PLACER DEPOSITS OF THE MANHATTAN DISTRICT, NEVADA.

By Henry G. Ferguson.

FIELD WORK AND ACKNOWLEDGMENTS.

During the field season of 1915 the writer spent four months in the study of the geology and ore deposits of the Manhattan district, Nev. The placer deposits offered problems of particular interest. Unfortunately in the present state of mining in the district these deposits could not be examined as thoroughly as might be desirable, and the present paper is offered as a description of an interesting type of deposit rather than a solution of the problems involved in the study of the Manhattan placers. The writer desires particularly to acknowledge his indebtedness to Mr. L. F. Clar, a veteran placer miner of the district, for much valuable information as well as for many helpful suggestions. The principal mining men of the district, among whom may be mentioned Messrs. C. Phillipps, S. E. Smith, T. S. Willetts, Percival Nash, and Omer Maris, all aided the writer in his work.

PREVIOUS WORK.

The geology of parts of the Toquima and Toyabe ranges was first made known by the geologists of the early surveys of the West. S. F. Emmons, of the King Survey, studied the Toyabe Range in some detail and also crossed the Toquima Range and visited Belmont, at that time the center of a prosperous mining district.[1] G. K. Gilbert, while a member of the Hayden Survey, also visited Belmont.[2] A geologic reconnaissance of the portion of the range between Belmont and the site of the present town of Manhattan was made by Spurr in 1899[3] in the course of his explorations in central Nevada. Soon after the discovery of ore, but before the discovery of the placers, Manhattan was visited by W. H. Emmons and

[1] U. S. Geol. Expl. 40th Par. Rept., vol. 3, pp. 320–345, 393–405, 1870.
[2] U. S. Geog. and Geol. Surveys W. 100th Mer. Rept., vol. 3, pp. 36, 180, 245, 1875.
[3] Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, pp. 90–93, 1903.

G. H. Garrey, and their report is the most important publication dealing with the geology and ore deposits of the district.[1] A description of conditions in the early days at Manhattan is given in a short paper by Claude T. Rice.[2] The first reference to the Manhattan placers occurs in an article by G. A. Packard,[3] which contains an interesting description of early methods of working the surface placers. An article dealing directly with the placer mines was published by C. C. Jones in 1909.[4] This paper gives a detailed description of the state of mining at that time. Other publications on the district deal exclusively with the lode deposits and the production of the lode mines.[5]

LOCATION AND TOPOGRAPHY.

The Toquima Range is situated in central Nevada (see fig. 18), between the Toyabe and Monitor ranges, and is one of the less prominent of the many narrow, isolated mountain ranges which are such notable features of the Great Basin topography. It trends in a northeasterly to northerly direction and extends from about latitude 38° 25′ N. to about 39° 25′ N. At Manhattan the range is broken by a low pass, and the portion of the range to the south is sometimes called the Smoky Mountains. The maximum elevation of this southern portion of the range is about 8,500 feet in the peaks west of Indian Spring. The main range is higher, and Jefferson Peak, east of Round Mountain, has an elevation of about 10,000 feet. The crest line is somewhat nearer the eastern than the western border of the range.

The range is bordered by desert valleys—Ralston Valley on the east and Big Smoky Valley on the west. On both sides, but particularly on the west, the boundary between rock in place and valley fill is irregular, in marked contrast to the sharp line of demarcation on the eastern front of the Toyabe Range. At its southern end a low, broad pass filled with desert wash separates the Toquima and San Antonio ranges.

[1] Garrey, G. H., and Emmons, W. H., Notes on the Manhattan district: U. S. Geol. Survey Bull. 303, pp. 84–93, 1907.

[2] Rice, C. T., The Manhattan mining district, Nev.: Eng. and Min. Jour., vol. 82, pp. 581–584, 1906.

[3] Packard, G. A., Round Mountain camp, Nev.: Eng. and Min. Jour., vol. 83, pp. 150–151, 1907.

[4] Jones, C. C., Notes on Manhattan placers, Nye County, Nev.: Eng. and Min. Jour. vol. 88, pp. 101–104, 1909.

[5] Jenney, W. P., Geology of the Manhattan district, Nev.: Eng. and Min. Jour., vol. 88, pp. 82–83, 1909.

Evans, C. R., Manhattan: Am. Min. Cong. 12th Ann. Sess. Proc., pp. 398–400, 1909.

Toll, R. H., Present aspect of the Manhattan district, Nev.: Min. and Eng. World, vol. 35, pp. 539–640, 1911.

Quinn, P. J., Treatment at the Big Pine, Manhattan: Min. and Sci. Press, vol. 111, p. 320, 1915.

Nash, Percival, The mines and mills of Manhattan: Tonopah Miner, Aug. 15, 1915; abstract in Min. and Sci. Press, vol. 111, p. 523, 1915.

Irregular hills jut out into the valley in many places. Between the waste-filled portion of the valley and the foothills of the range there is in most places an irregular strip, at the greatest 1 mile in width, where the rock surface continues the gentle grade of the valley sides. This is well shown in the northwestern part of the Manhattan area. The border of the range is more clearly defined on the side of Ralston Valley than on the side of Smoky Valley, and the hills facing Ralston Valley show bold escarpments, though here, as on the west side of the range, there is a border of rock plain between the hills and valley. South of Belmont a range of low hills extends southeast, connecting the Toquima Range with its eastern neighbor, the Monitor Range.

On the east flanks of the range the mountain topography is distinctly youthful, and the streams flow through steep canyons to the rock-cut bench which borders the valley. The hills are everywhere steep and rugged. On the west side, however, a more mature stage of erosion is reached, the stream valleys are flaring near their mouths and are graded in their lower courses, irregular smooth hills of more resistant rock show the effect of differential erosion, and it is only near the center of the range that there are steep canyons and rugged hills. A narrow belt along the crest of the range, above 9,000 feet elevation, shows a marked contrast to the rough topography below. Here there is a belt of rolling upland, not flat enough to be called a peneplain, but an area whose gentle relief indicates that it is a relic of very mature topography from a previous topographic cycle.

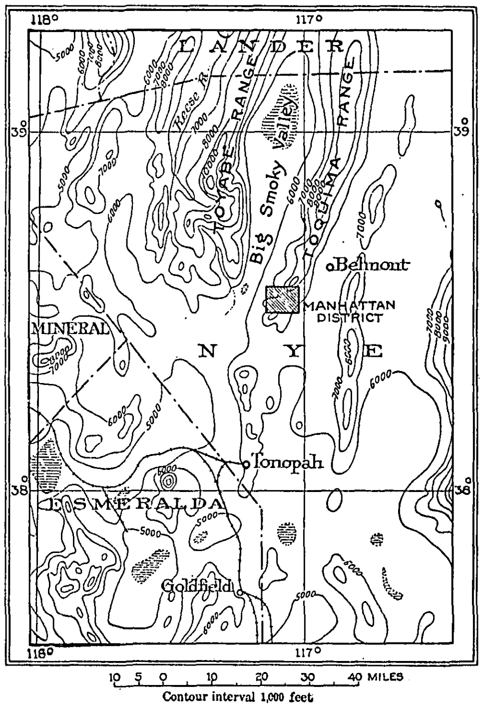


FIGURE 18.—Map of part of central Nevada, showing the location of the Manhattan district.

The Manhattan district has an arid desert climate, which is mitigated, however, by the presence of the mountains to the east. During the winter there is a considerable snowfall, and snow stays on the higher ridges for several months. In the summer short, heavy rains break the monotony of cloudless skies and at times give rise to destructive floods.

The Toyabe Range has a sufficient elevation to retain small patches of snow from year to year, and consequently permanent streams are fairly numerous, but in the Toquima Range streams are less common, although numerous small springs exist in the uplands. Northward from the south end of the range, as far as Shoshone Creek, a short distance north of Round Mountain, no stream carries sufficient surface water to allow it to overcome evaporation and reach the valley. In several of the dry canyons, such as Timber Hill Gulch and Manhattan Gulch, there is, however, a considerable underground flow beneath the gravels. In Manhattan Gulch this underground flow is estimated at about 50,000 gallons a day and is sufficient for placer-mining work.

The belt facing Big Smoky Valley supports only the usual desert bush growth. In the hills to the east, however, between elevations of 7,000 and 9,000 feet, there is a rather sparse growth of pine and juniper. Above the timber line only small clumps of mountain mahogany can exist. Shoshone and Jefferson creeks, before they are lost in the desert, are bordered by a thick growth of willows, which give a pleasant contrast to the parched surroundings. To the west the scanty desert vegetation becomes more and more sparse until the bare sun-baked playas of the central part of Smoky Valley are reached.

The nearest railroad point is Tonopah, 32 miles by road from Manhattan, with which it is connected by a daily automobile stage. Automobile stages connect Manhattan with Round Mountain and Belmont. In the early days of the Manhattan boom a railroad to connect Tonopah with Manhattan, Round Mountain, and Austin was surveyed but never constructed.

HISTORY AND PRODUCTION.

The discovery of the ore deposits of the present Manhattan district dates from April, 1905, when "specimen ore" was discovered by John C. Humphrey on April Fool Hill only about a hundred feet from the Belmont road. An old mine about 4 miles south of the present town of Manhattan had, however, been worked in the late sixties.

The discoveries of rich surface ore with plentiful free gold were made within a few hundred feet of the road leading west from the old camp of Belmont. It seems strange that such ore should have passed unnoticed for 40 years. The older prospectors, however, were looking for wide quartz veins of the type of those at Belmont, and took no notice of the inconspicuous lodes which characterize the later-discovered deposits.

In August following the discovery there was a rush of prospectors, but the camp was later deserted, though it filled up again the following winter. In March, 1906, there were 3,000 people in Manhattan and the immediate vicinity.[1] At about the time of the discovery of gold on April Fool Hill silver-bearing lead ore was found near the site of the now abandoned camp of Palo Alto.

During 1906 the district was in a state of great excitement, rich discoveries were constantly being reported, and people streamed in from all over the country. Besides Manhattan there were three other towns—East Manhattan, Central, and Palo Alto. To-day only rusty tin cans mark the site of Palo Alto, and a few shacks are all that is left of East Manhattan and Central. The winter of 1907–8 was marked by depression following the deflation of the boom, but the hard times, which led to temporary cessation of quartz mining, turned the attention of the miners to the placers of Manhattan Gulch and the possibilities of drift mining. Placer mining had been begun in 1906 with the dry washing of rich surface material on the Little Grey and Indian Camp claims, but the gulch was not prospected until the following year. The placers gave new life to the camp, for the gravel was extraordinarily rich in places, and mining comparatively cheap. The richest placer ground was exhausted by the end of 1912, and since then the placer production has decreased. Probably two or three years more will see the end of the more important placer operations.

The accompanying table[2] tells very clearly the story of the rise and decline of the lode and placer mines of the Manhattan district. The figures given for placer production are undoubtedly too low, for "high grading" is known to have been prevalent, and lessees sometimes conceal their returns to avoid payment of royalty and bullion tax.

Gold and silver production of the Manhattan district, Nev.

Year.	Lode mines.							
	Producing mines.	Ore (tons).	Gold.		Silver.		Total value.	Average value per ton.
			Fine ounces.	Value.	Fine ounces.	Value.		
1906	5	677	3,874	$80,074	5,697	$3,817	$83,891	$12.39
1907	5	....	....	....	....	....	33,622	....
1908	9	10,769	12,002	248,075	6,075	3,228	251,303	23.30
1909	13	4,198	3,710	76,691	1,937	907	77,598	18.48
1910	31	14,671	12,722	262,958	6,113	3,301	266,259	18.15
1911	....	13,945	20,255	418,683	8,489	4,499	423,182	30.35
1912	20	21,064	15,603	322,534	6,987	4,297	326,831	15.52
1913	31	46,228	13,733	283,854	4,516	2,728	286,582	6.19
1914	24	39,746	6,918	143,002	2,548	1,409	144,411	3.63
1915	19	46,990	7,742	160,064	2,621	1,329	161,393	3.43
	....	....	....	....	....	....	2,065,072	....

[1] Emmons, W. H., and Garrey, G. H., Notes on the Manhattan district: U. S. Geol. Survey Bull. 303, p. 85, 1907.
[2] From U. S. Geol. Survey Mineral Resources.

Gold and silver production of the Manhattan district, Nev.—Continued.

Year.	Placer mines.						Total value for lode and placer mines.
	Producing mines.	Gold.		Silver.		Total value.	
		Fine ounces.	Value.	Fine ounces.	Value.		
1906							$83,891
1907							33,622
1908	7					$16,371	267,674
1909	16	2,266	$46,847	965	$497	[a]67,344	[a]144,942
1910	29	4,772	98,644	1,958	1,077	99,701	365,960
1911	26	6,582	136,052	2,737	1,451	137,503	560,685
1912	17	8,152	168,512	3,232	1,987	170,499	497,330
1913	34	8,061	166,622	3,104	1,875	168,497	455,079
1914	31	6,307	130,370	2,323	1,247	131,617	276,018
1915	43	6,392	132,132	2,454	1,242	133,374	294,769
						924,906	2,979,980

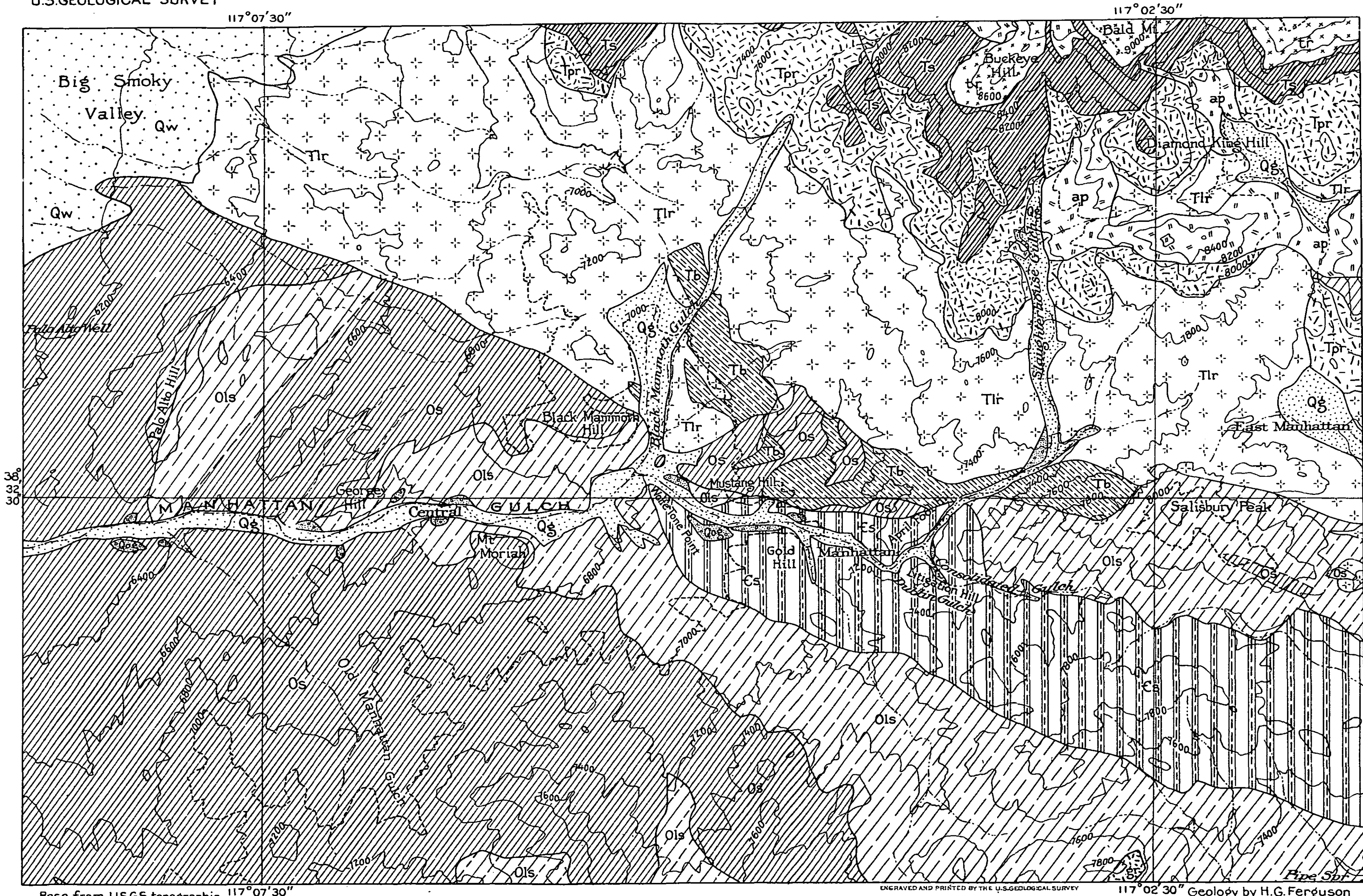
[a] U. S. Geol. Survey Mineral Resources, 1910, p. 526, 1911, states that placer production as given in the report for 1909 is $20,000 too low. This amount is therefore added to the totals, other figures remaining as given in Mineral Resources for 1909.

AREAL GEOLOGY.

ROCK FORMATIONS.

The rocks of the Manhattan district include Paleozoic sediments, intrusive granitic rocks of Mesozoic age, and Tertiary lavas and intrusives, with associated sediments. (See Pl. VI.) The older sediments are much metamorphosed and closely folded. Their general structure is that of an anticline whose axis strikes a few degrees west of north and pitches gently to the west. In the Manhattan district a threefold division of these sediments has been made. The first division consists dominantly of brown micaceous schist but also contains much quartzite and impure gray sandstone and a few small beds of crystalline limestone. It extends from Wolfe Tone Point southeast by east in a gradually widening belt, reaching a width of a little over a mile on the east border of the area. This division is followed by a series composed chiefly of dark limestone and black jasper but containing also much black and gray slate. This series occupies an irregular belt from half a mile to 2 miles in width surrounding the lower series. In places some of the beds are undoubtedly repeated by faulting.

The base of the highest sedimentary series is marked by lenticular beds of white quartzite, with which are associated a few feet of black slates. These slates contain numerous graptolites of Ordovician age. Above the quartzite horizon the upper series consists dominantly of schistose chloritic slates, with a few beds of brown slaty limestone and numerous small lenses of hard darker slate. These occur above the limestone series and occupy the extreme southwest part of the area. Here the ridges are in general parallel to the strike and more continuous than those of the limestone series.



PRELIMINARY GEOLOGIC MAP OF THE MANHATTAN DISTRICT, NEVADA

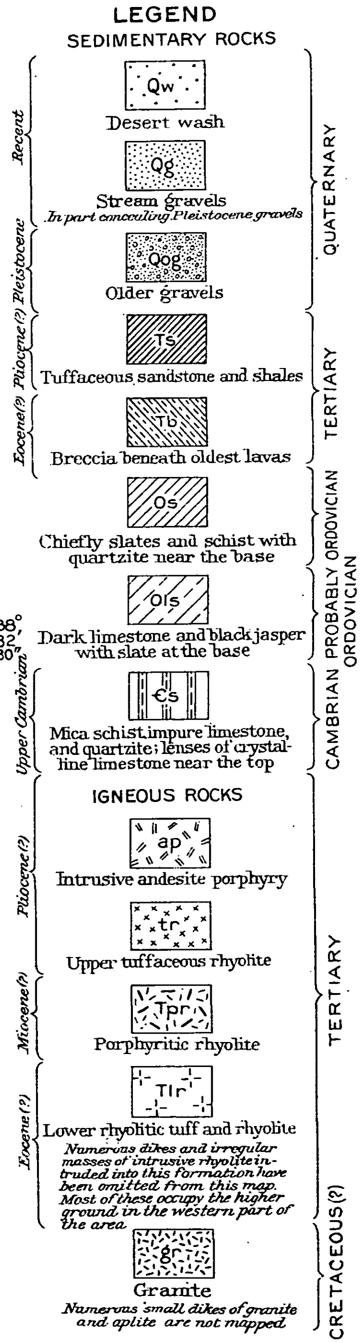
Geologic boundaries generalized and minor areas omitted

Scale $\frac{1}{48,000}$

1 ½ 0 1 Mile

Contour interval 200 feet

Datum is mean sea level



The lower limestone is in places silicified and extremely resistant and the quartzite bands differ widely in thickness. Hence the topography of the limestone area is extremely irregular, and isolated hills such as Black Mammoth Hill, Mount Moriah, and Palo Alto Hill stand without apparent relation to one another.

The rocks of the sedimentary formations all contribute to the Manhattan placers. Owing to their greater resistance quartzite pebbles are present in the lower gravels in far greater proportion than the other sediments. Large quartzite bowlders are common in nearly all the placers. The dark silicified limestone in some places occurs as large bowlders, but these are more rare. Pebbles of jasper and calcareous slate are numerous, but these rocks are too brittle to form large bowlders. Slate and schist occur chiefly as small flat pebbles, particularly in the fine gravels.

Granite is exposed over only a very small part of the area, but the isolated patches along the southern border are outliers of a mass which occupies large areas to the south, east, and north of the Manhattan district. Besides the granite there are many small alaskitic dikes which traverse the country rock, particularly in the southwestern part of the district. Granite is present only in a very small patch in the Manhattan Gulch drainage area. Granite pebbles are nevertheless not uncommon. It is probable that many of these pebbles were originally present as inclusions in the lower rhyolite, or it may be that the valley once drained a part of the granite area to the east.

Tertiary formations, chiefly lavas, occupy the northern and northwestern portions of the area. Between Big Smoky Valley and Black Mammoth Hill the contact with the sediments is sharp and is probably formed by a fault. East of Mustang Hill, however, a belt of breccia lies between the sediments and the lower member of the volcanic series. This is composed of angular fragments of the older sedimentary rocks and represents talus slopes of the prevolcanic period. In places it is well cemented but in the placer gravels is not distinguishable from the sediments from which it is derived. The earliest member of the volcanic series is a white rhyolite tuff containing numerous fragments of the older rocks. A few small flows of dark glassy rhyolite occur in the tuff series. The tuffs are easily eroded and occupy a broad lowland belt extending from the east border of the area to the northwest corner. The rock is too soft to be abundant in the placer gravels but forms a part of the unsorted wash close to the surface. Along a portion of the south border of the tuff area there are irregular intrusions of a fine-grained rhyolite. This rock is far more resistant than the tuff and finds topographic expression in the irregular hills north of Black Mammoth Hill and the Round Mountain road.

The next member of the series is a massive flow of porphyritic rhyolite, which forms the prominent cliffs of the hills south of Bald Mountain. It breaks into large blocks on weathering and has furnished a large proportion of the coarser material in the placer gravels. Above the porphyritic rhyolite are tuffs and sandstones of the same mineral composition which are only distinguishable from the lava where weathering has accentuated the bedding planes. Rhyolite and rhyolite-like tuff together have a maximum thickness of about 800 feet in the northeastern part of the area.

Above this series comes about 400 feet of thin-bedded quartzose sandstones and fine-grained shales, composed of material derived from the underlying rhyolite. These rocks, under the influence of weathering, split readily into thin plates, and the area which they occupy is marked for the most part by smooth slopes. The sandstones outcrop in an irregular belt above the steep slopes of the rhyolite porphyry near the summits of Bald Mountain and Buckeye Hill. As the rock is comparatively friable sandstone pebbles are not common in the placer gravels.

The next rock in the lava series is a white tuffaceous rhyolite, which closely resembles the lowest member of the series except that the foreign inclusions are much smaller and less conspicuous. This rock crowns Buckeye Hill and Bald Mountain and reaches its greatest development in the hills just to the east. It has a maximum thickness of 600 feet, though a part is lost by erosion. It is comparatively soft, and the pebbles are worn away before they enter the placer gravels of Manhattan Gulch.

An irregular mass of rather coarse grained andesite porphyry forms a line of sharp-pointed hills extending eastward from Slaughterhouse Gulch. This rock is intrusive into the lower tuffaceous rhyolite and porphyritic rhyolite and has probably entered along a fault plane, for the tuffaceous rhyolite is repeated on the north. Small dikes and masses of the same rock also occur on the flanks of Buckeye Hill and Bald Mountain, where they are intruded into the sandstone. These dikes were not found in the upper tuffaceous rhyolite, and as that rock carries no andesite pebbles the andesite porphyry is probably younger. It is very tough and resistant and pebbles are numerous in the placer deposits. The andesite porphyry occurs only in the northern portion of the area, so pebbles of this rock in the gravels south of the present gulch serve to distinguish the older stream gravels from the more recent wash from the hills to the south.

A small area of a more recent lava, probably dacitic in composition, overlies the sandstone in the northwestern part of the district but does not come within the Manhattan Gulch drainage area.

LODE DEPOSITS.

The lode deposits of the Toquima Range belong to two different periods. The intrusion of the quartz monzonite batholith and its accompanying silicic dikes was followed by a period of ore deposition, of which the most important examples are the tungsten deposits of Round Mountain and Spanish Springs and the silver-lead veins of Belmont. In the Manhattan district, however, no valuable deposits belong to this period. The Nemo mine, near Central, has been developed along small quartz veins containing galena, tetrahedrite, and chalcopyrite, and small silver-lead veins have been prospected near the abandoned camp of Palo Alto. A silver mine was worked in the sixties near the head of Old Manhattan Gulch, south of the area mapped.

All the gold and silver production has been derived from deposits of Tertiary age. The deposits are veins in the lava and schists and veins and replacement deposits in the crystalline limestone bands of the older schist series. In part, at least, the deposits are younger than the andesite porphyry, for the veins cut that rock.

The veins in the lavas have been prospected chiefly near Bald Mountain but have so far yielded little return. The ore consists of minute veins of iron-stained quartz, with minor amounts of calcite, which is in places replaced by quartz, barite, and rarely fluorite. Pyrite has been present but is now completely oxidized to limonite, though for the most part it retains the original shape of the pyrite crystal. Here and there minute specks of free gold can be seen on the surface of the grains of altered pyrite. None of these deposits has as yet reached the productive stage.

The veins in the Cambrian schist have been the largest producers in the district. These veins are confined to Gold Hill and the immediate vicinity. For the most part the lodes consist of numerous closely spaced minute quartz stringers, which cut the schist in all directions, following, however, a definite zone of mineralization. Near the surface these carry coarse gold in crystalline aggregates, almost certainly the result of secondary deposition. The little veins break readily from the schist country rock, so that it is possible to effect a preliminary concentration by screening. Barite is present in small amounts in the gangue and a little calcite was noted, but fluorite seems to be entirely absent. The mines working this type of deposit are the Big Four, Big Pine, Stray Dog, Jumping Jack, Union No. 9, Riley Fraction, and Little Grey, all within half a mile from the top of Gold Hill and within 3,000 feet of Manhattan Gulch. This type of deposit has undoubtedly furnished most of the gold to the placers of the gulch.

Narrow belts of limestone occur near the top of the lower schist series and have proved to be the locus of many ore deposits, particularly on Mustang, April Fool, and Litigation hills. Here the ore occurs both in narrow fissures and in replacement deposits extending out into the limestone from small mineralized fault fissures. In most of the deposits the gold is free and occurs in finely crystalline quartz. Near the deposits the limestone is in many places altered to very coarsely crystalline white calcite. Large crystals of fluorite are characteristic of the gangue. On the same belt of crystalline limestone, but differing from the other deposits, is the White Cap mine, at the head of Consolidated Gulch, about a mile east of town. Here the ore bodies consist of large replacement deposits in the limestone. In contrast to the other deposits free gold is lacking, and stibnite and realgar are present in considerable amounts. The gangue consists of hard, dense quartz and very coarsely crystalline white calcite.

The rocks of the upper sedimentary series have not proved productive, though small veinlets of quartz carrying free gold have been prospected on Black Mammoth and Georgey hills on the north side of the gulch.

In general the veins of the district have been characterized by the occurrence of rich "specimen ore" locally at the surface, followed by a sharp decline in tenor at moderate depth. Part of the gold has apparently been taken into solution and redeposited a short distance below the outcrop. Erosion has been more rapid than the process of enrichment, and a part of the gold of the enriched zone has been carried down into the gulch.

DEVELOPMENT OF THE PRESENT TOPOGRAPHY.

The period of volcanic activity ended sooner in the region occupied by the present Toquima Range than elsewhere in the Great Basin country, for Pleistocene lavas are probably lacking. The lava-covered region was eroded until an extremely mature topography, approaching the peneplain stage, was reached. This topography was fairly general over this portion of the Great Basin region, for Ball[1] mentions the existence of similar old topographic forms on the Kawich, Belted, Amargosa, and Panamint ranges to the south, and Meinzer[2] has found a similar mature topography on the Toyabe Range. As this older erosion surface extends over so large an area, it follows that the present mountain ranges must be of later date. Ball considers this mature land surface to be of late Pliocene age, as it is

[1] Ball, S. H., A geologic reconnaissance in southwestern Nevada and eastern California: U. S. Geol. Survey Bull. 308, pp. 16–17, 99, 119, 161, 202, 1907.

[2] Meinzer, O. E., Ground water in Big Smoky Valley, Nev.: U. S. Geol. Survey Water-Supply Paper 375, p. 90, 1915.

later than the "later rhyolite" of early Pliocene age and older than the later tuffs and older alluvium which mark the transition from Pliocene to Pleistocene. Hence the major part at least of the mountain-building movements must have been confined to the early Pleistocene, for at the period marked by the Pleistocene lakes a topography approaching the present had been attained.

A review of the controversy regarding Great Basin structure would be out of place in this paper. The writer believes that the Toyabe and Toquima ranges represent tilted fault blocks, the fault in each range being on the east side.

It would seem to be impossible for anyone looking at the eastern front of the Toyabe Range from the lower slope of the Toquima, across Big Smoky Valley, to doubt the presence of a fault scarp. Long spurs, which slope gently down from the crest, are sharply truncated and present steep triangular faces toward the valley. The great fault scarp is so fresh that, although the streams have cut canyons close to the valley, wide interstream areas are practically undissected. The streams themselves show the reversal of normal effects of erosion. The headwaters and upper reaches are wide and open, whereas at the mouths the streams flow through steep, narrow canyons. The front of the range follows a broadly sinuous rather than straight line, but in the 30 miles shown on the topographic map it varies less than a mile to either side of a north and south line. Faulting has continued until recent times, for Meinzer[1] reports that fault scarps cut the alluvial fans at the canyon mouths.

In the Toquima Range, however, there is an entirely different condition of affairs. On the west side the streams enter essentially at grade, and beneath the valley wash the rock shelf which borders the mountains deepens gradually westward. Moreover, the boundary between gravel and rock outcrop is irregular, and the gravel at the edges is clearly only a thin veneer resting on a planed-off rock surface. This rock bench ends rather abruptly on the east, in irregular ridges, the outliers of the main mountain mass. There is a notable lack of gradation between the gently sloping rock bench and the upland. The belt of irregular uplands shows generally youthful topography but approaching maturity. The larger stream valleys are in part filled with gravel in their lower courses, but the streams are still eroding their headwaters and eating back into the remnant of old topography which occupies the crest of the range. Terracing indicates more recent changes of level.

On the east side of the range there is a marked difference in the topography. Meadow Creek rises in the mature upland south of Mount Jefferson and flows southeast through a gradually narrowing valley until at its mouth it is inclosed in vertical walls of rhyo-

[1] Meinzer, O. E., op. cit., p. 91.

litic agglomerate. There is no flaring of the valley at the mouth, and the stream enters Monitor Valley over a broad, flat alluvial fan directly from the canyon. No difference in hardness of the rocks can explain this abnormality, for in its upper reaches the country rock is a dense rhyolite, whereas in the canyon it is a coarse rhyolitic agglomerate, which should be the more easily eroded of the two. East Manhattan Gulch also trends southeasterly from the low divide east of Manhattan to Ralston Valley, and, though without permanent surface flow, it exhibits the same inversion of normal conditions which characterizes Meadow Creek valley. Near East Manhattan there is a wide gravel-filled valley cut for the most part in the lower tuff and the underlying breccia but in part in the harder quartzite and schist of the older sediments. To the southeast the valley sides steepen until for a mile above its mouth the gulch is a deep, narrow canyon with walls of schist and jaspery limestone. These conditions in the two gorges probably indicate that the east front of the Toquima Range was formed by faulting, for if the large valley to the east were the work of erosion the tributary streams would of necessity be best graded near their mouths and would there closely approach the grade of the trunk stream that occupies the main valley. Other evidence of faulting is not as clear as in the Toyabe Range. The east front, particularly near Belmont, does not present a simple scarp, although north of the town a continuous line of rhyolite cliffs faces the valley. Movement along the fault plane bounding the Toquima Range probably ceased long before faulting had ended on the Toyabe, and wherever rocks of varying degrees of resistance were present, as the granites and Paleozoic sediments of Belmont, long-continued erosion has destroyed the fault scarp. Where the range is composed of fairly homogeneous rhyolite, as to the north of Belmont, the fault scarp has retreated fairly regularly, leaving a rock bench between it and the wash-filled valley.

The minor range connecting the Toquima and Toyabe ranges is probably the result of oblique faulting.

It is probable that a topography which in its main outlines at least resembled the present had been developed in early Pleistocene time, primarily through the agency of block faulting. During a period of less arid climate than the present, presumably contemporaneous with the Pleistocene Lakes Bonneville and Lahontan, two salt lakes, named Tonopah and Toyabe by Meinzer,[1] existed in Big Smoky Valley. Lake Tonopah was in the southern part of the valley, west of Tonopah, between Millers and Blair Junction, and Lake Toyabe occupied a portion of Big Smoky Valley between the Toquima and Toyabe

[1] Meinzer, O. E., op. cit., p. 90.

ranges. The southern limit of the lake was in latitude 38° 45′ N., a few miles north of Round Mountain, and it extended north to about latitude 39° 18′ N. Its length was about 40 miles, its maximum width 9 miles, and its depth 170 feet. Its position to-day is marked by the playa between Round Mountain and Milletts. According to Meinzer[1] the old shore lines are still horizontal.

MANHATTAN GULCH.

DRAINAGE AREA.

The drainage area of Manhattan Gulch extends eastward from Big Smoky Valley to a point on the Belmont road three-fourths of a mile west of East Manhattan, a distance of about 6 miles. The divide forming the eastern boundary follows a nearly straight line north to Bald Mountain and south to Summit Hill. The divide on the northern side is about 2 miles north of the gulch in the extreme eastern part, but it turns sharply southward, crosses the belt of soft rhyolite tuff at the head of Black Mammoth Gulch, and for the greater part of the distance parallels the course of Manhattan Gulch at a distance of a half to three-quarters of a mile to the north. On the southern side Timber Hill, a high ridge composed of metamorphic slates and a little granite, forms the divide, which follows a nearly straight westerly course about 2 miles south of Manhattan Gulch. The drainage area is thus notably asymmetric, for over the greater part of the area the divide is much nearer the gulch on the northern than on the southern side. It seems probable that the diversion of a part of the former drainage westward to Big Smoky Valley has been effected through the gradual disintegration of the belt of soft rhyolite tuff which crosses the head of Black Mammoth Gulch and the transportation of the material by occasional floods, rather than through normal stream erosion.

On the north side Manhattan Gulch receives two important tributaries, Slaughterhouse Gulch, which enters near the north end, and Black Mammoth Gulch, which joins the main valley between Black Mammoth and Mustang hills. Both gulches drain territory covered by volcanic rocks, and in both the prospect shafts show a deep filling of gravel. On the south side several gulches, of which the most important are Consolidated, Dublin, Big Pine, Auction, Old Manhattan, and an unnamed gulch in the extreme west, flow into the main valley. These gulches for the most part have a northwesterly course, roughly accordant with the strike of the sediments in which they have cut their valleys. None of them contain anything like the gravel de-

[1] Op. cit., p. 91.

posits of the northern tributaries, although all except the two westernmost are filled with gravel for a short distance back from their mouths. This difference is believed to be due not to any tilting northward but to the fact that the southward-flowing streams, in the period when erosion was at its height, easily cut their valleys down to grade across the belt of soft rhyolitic tuff, whereas those on the south, which flowed across rocks of more equal resistance, maintained a generally more even grade throughout.

There is no direct evidence of a change in either direction in the position of the main divide between Manhattan Gulch and the eastward-trending East Manhattan Gulch, though East Manhattan Gulch shows a topography directly the opposite of Manhattan Gulch. At its headwaters there is a low-lying area containing a few feet of waterworn gravel. Eastward toward Ralston Valley the stream flows on bedrock through a narrow canyon cut in metamorphic rocks. The stream has clearly the advantage in slope over Manhattan Gulch and is eating headward into the gravel area west of East Manhattan.

It is quite probable that the valley of the Pleistocene stream from which the present deep gravels are derived headed much farther to the east or southeast and lost its headwaters through capture. The only topographic evidence in favor of this change is the broad valley of Big Pine Gulch, which extends from Manhattan to Pipe Spring, in the southeast corner of the area shown on the Manhattan map. At a point about 1½ miles southeast of Manhattan and a mile west of Pipe Spring there is a low divide east of which the drainage goes eastward. At Pipe Spring the course of the stream changes sharply and turns southward through a steep canyon of granite and metamorphic sediments. South of the Belmont road is another low divide between the drainage of Manhattan and East Manhattan gulches, but there is nothing in the present topography to indicate stream capture. The lower gravels show an excess of pebbles derived from the sediments over those from the rhyolites, a relation which is reversed nearer the surface, and this change in the character of the gravels, together with the presence of well-rounded granite pebbles in the lower gravels, lends probability to the hypothesis that the stream formerly had a greater extension in the region covered by the granite and older sediments.

The course of Manhattan Gulch is an inheritance from an earlier physiographic cycle, for it is completely independent of the structure of the rocks across which it flows. The easily eroded rhyolitic tuff forms a lowland belt extending from east to northwest across the area but is nowhere occupied by a stream valley, whereas Manhattan Gulch over the greater part of its course is inclosed in walls of metamorphic sediments whose strike is transverse to the valley.

BEDROCK CONFIGURATION.

The gulch shows traces of several different stages of erosion. The earliest stage is not brought out in the topography but is shown in the patches of older gravels here and there along the valley sides at elevations whose greatest height is 70 feet above the present stream course. The later stages are preserved in the buried bedrock topography of the gulch itself.

The deepest channel on bedrock is at depths of 40 to more than 100 feet below the present surface of the gulch. Several fragmentary benches at higher elevations represent stages in the erosion of the canyon, but the outer walls are everywhere steep. The old Wolfe Tone shaft, for instance, reaches bedrock at a depth of 70 feet not over 50 feet from the rock outcrops on the end of Wolfe Tone Point, and at "The Narrows" below the Happy Day claim the slope to the deep channel appears to be even steeper. The rock benches, as far as could be observed, are not sharply defined but grade rather gently into one another and into the deep channel and are covered with a constant mantle of gravel.

The average grade of the present surface of the gulch, between the town of Manhattan and the Japan claim, is 3⅓ per cent, but the grade is slightly steeper in the eastern and flatter in the western part. The average grade of the bedrock is approximately the same, though the westernmost shafts are the deepest. It is, however, far less regular than the grade of the surface and alternates between level graded stretches, where the softer rocks have been worn down, and rapids, where the stream crossed the more resistant beds of the sedimentary series.

The deep channel has been explored for practically its entire length, but in the present condition of mining it is difficult to obtain sufficient data to reconstruct its course. It meanders about the valley bottom and at several points splits into two or more divisions, leaving small "islands," a few feet high, between the deep channels. The course as shown on the map has been compiled from data obtained from the open shafts, supplemented by maps furnished by Mr. Clar.

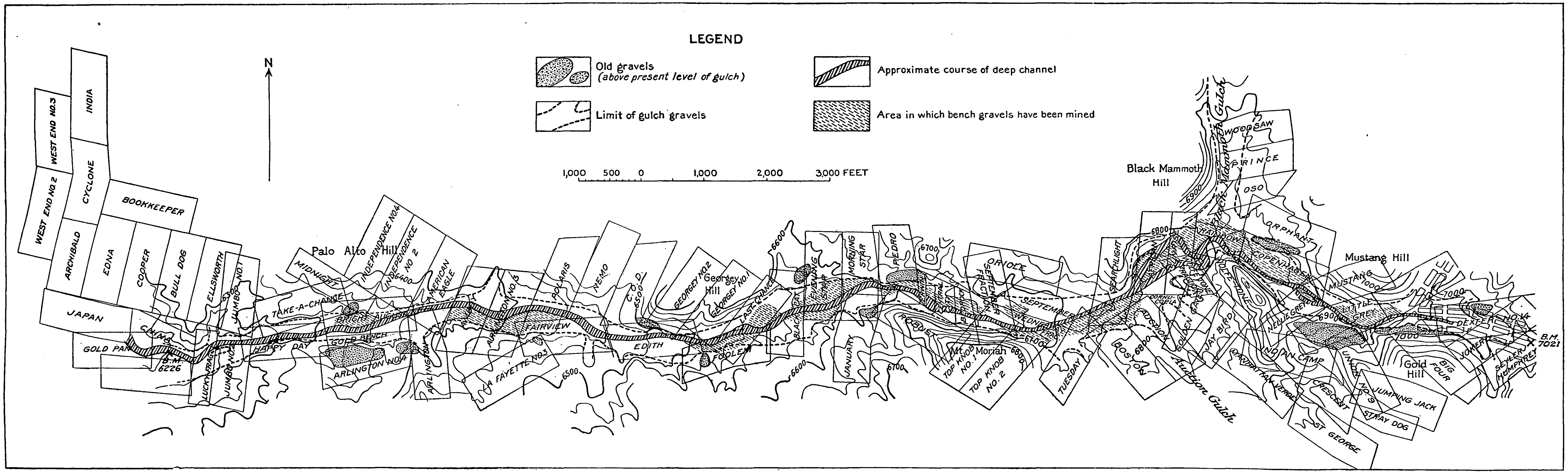
There is a depth of about 30 feet to bedrock under the town of Manhattan, but the depth increases to 60 feet in the shaft at the west end of the Dexter No. 14 claim, a short distance below the town. Probably the quartzite beds in the lower schists here formed a dam, for above this place the bedrock channel is fairly flat, at least as far as the mouth of Consolidated Gulch, where the depth is between 50 and 60 feet, showing a drop in bedrock of 95 feet, as compared to a difference of elevation of 125 feet on the surface, in a distance of about 2,500 feet.

Between the Dexter No. 14 claim and Wolfe Tone Point the grade of bedrock is only slightly steeper than the surface, since the shaft opposite Wolfe Tone Point has a depth of 72 feet. Along this stretch the deep channel follows the south wall of the canyon.

Between Wolfe Tone and African points there seem to be two, perhaps three channels of about equal depth, which unite again on the north side of the valley at African Point. Possibly the variation of the channel is due to the displacement of the stream by the delta of Auction Gulch. This tributary seems to have entered the stream at a steep grade and must therefore have deposited much of its load near its mouth. The grade of bedrock is only slightly less than that of the surface, for the upper shafts have depths of 70 feet or more and that of the African claim, near the junction of the channels, is 65 feet in depth. Below African Point there is a long stretch in which the bedrock is slightly flatter than the surface, for the depth is about 60 feet on the Searchlight, 50 feet at the Central City, and about 45 feet from the Pedro to the Last Chance claim. The channel swings from the north side of the canyon at African Point to the south side directly north of Mount Moriah and again to the north at the Last Chance. This graded stretch appears to be caused by the extension under the stream of the quartzite bed which forms the crest of Georgey Hill.

Below Georgey Hill there is a comparatively rapid fall, the canyon narrows, and for a short distance the benches are lost. The next known depth to the deep channel is 60 feet on the Arlington No. 3, a drop of 15 feet below the surface grade. The greater part of the fall is believed to be on the Fairview and the lower end of the Edith claims. Below the Arlington No. 3 the grade of bedrock is steeper than that of the surface, the depth being 78 feet on the Bright August, 88 feet in the western part of the Jumbo No. 2, 93 feet on the western edge of the Lucky Fraction, and 105 feet on the China. Between the Polaris and the Bright August well-defined bench gravels have been worked, but on the lower end of the Happy Day the canyon again narrows and the benches are lost. At the upper end of the Happy Day claim the depth to bedrock is 70 feet; at the lower end of the same claim it is 90 feet; and at "the narrows," just below, a depth of 98 feet is reached. The bedrock on the Happy Day claim is said to be very uneven and to show numerous "jump-offs." Below the narrows, on the China claim, the canyon is wider and the benches come in again.

Below the China the gulch turns sharply to the north and continues in this direction for about 5,000 feet, where it bends to the northwest. Along this stretch the surface expression of the gulch begins to be lost under the desert wash of Smoky Valley. The bedrock canyon seems to continue, however, though the grade is much flatter,



MAP OF THE PRODUCTIVE PORTION OF MANHATTAN GULCH, NEV.

Claims from map by Lidell & Lidell.

for the Japan shaft, 400 feet to the north, is 90 feet deep, and the farthest shaft, on the Hillsdale No. 1 claim, 8,000 feet beyond the China, is said to have a depth of 70 feet.[1]

In the accompanying map (Pl. VII) no attempt has been made to show the true width of the deep channel, for sufficient data are not available. In general it is widest in the graded stretches and narrows toward the rapids. In the long graded stretch east of the Last Chance it reaches a maximum width in places of about 100 feet. In the west end of the Bright August, just above the narrow portion of the Happy Day, the width is only 10 feet. Below, on the Japan claim, it is said to be 50 feet wide.

GRAVEL DEPOSITS.

Gold has been mined from gravel of three types: The old gravels, still existing in small patches along the sides of the gulch above the present stream level; the deep gravels of the gulch; and the surface wash and shallow stream gravels in the immediate vicinity of the lode outcrops.

OLDER GRAVELS.

As the stream is so entirely independent of structure it has probably held its course from some time previous to the rejuvenation of erosion which initiated the present physiographic cycle. Jefferson Creek, the next prominent stream to the north, shows its different stages of erosion by a series of well-defined terraces. In Manhattan Gulch the early gravels are preserved only in small patches here and there along the sides of the present gulch at elevations of 20 to 70 feet above the present valley floor. These areas of older gravels are in large part buried under more recent wash and probably cover a somewhat larger area than is indicated on the map. They are distinguishable from the more recent wash by reason of the greater rounding of their pebbles and the presence of pebbles of andesite porphyry, which must have been derived from the region of Slaughterhouse Gulch.

This gravel is coarse. The majority of the pebbles are rounded to subangular and about 4 to 8 inches in greatest diameter, though there are a few bowlders of larger size. Fine clay and sandy material serves as a cement, but only in one place was a distinct bed of sand or fine gravel seen. The best exposures were found in the upper part of the gulch, particularly in the north face of Gold Hill, the upper level of the Little Grey mine, and the ridge back of the transformer house, 800 feet southeast of the Manhattan Ore & Milling Co.'s mill. At the last locality the gravel consists of 2 to 3 feet

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[1] Jones, C. C., Notes on Manhattan placers, Nye County, Nev.: Eng. and Min. Jour., vol. 88, p. 103, 1907.

of hard cemented material, containing many bowlders, particularly of the resistant porphyritic rhyolite. Below this hard material to bedrock is between 10 and 15 feet of loose sand and fine gravel. The coarse gravel is so well cemented as to require the use of a pick in mining, but the underlying sand is loose and unconsolidated. These gravels indicate a stage in the history of the gulch when its valley was wider than at present, and probably represent a period of comparative rest between epochs of greater erosion. Following the deposition of these gravels came renewed erosion. the result of which is shown in the buried canyon of the present gulch. As the canyon was worn down the greater part of these older gravels was moved gradually downstream and their gold content in part reconcentrated at favorable points on the new bedrock channels.

These remnants of the older gravels have not shown sufficient promise to lead to extensive prospecting. A lessee who has been mining the angular surface material on the north side of Gold Hill finds that the older gravel beneath does not carry gold in workable amounts. The only place where this older gravel was being mined at the time of the writer's visit was on the ridge south of the transformer house, where small irregular pay streaks were found in the coarse gravel above the fine sand. Probably the concentration of the gold in this gravel did not equal the later concentration effected by the stream which cut the canyon, and it is also likely that the small patches of older gravel remaining do not represent the pay streaks of the original stream.

GULCH GRAVELS.

In the gulch the pay gravel is covered by finer gravel and sand and this, in turn, by a roughly stratified deposit of more angular material. Complete sections were difficult to obtain, as the shafts which are not closely timbered are for the most part caved. The following sections, however, taken at intervals down the gulch, show the general type of the deposit.

A shaft near the southwest corner of the Mustang claim shows in its upper portion about 45 feet of roughly stratified, rather angular coarse and fine gravel. The upper 10 feet is largely rhyolitic, but below this material slate and gray schist are dominant. Near the base this gravel is much coarser than that in the upper portion and contains several bowlders. Beneath this gravel for 15 feet are alternate bands, averaging about a foot in thickness, of clayey sand and fine gravel, the gravel about one-fourth inch in size. Below this material is 1 or 2 feet of half-inch gravel, which grades into the coarser pay gravel. The pay gravel here contains more bowlders than that farther down the gulch. The, bowlders and pebbles are embedded in a clayey matrix and sufficiently well cemented to stand without timber.

A shaft near the northwest corner of the Mustang extension (Copenhagen) claim, sunk 35 feet to one of the upper benches, shows about 30 feet of roughly stratified angular gravel, generally under 3 inches. Below this gravel is from 1 to 3 feet of loose rounded gravel of about half-inch size, with lenses of sandy clay. This loose gravel rests on 2 to 3 feet of the well-cemented pay gravel containing many bowlders, chiefly of quartzite, the largest of which are 3 feet in diameter. Another shaft of the same depth, 250 feet south of the last, shows only 12 feet of the angular rhyolitic wash, but below this wash about 20 feet of fine gravel, the largest pebbles of which are not over 2 inches and which near the base consists chiefly of very fine uncemented slaty gravel. The 3-foot layer of pay gravel resting on bedrock is similar to that of the northern shaft.

A shaft at the mouth of Black Mammoth Gulch, near its junction with the main gulch, has a depth of 25 feet to bedrock. The upper 3 feet consists of bowldery material, chiefly rhyolite porphyry. Below this material is about 15 feet of bedded sand and pebbles, and the lower part consists of coarse gravels and angular bowlders, the largest of which are about 1 foot in diameter.

On the African claim a 65-foot shaft on the southern branch of the channel shows 10 feet of very roughly stratified material, chiefly fragments of rhyolite. Below this comes 40 feet of evenly bedded fine gravel and sand, the gravel layers averaging about 1 foot in thickness and the sand layers 3 feet. From this level to the top of the pay gravel is uncemented very fine slaty gravel, the "chicken feed" of the placer miners. This fine gravel contains rare sandy lenses, but for the most part shows only very imperfect sorting. In the shaft the contact between the upper sand series and the fine slaty gravel dips 45° N., which is evidence of shifting stream channels. The pay gravel rests on a bedrock of dark crumpled slate and is from

The next shaft from which a section was obtained is on the Last Chance claim. Here the pay gravel is 1 to 6 feet thick and is covered with fine slaty gravel of the same type. A bench 4 feet above the main channel and 50 feet to the north shows similar conditions, except that here the pay gravel is rusty in appearance and in places irregularly stained with iron and manganese oxides. A second bench, to the south of the main channel and 15 to 20 feet higher, shows very little of this fine gravel, and the pay gravel is covered by clay and fine sand.

The China shaft, near the west end of the gulch, is 105 feet deep. The upper part to a point within 12 feet of bedrock consists of roughly stratified gravel, for the most part angular but without bowlders. Below this gravel lies 10 feet of fine dark sand, chiefly composed of minute slate fragments, containing lenses of clay. At the base of this stratum are a few bowlders of quartzite and rhyolite porphyry from 1 to 2 feet in diameter but without any material intermediate in size. The thickness of the pay gravel is here 2 feet but increases to 6 feet about 50 feet north of the shaft. The material is finer than higher up the gulch, and though it contains a few bowlders most of the gravel is less than 2 inches in diameter and the clayey cement of the upper claims is lacking. Still farther down the gulch the pay gravel is said to increase in thickness to 10 feet or more.

It is possible from the evidence at hand to reconstruct the history of the gulch. The older gravels found on the edges of the valley represent one or more stages in the early erosion of the gulch. After this early erosion the stream began to cut its canyon and the older gravels were largely eroded off, their gold content going to enrich the present deep gravels.

The present bench gravels represent stages in the process of canyon cutting. The lower gravels seem to indicate deposition by a swift-flowing stream which lost grade as it entered Big Smoky Valley, as is indicated by the smaller size of the pebbles and the thickening of the gravel near the mouth of the gulch. The waters, in time of flood at least, were capable of handling rather large bowlders, and the whole mass of material was in fairly continuous motion toward the valley. Fragments of bone have from time to time been recovered from this gravel and material from the mines in the vicinity of Central, collected by Mr. L. F. Clar, was submitted to Mr. J. W. Gidley, of the National Museum, for identification. Mr. Gidley reports as follows:

M 601. *Elephas* sp.: tusk, very badly broken.

M 602. *Equus* sp.: distal end of tibia, metatarsus, and other fragments. Cervid, cf. *Rangifer* sp.: parts of tibia and metatarsal. Both are probably Pleistocene.

M 603. *Equus* sp.: upper molar. Probably Pleistocene.

The bones were found scattered and are broken, but they were probably deposited during the bench or deep-channel period of erosion and not in the older gravels, otherwise they would hardly have survived, even in their present fragmentary state. The fossils seem to indicate that a less arid climate then prevailed. In all probability the period in which the canyon cutting was accomplished and the lower gravels laid down is to be correlated with the existence of the Pleistocene Lake Toyabe in the northern part of Big Smoky Valley.

The fine material above the coarse pay gravel indicates decrease in the carrying power of the stream, which changed to an aggrading rather than a down-cutting stream. This change was probably due to increasing aridity of climate rather than to any decrease in grade and perhaps was also consequent upon loss of part of its drainage area. From this time on there was probably little gold added to the pay gravels on bedrock. A few fragmentary plant remains were found in the clay lenses and finer sands, but none were sufficiently well preserved to admit of determination. The succession of stratified sand and fine gravel indicates a stream which was dominantly aggrading, and though in times of flood it scoured out new channels, it did not move the material directly above bedrock.

The last chapter of the stream's history is told by the poorly sorted rhyolitic material, which is found next the surface in the upper part of the gulch. This type of deposit indicates that there was no longer a constant surface flow but that this material was brought down from the hills to the north by the occasional heavy floods which are a feature of the present climatic conditions.

The gulch gravels have been productive over a distance of about 4 miles, beginning north of Gold Hill and extending down the gulch to the point where the stream valley makes its sharp turn to the north. Below this point a little work has been done, but the gold was found to be too finely divided and scattered throughout too thick a bed of gravel to be profitable for drift mining as at present conducted. North of Gold Hill there has been some work done from shafts at the lower end of town, but the deep gravels above town as well as those above Dublin, Consolidated, Slaughterhouse, and Black Mammoth gulches have not proved profitable. As gravel with a gold content of much less than $2 a cubic yard is rarely mined, it follows that the parts of the gulch worked represent only those in which gravel showed the greatest concentration of gold. The richest portion of the gulch, now largely worked out, was the part between the sharp bend opposite Wolfe Tone Point and African Point. Here the deep channel splits into several smaller ones and some of the gravel was extremely rich. One of these channels is said to have yielded over $50 a cubic yard across a face of more than 20 feet.

The gravels of the benches generally appear to be less valuable than those of the deep channel. On the Boston and Auction claims, however, these bench gravels were extraordinarily rich, probably because the northward-flowing Auction Gulch brought down much gold from the mineralized region just west of Gold Hill. According to information from Mr. Clar, however, the ground 500 feet up Auction Gulch showed no pay.

Only the bedrock gravel has proved workable, but gold is found in small amount throughout the gravel section. On one of the western claims a lens of coarse gravel above the fine material overlying the pay gravel was estimated to carry as much as $2 a cubic yard.

Streaks here and there in the finer upper gravels may show colors to the value of 50 cents a cubic yard.

The writer desires to acknowledge his indebtedness to Mr. L. F. Clar for the following notes as to the richness of the various claims. These are quoted almost verbatim from his letter of February 19, 1915, to Mr. J. M. Hill.

The December Fraction and Copenhagen (Mustang extension) were very rich pieces of ground. The Wolfe Tone, Rainbow, and Sunrise were all good, but what may be considered as the very best piece in the gulch is the Little Wedge and the adjacent portion of the African and Searchlight. The Little Wedge is the small triangular area bounded by the Searchlight, Auction, and African claims.

The southern part of the Wolfe Tone Fraction proved somewhat of a disappointment to the operators.

The southeastern part of the September and the northern part of the Boston, together with the intervening wedge formed by the southern part of the Searchlight, were all good ground.

The northeast corner of the Auction showed up well, but the greater part of this ground is still unworked.

Downstream the ground proved less profitable as far west as the Central City claim. From this claim westward the placers have all shown good ground as far down the gulch as the Jumbo No. 2. The Robust claim, in which the deep channel is dry, had a pay streak which yielded $7 a cubic yard.

The gulch narrows greatly at the lower end of the Happy Day, and the benches are lost. Below the Jumbo No. 2 the gravel is again poorer until the good ground of the Japan is reached. Westward from this claim the gulch is not sufficiently developed to furnish any information as to the comparative richness of the different claims.

Mr. Clar's notes seem to indicate that in a general way the richer parts of the gulch are those in which the stream flows along a more or less graded stretch above a steeper interval, or, in other words, where there has been some impounding of the gravel.

Although gold in workable amounts is concentrated in the coarse gravel close to bedrock, there are small amounts of gold in all the material from the coarse gravel to the surface. Except for the single upper lens of coarse gravel mentioned on page 183 there seems to be no concentration in the upper gravels, but the gold is scattered evenly through them, as would be expected in a deposit formed by an aggrading stream. As far as known these upper gravels nowhere carry more than 50 cents a cubic yard.

RECENT WASH.

Placer deposits consisting of recent wash have been worked in the neighborhood of Gold Hill and to some extent in the hills north and northeast of Central. These deposits yielded good returns, but were soon exhausted, and at the time of the writer's visit the only work on this type of deposit consisted in scraping the hillside north of the Big Four mine. The material consists of angular fragments of schist with little veinlets of gold-bearing quartz. The gold is coarse and angular, evenly distributed throughout the 2 or 3 feet of angular schist débris. This material rests on older gravel, which, however, does not contain sufficient gold to be workable.

THE GOLD.

No records have been kept with reference to the coarseness of the gold, but the operators agree that the size of the gold particles decreases gradually downstream. Fairly coarse nuggets, the largest of which were an ounce or more in weight, have been found in the upper half of the gulch. In the shafts in the extreme western part, however, the finely divided state of the gold is one of the chief difficulties of mining. Coarse gold is found throughout the gulch. In all the small samples of concentrates collected by the writer, from the portion of the gulch between the Wolfe Tone and Amboy claims, the majority of the gold colors were rather thin flakes exceeding 0.5 millimeter (40-mesh) in size, although few were greater than 1 millimeter (20-mesh).

For the most part the gold shows very little effect of abrasion and is usually arborescent or feathery in shape. The larger pieces almost invariably contain some quartz. The gold from the deep channel is clean and bright, whereas most of that from the pay streaks on the dry benches is slightly rusty and amalgamates less readily.

Of particular interest is the difference in purity of the gold in different parts of the gulch. The placer gold of the gulch, even in the vicinity of Gold Hill, is probably slightly finer than the gold of the lodes from which it is derived. Down the gulch to the westward the grade of the gold increases with the distance from its source. The fineness of the gold from the different claims, as determined from data collected by the writer and Mr. L. F. Clar, is shown in the accompanying table and the curve (fig. 19).

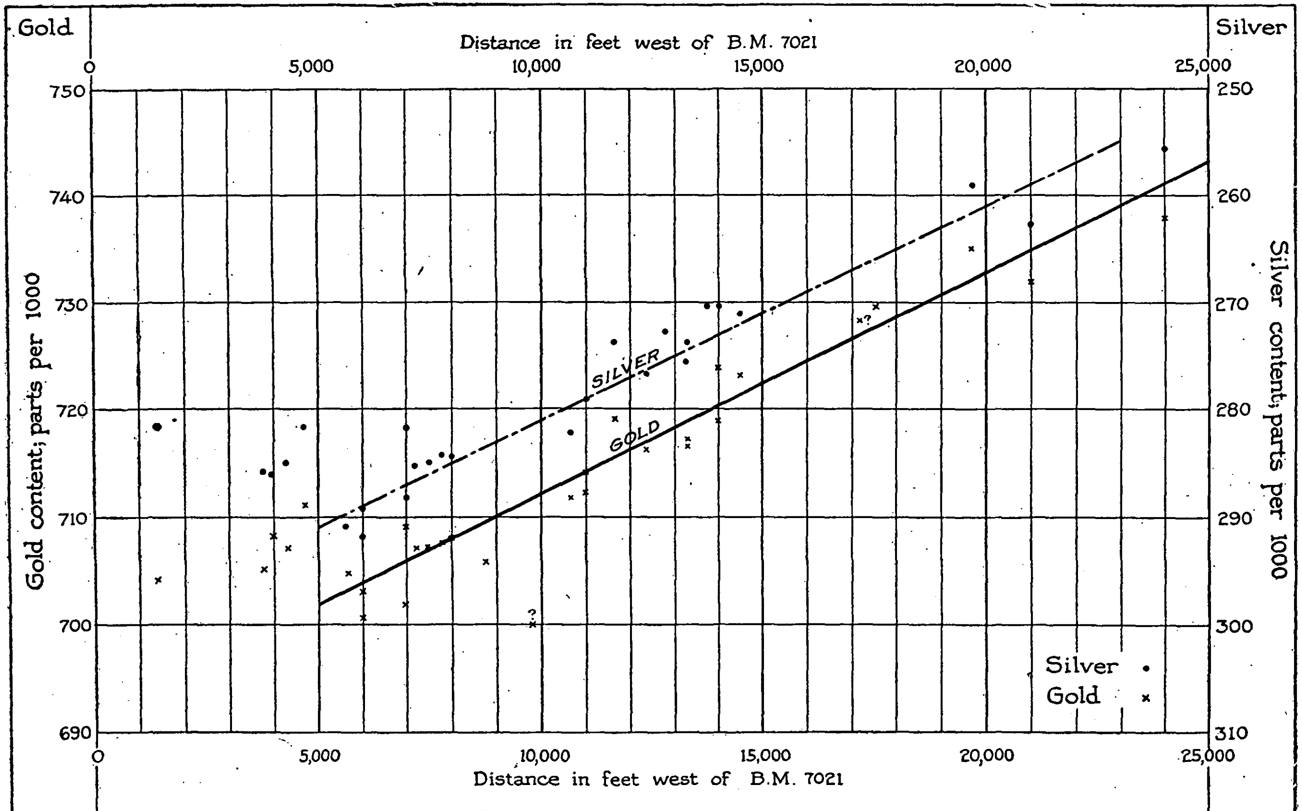

FIGURE 19.—Curve showing variations in fineness in placer gold of Manhattan district, Nev.

Variations in fineness of Manhattan placer gold.

Claim.	Approximate distance below B. M. 7021.	Gold (parts per 1,000).	Silver (parts per 1,000).	Base metals (parts per 1,000).	Remarks.
	Feet.				
Dexter 14	1,400	704.5	281.2	14.3	From deep gravel, single clean-up return. Most of the placer production of this claim was derived from the hillside wash, the gold of which showed a greatly varying fineness with a maximum of 0.690.
Mustang Extension (Copenhagen).	3,800	705.5	285.4	9.1	Upper end of claim. Average of 11 clean-up returns. Maximum variation 10 parts per 1,000.
Do	4,300	707.3	284.9	7.8	Middle of claim. Average of 27 clean-up returns. Maximum variation 17 parts per 1,000.
Do	4,300	707.8	285.9	6.3	Data furnished by Mr. L. F. Clar, who states that individual returns show greater irregularity than those from the lower part of the gulch.
Do	4,700	711.3	281.3	7.4	Lower end of claim. Average of 21 clean-up returns. Maximum variation 13 parts per 1,000.
Wolfe Tone	5,700	703.3	290.9	5.8	Average of 11 clean-up returns. Maximum variation 4 parts per 1,000.
Do	5,700	705	....	....	Operator's estimate.
Rainbow, Sunrise, and African.	6,000	700.8	289.0	9.3	Data furnished by Mr. L. F. Clar.
Sunrise	6,000	703.2	291.6	5.2	Average of 5 clean-up returns. Maximum variation 3 parts per 1,000.
Auction	7,000	709.5	281.5	9.0	Average of 6 clean-up returns. Maximum variation 11 parts per 1,000. Gold derived from bench gravels.
Do	7,000	702.0	288.0	10.0	Data furnished by Mr. L. F. Clar. Gold derived from bench gravels.
Boston	7,200	707.2	285.0	7.8	Do.
Do	7,500	707.5	284.75	7.75	Average of 12 clean-up returns. Maximum variation 6 parts per 1,000. Gold derived from bench gravels.
Do	7,800	707.7	284.0	8.3	Data furnished by Mr. L. F. Clar. Gold derived from bench gravels.
September	8,000	708.4	284.1	7.5	Average of 28 clean-up returns. Maximum variation 7 parts per 1,000.
Do	8,000	708.95	285.5	6.55	Data furnished by Mr. L. F. Clar.
Top Knob	9,000	706.0	....	....	Operator's estimate.
Pedro	10,700	712.0	282.0	6.0	Data furnished by Mr. L. F. Clar.
Robust	11,000	714.5	279.0	6.5	Do.
Do	11,000	712.5	279.0	8.5	Average of 2 clean-up returns.
Morning Star	11,700	675 (719.2)	257 (273.8)	68.0 (7.0)	Data furnished by Mr. L. F. Clar. Gold obtained from reworking of old dumps and contains much foreign material. Recalculated on a basis of 7 parts base metal (average of Pedro and Robust) shows fineness given in parentheses.
Black Cat	12,400	706 (716.4)	274 (276.6)	20 (7.0)	Data furnished by Mr. L. F. Clar. Gold obtained from reworking old dumps. Recalculated figures shown in parentheses.
Do	12,800	709 (720.2)	270 (272.8)	21 (7.0)	Data furnished by Mr. L. F. Clar. Recalculated as above.
Last Chance	13,300	717.25	273.75	9.0	Average of 4 clean-up returns. Maximum variation 4 parts per 1,000.
Do	13,300	716.7	275.5	7.8	Data furnished by Mr. L. F. Clar.
Foolem	14,000	724.0	270.2	5.8	Average of 6 clean-up returns. Maximum variation 7 parts per 1,000.
Do	14,000	719.0	273.0	8.0	Data furnished by Mr. L. F. Clar.
Georgey and Edith	14,500	723.25	271.0	5.75	Do.
Arlington	17,200	714–738	....	....	Operator's estimate. (See text, p. —.) Most gold taken from bench gravels, of which fineness is said to be between 0.719 and 0.738.
Arlington and Amboy	17,500	729.64	264.18	6.18	Data furnished by Mr. L. F. Clar.
Amboy	17,800	700–740	....	....	Operator's estimate.
Bright August	19,700	735	259	6.0	Data furnished by Mr. L. F. Clar.
Happy Day	21,000	732	262.5	5.5	Average of 2 clean-up returns.
Japan	24,000	738	255.5	6.5	Data furnished by Mr. L. F. Clar.

The highest claim in which the deep gravels have been worked is the Dexter 14, just below the town of Manhattan. No data are available for the deep placer gravels of the Little Grey and Nellie Grey claims next below, but on the Mustang Extension (Copenhagen) the gold shows a marked increase in fineness over that from the Dexter 14. The next claim from which data were obtained is the Wolfe Tone, just below the sharp bend at Wolfe Tone Point. Here the fineness is 8 parts per 1,000 less than that of the gold from the lower end of the Mustang Extension. This claim, however, was famous for the coarseness of its gold. Below this point the grade of the gold increases proportionately with the distance downstream, in the ratio of 1.6 parts per 1,000 to each 1,000 feet. The richer parts of the deep channel all lie below Wolfe Tone Point, and it is believed that the greater proportion of the gold mined from the deep channel entered the gulch at about this point, probably along Auction Gulch.

The average fineness of all placer gold produced during the six years for which figures are available likewise shows a steady increase, due, it is believed, to increased development in the lower part of the gulch and to the exhaustion of the surface placers on Gold Hill, as well as to better methods of mining, which resulted in the saving of a larger proportion of the smaller gold particles. The averages for lode gold, however, as derived from the totals in the volumes of Mineral Resources of the United States for the years 1908–1914, show great irregularity. For the years 1908 to 1912, inclusive, the average fineness ranged between 0.657 and 0.702. During 1913 and 1914, however, the fineness of the gold was 0.748 and 0.731, respectively. This is believed to be due to the fact that these two years mark the greatest period of activity of the White Cap mine. There is practically no silver in the ore from this mine, but as the gold is not free this type of ore has no effect on the fineness of the placer gold. The fineness of the lode gold, as indicated by mint certificates, shows great variety. For the following figures the writer is indebted to Mr. L. F. Clar. Gold from the limestone lodes on April Fool and Litigation hills had a fineness ranging from 0.527 to 0.740, with an average of about 0.680. The gold from the prospects in the rhyolite on Bald Mountain was even baser, about 0.500. A part at least of the gold from Gold Hill (Big Pine and Big Four) was as fine as 0.717.

Fineness of Manhattan lode and placer gold.

Year.	Lode.	Placer.	Year.	Lode.	Placer.
1908	0.664	....	1912	0.691	0.716
1909	.657	0.703	1913	.748	.721
1910	.675	.709	1914	.731	.722
1911	.702	.706	1915	.747	.723

The cause of the regular increase in fineness toward the mouth of the gulch is believed to be due to the solution, through long action of the surface water, of a portion of the silver and nearly all the base metal contained in the gold. To raise a mass of gold containing originally 700 parts gold and 300 parts silver to a fineness of 0.733 would require the removal of 15 per cent by weight of the silver, or about 4.5 per cent of the whole mass. As has been shown above, a part of the gold has undoubtedly been derived from the older gravels, and all the gold in the lower gravels, whether added to the placers at the end of the canyon-cutting period or reconcentrated from the older gravels, has certainly been exposed for a long time to the action of whatever solvent may be present in the water. Placer gold is commonly purer than the lode gold from which it is derived, as for instance in the Tertiary gravels of California,[1] and Smith[2] has shown that the gold of certain gulch placers of Alaska likewise increases in purity away from the source, but at Manhattan the great increase in a short distance and the regularity of increase are unusually well marked.

Although the regularity of the increase in fineness points clearly to a process of refining through solution by means of waters rendered acid through the oxidation of pyrite, it is not easy to imagine how this is accomplished. The proportion of "base metal," believed to be chiefly copper, represented by the difference between 1,000 and the sum of the figures for gold and silver, does not decrease greatly downstream, and it is difficult to conceive of a solvent capable of attacking the silver without removing the "base metal" as well. Furthermore, the ordinary solvents of the laboratory are not effective in "parting" the silver when alloyed in such small proportion with the gold.[3] It has been suggested that to account for this increase in fineness, so generally observable in placers, it is necessary to suppose that both gold and silver are to some extent dissolved but that the greater part of gold is soon redeposited.[4] But there is nothing in the appearance of the Manhattan Gulch gold which would tend to confirm this hypothesis.

It is not possible to draw any conclusions as to the possible solvents present in the water. The oxidation of pyrite may have given a slightly acid solution; iron salts, such as ferric chloride, may have been present, or the solution of a part of the fluorite might possibly have given the underground waters a minute amount of hydrofluoric acid.

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[1] Lindgren, Waldemar, The Tertiary gravels of the Sierra Nevada of California: U. S. Geol. Survey Prof. Paper 73, p. 69, 1911.

[2] Smith, P. S., The fineness of gold in the Fairbanks district, Alaska: Econ. Geology, vol. 8, pp. 449–454, 1913.

[3] Rose, T. K., The metallurgy of gold, pp. 97, 439–445, 6th ed., London, 1915.

[4] Idem, p. 97.

The important factors are, however, the length of time in which the gold has remained undisturbed and subject to a constant flow of water and the decrease in the average size of the gold particles with their distance from the source. As has been shown, the gold of the lower gravels has remained in its present position since Pleistocene time, and moreover a part of the gold was derived from the earlier placers represented by the older gravels. The size of the gold particles, as is natural to expect, likewise decreases down the gulch, the coarser and more compact nuggets being more common in the portion immediately below Gold Hill and the lower placers containing the greater amount of fine scaly gold. The fine gold, of course, offers a greater surface to the solvents contained in the stream water and hence has attained a higher degree of purity. The increase in purity of the gold is therefore believed to be dependent on the distance from the source only in so far as the gold has been sorted by size in transportation. The regular increase in proportion to distance shown by the curve (fig. 19) is believed to be in large measure a function of the decrease in size of the gold particles. If the gold particles were of the same average size on each claim the fineness should be approximately the same throughout the gulch, for as the bulk of the gold has been in its position since Pleistocene time, the difference in opportunity for solution between the head and mouth of the gulch would be negligible. If data were available a similar curve showing decrease in average size of grain downstream would probably exhibit an equal degree of regularity.

Another factor which may possibly have had some influence on the fineness of the gold is the increase in purity through oxidation of the outcrop. As the formation of the veins antedates the mature topography, remnants of which are preserved in the central part of the range, the outcrops must have been subjected to a long period of weathering, during which the gold would be to some extent refined in place through solution of the silver. Thus the gold fed to the placers may have been purer at the start, though with an increasingly high silver content as the rapid erosion of Manhattan Gulch outstripped oxidation. It is therefore possible that a portion of the gold near the mouth of the gulch represents material taken from a higher horizon in the veins.

Mr. Clar considers that it is possible that the rich stringers on Georgey Hill and elsewhere down the gulch added enough purer gold to bring up the average fineness of the gold in the lower claims. The regularity of the increase, as shown by figure 19, seems to make this impossible. Moreover, these smaller veins are insignificant in comparison with the metallized area around Gold Hill, and if they had added a sufficient amount of gold to raise the average fineness to the points shown on the curve the increase in the tenor of the gravels of the lower gulch would have been enormous.

No data are available in regard to possible differences in size or purity of the gold of the benches and the deep channel. The Boston claim derives its entire output from a bench 15 feet above the deep channel but shows the same degree of fineness in respect to its distance from the source as the others. On the other hand, it is said that tests of gold from the Arlington claim show differences in fineness as follows: Gold from upper bench, 30 feet below surface, $15.20 to $15.35 an ounce; gold from lower bench, 40 feet below surface, $15 to $15.10 an ounce; gold from deep channel, 60 feet below surface, $14.90 an ounce.

This observation is, however, an isolated one, and it is not possible to draw definite conclusions. It may be that in this locality, where the benches are more sharply defined than usual, the gold on the benches was derived from a more oxidized portion of the vein during an earlier period of stream erosion, and is therefore purer. Or it may be that local conditions favored the accumulation of finer gold on the benches than in the main channel. Although the deep channel alone has a constant flow of water, and the silver might therefore be supposed to be more completely dissolved, the bench gravels are everywhere moist, owing to seepage from the valley sides.

The gold from the surface placers on the north side of Gold Hill has a very low fineness. The different clean-up returns show great variation, due to foreign matter, such as shot, included with the bullion; but the gold has a maximum fineness not exceeding 0.680, which is distinctly lower than the reported fineness of the lode gold at present mined on Gold Hill.

OTHER MINERALS.

Aside from gold no other valuable minerals are recovered from the placers. The concentrates contain a large amount of barite, which is sometimes found in pebbles an inch or more in length. No such large masses were seen in any of the veins, although barite in small crystals is not uncommon as a gangue mineral in some of the Gold Hill veins.

As usual in placer deposits, the concentrates contain a large proportion of magnetite, but in many of the samples collected this is exceeded in volume by the barite. Magnetite occurs in minute sharp octahedra, nearly all of which pass through a 40-mesh sieve. The size of the grains probably averages about 0.3 millimeter. A small proportion of the black sand is nonmagnetic and appears to consist principally of psilomelane.

Cinnabar is reported from a number of the placer mines, but only very minute specks were present in the samples of concentrates collected by the writer. Although this mineral is not common in the district, it has been reported in the ore of the White Cap mine, and cinnabar prospects have been worked in the mountains to the north.

Fresh pyrite was found only in very rare minute specks. Small cubes completely altered to limonite are, however, fairly common.

Fluorite is a common gangue mineral in the mines of Mustang, April Fool, and Litigation hills, but it is extremely rare in placer concentrates, only two or three small specks being seen.

Besides these heavy minerals the average sample of concentrates contains many minute fragments of schist, the smallest a millimeter in size, quartz both as fragments of crystals from the veins and as small dihexagonal pyramids weathered out of the porphyritic rhyolite, and small feldspar crystals.

MINING METHODS.

The first placer work done in the district consisted of surface work in the vicinity of Gold Hill and Indian Camp. Water was scarce and the work was carried on either by means of dry-washing machines or by sluicing with a carefully conserved supply of water. The following notes, quoted from Mr. Packard's paper,[1] give an interesting description of the method of sluicing:

> Here water is hauled in barrels and dumped into a large tank. The gravel is shoveled upon a platform, * * * and the water from the tank is then drawn off through the sluice box, the gravel being fed in from the platform. The water from the sluice returns to a pit dug below the tank. It is then raised in a box attached to one end of the long pole. * * * To do this a man walks up the plank, * * * and, jumping off, catches hold of the other end of the pole and, lying over it, his weight brings the box up to the level of the top of the tank, and the water is then automatically discharged into the tank for further use.
>
> The saving by the dry-washing machines is not claimed to be over 70 per cent, while the saving by the Manhattan method is undoubtedly much higher. The disadvantages of the latter method lie in decreased capacity, greater expense, and the difficulty of finding a man whose stomach will stand the pressure necessary for operating the pole for a longer time than is absolutely necessary to secure money enough to last while hunting another job.

The water pumped from the neighboring lode mines is now available and sufficient in quantity for the small amount of work still done on the surface placers.

The placers of the gulch are all worked by drift mining, as the overburden is too thick for dredging or hydraulicking, even if there were sufficient water available. An attempt at mining by means of a suction pipe resulted in failure.

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[1] Packard, G. A., Round Mountain camp, Nev.: Eng. and Min. Jour., vol. 83, p. 151, 1907.

There is a constant flow of water through the pay gravels along the greater part of the deep channel. This flow ranges from 20,000 to 50,000 gallons a day, generally nearer the larger amount, but fails entirely in two places, where the canyon crosses limestone strata and the water is probably diverted to crevices or solution channels.

The water used for washing the gravels is pumped from the wet channel to small ponds below the sluice boxes and from there is pumped to the sluice boxes. The water is thus used continuously, and the amount obtained by pumping compensates for the losses from seepage and evaporation. Drifts are run in the pay gravel for a maximum distance of 300 feet from the shaft, and the pay streak is developed by short crosscuts. It is considered more economical to sink a new shaft than to increase the length of the drift beyond 300 feet. When the pay streak has been developed the gravel is stoped back toward the shaft after the manner of longwall coal mining. The schistose bedrock contains many small crevices in which the gold can lodge and is therefore removed to a depth of about a foot. The coarse, clayey gravel stands well, and few supports are needed in the stopes. Bowlders too large to be handled easily are not hoisted but are left behind as the work progresses. In most mines the tramming is done by wheelbarrows, but, in a few, tracks have been laid and the dirt taken in cars to a bin instead of directly to the shaft bucket. The power line of the Nevada-California Power Co. entered Manhattan Gulch in 1909, so electric pumps and hoists have supplanted the gasoline engine.

The gravels after screening pass to the sluice boxes. At some mines a quicksilver trap, which takes most of the coarse gold, is placed near the head of the boxes. Usually there are two sets of boxes, each about 20 feet long, provided with Hungarian riffles and set at an angle of 5° or 6°. By far the greater part of the gold is, however, recovered in the upper few feet. The writer was informed that in a clean-up of 50 ounces at the Last Chance mine only three-eighths of an ounce was recovered from the lower half of the boxes. Working in winter entails considerable loss unless great care is taken, owing to the freezing of the water between the riffles. As all precautions were neglected in the early days of mining, it has been found profitable to rework many of the old dumps.

No accurate account of costs has been kept at any of the mines, but it is the general opinion that in a well-equipped mine the cost of mining is rather more than $1 a cubic yard. At present there are very few operators working their own claims. Most of the work is being done by Serbian and Italian lessees, who are mining small patches of pay gravel left behind during the earlier operations.