption of the Laramie, the southern half of the range was covered by water, and it was either an estuary or a lagoon. The waves of the newly formed land extended and further extended into the water. In this way a great thickness of bedded rocks (carbonates) were formed. These were largely of volcanic material mixed with a large proportion of sand and gravel, the waste from the erosion of the Laramie. These rocks were deposited on the slowly sinking sea bottom, and conglomerates found in the Crazy Mountains were formed at this time. The presence of coal and other sedimentary rocks shows that there was a period of coal mining in the region. Coal is found in several parts of the region, with little evidence of the coal being mined in the present century. No evidence of coal mining is found in the Little Belt Range.

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Coal. — The occurrence of the coal-bear and sandstone formations are indicated upon the Economic Geology sheet by dark colors. By the use of this map, the economic region extends from the Crazy Mountains, through the Little Belt Mountains, to the Judith River, and includes the area of the Little Belt Mountains. The coal, however, is not found in the Little Belt Mountains. The deposits of coal in the Little Belt Mountains are of the same age as the coal deposits in the Crazy Mountains, but they are not as extensive. The coal is generally black, with a high percentage of ash, and is suitable for coking purposes. The coal is of the best quality and is suitable for coking purposes. The coal is generally black, with a high percentage of ash, and is suitable for coking purposes. The coal is generally black, with a high percentage of ash, and is suitable for coking purposes.

The Silver deposits of the Quadrate are of the same age as the coal deposits, and they extend from the Crazy Mountains into the Judith River. There are several large deposits of silver ore in the Judith River district. The deposits of silver ore are located in the Judith River district, and are of the same age as the coal deposits. The deposits of silver ore are located in the Judith River district, and are of the same age as the coal deposits.
The silver veins of the Nels Hart district are the most important ore deposit of the quadrangle. Many of the ore deposit, especially the quartz veins, did not become important producers until railroad communication was established, ten years later. The ores vary considerably in form and composition. Some consist of nearly solid veins, others of a network of fine, radiating, and irregularly shaped particles of various sizes. The ore consists of metallic silver, gold, lead, zinc, antimony, and iron. The ore is usually found in the form of thin plates, flakes, or crystals, and in some cases as filaments. The veins are often accompanied by quartz, which is the cementing material in the veins. The silver content of the ore is usually less than 10%. The veins are usually found in the form of thin, platy sheets, and are often associated with other minerals such as galena, sphalerite, and pyrite. The veins are often accompanied by quartz, which is the cementing material in the veins. The silver content of the ore is usually less than 10%. The veins are usually found in the form of thin, platy sheets, and are often associated with other minerals such as galena, sphalerite, and pyrite. The veins are often accompanied by quartz, which is the cementing material in the veins. The silver content of the ore is usually less than 10%. The veins are usually found in the form of thin, platy sheets, and are often associated with other minerals such as galena, sphalerite, and pyrite. The veins are often accompanied by quartz, which is the cementing material in the veins. The silver content of the ore is usually less than 10%.
treatment of rheumatism and certain other diseases, and especially the mud baths that could be easily given here, should attract more attention than is now given to the locality.

**COVER ORE.**

These ore are found at several localities in the quadrangle. They occur in well-defined fissure veins cutting the argillaceous shales and slates of the Belt formation. The veins are all narrow, show evidence of faulting, and are filled with fragments of shale cemented by quartz and calcite spattered with copper sulphides, altered to carbonates and oxides near the surface. The areas are rich, but were not sufficiently developed to afford data upon which one might form an opinion as to their size or mode of formation. The claims at Copperopolis, north of Castle Mountain, are the best known, having been discovered in 1867, when a few tons of ore were sacked and shipped. The deposits are certainly worthy of serious attention and a more careful exploration than has yet been made.

The prospects on Sixteenmile Creek, close to the railroad, are similar in character, but less promising as far as developed. Other prospects are found on the slopes above Spring Creek, on the south side of the Little Belt Mountains, on Richmond Creek, and near Comb Butte on lower Sleep Creek.

**GERM.**

**Sapphire.**—The Yogo sapphire mines are the most important gem mines of Montana, not of the entire country. The stones occur in a true dike of igneous rock cutting through nearly horizontal beds of massive white limestone. The locality is about 15 miles from Ulzic, in the mountain valley of the Judith River, between that stream and its northern fork, Yogo Creek. The area is a rolling bench land, in which the bare white limestone surfaces are seen, with grassy hollows intervening.

Yogo Creek has cut a canyon through the bench land, and the gem-bearing dike can be traced continuously from the canyon walls across the level bottomlands of the Judith River, a distance of nearly 4 miles. The limestones are the uppermost beds of the Missoula group; they form the limestone series on the top of the mountain, and are 1800 feet thick. The beds are very gently inclined to the east where cut by the dike, but elsewhere in the immediate neighborhood show small wrinklings and folding; they are the minor crumplings of the broad basin or trough inclined on three sides by the abruptly arched beds in the neighboring summits. The red earths and sandstones that overlie the massive limestones are seen along the eastern course of the dike.

The dike rock is nowhere seen actually cutting across the surface, but the course of the fissure can be traced by a grayer depression in the bare limestone surfaces, which is dotted with badger and gopher hopings. One of the hopings yielded several hundred carats of gems and was the direct cause of the discovery of the dike. The direction of the dike varies slightly from a straight line, but the average course is 85° W. magnetic. It is from 8 to 15 feet wide. A parallel dike of nearly similar rock has been found 600 feet to the north, but the rock is not gem-bearing. The workings consist of open cuts and a shaft that was 50 feet deep in September, 1897. The cut shows that the dike walls are nearly vertical, and expose the rough ends of the limestone beds, which seem to be the same on both sides of the fissure.

The upper part of the dike has been decomposed by atmospheric weathering and changed for a depth of 10 to 20 feet below the surface to a yellowish-colored, soft, flaky, earthy material. This contains frequent bowlders or angular fragments of limestones, evidently torn from the fissure walls, which are more or less altered but are generally hard and firm. In many places the upper part of the dike is seen to consist of a breccia composed largely of such limestone fragments held in a cement of altered dike rock. This is especially marked where the dike fissure pitches out and abruptly, as it is seen in the limestone forming the walls of Yogo Canyon. It is evident that the dike did not reach the surface and overflow as a lava stream at the time of its formation.

The weathered sapphire-bearing material is a dense, gray-green rock that might be designated a mica-trap. Bowlders of it are found in the weathered matter, and it forms the solid material of the dike in the shaft at a depth of 30 feet. The rock is fissured and checked with a coarse network of caliche films, and shows a pipe or vein of blue clay running irregularly through it. The gneiss occurs in this rock and the blue clay in the earthy material derived from them, but are not found in the limestone fragments or in clays derived from them.

This unaltered dike rock is of undoubted igneous origin. It is of dense texture and glistens with innumerable minute specks of mica. Small tablets of brown mica are the only visible crystals, but white and pale-green inclusions are very abundant. These inclusions are angular, of various shapes, and of all sizes up to 3 inches across. They consist of white calcite, vitreous quartz, and green pyroxene, and undoubtedly represent altered fragments of the sedimentary rocks carried up in the molten mass at the time the dike was formed. Studied in thin section under the microscope, the rock is seen to consist of biotite-mica and pyroxene of diopside habit. Both minerals rarely show crystal outlines, but are mostly in irregular grains closely crowded together. No foliation is seen. The rock is, therefore, a lamprophyre, but is unlike any rock yet named, though it closely resembles a nepheline.

The sapphire are embedded in this trap rock and the blue clay or earthy decomposition products derived from it. The stones are mostly small transparent masses which commonly show distinct crystal forms. Their surface is always pitted or corroded, and sometimes coated with a thin blackish crust. In the unaltered rock and blue clay the crystals are uncommon, but in the weathered material the stones are often fractured, and broken into fragments of washing. The common form of crystals is a thin flake with polygonal, generally serrated, outline. The top and bottom surfaces usually show a triangle raised above the surface. Stones rhombohedral forms occur more rarely and constitute the most valuable stones. The crystals are usually small, and stones cutting over a crust in weight are not common. The largest cut stone seen weighed 10 carats. The Yogo sapphires derive their greatest value from their rich blue color. Some of the crystals show dichroism, being green by transmitted light and red by reflected light. Careful search of the washed material failed to show the presence of any mineral but pyrite and sapphire.

This material in the rilles is collected each day and carefully passed by hand. The concentrates thus obtained consist of irregular grains of pyrite and the sapphire crystals, the latter being then picked out by hand. As the dike is sapphire bearing for its entire length, there is a very large amount of the soft, decomposed material available for washing.

WALTER HARVEY WEED,
Geologist.

May, 1898.
forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in uplands and those which flowed down to the seashore are armored ridges and mounds of sand and gravel, known as scarps or eskers, and kame. The material deposited in the sea, forming a plateau, stands out the different patterns representing formations. Each formation is further divided into a letter symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the period to which the formation is supposed to belong, the letter symbol of the period being omitted. The number and extent of surficial formations of the Pleistocene make them very important to determine the relative ages of the beds from their positions; thin fossils, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, fossils, it has been found that the epochs of each period of the earth's history have a characteristic type of fossils that differ from those characteristic of the periods of other periods. These characteristic fossil assemblages are called faunas and floras. Each assemblage is usually associated with one or more of the pliocene and are distinguished from one another by different patterns. The previous and present day climate have very different effects on the vegetation, and the rocks themselves have been moved about by glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual to class as surficial rocks those which are raised all at one time, but from ages to ages in the earth's history. Classification by age is independent of order, igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the thickness of a formation a unit, and such a unit is a unit of geologic mapping. Several formations considered together are designated a system. The time taken for the deposition of a formation is called a epoch, and the time taken for that of a system, some larger fraction of a period, a system, and the rocks mapped by formation are further classified into systems. The rocks composing a system and the time taken for their deposition is given by the number of years, for instance, Cambrian, Cenozoic system, Cenozoic period.

As sedimentary deposits or strata accumulate the oldest rock with the greatest age at the bottom and the relative ages of the deposits may be observed by observing their relative positions. This relationship holds exactly if the region of internal disturbance; sometimes in such regions the disturbance of the beds has been so great that their position is reversed and it is often difficult to identify original horizontal strata and determine the relative ages of the beds from their positions; thin fossils, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

In the Pleistocene, the Archean, and the Cenozoic, are distinguished from one another by different patterns. The previous and present day climate have very different effects on the vegetation, and the rocks themselves have been moved about by glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual to class as surficial rocks those which are raised all at one time, but from ages to ages in the earth's history. Classification by age is independent of order, igneous, sedimentary, and surficial rocks may be of the same age. When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the thickness of a formation a unit, and such a unit is a unit of geologic mapping. Several formations considered together are designated a system. The time taken for the deposition of a formation is called a epoch, and the time taken for that of a system, some larger fraction of a period, a system, and the rocks mapped by formation are further classified into systems. The rocks composing a system and the time taken for their deposition is given by the number of years, for instance, Cambrian, Cenozoic system, Cenozoic period.

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