DESCRIPTION OF THE COLORADO SPRINGS QUADRANGLE.

By George L. Finlay.

INTRODUCTION.

GENERAL RELATIONS OF THE QUADRANGLE.

The Colorado Springs quadrangle is bounded by parallels 38° 30' and 39° south and by meridians 104° 45' and 105° 00' and thus covers one-fourth of a “square degree” of the earth’s surface, an area, in that latitude, of 935 square miles. It is in central Colorado and includes a considerable part of El Paso County and small parts of Fremont, Pueblo, and Teller counties. (See fig. 1.) The city of Colorado Springs, from which the quadrangle is named, is in its northwestern part.

The quadrangle is in its northwest-central part. It lies north of the Sangre de Cristo Range. The southwestern extension of this range is the Sangre de Cristo Range. Still further west are San Luis Park, the range of the San Juan region, the Elk Mountains, and other mountains on the western slope of the Rocky Mountains.

The Rocky Mountains form the Continental Divide in Colorado. Middle Park and the mountains of the western slope drain to the Pacific Ocean by the headwaters of Colorado River. The Rio Grande, flowing southward through the Gulf of Mexico, has its source in San Luis Park, and the rest of the mountains drain eastward to the Mississippi by Platte and Arkansas rivers.

The main ranges of the Rocky Mountains are composed of central cores of pre-Cambrian rocks along the flanks of which Paleozoic and Mesozoic beds occur. Tertiary sediments overlap the older formations at many places and there are numerous occurrences of intrusive and extrusive igneous rocks. During Tertiary time there was great igneous activity. In the Pleistocene epoch the higher peaks were centers of glaciation.

The general structure of the Rocky Mountain province is simple, although the study of the province has revealed many perplexing geologic problems. The Great Plains province extends across the country in a broad north-south zone lying between the Rocky Mountains and the Prairie Plains of the Mississippi Valley. (See fig. 2.) It is characterized by rolling plains, varied by buttes, tablelands bordered by escarpments, and areas of badlands. The province is drained chiefly by large rivers that flow in broad, shallow valleys, the largest of these streams rising in the Rocky Mountain region. The province as a whole slopes eastward at the rate of about 10 feet per mile from an elevation of 6,000 feet at the base of the mountains to an elevation of 1,000 feet in the Mississippi Valley.

The surface of the Great Plains has been developed on a series of soft rocks, sands, clays, and loams, chiefly of Mesozoic and Cenozoic age. The constituent materials of these rocks have undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three groups of sediments and intrusive igneous masses which have not undergone such extensive metamorphism. In the Cripple Creek district, west of the Colorado Springs quadrangle, the prevailing rocks are granite, gneiss, and schist. Granite, which is locally known as the Culebra Range. These three
GEOGRAPHY OF THE QUADRANGLE.
GENERAL FEATURES OF THE RELIEF.

Lying as it does across two widely different physiographic provinces, the Colorado Springs quadrangle presents considerable diversity of relief. Mass thus half of it lies in the Great Plains, but the surface is trenched by broad valleys and is more or less rolling, though nearly level areas occur on the main divide. The Front Range rises sharply to 7,000 feet above the plains, forming a great escarp that crosses the northwestern part of the quadrangle. This escarp is mountainous and, further west, in the Manitou quadrangle, in Pike's Peak, at an altitude of 14,000 feet above sea level. (See PI. 1.) The side of a broad valley, reaching in one place an altitude of 7,400 feet, forms a rim of transitional character. The general upland surface of the plains slopes gently southward from an altitude of 6,000 feet or more near the base of the mountains and 7,000 feet near the north side of the quadrangle to less than 5,500 feet in its southeastern corner, the lowest point in the quadrangle. The quadrangle thus lies in three topographic districts—the mountains, the foothills, and the plains. The relief in each district has certain characteristic features, reaching chiefly from the nature and altitude of the underlying rocks, and such be described in turn.

THE MOUNTAINS.

A good deal of the mountain area, the highest summits of the Manitou quadrangle, contains altitudes of 11,000 feet or more above sea level. Pike's Peak stands at an altitude of 14,109 feet, and the highest points are Bold Mountain (12,565 feet), Mount Eol (11,495 feet), Mount Big Chief (11,220 feet), and Cow Mountain (11,150 feet). Blodgett Peak, in the upper reaches of Bijou Creek, Colorado Springs quadrangle, occupies a commanding position on the mountain front. Cheyenne Mountain (9,560 feet), which stands westward of Colorado Springs and is highly arid, is the highest point of the plains adjacent to this plateau. Mount Pikes Peak (8,320 feet) stands close to the foothills near the north edge of the quadrangle.

A prominent valley extends from north to south along the entire mountain front is the rolling plains that stands at an altitude of about 9,500 feet and that extends from Blodgett Peak on the north

without notable break to Un Pass, which is traversed by the Cov NE, to the moderately well-defined Cheyenne Mountain front. Between Un Pass and the Pikes Peak mass the surface of the plateau block is less regular, but its eastern side is fairly high, while the western side is also a continuation of the Blue Mountain region. The Pikes Peak mass rises boldly above this plateau. (See PL IV.) Tapering long gentle slopes, the most striking feature is its linear, precipitous northeastern front. From "The Umpa," in its northeastern end, to Windy Point the edge of the mountain fronting the plains is sharply defined by deep valleys. Bold Mountain and Mount Big Chief, separate masses a few hundred feet southward, form continuations of the ridges northeast of Pikes Peak. The southwestern slope of Pikes Peak is gentle and along the upper edge of this slope is laid the track of the last few miles of the railroad that climbs the mountain. The top of the mountain is dome-shaped (see PL II), and the downslope is smooth, with the lower and west for about a thousand feet is smooth to the heads of several well-marked valleys.

Much of the mountain area shows natural dissection, and along the mountain front from the north to the quadrangle to Cheyenne Mountain there are at many places bold escarp that face the foothills and the plains. At the south end of the mountain area there are no sharp, steep slope from the mountain to the plains is steep. Along the mountain front sharply cut canyons lead to the plains. The principal canyons in the area north of Manitou are those of North and West Monument Creek and Queens Canyon. In its upper reaches, about 100 feet back from the plains, Queens Canyon has a gentle slope, but for down the valley it becomes steeper and in irregular course. Along its middle reach it is deep, and near its mouth its walls are in many places precipitous. Queens Canyon, which is about 3 miles long and has unusually steep walls (see PL V), extends southward toward Manitou. Engle­mann Canyon is in many places a very narrow canyon mentioned, and its walls are not so steep. Bear Canyon, North Cheyenne Canyon, and South Cheyenne Canyon, all southwest of Colorado Springs, are long and deeply incised and have steep walls, which in places rise nearly a thousand feet above the streams. These canyons are famous for their rock scenery, and among their scenic features are numerous waterfalls. Rock Creek, Little Fountain Creek, Turkey Creek, Turkey Creek, and Red Creek, which emerges from the mountains farther south, flow in canyons that are as much as 250 feet deep.

The canyons that lead away from Pike Peak to the plains northeast of it present a marked contrast to those thus far described. Blue Creek, the Bottomless Pit, the short, sharp valley known as The Crags, the prominent valley at Windy Point immediately southeast of The Crags, and the valley in which Lake Manitou lies, unlike the canyons leading from the mountain frontward to the plains, have gently sloping beds along their lower courses and precipitous rock walls about their heads. These valleys owe their forms to glacial erosion, and their mode of origin is discussed on page 14. From the crest of Line of Pike Peak, which marks the head of one of those valleys, to the gently rolling plateaus below, the drop is at some places not less than 2,000 feet and at others as much as 4,000 feet. The sides of many of these valleys are walled and their cross section is U-shaped. Irregularities occur among the precipitous beds of these valleys at places where long spurs extend downward. The crest line of Pike Peak.

The valleys that run southwestward from points now the summit of Pikes Peak show similar U-shaped cross sections, but nowhere about their heads do walls of shear desert of more than a thousand feet high. Their walls are sharply cut, notably those of West Fork of West Beaver Creek, and the floor in this valley and that in that of East Fork of West Beaver Creek has a step and trend form. Redstone Creek, which leads down to Seven Lakes, flows in a long, gently sloping valley, not so deeply incised in the mountain block as the valleys just named.

The eastward-facing mountain front is very bold from the north line of the quadrangle to the mouth of Queens Canyon, where it is interrupted by the deep embayment in which stands the town of Manitou. (See PL I.) This is a marked topographic feature and similar embayments are found in the Perry Park region, north of the quadrangle, and near Canon City, southwest of Manitou. The topographic feature of the West Park outer edge of mountain front can be seen toward the east. The mountain front is the prominent feature of the entire quadrangle. The mountain front is the prominent feature of the entire quadrangle.
THE FOOTHILLS.

The foothills in and north of the Manitou embayment are unlike the foothills in Deadman Canyon and those still farther south, in Table Mountain. Ragged lines of low hills extend from near Bledgott Peak southward to the Garden of the Gods, where bold walls of rocky creek walls rise more than 200 feet above the surrounding country. (See Pis. VII, VIII, and XI.) The crests of these ridges show many small, sharply cut peaks. In the Manitou embayment, south where bold masses of rock make sheer wall-like ridges that rise more than 200 feet above the surrounding country. The Table Mountain region is unlike the foothill none of the Manitou embayment in the fact that the bounding foothill ridge has an even crest line and is much higher. From the bottom of the interior valley to the top of Table Mountain the relief amounts to 1,300 feet. Deadman Canyon shows features common to both the Manitou embayment and the Table Mountain region. Its western foothills have a sharply rectilinear arrangement. Its eastern side is formed by a broad, nearly level top, almost 400 feet higher, from which the ground slopes away abruptly westward, toward the small tributaries of Fountain Creek.

The plains.

The Great Plains extend from the foothills of the Rocky Mountains to the Mississippi Valley on the east. About half the quadrangle lies in the plains region, which extends westward as far as the line of the mesas. This part of the quadrangle is divided into two distinct topographic areas, one, with relief of 1,000 feet or more, lying north of a series of low irregular mountain valleys on or above the old plateau, at altitudes ranging from 9,500 to 10,000 feet southwest of Pikes Peak. The Colorado Springs region east of the mountains makes the cultivation of the soil confined to the valley bottoms. The lack of water in the region except for the relatively small loss by evaporation from the surfaces of the reservoirs, which cover 0.7 square miles, or 4 percent of the entire drainage area.

The following table shows the monthly and annual flow at the three weir stations:

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The above record cover a period too short to show conclusively the effect of altitudes on the run-off in the Pikes Peak region, but they show in general that the run-off per square mile increases with the altitude. In connection with the Cripple Creek region it should be noted that the average yearly run-off of 0.27 second-feet per square mile includes the heavier run-off from the higher altitude of 0.07 second-feet for the area above Bedrock Creek and 0.82 second-feet for the area above the Strickler tunnel. Therefore the run-off from the lower portion of the area below Bohmer Creek is considerably less than 0.07 second-feet. The effect of altitude is still further obscured by the relatively heavier precipitation on the southwestern slope than on the eastern.

Sediment and industries.

Colorado Springs is the chief city in the quadrangle. Colorado City adjoins Colorado Springs on the west, and Manitou lies 3 miles west of Colorado City. The combined population of these places is about 40,000. The most populous suburb of Colorado Springs is Broadmoor, and the town of Fountain lies 11 miles southeast of the city. The plains region east and southeast of Colorado Springs supports a sheep population, whose chief occupation is ranching. Except for a few permanent dwellings, occupied chiefly during the summer, the mountains are almost untenanted. The Santa Fe and the Denver & Rio Grande railroads line across the quadrangle.

The climate is of the C type of the Köppen classification, characterized by very warm summers and mild winters, with precipitation concentrated in the summer months. The climate is influenced by the proximity of the Great Plains to the west, which leads to a cooler, more humid climate than would be expected at the same altitude in eastern North America. The average annual precipitation is approximately 19 inches, with a January minimum of 3.6 inches and a July maximum of 9.4 inches. The growing season typically lasts from late May to early September, with temperatures ranging from a low of about 5°C in January to a high of about 30°C in July.

The following table shows the monthly and annual precipitation at several stations in the area:

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The United States Weather Bureau has maintained precipitation stations at Cripple Creek since 1905, at Victor since 1900, at Manitou since 1874, at Lake Montezuma since 1885, and at Fremont Experimental Station since 1909.

The precipitation at any one station shows the mean annual precipitation at the altitude of the station, which is usually about 9,000 feet.

The precipitation on the eastern slope does not decrease so rapidly with increase of altitude as on the western.

The precipitation is heavier on the eastern than on the western slope at the same altitude.

The United States Weather Bureau has made observations at several stations in the area, including Cripple Creek, Lake Montezuma, Manitou, and Montezuma. The observations show that the precipitation is greatest on the eastern slope of the mountains, with lesser amounts on the western slope.

The first station is the Strickler tunnel, in sec. 23, T. 14 S., R. 64 W., at an altitude of 11,000 feet, and shows the run-off from an area of 29.5 square miles above the tunnel, comprising the headwaters of West Beaver Creek, which lie at altitudes ranging from 11,000 to 14,000 feet. The sum of the inflow into the tunnel and the flow over the Victor weir gives the run-off from the entire area. The second station, known as the Butte station, is in sec. 36, T. 14 S., R. 65 W., at an altitude of 13,150 feet, and shows the run-off from 7.1 square miles, comprising the area above Strickler tunnel and the headwaters of Beaver Creek, which lie at altitudes ranging from 11,150 to 14,000 feet. The third station, known as the Victor tunnel weir, is in the 8.4 sq. sec. 11, T. 14 S., R. 68 W., at an altitude of 8,000 feet. To the flow at the weir is added the flow over the average weir below the Seven Lakes and the flow over the Victor weir to show the entire run-off from the area above the Cripple Creek weir, which comprises 17.1 square miles, including the area above the Strickler tunnel and Beaver Creek weirs. The altitudes range from 6,800 to 14,000 feet.

As Colorado Springs operates a series of reservoirs in this area the all the records are affected by storage and do not show the natural run-off. By averaging the record at each station for the entire period the effect of storage is merely eliminated except for the relatively small loss by evaporation from the surfaces of the reservoirs, which cover 0.7 square miles, or 4 percent of the entire drainage area.

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Distribution.—Nearly the whole of the mountainous area is occupied by the Pikes Peak granites, which form all of Pikes Peak except some small intrusive masses and is well exposed on the mountain slopes. (See PI. II.) It is of widespread occurrence throughout the Front Range for some distance north and south of Pikes Peak. The granite is commonly pink or reddish, and the two varieties are strikingly alike, exhibiting no greater difference than that between specimens collected from the same intrusive masses. It is believed that the two varieties of granite are genetically closely related.

Windsor.—The granite breaks into small angular plates on weathering. It does not weather into large rounded boulders nor break down into coarse angular gravel, like the Pikes Peak granite, and on the whole it appears to be more resistant, for unweathered blocks of granite stand out prominently in the midst of the area of the rock. It is everywhere exposed to grinding processes and some of it is fine from inclusions, but many granites, besides containing the minute needles and black dots that are characteristic of mica, also contain quartz, feldspar, and mica in various sizes and numbers, and some of it is fine from inclusions, but many granites, besides containing the minute needles and black dots that are characteristic of mica, also contain quartz, feldspar, and mica in various sizes and numbers, and some of it is fine from inclusions.

Chemical composition.—The analysis shows that the composition of the rock is strikingly like the Pikes Peak granite. It is nearly the whole of the mountainous portion of the area is occupied by igneous rocks, chiefly granite, and all except the phyllites are of Precambrian age. By careful study of the granite, ten types of granite have been described, chiefly by means of differences in texture. The several types are strikingly similar in mineralogical character and chemical composition, and a number of them are closely related local facies of a single granite mass. For this reason and partly because of the importance of the granite in the history of the basin, a number of types have been distinguished, each distinguished from the others by its own characteristic mineralogical and chemical properties. The Pikes Peak granite is remarkably uniform in texture and composition throughout large areas, but the minor varieties differ in these respects even in the same small area. A few of the most characteristic and important rocks have been named and described in the preceding pages. The granite in some places has also been mapped.
The rock of the dikes consists essentially of feldspar, hornblende, and lepidomelane, readily with small phenocrysts of flash-colored feldspar. It is distinctly richer in ferromagnesian minerals than the other igneous rocks and on weathering becomes stained brown by the oxides of iron.

**Petrography.**—The study of thin sections shows that the essential minerals are nesitic feldspar, hornblende, and lepidomelane, with quartz, magnetite, apatite, and zircon as accessory minerals. In general the light and dark minerals are in nearly equal amounts, although in some specimens dark crystals distinctly predominate. The rocks are holocrystalline and invariably fine grained, the average diameter of the individual crystals being but a hundredth of a millimeter. A notable characteristic is the universal tendency toward automorphic development of the feldspar, with attendant clustering together of the dark silicates.

The feldspars are almost invariably subhedral, tabular parallel to the clinopinacoid, and older than the ferromagnesian minerals. They are very generally altered. Orthoclase, with almost universal Cerblad twinning, is present and in some of the dikes it forms conspicuous popes crystallize up to a quarter of an inch in diameter. The chief feldspar, however, is a sodic plagioclase. Twisting after the albite law is shown by excessively thin lamella. Symmetrical extinction in the zone at right angles to (010) are invariably low and serve to fix the feldspar as oligoclase.

Among the dark constituents green hornblende in subhedral irregular individuals is the most abundant. Subhedral prismatic crystals bounded by the two pinacoids are rare. The usual cleavage is present. The hornblende is closely intergrown with bluish-brown yellow pleochroic lepidomelane. The amphibole and mica occur most commonly in clusters of intergrown crystals that fill the spaces between the feldspar. The dark silicates are invariably fresh.

In some of the dikes there is no quartz; in others quartz in irregular masses is an abundant accessory constituent. Zircon was not observed in most of the dikes, but in some it is conspicuous in subhedral or subhedral green-brown crystals a few hundredths of a millimeter in diameter. Apatite and magnetite are both abundant.

**Chemical composition.**—An analysis of the rock is given below in column A. Its similarity in composition to syenite in striking, and for comparison an analysis of syenite from Yogo Peak, Mont., is placed beside it in column B.

- **Distribution and character.**—Dikes of pegmatite are widely distributed throughout the area of granite, especially northeast of Buell, in the Pikes Peak quadrangle, and along the valley of South Cheyenne Creek. Many of the dikes are rich in sodic amphibole and appear to be associated with the Mount Rosa granite. At one place an anorthophyllite-bearing pegmatite dike found to be intimately connected with the main body of that granite, but the evidence strongly favours the view that the two rocks are genetically related. Pegmatite dikes without amphibole are abundant throughout the Pikes Peak granite area of Cameron, north of the Cheyenne Mountain Range. The pegmatite dikes are composed of single crystals not uncommonly several inches long. The pegmatite dikes have yielded some valuable specimens to collectors, chiefly the accessory minerals described under the following heading.

- **Petrography.**—Petrography is the commonest of the dikes, which in places constitute as much as 40 per cent of the rock. Some of the crystals are well bounded, displaying six or more faces, and both Carlsbad and Baveno twines are developed. The mineral is pink, flesh-colored, or green. Plagioclase forms subidiomorphic equidimensional twins, and the extinction angles fix its composition as that of albite. It is commonly intergrown with deeply weathered and turbid orthoclase. Quartz is as a rule much less abundant than the feldspar. It forms large irregular masses, some of them transparent, but most of them milky white. Graphite intergrowths with feldspar are abundant.

The most abundant dark silicate in many of the dikes is biotite, which in places forms 15 per cent of the rock. Some of the larger crystals are 2 inches across and a foot long. The pleochroic cleavage is uncommonly well developed and is conspicuous in hand specimens. The color is black or black with a faint tinge of olive. The pleochroism is similar to that of the riebeckite in the Mount Rosa granite: X = dark silicates, Y = yellow, and Z = yellow-green. The pitchblende is pink, flesh-colored, or green. Pitchblende forms subidiomorphic equidimensional twins, and the extinction angles fix its composition as that of albite. It is commonly intergrown with deeply weathered and turbid orthoclase. Quartz is as a rule much less abundant than the feldspar. It forms large irregular masses, some of them transparent, but most of them milky white. Graphite intergrowths with feldspar are abundant.

- **Chemical composition.**—An analysis of the rock is given below in column A. Its similarity in composition to syenite is striking, and for comparison an analysis of syenite from Yogo Peak, Mont., is placed beside it in column B.

- **Distribution and character.**—The Mount Rosa granite is most extensively developed on the slopes of Mount Rosa, from which it is named. Another mass crops out in the valley of North Cheyenne Creek. The rock is intruded into the Pikes Peak granite in irregular masses, sheets, and dikes. It is a fine-grained nonporphyritic bluish-gray rock made up chiefly of microcline, quartz, and riebeckite. It is a hard, resistant rock that of the riebeckite in the Mount Rosa granite: X = dark silicates, Y = yellow, and Z = yellow-green. The pitchblende is pink, flesh-colored, or green. Pitchblende forms subidiomorphic equidimensional twins, and the extinction angles fix its composition as that of albite. It is commonly intergrown with deeply weathered and turbid orthoclase. Quartz is as a rule much less abundant than the feldspar. It forms large irregular masses, some of them transparent, but most of them milky white. Graphite intergrowths with feldspar are abundant.

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than 45 feet. Because of lithologic character and stratigraphic position it is correlated with the Sawatch quartzite (Upper Cambrian) of the west side of the Front Range, which is named from the Sawatch Mountains, along the flanks of which it is typically exposed.

The Ordovician system. The principal area of the formation in the Colorado Springs quadrangle is along the northwest side of the Manitou embayment, where it projects out in a narrow zigzag band at the base of the sedimentary series, upon or in contact with the granite. In the valley of Fountain Creek above the city, there are a few small outliers of the formation, one of which is large enough to be mapped. The formation also crops out in a small area at the base of the mountains, a mile north of Blair Athol. South of the Manitou embayment the formation is not exposed in sufficient thickness to be shown on the map as a separate unit.

Character.—The lower part of the formation is a bed of white or cream-colored sandstone 11 feet thick, at the base of which in a few places there is a thin conglomerate sandstone. The pebbles of the conglomerate are almost invariably quartz, although a very few are granite, and most of them are much less than an inch in diameter. The conglomerate is not found at many places and is nowhere conspicuous. The zone of the base sandstone is even grained, more or less fossiliferous, and without prominent jointing. The constituent grains are prevailingly quartz, but the quartz grains are accompanied by a little feldspar, and many of them are nearly spherical.

The upper 30 feet or so of the formation consists of beds of coarse reddish-brown gritty sandstone deeply stained by iron oxide to the color of rust, the middle of which is stained with green, due to the presence of glauconite. In places the grains of feldspar are more abundant and the sandstone is colorless. In typical sections a bed of clear-red limestone 2 feet thick is found in the middle of the red sandstone. The single layers of sandstone 2 to 10 inches across, the arkose sandstone more calcaceous toward the top, where it is succeeded by the Ordovician limestone.

The formation lies on a remarkably even surface of granite. (See PI. VI.) The contact is exposed almost continuously from Fountain Creek to Glen Eyrie, and at any and in nearly every place there is a deposit of more than a foot or two from a perfectly even surface. In the sections in the canyons the overthrusting is everywhere a little.
The Lyons sandstone is named from Lyons, Colo., in the Colorado Springs quadrangle. It consists of fine-grained red and white sandstone having a maximum thickness in the quadrangle of 800 feet. The formation is equivalent to the upper part of the Fountain formation in the Colorado Springs quadrangle, but in northern Colorado foothills of Pennsylvanian age have been obtained from limestones that are in part equivalent to the upper portion of the Fountain formation; hence the whole formation is regarded as Pennsylvanian.

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**Age and correlation.**—From the black shaly lenses near the base of the Glen Eyrie shale member in Quarry Canyon were collected fossil plants that were identified by David White as *Lepidostrobus* sp., *Klymenopterus* sp., *C. corylioides*, *Lepidolobodon clarvatum*, *L. norbest*, *Lepidotrules sp.*, *Lepidodendron expansum*, and *Sipynia arenaria* Aris. The whole formation was carefully examined, though not sufficient to determine accurately the age of the bed, is referable to the lower part of the Pennsylvanian and probably represents a stage in the Kentucky series.

Institute brachiopods are found in several layers of brownish-red and green shale about 400 above the base of the Lyons sandstone. They are identified by G. H. Girty as *L. manhattanensis*. No fossils have been found in the upper part of the formation in the quadrangle, but in northern Colorado foothills of Pennsylvanian age have been obtained from limestones that are in part equivalent to the upper portion of the Fountain formation; hence the whole formation is regarded as Pennsylvanian.

**PERMIAN SERIES.**

**FOURTH FORMATION.**

**Definition.**—The Lyons formation consists of less than 200 feet of thin-bedded, predominantly red sandstone and shale with gray shaly lenses near the top, the upper 800 feet of bedrock, and this bed consists of gray or reddish-brown clays containing numerous dinosaurian fossils and has therefore been called the *Athey'saurus bed*.

Reduced strata. The Lyons formation unconformably upon the underlying Lyons formation, a relation that is not apparent in the Colorado Springs quadrangle, although it is evident elsewhere. It is evident in apparent conformity by the Lyons sandstone member of the Purgatoire formation. At some places in Colorado there is evidence of a slight unconformity at the top of the formation, but it is probably not extensive.

**Distribution.**—In the foothills in the northern part of the quadrangle the formation crops out in a narrow belt lying just above and parallel to the Lyons formation and extending southward from the north margin of the quadrangle to Bear Creek. A small area is exposed at the southeast base of Cheyenne Mountain. In the southwestern part of the quadrangle the formation occupies several areas, the largest being a band lying parallel to that occupied by the Lyons formation and extending from Bear Creek southward to the north margin of the quadrangle and thence southwestward, and again southwestward, along the north face of Table Mountain, to the north margin of the quadrangle. A young projects southward from this belt down Salt Canyon for more than 2 miles, and a small area occupies a part of Patten Canyon, in the extreme southern part of the quadrangle.

**Age and correlation.**—The Lyons formation crops out in the northern part of the quadrangle as a narrow belt extending southward along the foothills as far as Bear Creek, west of Colorado City, but interpolated by quartz veins and as far as the north margin of the quadrangle southward by the Black Hills of South Dakota. From this point, it occupies an area increasing in width southward from a very narrow strip at Rock Creek to a broad belt through the western margin of the quadrangle where the Lyons are present, and thence toward the north margin where they are abundant. It is composed of notably rounded grains of quartz cemented by iron oxide. Cross-bedding is a prominent feature of the rock. The sandstone, which contains much more than 50 per cent of fine-grained sandstone, is succeeded by 18 inches of finely laminated thin-bedded white calcareous sandstone with wavy banding and small inclusions of reddish sand. The sandstone is left in prominent relief by weathering action. Next above is a zone of fine-grained thinly bedded sandy shale resembling that at the base of the Lyons formation.

**Age and correlation.**—The Lyons formation consists of a lower part of the Lyons sandstone, a relation that is seen at the horizon where the red-bed, pink, or white sandstone of the Lyons gives way to fine-grained lilies and thin beds of gray or reddish-brown clays containing numerous dinosaurian fossils and has therefore been called the *Athey'saurus bed*. No fossils have been found in the upper part of the formation in the quadrangle, but in northern Colorado foothills of Pennsylvanian age have been obtained from limestones that are in part equivalent to the upper portion of the Fountain formation; hence the whole formation is regarded as Pennsylvanian.

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Morrison formation in apparent conformity, although in other parts of the State a slight unconformity is recognized at the horizon of separation. The formation is confined within an unconformity, of slight extent, and at every point in the quadrangle it overlies by the Dakota sandstone.

Distribution.—The formation crops out in a narrow interrupted belt extending along the foothills from the north border of the quadrangle southwest to Bear Creek and also in a small area at the west base of Cheyenne Mountain. In the southern part of the quadrangle it occupies an irregular belt extending from the ridge south of Rock Creek southward along the divide between Salt Creek and Bear Creek. Another area extends in a small area in the southern part of the quadrangle southward to Bear Creek and also in a small area in the southern part of the quadrangle where the top of the Niobrara is defined by a thin bed of limestones, the two formations can be easily separated.

The formation rests conformably upon the Bear Creek shale, from which it is sharply distinguished lithologically. It is conformably overlain by the Pierre shale, and in the southern part of the quadrangle, where the top of the Niobrara is defined by a thin bed of limestones, the two formations can be easily separated. The Bear Creek shale, from which it is sharply distinguished lithologically. It is conformably overlain by the Pierre shale, and in the southern part of the quadrangle, where the top of the Niobrara is defined by a thin bed of limestones, the two formations can be easily separated.

In some rule north of the Colorado Springs quadrangle the limestones and shales are mapped separately as the Timpe limestones and the Niobrara shales, but they have not been separated in this folio.

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Character.—The Bear Creek formation, which is named from Lytle, in the valley of Turkey Creek, consists of sandstone and shales and some bands of graywacke. Its base is generally marked by a coarse, massive sandstone 15 feet or less thick, composed of prevailingly alluvial white, yellowish-brown, or blackish grains. The average thickness of these grains is about an eighth of an inch, but the largest fragments are an inch across. In some places, as near Colorado City, the base of the member consists of fine-grained white or cream-colored sandstone 100 feet thick. The Lytle member contains pebbles of various sizes and scattered blocks of granite and red beds, the latter in the northern part of the quadrangle ranging from 400 to 500 feet. It is the upper formation of the Colorado group.

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at some places the upper part of the Pierre consists wholly of shale, so that the transition to the Hills is abrupt.

Mr. Knowlton states that most of these species occur in the Laramie formation and in the Pierre Rock quadrangle. The lower beds of the Pierre formation are, however, of especial interest. A number of these species have also been found in the "Lower Laramie" of Custer County, Wyo., which Mr. Knowlton holds to be of the same age as the Laramie Rocks.

| Definition and relations. - The name Dawson arkose was applied by Richardson in 1912 to the series of arkose sediments that lie above the Laramie formation and in the Pierre Rock quadrangle. This has been deposited secondarily in large quantities. Such arkose beds are conspicuous. The upper part of the shale has been produced in this way. They may be seen in their position similar to that of the Denver formation of the Denver Basin, and are listed below.

| Summary. - The Pierre sandstone is generally clear white, but at its base it is stained brown. It is even grained, finely laminated, and well bedded. The sediments are interpreted as continental deposits, and the eastern margin of the quadrangle. These andesitic conglomeratic layers are present near the middle of the series. Few of the pebbles are more than an inch in diameter, and most of them are less. Variable amounts of quartz occur in the fine sandstone matrix in which the pebbles lie. Above the arkose beds which constitute the body of the Dawson formation. Their prevailing color is greyish white. The lower arkose beds in the quadrangle differ considerably in coarseness and in the relative amounts of their interbedded carbonaceous clays. Immediately above the arkose beds near Austin Bluffs is a bed, 20 feet thick, of unusually well-worn pebbles, the largest measuring 2 inches across. Granite, pisolitic, olivine, quartz, quartz, and felsic and mafic rocks are among them. The rock that makes up the higher reserve beds of the Dawson, many of which are 20 to 60 feet thick, is friable arkose consisting of angular or subangular fragments of quartz, white kaolinite, and, to a lesser extent, weathered granite. Here and there throughout the series there are thin interbedded white quartz-rich sandstone lenses with lenses of white, buff-colored clay. The sediments are interpreted as continental deposits, chiefly of fluvial origin, although some parts of them were partly lined down in bodies of standing water. The occurrence of plant remains supports this view. Near the base of the formation there are occasional layers of arkose whose grains have been cemented together by lime. This has been observed on several occasions. The arkose beds are very firm and strong, and the parts of them that are still unweathered by surfacing, forming protecting caps for the worker arks. The arkose beds are also well-bedded and contorted forms have been produced in this way. They may be seen in their most striking forms in Monument Park. (See Fig. XII to XV.) At many places they have been worn into the bases of cliffs by solution.

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The Quaternary deposits of the area consist of glacial drift, outwash, and stream terraces. The Pliocene and Pleistocene deposits are found along the northern and southern margins of the area. The Pliocene deposits consist of alluvial fans and piedmont deposits, while the Pleistocene deposits consist of terminal moraines and outwash plains.

The terminal moraines are well-developed in the northeastern part of the area, where they form a continuous band along the eastern margin of the Chugwater Formation. The outwash plains are extensive in the southeastern part of the area, where they form a series of terraces along the eastern margin of the Chugwater Formation.

The Quaternary deposits are important in the study of the geology of the area, as they provide evidence of past climate change and the movement of glaciers and ice sheets. The deposits are also important in the study of paleoecology, as they provide information about the plants and animals that lived in the area during the Pleistocene and Pliocene periods.

The Quaternary deposits are also important in the study of human habitation, as they provide evidence of ancient human activity in the area. The deposits have been studied extensively for evidence of early human occupation, and have yielded a number of important archaeological sites.

In conclusion, the Quaternary deposits of the area are a valuable resource for the study of the geology, paleoecology, and human habitation of the area. Further research is needed to fully understand the depositional history and significance of the deposits, and to fully appreciate the contributions they make to our understanding of the Earth's surface processes and history.
GLACIAL DRIFT.

Distribution.—Glacial drift is found in each of the larger valleys leading away from Pikes Peak, within 5 miles of the summit. The largest deposits lie along the East Fork of West Beaver Creek, southeast of the peak, and at the headwaters of the North Fork of French Creek, north of it. There is a great accumulation of glacial gravels in the valley of the "Bottom­

lace," and another deposit occurs near Glen Cove and The Crater, as well as in the cirque valley north of the west ridge of Pikes Peak, now filled with water, below Patent No. 2 and between reservoirs Nos. 4 and 5. There are several areas of these gravels. Glacial drift nearly surrounds Lake Moraine, and a small area of ice-block gravel begins at the lower end of the valley of the West Fork of West Beaver Creek and extends outward into the western border of the Manitou quadrangle.

Form and thickness.—Glacial drift in the form of lateral moraines is not common in the Pikes Peak region. The most conspicuous lateral moraines are on the north side of the valley of the North Fork of French Creek and on the sides of the valley of Lake Moraine. Their upper ends lie at points where the rim of the valley begins to open out or fray away. Their slope toward the center of the valley is larger and gentler than that on the opposite side. Their crest lines are even, and they fall away rapidly downstream. Prominent long or lateral terminal moraines extend across the glacial plains. The highly irregular distribution of the drift gives rise to hummocks, hollows, uneven short ridges, and long depressions. Many of the moraines have notches on their downstream sides and gentle slopes upstream.

The most pronounced terminal moraines lie north of Blue River. It is nearly a mile long and is from half to one mile wide. The compound terminal moraine at the point where The Canter and the cirque valley southeast of it come together is remarkable for its irregular surface and steep front. The terminal moraines on Seven Lakes consist of many small ridges, not extending across the valley.

The thickness of a few of the terminal moraines on the northeast side of Pikes Peak can not be less than 500 feet. The moraines north of Blue River, however, is only about 150 feet thick at a maximum, and the moraines at Seven Lakes is in many places still thinner. Clarke.—The glacial drift is made up almost wholly of the Pikes Peak granite and contains only small amounts of the Crisp Creek and Windy Point granites. The material consists of angular fragments of many sizes, the largest 8 or 10 feet in diameter. Few pieces of the drift show stratifications indicating its work, and much of it is relatively fresh and unweathered.

GLACIAL GRAVEL.

Distribution.—The mountains are at many points flanked by long talus of gravel whose surfaces, if they were extended across the low valleys that cut through them, would form a continuous sloping plane. These gravel-covered slopes gently grade from the mountains at angles of 3° or less. At many places along their eastern edges the gravel is 35 to 50 feet thick, and on the east it thins away to 10 feet or less at a distance of 5 or 6 miles from the mountains. Where the gravel slope up against the mountains it is thickened by talus.

These gravel masses lie along the flanks of the mountains from the western side nearly to the northern boundary of the quadrangle. They occur at many points north of Quaosa Canyon and in the Manitou embayment. West of Colorado Springs lies the prominent "Mesa" called "The Moraine," shown in Plates I and IV, which is capped by these gravels. A still larger moraine lies along the eastern face of Cheyenne Mountain. Areas of these gravels appear on both sides of Rock Creek and the area on the north extends eastward nearly as far as Fountain Creek. A similar long tongue of the same material runs from Deadman Canyon to the southern border of the quadrangle. Smaller areas appear at several places along Fountain Creek.

Twosigh.—This gravel was brought to its present position by streams that deposited it on the gentle slopes at the foot of the mountains. It consists mainly of fragments of granite that are prevalently angular, though the larger pieces, by their rounded surfaces, show the wear and tear of stream work. They are of many sizes. The largest are 8 or 4 feet across, but most of them are more than a fraction of an inch. The deposits include a few unusually large blocks of granite, which have rolled down from the steeper valley slopes, as from the flanks of Cheyenne Mountain. All the fragments of granite, large and small, are roughly sorted and interlaced with abundant sandy material. Not only by every rock, but every fragment of granite that are prevalently angular, though the larger pieces, by their rounded surfaces, show the wear and tear of stream work. They are of many sizes. The largest are 8 or 4 feet across, but most of them are more than a fraction of an inch. The deposits include a few unusually large blocks of granite, which have rolled down from the steep valley slopes, as from the flanks of Cheyenne Mountain. All the fragments of granite, large and small, are roughly sorted and interlaced with abundant sandy material. Not only by every rock, but every fragment of granite, large and small, are roughly sorted and interlaced with abundant sandy material. Not only by every rock, but every fragment of granite, large and small, are roughly sorted and interlaced with abundant sandy material. Not only by every rock, but every fragment of granite, large and small, are roughly sorted and interlaced with abundant sandy material.

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North Cheyenne Creek, and along the northeastern slopes of Cheyenne Mountain, all showing southeast strike, parallel to North Cheyenne Creek, and along the northeastern slope of much talus at almost every point, but the evidence along the of the Ute Pass fault. Beyond the southern end of the moun-

tain, however, the contact between the granite and the sedi-
mentary rocks is obscured by a heavy cover of outwash gravel. The Dakota sandstone and older rocks, with southwest strike,

cuts across the edges of all Sa watch sandstone to the

thickness is at least 6,000 feet. The granite mass south of Ute

Pass has evidently been thrust

southeastward, probably as

is shown in figure 6, together with the folding is gentle and no faults have been observed.

GEOLOGIC HISTORY.

PENT-CAMBRIAN TIME.

The earliest geologic events recorded in the Colorado Springs quadrangle are those indicated by the presence of small areas of granite and schist in the midst of the Pike Peak granite. The record of these events is fragmentary, but it covers a long period of time and a complicated history. Some of the rocks are of sedimentary origin, but none of the sediments composing them are at or near the surface. They were probably involved in movements that produced folding and faulting, and the minerals they show must be attributed largely to dynamic agencies, although some of the metamorphic rocks appear to be due to later igneous intrusion. All these rocks underwent great erosion, and the erosion was followed by a considerable uplift, as is indicated by the presence of crystalline masses with which the metamorphic rocks are intimately associated.

Later in the Paleozoic era the granites and schists above

referred to, was intruded the mass of Pike Peak granite, now covering many thousand square miles. Paghamictic affinities of this granite occur at many places.

Later in the post-Cambrian time fine-grained granites—the Crip-

ple Creek, Windy Point, and Mount Rose—were intruded into the complex. The time covered by these intrusions was prob-

ably not long, and the relations of the granites do not make clear the order of their intrusion. None are older than the Pike Peak granite, but they are as far as we can determine spatially related to this formation.

In Pennsylvania time erosion was followed by slight uplift and erosion, with which the Carboniferous period marine conditions prevailed along the Front Range imme-

diately north of the Colorado Springs region and a few miles southeast of it.

CARBONIFEROUS PERIOD.

MISSISSIPPIAN EPOCH.

The Colorado Springs area probably underwent conditions before the Mississippian epoch, which was uplifted and eroded before the Pennsylvanian epoch. The evidence for this subsi-

dence and uplift is found in the adjoining Castles Rock and

Canon City quadrangles. No Mississippian beds are known in the Colorado Springs quadrangle, but beds of that age have been found a few miles north of it. They are known as the Millip lime stones. In Garden Park, north of Canon City, this formation appears only a few miles west of the Colorado Springs quadrangle. These Millipite is limited and above by unconformities, and the record of erosion seen in the unconformity between the Millipit and the overlying Pennsyl-

vanian rocks indicates the presence of such Millipite sediments at some time in a geologic past. These sediments are not now preserved in the Colorado Springs quadrangle, but they have been observed in the adjoining Castles Rock and the Pennsylvanian epoch. Widely distributed sedimentation fol-

lows, leading to the deposition of the thick series of "Bed
their dissolved salts were at least in part precipitated. Deposi­tions earlier sediments as well as of the older crystalline rocks. 'quadrangle, taken in connection with the events that occurred limestones of the Morrison formation, which in this area succeeds a via*tile and lacustrine sediments, and the sand and clay were in .the beds that are regarded as probably Permian. To Lyons sediments were deposited seem to have varied but little signifies renewed activity of the streams. After; the deposition marks only a short time and was due to local conditions, for from those which had just before been deposited. Fairly coarse sandstone containing species of Lingulidiscina indicates a small amounts of limestone accumulated in lakes which grad­Alternating deposits of shale and fine-grained sandstone and deposited conformably upon the coarser beds of the Lyons. To Lykins sediments were deposited, near the end of the Paleozoic period, though a portion of it was doubtless laid down in standing water. The lack of any beds of known Triassic age within the region consisted of masses of lava that lay on the periphery of the igneous rocks split from the Cripple Creek region. The sand rock was poured out in a number of places and flowed over the Colorado Springs region. The succeeding Eocene history of the region is supplied by the sediments in the Castle Rock quadrangle. A few sediments were derived from rock diastrophism in the Cretaceous region, and it was also derived from the mouth of the rivers that attacked partly or nearly uplifted land masses. The most plausible view of Dakotas sedimentation is that the depos­i­its were laid down along the shores of an open sea. At times thin beds of carbonaceous shale and of coal were deposited. At the end of the Dakotas epoch marine conditions prevailed. Lyons and Montrose deposition. - The earliest beds laid in the deep waters of the Colorado region were shales, limy shales, and thin limestones, deposited in alternation. Upon the beds that accumulated in early Colorado time—the Greenhorn shale and Greenhorn limestone—was laid down the sand that formed the Castle Rock shale. Near the close of Dakotas deposition a thin sand, nowhere thicker than 10 feet in the Colorado Springs Quadrangle, was deposited over the whole area. There was another short period of erosion by the last extensive deposition of limy-sandstone-making material in the region, forming the Niobrara. After the pure calcareous beds of the Niobrara, beds of coarser sand were brought in by the rivers and spread broadcast over the sea floor, producing sediments that are among the thickest in the stratified series, the Pierre-shale. There was a very exten­sive wearing down of the supply land areas. At the close of this period of surficial series, the Pierre-shale occupying the region and several hundred feet of sand (the Fox Hills sandstone) was deposited. After this the region was uplifted and less coarse and more limey sand was deposited. Lyons deposition. - By gentle oscillations the land, which had been so long under water in the Cretaceous period, was brought to a stand several hundred feet above sea level at last but one short geologic period of the region. This land probably lay rather low and it remained low throughout the Triassic and Jurassic periods and well into the Cretaceous. Fluvialite and beachite sediments probably accumulated during Triassic time, but so as known they have all been removed by erosion. There is no indication that the sea trans­gressed over the region. Furthermore, it is not known that the deposition took place before the end of the Triassic. 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ECONOMIC GEOLOGY.

The mineral resources of the area comprise coal, building stone (including sandstone and granite), shale and coal, cement materials, limestones for other uses than building, gypsium, semiprecious stones, sand, and gravel. The water resources comprise springs for the supply of municipal water and underground water. The soil is a resource of great importance. Small metallic deposits, although unproductive, have been prospected at many points in the region.

_COAL._

Occurrence.—The workable coal is confined to the Laramie formation, the outcrops of which extend from Colorado Springs southward through the quadrangle. The Colorado Springs coal field is structurally a part of the basin-like area which is defined by the outcrops of the Laramie formation and the overlying Dawson arkose and Castle Rock conglomerate. The coal-bearing strata within the quadrangle have an average dip of 2° or 4° in a direction slightly east of north. The coal crops out at several places northeast of Colorado Springs and may be very generally distributed through the Laramie formation beneath the surface in the syndepositional basins that line between Colorado Springs and Denver.

The higher slopes of Pikes Peak were covered with snow, but the summit was not glaciated, and the ice sculpturing of the mountain did not proceed far enough to reduce its mass greatly. With a change of climate, which probably involved a reduction in precipitation, the streams of glacial ice diminished in volume. In the Pikes Peak region they did not persist until the Recent epoch, although in northern Colorado small masses of glacial ice still exist.

Deposition of coal.—Along the eastern front of the mountains a wide, extended, gently sloping plain of gravel was laid down in Pleistocene time. This gravel consists almost entirely of fragments of granite and is the product of stream work in the canyons bordered by the mountains and along the steep faces of the granite mountain front. The formations in the foothills made only a small contribution to this gravel. At one period or another during Early Pleistocene time the streams were at work at every point along the plain. They deposited the gravel very unevenly over the surface, making a roughly undulating surface, which at one time bordered the mountains without a break from the northern line of the quadrangle to its southern boundary and extended eastward for 10 miles beyond the foothills. The coal was made along the steep mountain front at many points.

Later, when the major streams flowing out from the mountains were eroding their canyons in the granite rocks still more deeply, they dissected the gravel plain where they crossed it and eroded valleys in the underlying soft shale and other sedimentary rocks. After they had removed the gravel, the streams also worked laterally, cutting away the outskirts gravel along the sides of their valleys and gently rounding the areas occupied by the deposit, which now forms long ground-watered spurs between the streams valleys. (See PL I.)

In the course of this work the gravel was successively laid down at lower levels along the streams as terraces. The gently sloping bench of fine gravel on which the city of Colorado Springs is built is one such terrace. Almost all these terraces have been removed by the stream action that formed them.

Recent epoch.

Deposition of alluvium.—Stream work has not been checked since the Pliocene epoch, and at present the area is subjected to a much greater depth of sedimentation than that of most of the year they do not even reach the surface into which they are cut.
and of even texture, and it has a dumpy head between the grained of quartz. The cement may be calcareous, but more commonly it is siliceous. The colors of the rock at different places are gray, yellowish, red, and black. It is quarried on Turkey Creek, outside the quadrangle, is bluish gray. The rock is of even texture, and it has a durable bond between the strata. It works well under tools, although it is somewhat brittle for the purpose of quarrying. Blocks as much as 50 feet long and 6 feet thick are obtainable. The best grades are those with bluish tones and with fault lines like the veining in certain marble, probably due to the presence of manganese dioxide. The bluish markings add greatly to the beauty of the stone. After three or four years of exposure the rock is likely to grow dingy, but it is none the less a stone of high grade. Weathered non-cemented surfaces have been much sought for rustic effects. The creamy or yellowish layers are stained by limonite and generally contain specks or larger tailed-back concretions of iron oxide which may make the stone unsuitable for use as building material. Quarries have been opened along the ridge south of Colorado City. No stone has been taken out at the south edge of the quadrangle, but the same rock is extensively quarried near Turkey Creek, a few miles further south.

Archaic.—The Dawson arkose is often used for foundation and outside work. Layers in which the constituent pebbles and small grains are bound together by limonite form a strong conglomeratic rock. The natural surface is taken, and rough pieces are finished. The rock occurs in thin layers at a number of horizons along the outcrop northwest of Colorado Springs.

Limestone.—The Niobrara formation affords the best lime stone that is easily obtainable in the quadrangle for use as building stone, but it is not of very good grade. The single outcrop of the rock at the north side of the city is 22 to 26 inches thick and is separated by a clay layer. The color is a good bluish gray or brownish gray but the stone has two very serious defects—it contains small iron concretions like those in the Dakota sandstone and it has a strong tendency to break irregularly. It is much cut by small cracks and is not so strong as it appears to be on casual examination.

Cement Materials. The quadrangle is abundantly supplied with materials for making Portland cement. The limestone and shale of the Niobrara formation are available for this use, though in the vicinity of Colorado Springs, owing to the nearly vertical dip, the costs of mining and transportation would prohibit its use except for the production of other cements. The area of the Niobrara formation at Colorado City within reach of the railroad is not so great as that in the Dinosaur Canyon region, but the cost of transportation would prohibit quarrying, for the locality is many miles from the railroad line.

Shale and Clay. Building bricks are manufactured near Colorado City at a point about a mile north of Fountain Creek and along the railroad just south of Colorado Springs. The soft shales of the Pierre formation are used, and the supply of this material is inexhaustible. There has been little demand for the better grades of pressed brick, and the output of ordinary brick is largely consumed in the neighborhood. The clay deposits of the Dakota sandstone are available for making fire brick. They have been mined near Colorado City and farther north within the quadrangle, but for several years the output of the plant at Colorado City has been small. At the southern edge of the quadrangle, where the Dakota sandstone occurs in extensive beds, there is considerable clay, but owing to its distance from rail lines it has not yet been mined.

Sand and Gravel. The quadrangle is well supplied with sand and gravel in the deposits which cover the Pierre shales and which have beenmapped as mass gravel. The Mass, west of Colorado Springs, has yielded within the city limits large amounts of this material in different degrees of fineness. Sand adapted to structural uses is obtainable at many places, and large amounts of gravel are employed in road work in the western part of the quadrangle, where at slight cost bedrock shale can be overlaid with gravel close at hand.

Lime and Limestone. Limestone has been burned to obtain lime for local needs at kiln sites extending between Manitou and Colorado City. Limestone of the Niobrara formation was once burned at a few places northwest of Colorado Springs and in Limon Valley, south of it. The Manitou limestone has been quarried for making lime near Manitou and still more profitably for refining beet sugar. The principal quarries were on the ridge above William Canyon, at a point on a mile north of Manitou and a mile and a half southeast of Glen Eyrie.

Oystere. Near Colorado City, north of Fountain Creek, a bed of gypsum about 20 feet thick was long worked to a slight extent, but the most valuable deposits of gypsum in the quadrangle are at its southern end, in the valley of Red Creek. Here, at the top of the Eyekus formation, they attain a thickness of 90 feet. The beds are almost horizontal and are readily accessible. The material is largely impure, but many layers are free from any impurity. The usual color is pinkish white or clear white. The supply for structural uses and for application to the land as fertilizer is so large as to warrant long continuance of the industry at this point.

Semitropical Minerals. The Pikes Peak region has long been famous among collectors of minerals. The microlite (mossanite), smoky quartz, and topaz occurring in crystallites in the granite within a few miles of the summit of Pikes Peak have supplied many beautiful specimens. Near St. Peter's Dome pegmatite veins have yielded zircon, astatophyllite, eudialyte, aferedonite, thomsonite, and preopesite, as well as the rare minerals gaskarite, masonicite, saliphite, and zevellite. On the Hawks of Canon City in Crystal Park topaz and phoselite have been found.

Metalliferous Deposits. Small metallic deposits, although unproductive, have been prospected at many places in the mountains. The St. Peter's Dome region has been searched systematically for gold, and for years serious prospecting for gold and copper was carried on at Peaks Camp, about 4 miles south of Southside on the Colorado Springs and Cripple Creek District Railway.

Water Resources. Streams and Wells. The small streams that issue from the mountains are utilized for irrigating land in the valley of Cripple Creek and at many other places near Colorado Springs. Several projects involving dam sites in the southern part of the quadrangle have been favorably considered, but only a small quantity of water has yet been used, and the supply available is not large. A few miles south of the quadrangle small quantities of artesian water are obtained at relatively shallow depths, but the search for artesian water within the quadrangle has been unsuccessful, though several wells, one of them 3,000 feet deep, have been sunk near Colorado City. The Dakota sandstone and the Lytle sandstone member of the Purgatoire formation generally contain water, but as they dip so steeply that they afford only a comparatively small gathering ground and as the average annual rainfall on the drainage basin is only 14 to 17 inches it is doubtful whether their supply is sufficient to produce flows within the quadrangle. In the central part of the quadrangle these sandstones lie so deep that the cost of reaching them has prohibited their use as a source of water.

Mineral Springs. Much of the prosperity of Manitou rests on the occurrence of a number of mineral springs that are strongly charged with carbon dioxide. They are in Ute Pass, near the Ute Pass fault, where the Pikes Peak granites and the Manitou limestones are faulted together. The springs are generally related to the Ute Pass fault, and though they are not thermal waters they probably rise from considerable depths. They have no known connection with that igneous rocks as lie about the Cripple Creek volcanic center. The waters are palatable and are among the most widely sold table waters of the West. The Manitou or Soda Spring is the best known. An analysis of the Manitou table water is given below.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Concentration (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
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</tr>
<tr>
<td>Potassium</td>
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</tr>
<tr>
<td>Calcium</td>
<td>30.6</td>
</tr>
<tr>
<td>Magnesium</td>
<td>10.5</td>
</tr>
<tr>
<td>Chloride</td>
<td>226.5</td>
</tr>
</tbody>
</table>

Soils. The alluvial soils in the bottoms of the valleys are the only soils in the quadrangle that have been much used for agriculture. Some of the residual alluvial soils, produced by the washing of alluvium in place, are notably infertile. Relatively little land—probably only 1 or 2 per cent of the area—is devoted to crop growing in the Colorado Springs quadrangle, for the quantity of water available for irrigation is small. Crops have been cultivated successfully in the valley of Cripple Creek, the water being drawn from Quanis Canyon. Small areas along Rock Creek and Little Rock Creek have been similarly brought under cultivation. In the valley of Red Creek the same amount of labor only a third of the crop can be raised by dry farming that can be raised by dry farming that can be raised by dry farming than that grown by irrigation. The bottom lands along Fountain Creek, however, have yielded considerable amounts of forage. Nearly all the agricultural products of the region are consumed locally by residents.

June 1914.