GEOGRAPHY AND TOPOGRAPHY.

The area of country covered by the Livingston sheet is the Snowy and Gallatin ranges, Bridge and Snowy, extraverted from Montana.

The principal topographical and geological features of the Livingston sheet are the Snowy range, Gallatin range, Bridger range, Crazy mountains, and Yellowstone valley.

The Yellowstone river is the main drainage channel for this region, receiving all the waters except a few small streams on the west side of the Gallatin and Bridger ranges. It has its source in Yellowstone lake on the Park plateau. Flowing northward along the Grand canyon of the Yellowstone, it is crossed by the northern side of the Snowy range, leaves the Park near the boundary of Montana. Thence north to Livingston it flows through a broad valley with the northernmost of the Snowy ranges of bold aspect. This valley widens to three miles and is over 50 miles long. Just before reaching Livingston the river traverses a narrow gorge cut through uplifted sedimentary rocks, extending in excellent section across the Paleozoic strata.

The Crazy mountains, making a sharp appearance on the southern slope of the Snowy range, is the eastern end of the great plains of the Missouri river. The Yellowstone valley sharply divides the Gal­latin and Crazy mountains and the Snowy range.

The Snowy range occupies a third of the area represented on the map and is bordered by the Yellowstone river in the east. The central part of these mountains is characterized by high plateaus and table-topped ridges, which differ greatly in origin as they do in materials. To the west of the plateaus of granite which is drained by the Boulder river and its tributaries appears to have been placed to the level of an ancestral sea. The eastern part of the Snowy range is cut through at lower levels than the western part and is characterized by high plateaus and table-topped ridges, which differ greatly in origin as they do in materials. To the west of the plateaus of granite which is drained by the Boulder river and its tributaries appears to have been placed to the level of an ancestral sea.

The flat tops of the volcanic ridges to the south of the granite plateaus are formed by nearly horizontal beds of lava. Along the west side of the Yellowstone valley the Gallatin range trends north and south with peaks and crags rising high above the river. The greater part of the range lies west of the meridian of 111° outside the limits of the map. Beyond the Gallatin range, the Bridge range stretches northward for a long distance, and its western spurs also extend across the map limits. The western side of the range rises gradually from the parallel of 1440 feet elevation between that state and Wyoming. It includes portions of Gallatin and Park counties, and derives its name from Livingston, the mountain town within its limits. It is an elevated region, wholly west of the map, is lost beneath lavas. The small area of Cretaceous rocks south of this fault represents the other limb of the synclinal fold.

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In the northern half of the Livingston sheet the folding of the Paleozoic rocks presents several features of interest. Along the northern flanks of the Snowy range the Paleozoic beds, instead of being thrown southward in the great accumulation of Mesozoic sediments, which rest on the Livingston beds, are crumpled in the great Livingston fold. This feature is of frequent interest, but with the exception of the broad fault which is shown, it is entirely concealed by more recent deposits.

The Bridger and Gallatin ranges are closely connected. East of the northern limb of 111°, the latter range trends northward, while the former shows the whole of the Great Basin. The northern part of the range, northward from the Yellowstone, is cut by faulting, which brings the Mesozoic strata against the Precambrian gneiss in a series of parallel folds, and between the faults and above the upthrust, great volumes of Mesozoic rocks are cut off. The general upthrust of the northern limb of 111°. The great Livingston fold, with its northern limb of 111°, is entirely concealed by more recent deposits.

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DISTRIBUTION OF VOLCANIC ROCKS.

The most extensive areas of volcanic rocks are found in the southern half of the region. Here they consist of tuffs and breccias with lava flows. Volcanic centers of eruption may be recognized in at least five localities by the arrangement of dikes that radiate from various points or near ancient craters. This is the case at Electric peak, Emigrant gulf, Haystack peak, the head of Deer creek and the Crazy mountains, and the mouth of the Gallatin. These areas have been designated the front ranges of the Rocky mountains.

The Algonkian rocks sank and were deeply buried under a great thickness of Paleozoic and Mesozoic strata. They were, however, exposed by the folding and upthrusting of the Mesozoic beds. The Algonkian rocks include a very large number of localities large masses of igneous rocks are erupted, modifying still more the earlier consolidated basalt and andesite. The great body of basement rocks and their outcrops were laid down in relatively deep waters. Some of the coarser of these basaltic rocks consist of large basaltic boulders, while portions of the finer material were deposited farther from land.

Along the west side of the Yellowstone valley the Gallatin range trends north and south with peaks and crags rising high above the river. In the valley of the Yellowstone river, the great Livingston fold is lost beneath lavas. The small area of Cretaceous rocks south of this fault represents the other limb of the synclinal fold.

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peaks eastward have left imposing terminal em-
placements to the north of the Madison and in the Bridger range and in the Crazy mountains, local glaciers existing whose moraines of angular debris are among the lesser features of the foothill slopes.

Since the melting of the glaciers the rivers have deposited fine gravel, sand, and silt that now form the valley terraces and fertile flood plains.

DESCRIPTIONS OF THE SEDIMENTARY ROCKS.

Sedimentary rocks cover nearly onethird of the 2,300 square miles of the Livingston sheet, and they embrace a total thickness of 20,000 feet in which all the grand divisions of geologic time since the Archean are represented. The most striking feature of the various strata deposited within this region is the great development of Cretaceous, or to be more exact, the latest Cretaceous strata, of which there is a thickness of 12,000 feet above the Laramie coal measures, while the formations of the Paleozoic age attain a total thickness of 3,500 feet.

The Paleozoic strata, which are in general the mountain-forming rocks of the series, occur upturned at steep angles against the crystalline schists or in sharp anticlines. The thickness of these rocks is not well known, since they are not long recognized in the Rocky mountain region and generally regarded as the base of the Paleozoic system, overlying a layer of unbroken Cambrian age. The Triassic period is represented by a few feet of limestone whose fossils fail to furnish a sufficient criterion for its determination, while the Devonian period is clearly defined by its sediments, though they average but 450 feet in thickness, as the evidence of fossils. The Carboniferous is more completely represented than the other periods. Its massive beds of limestone, averaging 2,000 feet in thickness, form the crest of the Bridger range and the summits of many of the peaks of the Snowys.

The Trias is recognized in the red sandstones of the Cinna mountain, but this is cut northward and cannot be discriminated in the northern part of the sheet. The Jurassic also varies through a wide range of character within this region. The combined thickness of deposits of the Jurassic period is 500 feet.

The rocks of the Cretaceous period consist of more than half the entire thickness of sedimentary strata. At the base of this period the Dakota is a conglomerate known as the Dakota which is a readily recognizable horizon throughout the region. The marine Clastics of this formation, as often elsewhere, is not typical, but is well developed in the middle of the region, the beds alternating rapidly and containing much sandstone.

Nessan rocks are represented by strata deposited in two intermontane lakes which occupied the upper Yellowstone and the Gallatin valleys respectively. Pliocene deposits, though in the southern parts of the area a prominent feature of the present scenery, are not generally important, and the period is marked by many hot springs occurring at four localities, but are important only near Gardiner.

The rocks of the Carboniferous consist of two formations, lithologically distinct, the upper Pennsylvanian and the lower Pennsylvanian. The upper Pennsylvanian consists of thinly laminated, black shales generally covered on the outcrop by soil and vegetation. The outcrops at Chimney rock on the western flanks of the Yellowsnow range show shales differing but little from those of the lower Pennsylvanian in general, while the strata along the northern flank of the Gallatin mountains are much more sandy. Marine fossils are found in the Blackfoot and distinct vegetable remains characterize the beds.

The Devonian rocks consist of two formations, the lower, or Ordovician, is a thin black shaley bed of limestone containing concretions of chert. The upper beds are characterized by abundant concretions resembling canvas balls. The upper beds are readily distinguished by the great reddish-brown sandstones and the dark red beds which grade into very sandy limestones.

The Cretaceous rocks cover the northern third of this sheet, and by far the largest part of the area occupied by sedimentary beds. The highest rocks are those forming the Cretaceous mountains where the strata have been preserved by inundation. In general Cretaceous beds form the foothills and the lower open country. They embrace 16,000 feet of strata, or the larger part of the sedimentary section, and are divided into five groups, of which the lowest member is the Livingston and the highest is the Dakota.

The Dakota sandstone consists of fine grained, well sorted quartz sandstone which is generally white but may have a slight pinkish tinge. The Dakota sandstone is the lowest member and the Livings-

The Oligocene beds consist of thin, greenish, clayey sandstones. The beds are generally thin and frequently weather in irregular patches. The greatest thickness is about 1,000 feet, estimating from the tops of the Montana to the base of the Livingston grits.

The Pleistocene beds which form the southern part of the sheet are not extensive and they occur where the coal beds and fresh water beds in the sandstones. The average thickness is about 1,000 feet, estimating from the tops of the Montana to the base of the Livingston grits.

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but it is greatly exceeded in other parts of the Gallatin valley. The beds are slightly tilted, dipping at angles of 3° to 3° westward, and rest unconformably upon Archean schists and gneisses. A small area of lake-beds assigned to this age occurs near Flaxley, in the upper Yellowstone valley. The rocks consist of light graywackes and marls, becoming conglomerates near Flaxley. Upon these streams gravels were deposited and three wells were put down to explore for oil. These beds were formed in an independent lake occupying this part of the Yellowstone valley.

**SUPERFICIAL DEPOSITS OF THE PLEISTOCENE PERIOD.**

**Glacial drift.**—Gravel, sand, and boulders of a great variety of crystals, igneous and sedimentary rocks cover the surface of a large part of the valley from Chicoiray southward. Occurring generally in a confused assemblage of hillocks, five to twenty feet high, they form the terminal moraines of the glacier that once occupied this part of the valley. A part of the glacier ice therefore extended some distance east of the area of the map, at the southwest base of the Crazy mountains, and several varieties have been included in one group on the map. On account of the small-scale maps the very narrow bodies of intrusive igneous rock, of whatever nature, are not distinguished from breccia. The later basalt flows are not distinguished from breccia. The later basalt flows are

**Assorted drift.—** Sands and gravels sorted by water form broad terrace levels in the mountain valley of the Yellowstone proper and the adjoining valley. In this district the sands and gravels that form the river benches in the mountain valley of the Yellowstone, in general, are hardly distinguishable from the sands and gravels of the drift. The material varies from fine sand to coarse gravel, is more or less water-worn, and is coarsest near the margins of the river.

**Alluvium.**—The fluvialite deposits classified as alluvium consist of the clays forming the river bottoms, the silt of the sands and gravels that form the river benches in the mountain valley of the Yellowstone. In general, the alluvial deposits have not been indicated on the map, they are usually found in all the valley.

**Transvaal, a calcareous tufa or limonite formed by the waters of hot springs.**—Within a few miles of the margin of the great rhyolitic flows of the Yellowstone, in a butte north of Pine creek. It forms the margin of the great rhyolitic flows of the Yellowstone, in a butte north of Pine creek. It forms

**Travertine.**—The travertine, which has been described as occurring in Bear gulch, is a very pure carbonate of lime and has been used for lime-making.

**Building stone.**—The sandstones of the Laramie coal measures are quarried for building-stone in the vicinity of Livingston and in Bridgey canyon. They are easily quarried, occur in beds 2 to 3 feet thick, and are worked near Livingston and on Boulder river for the town of Big Timber.

**Copper ore.**—Copper ores have been found in the region about the head of the Boulder river and in the mountains at the head of Slough creek.

**Coal.**—The chief source of brake clays has thus far been the alluvium of the valley bottoms about Livingston, which burns to a very fair quality of brick. The clays of the Bozeman lake beds have been very successfully used for brick-making. Other clay deposits of value occur in the Cretaceous rocks, but they are not yet utilized.

**Limestone.**—The limestones of the Carboniferous afford a satisfactory quality of lime and are quarried at several points both in the coal and in the limestone. The limestones of the Bozeman are of the most value.

**Coal vein.**—Two important coal fields are embraced within the limits of this sheet—the Gallatin field in the south, and the region of the mountains west of the Yellowstone river. The coal of the Bozeman field has been applied. At both these fields the coals are exposed in Laramie strata. The faults vary from a few hundred feet to 1,000 feet in thickness, with a high percentage of volatile matter and water, to fairly dense coals suitable for railroad tracks, those of Hay and Cokelake, yielding a high percentage of coke. The surface of the Laramie strata or coal measure sandstones, estimating from the top of the sandstones to the head of Cinnabar mountain, together with the narrow belt of the Cinnabar field, is a very 2,000 feet above the Jurassic beds. The sandstones are light colored and are well bedded, and the individual strata vary rapidly in thickness and character. The lowest seam occurs in both fields 2,000 feet above the Jurassic beds. The number of coal seams varies greatly at different localities, there being at some places as many as 12, of which several are more than 5 feet in thickness. In general, however, only three seams have proved to be of workable thickness and extent. The aggregate thickness varies from 12 to 18 feet. The coals vary considerably in character in different seams, and even in the same seam, and as the beds occasionally dip in a short distance or are cut out by sandstones, the expense of mining may be considerable.

**Copper deposit.**—This comprises the area of coal-bearing strata in the vicinity of Cinnabar mountain in the southern part of the map. It embraces an area of a few square miles and is from 3 to 5 feet in thickness. The copper veins are of two classes, one consisting of ore bordering the wide belt of coal, and the other of ore bordering the narrow belt of coal. The former is more abundant and is mined near Juneta and is of a workable character. The latter is mined near Juneta and is of a workable character.
mines. The How workings yielded an annual output of about 30,000 tons in 1889. Three seams are worked, their total thickness being 15 feet. The coal is a bright bituminous fuel yielding a fine coke. The block coal meets with a ready sale and the screenings are coked in ovens near the mine.

On the east bank of the river, at the Bowers mine, the coal measures form a narrow block, faulted against the gneiss at the mouth of Trail creek and covered southward by a basaltic lava cap. The seams dip into the mountain at an angle of 40° to 60°, the bed now worked showing 3 feet of clean brilliant coal.

The Bozeman coal field.—This embraces a part of the great belt of coal-bearing, Laramie strata that follows the front of the Rocky mountain system throughout the state. Although the Laramie rocks extend eastward from Livingston, but one opening is worked, all the other mines of the field being west of that town. In this part of the field, the coal measures overturned at angles of 40° to 60°, being folded about the flanks of the three anticlinal ridges of Canyon mountain, Timberline and Rock canyon.

At Cokedale the coal measures sandstones are about 900 feet thick, light colored, with the more massive beds forming prominent outcroppings of yellow sandrock characterized in certain zones by darker concretions a foot or two in diameter, resembling cannon balls. In general the field has three workable seams, but the fuels vary more than those of the Clamabur field. At Cokedale the highest of the three seams is worked. Average sections show from 4 to 7 feet of clean coking coal, in three to four benches with sandstone partings of half an inch to six inches in thickness. These partings are variable in thickness, but quite persistent throughout the seam. The two lower beds of coal show from 5 to 7 feet of firm clean coal separated by similar partings. The output at Cokedale was 49,400 tons in 1889. West of Cokedale the coal measures are nearly vertical and the outcrop is S-shaped as the strata curve around the end of the Canyon mountain anticline. There are no productive workings westward until the Yellowstone-Missouri divide is crossed, beyond which the Timberline mines are located. The strata here dip at 45° north into the hill. Five seams have been worked at this place, but the output is now almost wholly from two. The upper of these two seams is 4 feet thick, separated into three benches by partings. The coal is hard, little broken in the seams, and bears handling well. The lower of the two seams worked is 6 to 8 feet thick and rests upon a poorly defined floor of bone and shale. The coal is much crushed, very soft, crumbling in the fingers, quite bituminous, and can be lighted with a match. It is used for blacksmithing at the mines. The output from this seam is mixed with the harder coal of the seam above for the market. The output was 44,000 tons in 1889.

The same seams are worked at the Mountainside and Chestnut mines, though the coals change somewhat in character.

A small synclinal basin of the Laramie coal measures occupies the valley of Trail creek a few miles south of Timberline. Two seams have been worked.

West of Chestnut the coal-bearing strata curve about the anticline of Rocky canyon, reappearing in Bridger canyon where one of the seams has been worked. Although the coal strata extend northward along the east front of the Bridger range, no openings have been made there.

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