60002220

Mining District File Summary Sheet

DISTRICT	Goldfield
DIST_NO	2160
COUNTY If different from written on document	Esmeralda; Nye
TITLE If not obvious	The Geology and Petrography of the Goldfield Mining District, Nevada
AUTHOR	Hastings, J.; Berkey, C
DATE OF DOC(S)	1906
MULTI_DIST Y / (N?)	
Additional Dist_Nos:	
QUAD_NAME	Goldfield 7½'
P_M_C_NAME (mine, claim & company names)	Copy from map on p. 2,3
COMMODITY If not obvious	Gold; silver
NOTES	Geologic report; geology; cross section; paper read before the AIME at the Bethlehem meeting, February 1906; geologic map 20 p.

Keep docs at about 250 pages if no oversized maps attached (for every 1 oversized page (>11x17) with text reduce the amount of pages by ~25)

	Initials	Date
SS:	DD	12/16/08
DB:	PB	12/1/09
SCANNED:		

Revised: 1/22/08

The Geology and Petrography of the Goldfield Mining District, Nevada.

BY

JOHN B. HASTINGS, Denver, Colo.

AND

CHARLES P. BERKEY, New York, N. Y.

A Paper Read Before the American Institute of Mining Engineers, at the Bethlehem Meeting, February, 1906.

PRICE 30 CENTS

AU[redacted]ITION.

1906.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Geology and Petrography of the Goldfield Mining-District, Nevada.

BY JOHN B. HASTINGS, DENVER, COLO., AND CHARLES P. BERKEY, NEW YORK, N. Y.

(Bethlehem Meeting, February, 1906.)

I. Geological.*

The reconnaissance of the Goldfield mining-district, described in this paper, was made in May and June, 1905, and, though this time was too short for a complete report, the work accomplished may serve as a basis for more thorough future research. Dr. Berkey has examined the rocks collected by myself, and I am using his classifications. As a result of further field-work, and Dr. Berkey's examination of the rocks, this paper is an elaboration and correction of my views expressed in the *Goldfield Sun*, May 12, 1905. The sketch-map, Fig. 1, illustrates the geology of the Goldfield mining-district.

Goldfield is an eruptive complex, consisting of alaskite (binary granite), hornblende-andesite, hornblende-dacite, rhyolite, pyroxene-andesite, pyroxene-dacite (sometimes containing a small quantity of olivine), quartz-felsite, olivine-pyroxene-andesite, and basalt. Considering this list to be arranged in the order of eruption, the age-sequence of the rocks conforms to Richthofen's law, formulated in 1868. From his observations in Europe and America, propylite, andesite, trachyte, rhyolite and basalt, occurring together, succeed one another. In a general way, the medium and the more acidic rocks precede the most basic—a result supposed by some to have arisen from their position beneath the surface, and due to a rude stratification by gravity in the original cooling magma during the older history of the earth, or to the same differentiation occurring during a quiescent (molten ?) period preceding eruption, being aided by the ease with which acidic rocks, mixed with water vapors, become fusible. In effect, the more basic and less re-

* By John B. Hastings.

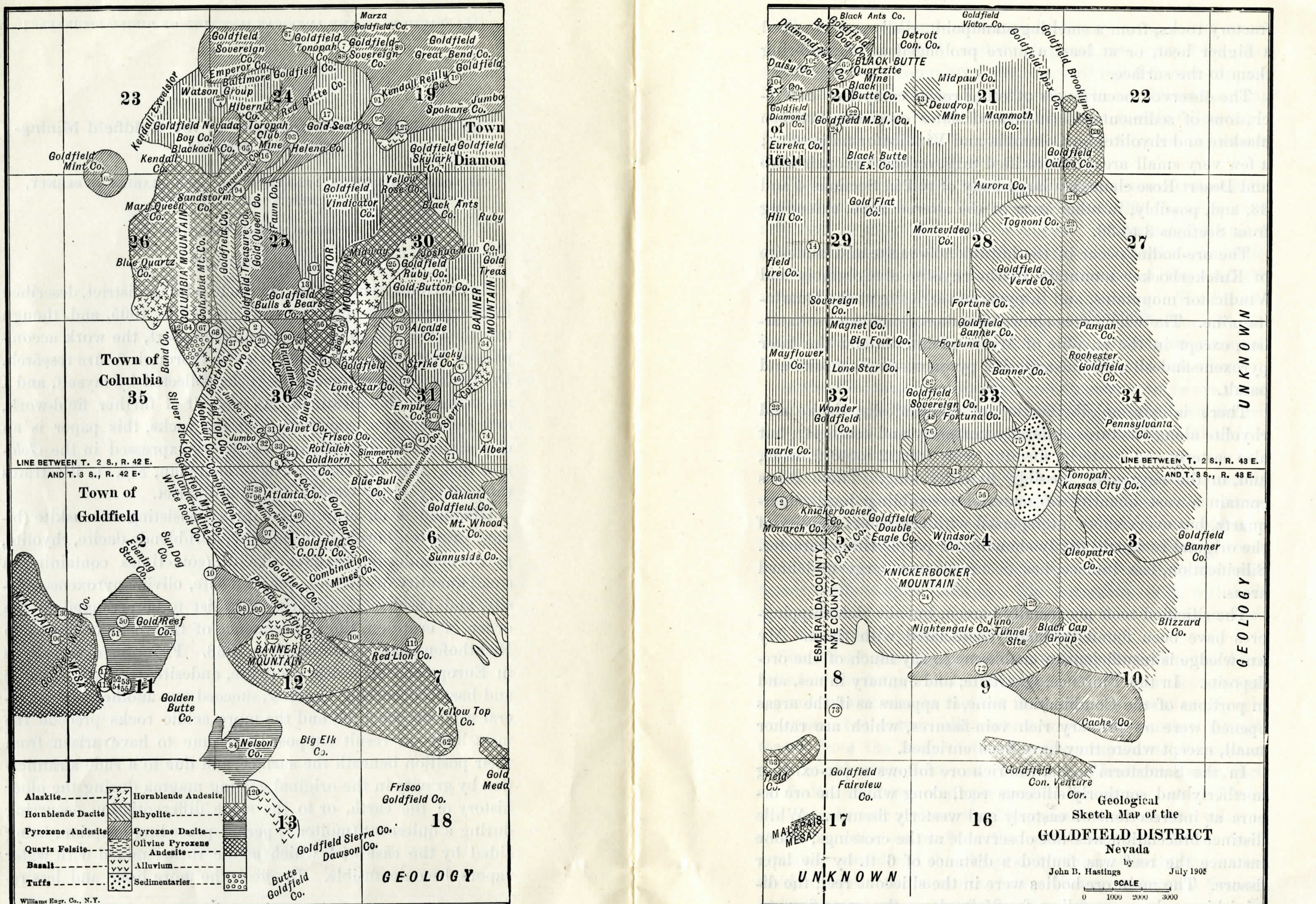

FIG. 1.—GEOLOGICAL SKETCH-MAP OF THE GOLDFIELD MINING-DISTRICT.

fractory rocks, from a smelting-standpoint, really seem to need a higher heat, or at least a more prolonged action, to bring them to the surface.

The observed occurrences of other rocks comprise: two inclusions of sedimentaries (indurated slates or shales, between alaskite and rhyolite) on Columbia and Vindicator mountains; a few very small areas of stratified tuffs, on the Tonopah Club and Desert Rose claims; a large body of tuff in Sections 4 and 33, and, possibly, in other areas of the altered zone, extending from Sections 3 to 36.

The ore-bodies occur in the hornblende-dacite and andesite of Knickerbocker mountain, in the rhyolite of Columbia and Vindicator mountains, and in pyroxene-andesite at the Quartzite mine. The whole area shows abundant remains of solfatarism, except in the rhyolite of Myers mountain, and the later pyroxene-andesite, olivine-andesite, pyroxene-dacite, felsite and basalt.

There is extreme silicification of the andesite, dacite and rhyolite along fractures generally northerly and southerly, but also easterly and westerly, forming reefs from 2 to 40 ft. wide, and, in the aggregate, possibly 40 miles long. These zones contain a vast quantity of material resembling hard sugar-quartz, but everywhere interspersed with a greater quantity of the original rock, still dimly showing its porphyritic character. Silicification, less intense, has occurred over large undefined areas.

The silicified reefs are usually barren, but the rich shipping-ores have been found intimately associated with them. My knowledge is insufficient to enable me to say much of the ore-deposits. In the Florence, Quartzite, and January mines, and in portions of the Combination mine, it appears as if the areas opened were on primary rich vein-fissures, which are rather small, except where they have been enriched.

In the Sandstorm mine, the rich ore follows a pre-existing northerly and southerly siliceous reef, along which the ore occurs at intersections of easterly and westerly fissures. While distinct brecciation was not observable at the crossings, in one instance the reef was faulted a distance of 6 ft. by the later fissure. The main ore-bodies were in the siliceous reef, the diminishing values extending for 25 ft. along the cross-fissures. The enclosing rock is rhyolite.

The Florence, Combination, and January veins, in the southerly area, striking NW. and dipping east, are crossed by other simultaneously mineralized fissures, striking NE. and dipping NW., into which the ore is deflected. The northwest fissuring continues, and the ore in the cross-fissures may only follow them for a certain extent, to be picked up again later in the parent fissures. The enclosing rock is dacite.

The Quartzite mine is the representative fissure in the northern end of the district. The vein strikes N. 20° W., dips westerly, and is about 5 ft. wide as stoped. A characteristic piece of the enclosing rock from the dump was pyroxene-andesite, having the same blue color and appearance as the southern mineral-bearing dacite, but lacked the quartzes. The brownish pyroxene-andesite, west of the Quartzite, in Sections 19 and 24, is later than the silicified zones, peaks of the latter, too small to be mapped, outcropping like islands in the andesite-flow.

In the Florence, Combination and Quartzite, there are cross-fissures younger than the mineralization, which have faulted the veins, and this may be generally expected from the more recent vulcanism.

The tuffs on the Tonopah Club and Desert Rose, cursorily alluded to before, are in shallow detached bodies, occurring as shaly deposits on the present surface, and surviving only in a few depressions. At the Tonopah Club mine several of these small deposits, from 2 to 10 ft. deep, are crossed by the vein-fissure, with a slight faulting. The horizontal tuffs, with bedding-planes at right angles to the fissure, have been permeated and mineralized by the ascending solutions.

Since the beginning of the last century, attention has been called to the large amount of water and its vapor accompanying vulcanism; also to the fact that, after the cessation of rock-extrusion, hot waters still make a way to the surface, though forced from the body of the inactive eruptive to its contact with neighboring rocks and other lines of least resistance, such as faults, fractures and permeable limestones, etc. These waters, saline or vadose, were supposed to reach the volcanic rocks from the sea or from the earth's surface. It has been generally considered that, by gravity and capillarity, the waters would descend to the molten areas through saturated fissures and rocks, which, in turn, seemed to afford an easy passage to the surface. On the other hand, some observers proclaim it impossible for water to travel against the pressure of vapors which would be created in rocks surrounding the deep scene of volcanic action.

It has been pointed out that but little capillary or other water is found in deep mines. In discussions on this subject I do not remember to have seen mentioned that fissures, later than the veins, now carry the surface water. It is usual, in mining, to find the veins dry, and some cross-fissures flooded. Mine after mine has been cited as dry in its lower levels, and even the Rand mines are said to be making very little new water. Apart from local unfitness, I should imagine the center of such a synclinal, as the Rand, to be an ideal spot for artesian water. However, the chief fact seems to remain in prominence, namely, that there is much less water in underground circulation than was formerly supposed.

The most recent theory predicates the great central mass of the earth, beginning 190 miles below the surface (equaling 0.975 of its whole bulk), to be a core of compressed gases, similar to the sun's central nucleus; only, in the case of the earth, which has four times the density of the sun, these gases, on account of their specific gravity and resistance to deformation, must be nearly as heavy and as rigid as steel. As an addendum to this premise, water of volcanoes is then presumptively evolved from these gases, and escapes during a slight relief from the pressure which accompanies igneous phenomena.

Whatever may be the origin of volcanic waters and associated vapors and gases, their passage upwards, under great heat and pressure, thoroughly permeating large bodies of molten eruptives, would furnish the most ideal solvent in the best source of supply imaginable.

There is no proper drainage-system in Nevada. None of the rivers reach the ocean; all sink, either in the channel itself or in the lakes in the great valleys. Probably an important migration of vadose water progresses underground, which, in the past, has been interrupted by newly-formed volcanic necks. These waters became heated, joined magmatic waters, and rose to the surface; hence, as the rocks cooled and magmatic waters ceased, the springs dried up. Since there has been a succession of eruptive actions in Goldfield, there has also been one of

solfatarism. Perhaps more than ordinarily, the Goldfield deposits suggest the derivation of the ores from ascending hot magmatic and vadose waters.

II. Topography.*

The Goldfield district has the erratic topography of a recent volcanic area, modified but slightly by erosion, the silicified portions forming small peaks by their resistance to the elements.

Columbia mountain, while composed largely on its south end of alaskite, as shown by the Columbia Mountain tunnel, is a rhyolitic neck; Vindicator mountain also is a rhyolitic neck.

Banner mountain, which may also be a volcanic peak, is possibly the product of erosion, since the summit is a mass of hard silicified andesite, and the surrounding basal plain a soft andesite and dacite.

Knickerbocker mountain is a great volcanic cone, from which the dacites have flowed northwesterly and easterly, partly covering the older hornblende-andesite.

Table mountain in Section 9, on which the Black Cap group and the Juno tunnel-site are located, is a basaltic neck, with a later flow of pyroxene-andesite, the hard andesite protecting the soft, underlying, altered dacite, which forms a ring around the obtruding cone.

In Sections 12, 13 and 14 is another table mountain protected by dacite and basalt, the two effusions exposed side by side.

Myers mountain, another volcanic neck, at first extruded rhyolite, in Section 7. This rhyolite is more basic than and different, macroscopically, from rhyolites of Columbia and Vindicator mountains. Olivine-pyroxene-andesite (Section 12) followed the rhyolite, then pyroxene-andesite (Section 1), and, finally, basalt (Section 12), now crowning the summit.

The Malapais mesa, west of Goldfield, extending 4 miles northerly and 4 miles southerly, and as much as 4 miles wide, is a marked example of a table mountain protected by a hard cap. Here lake-beds and tuffs were covered with a thin bed

* By John B. Hastings.

(from 10 to 50 ft.) of quartz-felsite; the felsite itself was covered soon after by a similar sheet of olivine-pyroxene-andesite.

The pink felsite and black andesite are a marked contrast: the former is a fine example of igneo-aqueous fusion, with steam vesicles up to a diameter of 5 ft.; it may have been an underwater flow. The andesite is comparatively solid. These rocks seem like rivals, and one is struck with the tenacity with which the darker basic rock has so completely covered the lighter acidic rock. The depths of the flows vary, but not much so, one from another; the edges are exposed for many miles on top of the bluff.

A somewhat interesting duplication occurs in Section 11, on the south end of the Wild Horse claim, which, at first, seemed suggestive of a downward faulting on the mesa scarp. This

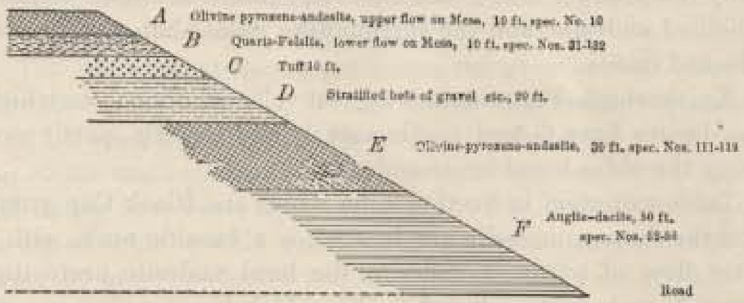

FIG. 2.—IDEALIZED GEOLOGICAL SECTION ON THE SOUTH END OF WHITE HORSE CLAIM, SEC. 11

occurrence is explained by Fig. 2. The augite-dacite, *F*, has a slight superficial resemblance to the felsite, *B*, and the olivine-pyroxene-andesite, *E*, to the olivine-pyroxene-andesite, *A*. This last rock preserves its marked characteristics for miles, perhaps the most noticeable being the iron-stained olivines. I could not determine whether *E* and *F* emanated southerly from under the mesa; they disappeared northerly under the wash. Perhaps the olivine-pyroxene-augite occurring in the wells of the Goldfield Brewery and Los Angeles Co. are connected with *E*. There is another nearby outcrop ot olivine-pyroxene-andesite, a fine-grained rock, between the Water Tank butte and Mesa (Section 2). The dacite, *F*, is traceable in detached areas to and beyond the summit in Section 14, and east of the Lida road.

The mountains in Sections 27 and 34, on the east boundary of the district, are composed of a coarse typical andesite with quartz phenocrysts, that is,—hornblende-dacite much younger than the dacites of Knickerbocker mountain.

Mapped with the dacites of Knickerbocker mountain are fine-grained altered areas, the composition of which I was unable to determine.

III. PETROGRAPHY.*

The chief object of the microscopic study of the specimens of rock, gathered by Mr. Hastings, has been to identify them and suggest relationships as an aid to field-mapping, and the interpretation of geological structure. At the same time the characteristic secondary changes in the rocks, and the relationships of these to the ores, have been constantly in mind, with a view to the bearing upon the genesis of the ore-deposits of the district. Mr. Hastings, in the first part of this paper, has given the field-relationships, and makes the appropriate applications of such suggestions as a microscopic study of the rocks seems to warrant. On account of the interest felt in the district, and the rather unusual series of rocks represented at Goldfield, it seems advisable to add more detailed notes on the petrography of the area. The only notes published, so far as I know, are those of Mr. J. E. Spurr.[1] For the material and permission to use it in this way, I am indebted to Mr Hastings.

The specimens of rock and ore have been collected in a systematic study of the Goldfield district and vicinity. A greater number of these specimens necessarily represent the more obscure or less easily identified of the outcrops, together with the more complex structural areas. Altogether, however, the set must represent quite fully the range of rock-types of the district, and the comparative number of specimens in each type must indicate roughly their relative importance either areally, structurally, or economically.

The list of rock-types[2] includes,—(1), felsites, rhyolites, tra-

* By Charles P. Berkey.

[1] *Bulletin No. 260, U. S. Geological Survey*, p. 133 (1905). *Bulletin No. 225, U. S. Geological Survey*, pp. 118–119 (1903).

[2] A similarity to the rocks of Tonopah, Nevada, is readily noted. The chief types described by Spurr for that area are: rhyolite, andesite, and dacite. *Bulletin No. 219, U. S. Geological Survey*, p. 12–15, 1903. *Professional Paper No. 42, U. S. Geological Survey*, p. 30–71.

chy-andesites, dacites, andesites, and basalts, representing felsitic and porphyritic varieties; (2), a granite as the only granitoid variety, except two or three cases of granular holocrystalline andesites and basalts that may, with equal propriety, classify as diorite and dolerite, so far as this examination applies; (3), rhyolitic, dacitic, and andesitic tuffs among the pyroclastics; and (4), a carbonaceous quartz-slate as a representative of hydroclastics.

Andesites, the dominant type, include 78 specimens, or more than half of the total number. Next, numerically, is dacite, of which there are 21 specimens. Then follows the rhyolites to the number of 8 specimens, and, finally, basalt, of which only 3 in the original identification list were so classed, although there are 5 more, included with the andesites, that carry so much olivine and are of such strong basic affinities that they could, with equal reason, be included with the basalts. No other type occurs in large numbers.

Silicified, indurated rocks include the specimens of ores and several others, and are treated separately.

In the following list the numbers of the specimen corresponds to the numbers on the map, Fig. 1, and are the serial numbers preserved with them and the corresponding thin sections in the Petrographic Laboratory of Columbia University, New York, N. Y., and by Mr. Hastings at Denver, Colo.

Granite, No. 1. The rock is very coarse-grained, with an unusually large amount of quartz, which carries numerous inclusions, largely in trains, some passing from one grain to another. Cracks also extend across in a similar manner, showing, on the whole, considerable crushing and recementing. The rock has no other gneissic characters. Orthoclase is abundant and uniformly clouded with kaolin-alteration, making it nearly opaque. There is a little albite. Iron oxide, hematite, gives a brown stain in a few spots. No identifiable dark mineral is seen in the slide. The rock is an exceptionally acid variety of granite, and is a fair representative of the alaskite of Spurr.

Rhyolite (Nos. 62 to 68). Most of these rocks show a characteristic flowage-structure, and a spherulitic or mottled, devitrified ground-mass. Quartz is abundant, both in the ground-mass and in rounded or angular phenocrysts, sometimes giving

a decided porphyritic aspect. Resorption of the phenocrysts is marked. Biotite is the chief dark mineral. Orthoclase predominates over plagioclase. Magnetite is abundant in one or two specimens. The dark minerals are not conspicuous. Scapolite is developed to a considerable extent in 3 specimens, taking, in part, the place of original feldspars. A mottling of the rock, due to silicification, is also noticeable. No attempt has been made to indicate the field-relationships or the history by a differentiation into rhyolites and quartz-porphyries.

Felsite (Nos. 129, 130). There are two rocks of acid character, with glassy and devitrified ground-mass, showing flowage, that are called felsites, chiefly because of inability to decide whether rhyolitic or dacitic affinities prevail. Quartz is the only abundant determinable mineral, although both orthoclase and a plagioclase are present. Biotite and pyroxene are also present. The two rocks are not alike, however, and evidently do not belong to the same flow. They are regarded as a sub-type between the characteristic rhyolites of the district and the dacites proper, both of which are well recognized.

Dacite (Nos. 27 to 61). This group shows considerable variation. There are no less than 8 sub-varieties or sub-groups, based upon minor specific differences among them, as seen in the microscope. One specimen, at least, has about an equal claim to classification with the rhyolites, and from this they represent many different mixtures and proportions to the other extreme, where one specimen of decidedly basic character, and in which olivine and augite are prominent constituents, can, with even better propriety, be placed with the quartz-basalts. The ground-mass of these rocks is either glassy to felsitic, or spherulitic and mottled, or pilitic. Flowage is a prevailing structure, specially marked in those of pilitic habit, and is well-developed even in the more crystalline varieties. Nearly all are porphyritic, although the phenocrysts are mostly very small, or, at best, inconspicuous, except as seen in thin section. Plagioclase is abundant as phenocrysts. The medium types all carry biotite in considerable amount as the chief dark constituent (Nos. 28, 29, 30). Hornblende is present with biotite, and in Nos. 31, 32, 41, 42 and 85 it becomes the chief ferro-magnesian constituent, and is developed in fine idiomorphic individuals. Most of those, low in biotite and hornblende, carry augite, showing the same range as is seen in the group of andesites proper, and the extreme in this direction is reached in the specimens before noted, in which olivine also appears. Therefore, as outlined above, the series, in which quartz is a prominent constituent, exhibits the complete range from rhyolite and quartz-felsite, through mica-dacites, hornblende-dacites, augite-dacites, to quartz-basalts.

Trachy-Andesite (3 specimens). There are no true trachytes. One specimen in particular (No. 94), and two others to less-marked degree, are decidedly more acid than the average andesite, and have a trachitoid structure. The relative abundance of the different feldspars is in question. But the relative position of these rocks, among the others of the whole series, is best indicated by the above name.

Andesites (78 specimens, subdivided below). The andesitic rocks are in greatest number, surpassing all other types combined, and exhibiting the greatest number of minor differences among themselves, which indicate separable structural field-units of flows, sheets or dikes. The more basic varieties are the most perfectly preserved rocks of the district. The large number involved, and the evident importance of the group, make it advisable to subdivide into specific mineralogical varieties. Porphyritic development is prevalent, though often on a microscopic scale. Those most notable are referred to in the geology of the district as andesite-porphyries. In the present discussion, however, those textural variations are largely ignored in the effort to indicate the mineralogical relationships. They cover the entire range from trachy-andesites to the basalts proper.

Mica-Andesite (3 specimens). Biotite is the chief ferro-magnesian mineral. Hornblende is either negligible or is present in subordinate amount. Chlorite is a common secondary (Nos. 3, 4, 17). In several much altered specimens the ferro-magnesian mineral is destroyed. Some of them probably belong in this group.

Hornblende-Andesite (11 specimens). Hornblende is the chief dark mineral (Nos. 5, 19, 20, 26), occurring abundantly as phenocrysts with resorbed borders, and frequently attacked by chloritic alteration. Plagioclase is, however, the chief idiomorphic mineral, sometimes showing exceptional zonal growth

and giving a marked porphyritic texture (Nos. 20, 19). Biotite is usually present in minor amount. The ground-mass is mottled or exceedingly fine felsitic or pilitic in texture. Occasionally, there is excessive alteration and induration of the whole rock (No. 45), and the structure and appearance of the product is precisely the same as specimens of ore. Iron oxide and calcite are common secondary products. One rock included here is heavily impregnated with iron oxide in small grains or specks that are so persistent and uniformly distributed as to suggest simple oxidation of a pyrite-rock. It is otherwise also much modified in composition by the usual weathering products, so that nothing but these and a few structural outlines remain to indicate its relationships (No. 23). The group, in part, include rocks that carry little dark mineral and are of acid character. A great number are of medium andesitic composition.

Pyroxene-Andesite (augite-andesite), (41 specimens). By far the greater number of andesites carry pyroxene. Common augite is the prevailing species. There are 41 rocks of this class, exclusive of those also carrying olivine, which are discussed separately; 14 specimens have little pyroxene, or, indeed, any other ferro-magnesian constituent. A few of them are among the most acid of the andesite group. As a rule, they have a fine pilitic ground-mass; they usually show flowage, and a porphyritic texture prevails. Resorption of the phenocrysts and zonal growth are almost constant characters; 18 have a trachytoid structure, with chiefly lath plagioclase instead of orthoclase in the ground-mass; 4 rocks (Nos. 88, 86, 83, 76) have biotite, in addition to augite, as a dark constituent. Hornblende is the additional basic mineral in 8 specimens, though it is abundant in only 2 (Nos. 16 and 85), and there is an occasional grain in many others; 4 are very strongly porphyritic, giving a strikingly granular aspect to the ground-mass, which, with higher magnification, exhibits multitudes of stout pyroxene rods. This variety is also the extreme in basicity of the simple pyroxene-andesite group (Nos. 72, 73, 74). Two specimens (Nos. 87 and 24) have a dense, stony, perhaps devitrified, ground-mass, giving a distinct structural variety. One (No. 98) has zonal growth of the feldspars and pyroxenes developed to an extraordinary degree—some of them also marking resorption stages. One specimen (No. 12) is distinctly fragmental in its larger units, but is considered a flowage breccia rather than a tuff. As a group, the augite-andesites are of great variety in minor characters, and represent numerous different field-units.

Hypersthene-Andesites. In 3 specimens hypersthene occurs as an essential constituent, in addition to augite and some hornblende (Nos. 92, 100, 105). They are not all of the same structural type.

Olivine-Bearing Pyroxene-Andesite (20 specimens). This whole sub-group carries olivine in addition to augite. Hornblende and biotite are absent, except rarely. The set of rocks classified here varies from very little olivine (which is true of 4 specimens) to an equal number at the other extreme, where it becomes the chief basic constituent, and where the general basic composition so nearly balances the feldspathic component that they may, with equal propriety, be included with the basalts. In a large majority of the numbers, however, the light-colored, leucocratic minerals are in excess of the melanocratics. The type is, therefore, of considerable abundance in the district. Labradorite is the abundant feldspar, but anorthite appears in the most basic. Three (3) specimens show diabasic structural tendency. One (No. 116) is also rather coarse-grained for this group, and therefore is of dolerite or diabase affinities (No. 125). These rocks are, for the most part, strongly porphyritic. They are not so prominently modified by alteration as many of the more acid groups. They are not indurated, and in a large number the olivines are still very fresh. Two of the specimens have a notably granular ground-mass (No. 113), due to pyroxene of the second generation. A fine pilitic or trachytoid ground-mass is more common. One (No. 127) shows marked flowage-structure and zonal growth of the phenocrysts to an unusual degree—16 stages appearing on one feldspar. All of the constituents occur as phenocrysts. Magnetite is very abundant in some cases.

Quartz-Basalt.—One of the most basic of the above series (No. 115) carries quartz phenocrysts as a prominent constituent. Olivine is plentiful and augite is very abundant,—both together, at least, equalling the feldspars in the rock. The quartz occurs in large grains, showing resorption, and surrounded by a mass

of granules and columns of augite resembling the Lassen's Peak quartz-basalt, described by Diller. The rock forms the basic limit of the quartz-bearing porphyries of the district, already mentioned under the dacites.

Basalt (3 specimens).—All are olivine basalts of the same general character as the most basic described under the olivine-bearing pyroxene-andesites above. These are still more basic (Nos. 122, 123, 124). Olivine occurs in the ground-mass and as phenocrysts. Much of the augite is granular or micro-idiomorphic in the ground-mass. In relative abundance the constituents are augite, plagioclase, olivine, magnetite. The rocks, which form the basic end of the series at Goldfield, are fresh, the olivines showing staining only along the cracks.

Alteration-Varieties.—A few of the specimens show unusual or exceptionally complete alteration. No. 7 was originally an olivine-bearing augite-andesite. The traces of original structure are still so well preserved that the zonal growth of former feldspar areas can be seen. But the rock is now largely composed of a very feebly porlarizing substance, so feeble in places as to require a sensitive tint to detect the change, and this has taken the place not only of the feldspar and olivine, but of any other constituent. It is regarded as chiefly serpentine. The rock is a pseudomorph throughout. Three of the rocks, and, to a lesser degree, a few others, have developed scapolite. They are types of dacitic affinities where determinable. Pyrite is abundant in them, and secondary quartz is in large amount in them. Scapolite has formed at the expense of the feldspar. Traces of original biotite and hornblende occur, and magnetite is the only prominent original mineral left, except an occasional quartz phenocryst. A good many of the slides show silicification. The mottled quartz-bespattered ground-mass, so often seen in the more acid and more altered varieties, is doubtless due to this process. It is a common condition in these rocks, and is especially marked in the ores and in those specimens heavily charged with pyrite. Silicification is the most characteristic alteration effect seen in the rocks of the district.

Volcanic Ash, Tuff.—Several specimens are extremely fine-grained, and lack all the structures that are so persistent in the other rocks. They are evidently much altered also, which adds to the uncertainty of their identification. The coarser ones are more satisfactory, and are certainly tuffs. The finer ones are called volcanic ash (Nos. 133–137),

Shale, or Slate.—Two specimens (Nos. 140 and 141) are very uniformly granular, black, very fine-grained, in which quartz, sometimes interlocking, can be identified. Besides, there are multitudes of uniformly distributed black specks, in part, perhaps iron oxide, but, in part, thought to be carbonaceous matter. Small quartz-veinlets abound, especially in No. 140. The rock, a sedimentary one, is a silicified carbonaceous shale, and occurs as an inclusion in one of the trachy-andesites.

Ores.—Not more than 10 of the specimens are ores. They are all quartzose. The interlocking-grains are small, prevailingly of microscopic size. In some specimens, all original structures are obliterated in the process of silicification and mineralization that they have endured. In a few, however, there are satisfactory traces of original structures and minerals,—such as original phenocrysts,—that prove the igneous character of the original rock. The forms of the phenocrysts have persisted after everything else has been lost. There is no doubt in these cases that the ores are essentially silicified porphyry, and that the mineralization has accompanied silicification. Scapolite occurs in some of these cases. A few show previous crushing, the traces of brecciation being still preserved. Therefore, the silicification probably follows these crush-zones through the formations. Hematite (No. 138) occasionally holds the place of original pyrite. But in the best slides 4 metallic minerals occur—all perfectly fresh,—gold, pyrite, a massive or granular reddish-bronze, dark, metallic mineral (unidentified), and a whitish-gray columnar or acicular metallic mineral, probably bismuthinite. There are strong tests for bismuth from fragments of the ore, and it is thought that both the last two minerals (No. 40) carry that element. The metallics are promiscuously distributed through the siliceous matrix, and, in the same manner, through and among each other. Doubtless, they were all formed in the process that involved the silicification of the rock, and, in these cases at least, they have suffered little change.

IV. List of Specimens.*

The following list of rock-specimens gives the specific localities and the identification; the numbers correspond to those on the map, Fig. 1.

1. S. 85 E., 250 ft. from NW. cor. Examiner, Section 36. Granite.
2. N. 20 E., 300 ft. from S. side center Huntch Bell, No. 18, Section 5. Felsitic andesite.
3. Half-way between Banner and Knickerbocker mountains, Section 32. Mica-andesite.
4. A piece from near the flagstaff on Banner mountain, as little altered as could be found, Section 31. Indurated mica-andesite.
5. Butte 250 ft. SW. of SW. cor. of Blind Ledge, Section 33. Hornblende-andesite.
6. Butte 1,200 ft. S. of ¼ cor. to Sections 4–33, Section 4. Andesite.
7. Fine-grained altered rock from shaft back of hill on S. end of Jumbo, Section 1. Andesite.
8. Float from St. Ives, probably came out of workings S. of shaft, Section 36. Altered andesite.
9. Dump about 800 ft. S. (?) of Portand Mining Co.'s shaft, Section 12. Olivine-andesite.
10. Butte adjoining W. side center Gold Coin, Section 2. Pyroxene-andesite.
11. Rustler Fraction W. side center, Section 1. Andesite.
12. Breccia from Piedmont Fraction; this outcrops at foot of hill below the rhyolite, Section 35. Andesite flowage-breccia.
13. Gold Standard discovery, Section 25. Andesite.
14. Ridge at W. side cor. Gold Watch, freshest piece to be found, Section 29. Felsitic andesite, scapolite rock.
15. Little E. of N. side cor. Utah, Section 24. Andesite.
16. Tonapah Club, SE. cor., Section 24. Pyroxenic hornblende-andesite.
17. N. 10° W., 100 ft. from Belmont Queen discovery, Section 24. Mica-andesite.
18. Oakes discovery, Section 24. Andesite.
19. Half-way between Victor and Great Bend, Section 19. Andesite.
20. Between Diamondfield and the Black Butte claim, Section 20. Andesite.
21. Outcrop near Nye and Esmeralda Co.'s boundary stake, on road to Diamondfield, Section 20. Andesite.
22. 200 ft. S. of SW. cor. of Black Butte, Section 20. Andesite.
23. N. 65° E., 140 ft. from Calico discovery, Section 22, the freshest piece to be found in a large area. Andesite, badly weathered.
24. Dike on Willows claim, Section 27. Andesite with glassy ground-mass.
25. 100 ft. NE. from SE. cor. Hesperion, Section 30. Trachyte tuff, probably.
26. Knickerbocker mountain, exact location lost, Section 5. Indurated andesite.
27. Oro Goldfield shaft dump, Section 36. Dacite-porphyry.
28. Same, a little away from the shaft. Dacite-porphyry.
29. Same, from this vicinity, Section 36. Dacite-porphyry.
30. From low hill near NW. cor. of St. Louis. Dacite-porphyry.

* Collected by Mr. Hastings and determined by Dr. Berkey.

31, 32. Jumbo Ex. dump, Section 36. Dacite-porphyry.
33, 34. From open cut N. of St. Ives shaft, Section 36. Dacite-porphyry.
35. Knickerbocker mountain summit, Section 4. Dacite-porphyry, indurated
36. Typical sample of the country-rock carrying the veins. Dacite-porphyry.
37. Florence rock from the dump, Section 1. Altered dacite, scapolite rock.
38. Ditto, heavily silicified, Section 1. Indurated dacite, ore.
39. Rich mill-rock, Florence. Indurated dacite, ore.
40. Florence ore.
41. About 300 ft. E. of Minnevada tunnel, Section 31. Dacite-porphyry.
42. Ditto, 200 ft. E. of tunnel. Dacite-porphpry with pyroxene.
43. Dewdrop shaft, Section 21. Dacite.
44. Gold Fountain, SE. cor., Section 20. Hornblende-dacite-porphyry.
45. Huntch Bell, S. side center, Section 5. A much-altered rock, either andesite or dacite.
46. NE. cor Midway Fraction, Section 31. Dacite.
47. Ditto, from N. end of flow. Dacite.
48. New York No. 1 discovery, Section 33. Silicified porphyry.
49. 500 ft. SW. of SW. cor. Union Jack, Section 1. Silicified and scapolitic rock.
50, 51. Butte, 1 mile S. of town, Section 11. Dacite-porphyry.
52. Wild Horse claim, S. end, lower flow butting against mesa, Section 11. Dacite.
53, 54. Wild Horse claim, S. end, lower flow butting against mesa, Section 11. Olivine-bearing pyroxene-dacite.
55, 56. Same as the last three, but east of the road. Dacite-porphyry.
57, 58. Regarded as the same rock as No. 52, from bluff east of Lida road, Section 14. Dacite.
59. Detached area S. of No. 59. Dacite.
60. Top part of No. 57 flow. Olivine-bearing pyroxene-dacite.
61. Valley View—Eclipse claims, from top of the Table mountain on which these claims are situate, Section 12. Dacite.
62. Meda claim, Section 7. Spherulitic rhyolite-porphyry.
63. Cor. to Sections 7, 8, 17, 18, Section 17. Rhyolite.
64. West slope of Columbia mountain. Rhyolite.
65. SE. cor. Desert Rose, No. 1, the rock with abundant quartzes E. of Sandstorm, Section 24. Rhyolite.
66. Lucky Boy amended discovery; the slates are 125 ft. wide, and west of them this rock outcrops, Section 36. Rhyolite.
67, 68. From top of Columbia mountain. Rhyolite.
69. Quartzite shaft dump, Section 20. Pyroxene-andesite.
70. Alhambra, S. side center, Section 31. Pyroxene-andesite.
71. Just E. of intersection of Commonwealth and N. Y. side line, Section 31. Pyroxene-andesite.
72. 600 ft. SE. of NE. cor. Ida May, Section 9. Pyroxene-andesite.
73. Grasshopper Nos. 1 and 2, 50 ft. E. of E. and W. side center, Section 8. Pyroxene-andesite.
74. 75 ft. W. from N. side center Huntch Bell, No. 9, Section 31. Pyroxene-andesite.
75. Chicago, SW. cor., Section 33. Pyroxene-andesite.
76. N. Y. No. 1 discovery shaft, Section 33. Pyroxene-andesite.
77, 78. True Bell, W. side center, Section 31. Pyroxene-andesite.
79. E. side center Lady June, Section 31. Pyroxene-andesite, chloritic.

80. 50 ft. E. of SW. cor. of Fraction claim at foot of east slope of Vindicator mountain, Section 30. Pyroxene-andesite.
81. NE. cor. Gold Standard, Section 25. Pyroxene-andesite.
82. N. Y. No. 2, W. side center, Section 33. Pyroxene-andesite.
83. S. 20° E. 200 ft. from SW. and SE. corners Elizabeth and Jack Rabbit Fraction, Section 31. Pyroxene-andesite.
84. Oakes discovery shaft, Section 24. Pyroxene-andesite.
85. 200 ft. SW. of SW. cor. Adams, Section 25. Pyroxene-andesite.
86. Blackrock discovery, Section 24. Pyroxene-andesite.
87. Sections 13–24. Pyroxene-andesite.
88. Cloudy day dike? from shaft, Section 24. Pyroxene-andesite.
89. Red Butte, NE. cor., Section 19. Pyroxene-andesite.
90. From hummock east of low hill near NW. cor. of St. Louis, Section 36. Pyroxene-andesite.
91. N. 70° E. from SE. cor. Red Butte, Section 19. Pyroxene-andesite.
92. Athabasca, E. side cor., Section 19. Pyroxene (hypersthene)-andesite.
93. Autumn discovery, Section 24. Pyroxene-andesite.
94. Butte near Adams shaft, Section 25. Pyroxene-trachy-andesite.
95. S. 64° W., 100 ft. from NW. cor. Huntch Bell, No. 3, Section 5. Pyroxene-andesite.
96. Area close to Florence shaft on the east, Section 1. Pyroxene-andesite.
97. Rustler Fraction, N. 30° E. from E. side center, Section 1. Pyroxene-andesite.
98, 99. From hill west of Myers peak, Section 1. Pyroxene-andesite.
100. Red Lion boundary, Section 12. Hypersthene-andesite.
101. Location unknown. Pyroxene-andesite.
102. 100 ft. E. of S. side cor., Section 20. Pyroxene-andesite.
103. Top of bluff on summit, east of Lida road, Section 14. Pyroxene-andesite.
104. Summit of butte, south of Blue Bird, Daisy No. 2, and 3 Friends Fraction, and west of Black Butte, Section 20. Pyroxene-andesite.
105. Detached dome west of Tonopah road, Gold Leaf discovery, Section 26. Hypersthene-andesite.
106, 107, 108. Upper flow on mesa west and southwest of town, Section 11. Olivine-bearing pyroxene-andesite.
109. Top of butte where tanks of Goldfield Water Co. are situated, Section 2. Olivine-bearing pyroxene-andesite.
110. Upper flow on mesa at head of gulch at Wild Horse claim, A of Fig. 1, Section 11. Olivine-bearing pyroxene-andesite.
111, 112. E. of Fig. 1, south end Wild Horse claim, Section 11. Olivine-bearing pyroxene-andesite.
113. From behind butte on which water-tank is situated, at mouth of gulch west of town. Dike? Section 10. Olivine-bearing pyroxene-andesite.
114. Goldfield Brewery well, Section 3. Olivine-bearing pyroxene-andesite.
115. Well at Los Angeles Co.'s mill west of town, Section 2. Quartz-basalt.
116. Fifty-foot well, S. 10 E., 660 ft. from Goldfield Hospital, Section 2. Olivine-bearing pyroxene-andesite.
117. Area, Section 12. Olivine-bearing pyroxene-andesite.
118. 1,650 ft. E. of cor. to Sections 4, 5, 32, 33. Olivine-bearing pyroxene-andesite.
119. NW. cor. Red Lion Fraction, Section 7. Olivine-bearing pyroxene-andesite.

120. Capping of hill, 100 ft. E. of W. side center Anaconda, Section 22. Olivine-bearing pyroxene-andesite.

121. Willows No. 1, near W. side center, Section 27. Olivine-bearing pyroxene-andesite.

122, 123. Myers Peak, Section 12. Olivine-basalt.

124. From top of bluff, a little SE. of summit, on Lida road, Section 14. Olivine-basalt.

125. Alvarado, SE. cor., Section 13. Olivine-bearing pyroxene-andesite, near basalt.

126. Grubstake Fraction, on S. side of SW. cor., Section 4. Olivine-bearing pyroxene-andesite, near basalt.

127. Highwater, SW. cor., Section 19. Olivine-bearing pyroxene-andesite, near basalt.

128. From top of bluff, a little east of Lida road, after crossing summit, Section 14. Pyroxene-andesite.

129. Lower flow on malapais mesa, near divide on Lida road, S. of town, W. of road, SE. cor. of map. Felsite.

130. Normal piece from lower flow on mesa, SW. of town, Section 11. Felsite.

133, 134. Desert Rose No. 1, Section 24. Volcanic ash.

135. Tonopah Club, Section 24. Volcanic ash.

136. Locality unknown. Volcanic ash.

137. Near Tinhorn, Section 5. Volcanic tuff.

138. An indurated rock of doubtful identity.

139. West slope Columbia mountain, near foot, Section 35. Tuff.

140. Lucky Boy, inclusion in alaskite and rhyolite, Vindicator mountain, Section 36. Indurated shale.

141. SW. end of Columbia mountain, inclusion in alaskite and rhyolite, principally former, Section 35. Black slate or indurated shale.

142, 143. Locality unknown. Silicified rock, indurated porphyry.