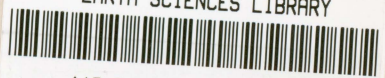


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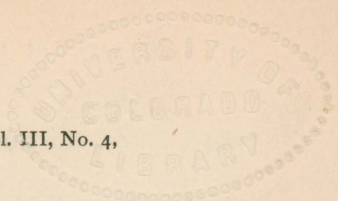
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AREAL GEOLOGY OF LOWER CLEAR CREEK (COLORADO)¹

BY JAMES UNDERHILL

INTRODUCTION

The area under consideration, shown on the key map, Fig. 1, embraces the northern portion of what I have called the Evergreen Quadrangle, about 180 square miles, and the southern portion of the Black Hawk Quadrangle, about 60 square miles. I have also covered in great detail, as far as the dikes are concerned, the region embraced in the so-called Idaho Springs and Central City special maps, an area of about 18 square miles.

For the Black Hawk I had the excellent topographic map of the United States Geological Survey on a scale of 1-45,000, or about 1½ inches to the mile. For the special area I had the Idaho Springs and Central City specials on a scale of 1-12,000, or about 5 inches to the mile.

There being no topographical map of the Evergreen Quadrangle, one had to be made before geological mapping could be done, and this has been in part constructed as follows: Where the Georgetown and Black Hawk Quadrangles overlapped on the Evergreen Quadrangle, the topography of these maps has been used. On the south and east the topography of the Platte Cañon and Denver sheets respectively has been used. Surrounded as the Evergreen Quadrangle has thus been, it has been admirably checked on all sides. Several triangulation points of the U. S. Geological Survey on the Evergreen Quadrangle, with some other triangulation points on other quadrangles that may be seen from it, have been platted. Other points have been more or less accurately determined with the pocket sextant. Then the township lines were laid on with checks by the topographic sheets above mentioned, and finally the sections and their topographic "guesses"—for they are little better—were sketched in. These topographic features have been found reasonably accurate at the intersections with the township lines, but as a rule

¹ Presented to the Graduate Faculty of the University of Colorado in a partial fulfilment of the requirements for the degree, doctor of philosophy.

absolutely unreliable in other places. These features, which consist usually only of the creeks, have been checked as well as may be by the pocket sextant, and also by pacing and courses taken with the Brunton Compass. The notes of the pipe-line for the City of Golden water-

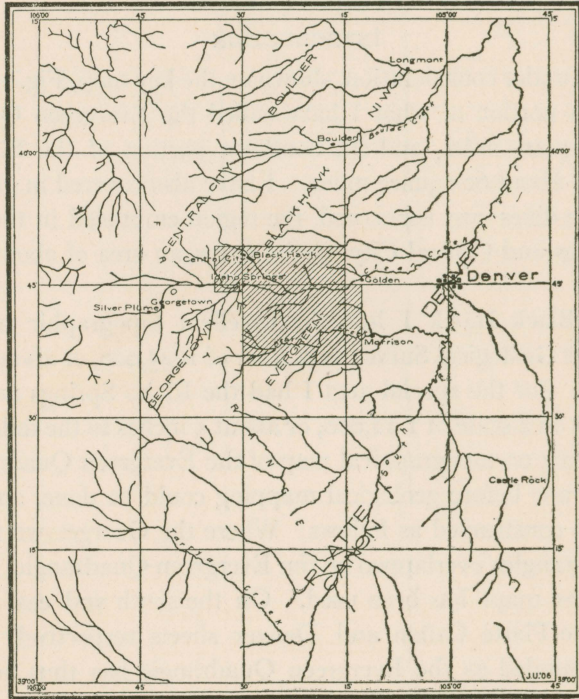


FIG. 1.

works kindly furnished by Mr. Carstarphen, the city engineer, have been of great service as a check on the northern portion of the Evergreen Quadrangle.

TOPOGRAPHY

The topography of the area in question may be divided into two divisions, the western and eastern sections. The topography of the western section is seen to be rugged, and, while not so much as the Georgetown and Central City Quadrangles to the west, its topography is more accen-

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tuated than the topography of the eastern section. The topography of the eastern portion may be defined as subdued topography, except where it is deeply cut by Clear Creek and Bear Creek.

Unlike the Georgetown and Central City Quadrangles, there is little evidence of glaciation. On the flanks of Squaw Mountain, especially at the head of North Beaver Creek, the amphitheater-like topography gives one an impression of a glacial cirque, and the idea receives confirmation by an accumulation of detrital material just at the beginning of the V-shaped valley of North Beaver Creek. To a less extent South Beaver Creek

exhibits the same phenomena, and both creeks continue their courses as V-valleys. The subdued topography of the eastern portion strongly reminds one of a peneplain, and there is good reason to consider that all the eastern portion was once base leveled, and

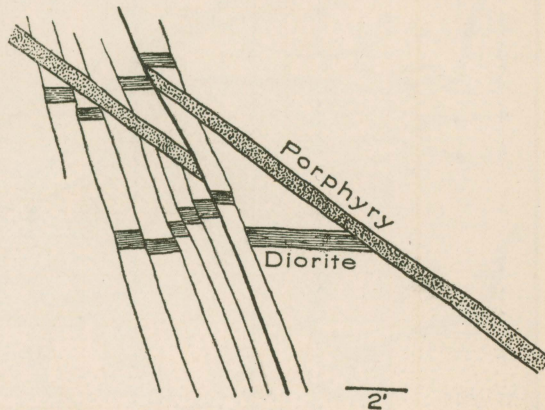


FIG. 2.

since has been deeply dissected on the north and south by Clear Creek and Bear Creek, and their respective tributaries.

This peneplain or base-level was elevated in common with the remainder of the Rocky Mountains in Tertiary times, and Clear Creek and Bear Creek cañons with the cañons of their tributaries have been entirely eroded since that period. In many cases the side streams have not yet cut deep cañons, and we have at their sources the gentle, well-rounded slopes of Tertiary time, in sharp contrast with the deep cañons of the lower portions of the same streams. This is true also of the upper waters of Clear Creek and Bear Creek outside of the area here considered. In fact, a very close approximation to Tertiary topography could probably be reached in a topographic map of the eastern portion of the area under consideration by simply neglecting the deep cañons and putting in their

place mature valleys with gentle slopes to represent the stream system of that time.

GEOLOGY

In nearly all the accounts of this region and the associated areas of the front range, especially those written some years ago, the rocks have been

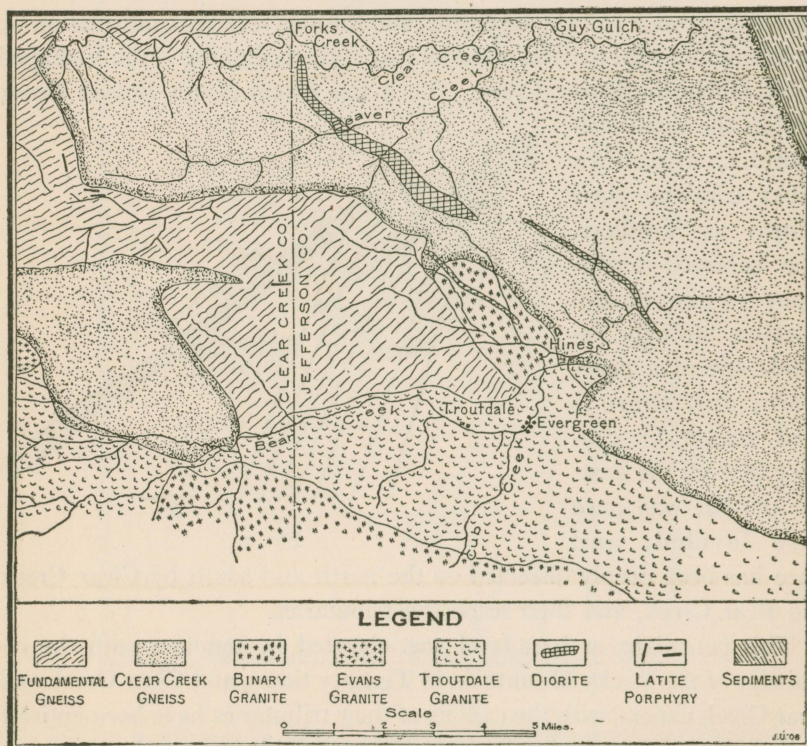


FIG. 3.—Portion of the Evergreen Quadrangle.

assumed to be of sedimentary origin, and so described. The banding has nearly always been regarded as the stratification, and thought to represent the dip of the original sedimentary rocks, from which the present complex was derived.

The geology of the lower Clear Creek area is a complex of presumably metamorphosed igneous rocks, usually designated as pre-Cambrian, but

only certainly pre-Jura-trias, and then only for the main masses. That certain portions are of late eruptive origin can be proved, and possibly all of the country will some day be shown, as in the case of the Green Mountain area in Massachusetts, to be as late as Devonian.

That this supposedly pre-Cambrian complex was originally igneous and since metamorphosed by great dynamic forces, regional metamorphism, and thus as a consequence has taken on a well-defined schistosity,

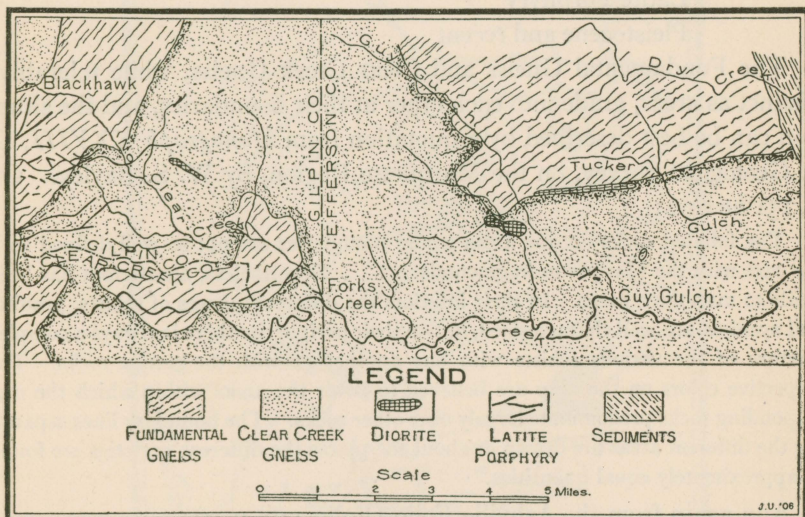


FIG. 4.—Portion of the Black Hawk Quadrangle.

is borne out by its comparative homogeneity over large areas in the field, and by the thin sections studied. It is difficult to believe that alternating strata and formation of sedimentary rocks could have been metamorphosed into such areas of homogeneous material as at present exist, and the appearance of the lithologic units as mapped up to the present strongly give the idea of an arrangement by igneous forces. While the complex of the lower Clear Creek area may be divided into a number of lithologic units with more or less certainty, in all probably about eleven or more, only ten can be recognized with certainty in the area in question. These formations beginning with the oldest, the Fundamental Gneiss, have been arranged as follows:

Fundamental Gneiss
 Clear Creek Gneiss
 Binary Granite
 Central City Granite (Evans Granite)
 Troutdale Granite
 Diorite
 Pegmatite and Aplite
 Latite Porphyry
 Pleistocene and recent

The Fundamental Gneiss and Clear Creek Gneiss, while tolerably distinct as areas, grade into each other at their boundaries, and the situation can be best described by a quotation from *Monograph XXVIII*, U. S. Geological Survey, on the Marquette Region, by W. S. Bayley. On p. 151 he says:

The foliated rocks occupy areas whose boundaries are not so well defined as is the case with the Marquette fragmentals. . . . Nevertheless, an attempt has been made to map these areas. In their interiors the different phases of schists, granites and syenites are well characterized, but on their peripheries there is always a complex mixture of the various schists with one another or with the granite rocks. The respective colors on the map are believed to cover the areas within which the corresponding rocks predominate largely over other rocks. The boundary lines separating the different areas are drawn at about the places the different varieties are found in approximately equal quantities.

And again from the Ashville Folio (Folio 116, p. 4):

In only a few cases do the boundaries shown on the map represent a single contact between two large masses; they usually indicate a narrow zone beyond which one rock or the other predominates. Sometimes an area shown as gneiss may contain many small beds of granite, or it may be substantially all gneiss. On the other hand, many of the areas represented as granite include also small bodies of gneiss. These may be continuous with one another or may be disconnected inclusions. Except where these bodies were the prevalent rock over considerable areas, they were disregarded in the mapping.

It might be added for the whole Clear Creek district that one outcrop may give examples of any or almost all of the lithologic units in question.

It is well known that pre-Cambrian areas have a close resemblance the world over. The lower Clear Creek area closely resembles other areas in the United States that have been most closely studied, as, for example,

the Lake Superior, Southern Appalachian, Southern Colorado, and Grand Encampment regions.

FUNDAMENTAL GNEISS

Wherever in the Clear Creek section the rocks have been studied, this biotite gneiss is found to be with the Clear Creek Gneiss, the prevailing lithologic unit recognized and

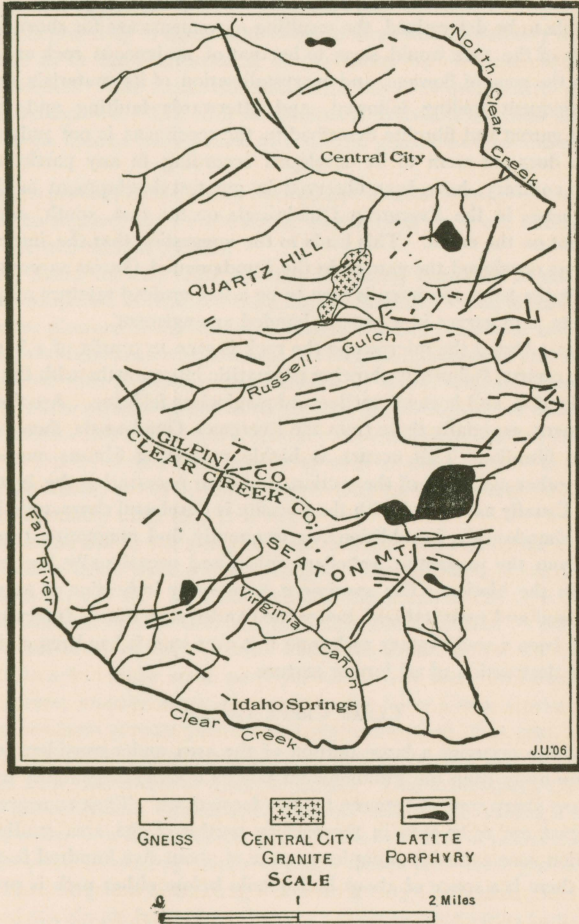


FIG. 5.—Idaho Springs and Central City Special Maps.

mapped. The Fundamental Gneiss as the prevailing rock is everywhere much plicated and crumbled, and shows signs of having been subjected to intense dynamic metamorphism. It is far more metamorphosed than any other rock of the country thus far studied,

and is older than any other petrographic unit. Except where it is in contact with the Evans Granite, its schistosity or banding has a prevailing dip to the north at every possible angle. Its strike is east and west. Where in contact with Evans Granite, it dips away from the granite with a strike parallel to the contact. In the intense metamorphism resulting from pressure, it takes on the most fantastic and varied plications and crumpplings possible, and every variety of folding to be found in any mountain region can, as a rule, be found here within a restricted area. The folding is accompanied by faulting, but, wherever possible to be determined, the resulting movements are for short distances only.

The history of the rock would seem to be that of an igneous rock exposed to great compression in the zone of flowage, and recrystallization of its materials along bands or zones. A subsequent folding followed, and afterwards faulting and jointing. The development of garnet and fibrolite described in the specimens is not universal, and the fibrolite gneiss does not seem to be developed according to any particular law. The garnets, on the contrary, have been observed in greatest development on the borders of the granitoid gneiss, in the Evergreen Quadrangle on the east, south, and west of the mass, though not on the north. This leads to the suggestion that the intrusion of Clear Creek Gneiss has developed the garnets in the Fundamental Gneiss as contact minerals.

The rock in the hand specimen is seen to be a fine-grained mixture of quartz, biotite, feldspar, fibrolite, and garnet in a general banded arrangement.

Microscopic.—Under the microscope the rock is seen to consist of a banded arrangement of biotite, quartz, frequently showing pegmatitic intergrowths with the feldspar, and undulatory extinction, and both microcline and plagioclase feldspar. Apatite is abundant. In many specimens, especially those from the Evergreen Quadrangle, there is an abundant development of fibrolite. This occurs as highly polarizing fibrous masses in parallel bands with the other materials of the section, and even penetrating the biotite, following the cleavage. Usually associated with the fibrolite is developed characteristic iron garnet, often in great abundance. In addition, we frequently find magnetite, hematite, apparently formed from the magnetite, rubellane mica, and occasionally hornblende, closely interwoven with the biotite. The specimens have every indication of an eruptive rock, greatly compressed and recrystallized, hence the banded structure. It nowhere shows any signs of having been a sedimentary rock, and if it ever was, it has been entirely remelted to the complete destruction of all former texture.

CLEAR CREEK GNEISS

This formation occupies a large portion of the area under consideration, and while at some distance away from the Fundamental Gneiss it differs essentially from that unit, there is rarely any sharp contact between the two formations. The two nearest approaches to a sharp contact are to be seen in the eastern portion of the area studied. Here the contact transition zone probably occupies a space of about five hundred feet. On North Beaver Creek there is a space of about half a mile before either rock is prevailingly the unit mapped.

While the Clear Creek Gneiss shows the effects of having its banding or gneissic texture developed by great compressive forces, it has nowhere, except perhaps in the transition zone noted on North Beaver Creek, been so much plicated as the Fundamental Gneiss, neither has it suffered intrusion of pegmatite and diorite in so marked a degree as the

Fundamental Gneiss. Like the latter, its dip is prevailingly to the north. It is predominantly the home of the latite porphyry dikes.

Microscopic.—The hand specimen consists of an evenly banded arrangement of quartz, feldspar, and mica, but without the plications usual in the Fundamental Gneiss.

Microscopic.—Under the microscope the rock is seen to consist of quartz, orthoclase, plagioclase, microcline, biotite, muscovite, magnetite, apatite, epidote, titanite, calcite, zircon, fibrolite, and hematite. Sericite is occasionally developed.

The quartz is generally in excess and shows in every case undulatory extinction. The feldspars appear as in the Fundamental Gneiss series, but in most cases show marked undulatory extinction. The muscovite and biotite occur as independent aggregates, and also frequently intergrown. The rock in question is distinguished from the Fundamental Gneiss series by its greater resemblance to a normal granite and by the smaller quantity of biotite.

For the areas covered by the Idaho Springs and Central City special maps no attempt has been made to separate the Fundamental Gneiss from the Clear Creek Gneiss on the map. There are two reasons for this.

In the first place, the two units are very intricately combined in one vast complex, which has been subjected to repeated fissuring and faulting. The faulting is not important, so far as the distance of movement is concerned, but when one considers the area affected, it assumes considerable importance. Then, too, this special area has been almost universally injected with pegmatite, and intruded by recent eruptive dikes. In addition to all this, we have the metamorphism of the rock by the subsequent, or usually subsequent, vein-filling solutions. All this causes a complex exceedingly difficult to unravel, and still more difficult to represent on a small scale map such as must be used in a report of this kind. It may be stated, however, that detailed notes have been taken for this area, and material for a reasonably exact map is at hand.

To anyone interested in the study of these Gneisses the Newhouse Tunnel offers an admirable section of some three miles in length. The direction of the tunnel in round numbers is about N. 15° W. At a few hundred feet south of the Gem vein the tunnel leaves the Fundamental Gneiss and cuts the Clear Creek Gneiss. This contact is still further to the south on the surface; in other words, the contact dips to the north at an angle of something like 45°. While some porphyry dikes have been cut in the Fundamental Gneiss, a far greater number are to the north in the Clear Creek Gneiss. The Fundamental Gneiss has been greatly plicated and more disturbed, it is true, than the Clear Creek Gneiss to the north, but it is in this latter that we can see most clearly, though not on such a large scale, the effects of dynamic action. This is fortunate, for in the narrow section cut by the Newhouse Tunnel every possible example of faulting and folding is in evidence in the course of a few thousand feet. These evidences of movement are rendered clear by the frequent alternating bands of black diorite and white gneiss, and strongly reminds one of the diagrams illustrating works on geology. In most cases the faults are not composed of one simple fault-plane, but are a series of distributive faults or fault zone. Frequently the fault-planes are so numerous and close together that we have simply a zone of sheeting. One of the very interesting occurrences is that shown on the west side of the tunnel just beyond the Sun and Moon vein (Fig. 2).

BINARY GRANITE

This granite occupies a small area just north of Hines' and a much larger area south of the Troutdale granite. No traverse yet made has reached the southern boundary of this mass. As this granite is easily weathered, it is almost impossible to find good outcrops, and it can be traced only by its residuals and by an occasional cutting. In this way we find the topography of the area occupied by the Binary Granite subdued, and relatively rolling with well-rounded slopes, especially in comparison with the Troutdale Granite area.

Petrography.—In the hand specimen this rock consists essentially of an intimate mixture of quartz and red feldspar.

Under the microscope the quartz is seen to have an undulatory extinction. The feldspar is, as a rule, microcline, with some acid plagioclase and occasional orthoclase. The accessory minerals are apatite and biotite occurring in small amount.

CENTRAL CITY GRANITE

This rock, so far as known, occurs only on each side and a little to the south of the head of Spring Gulch just south of the Central City Railroad Station. It is very clearly a mass of granite intruded into the surrounding gneiss, with which it forms a sharp contact to the north on the road to Central City. With the exception of a small hill on its most southerly extension, this granite is easily disintegrated and forms characteristic well-rounded outcrops.

Petrography.—In the hand specimen this granite proves to be a hypidiomorphic arrangement of quartz, feldspar, and biotite. There is a suggestion of a banded arrangement, which is more evident in the larger masses.

Under the microscope the quartz shows the results of dynamic action by its undulatory extinction. The feldspar is found to be nearly all an acid plagioclase, with some few grains of orthoclase. There is an abundance of biotite, also a little hornblende. Apatite, titanite, magnetite, and zircon occur in the usual form of these minerals.

The rock is classed with the alkali granites or granitites.

EVANS GRANITE

This granite occupies a small area on the western portion of the Evergreen Quadrangle. It strongly resembles the Central City Granite, and is very likely the same petrographic unit. No petrographic determination was made of this rock.

TROUTDALE GRANITE

As can be seen from the map, this petrographic unit occupies a territory on either side of Bear Creek, from a point just east of the town of Evergreen to the western boundary of the Evergreen Quadrangle. It shows every evidence of being a true eruptive granite, and in many cases along Bear Creek, at best just west of Troutdale, are seen apophyses of granite in the Fundamental Gneiss. This has been called the Troutdale Granite on account of its picturesque development at the resort of that name. It is probably, judging from the comparison of hand specimens, the same granite that occurs at Georgetown, Colo., though, so far as known, there is no direct connection. While not found cutting the Binary Granite, there is good reason for thinking it is younger, especially as it seems to divide the Binary Granite into two masses. The topography of the area occupied by

the Troutdale Granite is rough and accentuated, forming in many cases deep cañons with steep walls and picturesque towers of rock. This area is in marked contrast with the subdued areas to the north and south.

Macroscopic.—In the hand specimen this granite appears as a hypidiomorphic mixture of quartz, red or pink feldspar, and biotite.

Microscopic.—Under the microscope we find that the quartz has a slight undulatory extinction at times; the feldspar is chiefly an acid plagioclase with some orthoclase and microcline. The microcline frequently shows Carlsbad twinning in addition to the characteristic cross-hatching. Sometimes the feldspar is seen in pegmatitic intergrowths with the quartz. The feldspar is frequently found altered to sericite. In addition to these minerals, we have muscovite, apatite, titanite, magnetite, and zircon.

This is also an alkali granite. It differs from the Central City granite in the less amount of femic or ferro-magnesian minerals, and in the presence of muscovite, wanting in the Central City Granite.

DIORITE

The next lithologic unit of importance is represented by the numerous diorites, of which one large mass east of Creswell is particularly interesting. This mass, extending nearly to Clear Creek Canon, turns toward the southeast to a point north of Bear Creek. Except in several local instances, this rock is a massive diorite, and shows little or no evidence of dynamic metamorphism, though there is good reason to believe, from the study of the specimens collected and examined, that chemical metamorphism has been active.

Besides this large mass of diorite, there are everywhere present in the Fundamental Gneiss, and to some extent in the Clear Creek Gneiss, small dikes of diorite, for the most part parallel to the schistosity or banding, and, while almost without exception greatly sheared and squeezed by dynamic forces, are but rarely plicated. These, while not so extensively metamorphosed as the inclosing rock, are still greatly affected by the same or similar forces. The greater metamorphism of the smaller dikes seems to imply either a greater age for these intrusions, as a rule, than for the larger mass of diorite, or else a less ability to withstand the forces of metamorphism than was possessed by the larger mass of diorite. No attempt has been made to map these smaller dikes, only the most important receiving attention.

Macroscopic.—The rock consists of an even grained holo-crystalline mixture of hornblende and plagioclase feldspar. In many specimens and in the larger masses of rock, as a rule, there is no striking evidence of banded texture, but some specimens have a banded appearance which at times becomes schistose. In some of the dikes there is a marked coarse-grained texture, strongly suggestive of a typical gabbro, and here the component minerals occur in large crystals with abundant development of garnet.

Microscopic.—Under the microscope the rock is seen to consist essentially of a holo-crystalline mixture of green hornblende and plagioclase, with some biotite, augite, quartz, apatite, magnetite, titanite, epidote, garnet, and secondary calcite and actinolite; the whole, as a rule, taking on a banded arrangement.

The hornblende is of the common green variety, showing basal sections predominating, with the usual two prismatic cleavages. It is, as a rule, distinctly pleochroic, but in some specimens shows only the faintest pleochroism. In the strongly pleochroic

varieties we have a =yellowish green, b =dark green, c =yellowish green. Absorption showing $c=b > a$. The feldspars are all striated, showing polysynthetic twinning according to both the albite and pericline laws. As no examples of Carlsbad twinning were observed, it was found impossible to determine the plagioclases according to the method of Michel-Lévy, but, as the extinction angles average about 15° and one as high as 40° was observed, the composition is probably about oligoclase-andesine. Nearly all the feldspars show undulatory extinction, showing that they have been exposed to great pressure, but at the same time not so much as would be expected from the appearance of many of the hand specimens. This would seem to imply that considerable recrystallization had taken place.

In the very coarse-grained varieties an iron garnet is very abundant. Inclosed in the garnet have been noticed quartz, plagioclase, and hornblende. The other minerals mentioned above present the usual aspects.

PEGMATITE AND APLITE

Every rock noticed in this district has been intruded by pegmatite and aplite, usually acid in nature, but more rarely, as in the case of the diorite pegmatite described for Guy Gulch, and also another occurrence near the Gem power plant on Clear Creek, basic in composition. These pegmatites, intruded in every imaginable way into older rocks, have the most fantastic and varied cross-section. They frequently carry great quantities of magnetite, which afterwards supplies in great part the black sands and pebbles in the placers. Locally, graphic granite is often developed, probably at its best near Roscoe on Clear Creek. The pegmatite rarely shows evidences of having been subjected to great dynamic forces. It has a common development near bodies of sheared diorite.

It has been found impossible to map satisfactorily the pegmatite injections, and for this area no attempt has been made in this direction. Some petrographic descriptions of these rocks are, however, added.

PEGMATITE (*Graphic Granite*). Roscoe, by C. & S. tracks

Macroscopic.—The rock consists of bands or pencils of quartz and feldspar showing on cross-section the common graphic texture.

Microscopic.—Under the microscope the rock is seen to consist of alternating bands of quartz and microcline, the former showing undulatory extinction, giving in one place the appearance of twinning. The microcline has the usual cleavage texture, but with one cleavage developed parallel to the quartz, the other at right angles. This would seem to indicate a continued pressure in one, or perhaps two, definite directions.

APLITE. N. W. Corner of Evergreen Quadrangle

Macroscopic.—The rock is a pegmatitic rock consisting of quartz, feldspar, and some pyrite. The specimen is traversed by a small vein of oxidized material.

Microscopic.—The rock under the microscope is seen to consist of a medium fine-grained holocrystalline mixture of quartz, microcline, and some orthoclase, with small amounts of pyrite, magnetite, and muscovite. The quartz shows undulatory extinction, and the whole rock shows signs of compression, and effect of dynamic forces, as is also suggested by the microcline twinning. The specimen is seen to be traversed by a small vein consisting of oxidized material, and here the feldspars have been impregnated and somewhat altered.

DIORITE PEGMATITE. Guy Gulch, by C. & S. tracks

Macroscopic.—The hand specimen is a rather pegmatitic-looking mass composed entirely of hornblende, feldspar in most cases striated, and black mica.

Microscopic.—Under the microscope the rock is seen to consist of a coarse-grained aggregate of green hornblende, biotite, plagioclase, orthoclase, the former predominating, together with a little quartz, apatite, epidote, calcite, titanite, and magnetite, all exhibiting the ordinary characteristics of these minerals. The quartz and feldspar show frequent pegmatitic or granophyric intergrowths. The plagioclase appears to have a low extinction angle, and to be near the albite end of the series, probably oligoclase.

LATITE PORPHYRY

In certain portions of the district in question, notably the areas covered by the special maps, and also in the western portion of the Black Hawk Quadrangle, the country is extensively traversed by porphyry dikes. While these dikes run in every direction, the majority of them have a course N. E. by S. W., or the same as the prevailing vein system. It is interesting to note that, while there are no veins of importance outside of the area traversed by the dikes, the area of the dikes at the same time extends beyond the area traversed by the important veins. These dikes vary in size from a few inches to hundreds of feet in width, and from a few feet to many miles in length. As a rule, however, they die out in a few hundred feet. In the field they all have the same general characteristics, and vary in color from brown and red to gray. They are reasonably straight, but dip at all angles, though, like the veins, in the majority of cases the dip is rather steep.

At various points all over the area studied, and especially near veins, the dikes have been brecciated, and in some cases the fragments in every way resemble water-worn pebbles. These occurrences have been explained as true conglomerates of as early as Algonkian time, notwithstanding the fact that there is good reason to consider the porphyry composing the pebbles as Tertiary. The phenomena have also been explained as resulting from the fall of water-worn pebbles into open crevices. The true explanation of the phenomena probably is the extensive brecciation and complete shattering of the dike. Subsequent kneading movement, possibly aided by solution, reduced the angularity of the fragments, and in some instances gave them the appearance of water-worn pebbles. The best places to study these phenomena are Banta Hill and the so-called "Queen's Chair."

The dikes, as a rule, are closely "frozen" to the inclosing walls, and, though carefully sought for, in but one case was any sign of contact metamorphism observed. That there has been shrinking in cooling is evident by the lines of fracture when the rock is broken.

It is difficult to obtain fresh specimens on the surface, and when near veins they are also greatly decomposed, as a rule. The best specimens are to be procured in cross-cut tunnels outside of the vein area and in newly made roads. The dikes usually have a fine-grained appearance when fresh, and the porphyritic appearance and the display of phenocrysts, as a rule, are the result of weathering or underground decomposition. In the hand specimen the rock varies through all the stages from what might be called a felsite, which is all ground-mass with no phenocrysts, to a granite porphyry which has little ground-mass, and which might be said to be all phenocrysts. This latter phase is often taken for a granite and not regarded as a porphyry at all. Those rocks locally known as porphyry

have been described by every name from andesite to phonolite in different reports. They do vary from the composition of andesite to that of trachyte, but in the area specially studied they are of intermediate composition, and may be called Latite Porphyry.

It is very possible that they are the necks of surface flows which furnished the andesite pebbles for the beds of the Denver Formation.

Microscopic.—Under the microscope the porphyries vary from a rock composed of a holocrystalline ground-mass of quartz and feldspar with no phenocrysts, to a rock with little ground-mass and resembling the true granite. As a rule, the ground-mass is a fine-grained granitic mosaic, and might be called a micro-granite. In many specimens, especially those that are highly iron-stained and rich in magnetite and hematite, the feldspars are lath-shaped, and the quartz is allotriomorphic to the feldspar and arranged in the spaces left over after the consolidation of the feldspar. Here in many cases the feldspars are iron-stained all through; in other cases the stain has not penetrated to the center. The lath-shaped feldspars have here usually taken on a rough flow structure. In the case of vein breccias and the more andesitic varieties the ground-mass may resemble a felted paste. The highest powers of the microscope fail to resolve this paste into its component minerals.

In the ground-mass, of whatever character, as a rule are larger crystals of phenocrysts of one or more generation. The larger crystals are generally plagioclase, with some orthoclase. These nearly always show evidences of zonal development, and are of intratelluric formation. The feldspars frequently show evidence of rebuilding. The crystals of a second growth are the same as those of the first growth, but, as a rule, rather more acid, with quartz, biotite, and hornblende. In no case in this area has the quartz been seen in large crystals, though one dike on Mill Creek studied outside of the area shows good quartz phenocrysts, with perfect crystalline outlines. All these larger crystals have suffered more or less from corrosion by the magma before the consolidation of the ground-mass. This is especially true of the biotite and hornblende crystals, of which in many cases only the skeletons remain for identification. In one case portions of the ground-mass were noticed entirely inclosed in a phenocryst of feldspar. Among the earliest consolidations are apatite and titanite, frequently in relatively large and well-formed crystals. In the ground-mass, and in addition to the quartz and feldspar previously noticed, are found pyrite, magnetite, biotite, hornblende, augite, hematite, zircon, and in one case fluorite. Sericite, epidote, zoisite, calcite are present as alteration products, with frequent secondary quartz.

PLEISTOCENE AND RECENT

At several places noted previously under glaciation, and also at various points in Clear Creek Cañon, gravel deposits have accumulated. On the northwest portion of the Evergreen Quadrangle by the Silver Age Mill on the north side of Clear Creek, and also nearly opposite Sawmill Gulch, on the north side of Clear Creek, the remains of an old stream terrace can be seen about one hundred feet above the present stream-bed. These correspond to the old terraces which are more prominently developed on the Georgetown Quadrangle around Idaho Springs. Some of these are more or less completely consolidated into conglomerates.

SEDIMENTS

No attempt has been made to map the sediments which have been described in the Denver Monograph.

