THE ANCIENT RIVER BEDS OF THE FOREST HILL DIVIDE.

By Ross E. Browne, Mining Engineer.

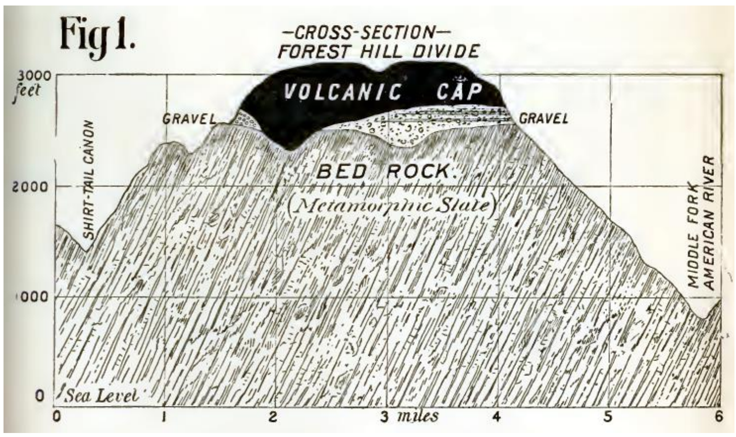
The Forest Hill Divide is situated in Placer County, between the North and Middle Forks of the American River. It is one of the numerous spur-like ridges of the western flank of the Sierra Nevada. The ridge-line is uniformly graded and unbroken for twenty-five miles or more, extending from an altitude of five thousand eight hundred to two thousand three hundred feet above sea level. Midway between these points the ridge branches, the northerly branch being the Iowa Hill Divide, and the southerly, or main branch, the Forest Hill Divide proper. The general course is south of west, or approximately normal to the axis of the main Sierra Range.

At certain favorably located points an extended view is obtained of this and neighboring divides. Upon losing the effect of the detail one receives the impression of a general uniformity in the grades of the summit-lines. These summit-lines appear as the remaining traces of a gently undulating plane, sloping regularly from the bases of the massive peaks of the Sierra to the Sacramento Valley. One readily conceives the idea that the deep canons and gulches, which give to the modern surface its broken and rugged character, are but the results of the prolonged erosive action of the present streams.

An examination of the district shows that the bases and main bodies of these ridges are composed of metamorphic rocks of great age; and that there are commonly exposed on the summits large accumulations of volcanic material and extensive river deposits of a comparatively recent geological epoch. In a popular sense, however, these deposit are decidedly ancient, and they have been appropriately credited to an ancient river system.

A characteristic cross-section of the Forest Hill Divide is given in Fig. 1.

Fig 1.



The Metamorphic Rocks forming the base and main body of the ridge and constituting the country rock of the district are commonly slates carrying seams and ledges of gold-bearing quartz. The slates vary in character; they are finely laminated or coarse and blocky, talcose, argil laceous, or highly siliceous. There are several belts of soft laminated slate in which the quartz ledges and seams are specially numerous.

The strike of the slates is generally between north and northwest, and the dip 75 degrees to 85 degrees to the east.

Prominently exposed are patches and dikes of diorite and a broad zone of serpentine.

The term "bedrock," though evidently intended to apply only to the rock immediately forming the bed of the river, is nevertheless used in a general way to designate the country rock of the district.

The River Deposit consists of well washed bowlders, pebbles, and sand, composed of the harder materials eroded from the bedrock—mostly quartz and siliceous rocks. Clay strata are of frequent occurrence, particularly in the upper portion of the deposit. Trunks of trees, commonly cedars and oaks,* are found imbedded in the upper layers, either petrified or somewhat lignitized. Certain layers of the gravels thus formed have become strongly cemented, owing, probably, to the percolation of siliceous and calcareous waters. The color is gray, blue, green, reddish brown, or white, according to the material, as

*I. e., trees similar in appearance to our present cedars and oaks.

well as the degree of oxidation of the iron contained in the cementing substance.

Gold occurs throughout this deposit in the form of rounded nuggets, scales, and dust (see Fig. 12). This occurrence is the result of the breaking and grinding of fragments and bowlders of the gold-bearing portions of the bedrock. By a natural process of concentration the bottom layer of each deposit of gravel has become, as a rule, the richest. That these auriferous gravels are river deposits, was but one of a number of the theories advanced during the first decade of active mining operations. The theory was well established, however, by Professor Whitney in his earlier work as State Geologist, and the accumulating evidences have long since become conclusive.

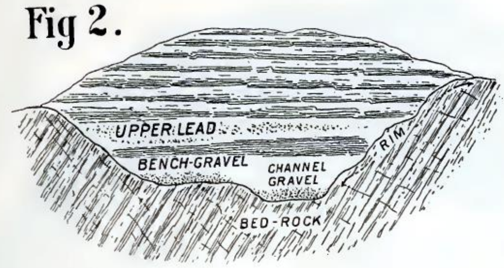
The Volcanic Cap consists of massive layers of beds of light gray, reddish brown, and dark-colored cements and conglomerates. It contains large bowlders and fragments of volcanic rocks, and in its bottom layers occasional trunks and branches of trees somewhat lignitized. It carries no appreciable quantities of gold, and is, in fact, the barren material of the district.

Between these massive beds are layers of gravel, marking distinct periods in the flow.

Doubtless the volcanic cement was originally in the form of a semiplastic fluid, or mud, solidifying or "setting" soon after depositing. Some of the gray and dark-colored cements are as firm as an artificial concrete, and resist the erosive action of the water better than the softer, finely laminated slates.

Mining Developments.—The Forest Hill Divide has been for thirty-nine years an active field for mining enterprise. There have been exposed by hydraulicking many sections of the river deposit and extensive areas of the river beds; and by drift mining a number of the channels have been explored and worked continuously for a mile or more of their lengths. The principal developments are indicated upon the accompanying map.

Fig 2.



Mining Terms.—Of the mining terms used it appears necessary to define a few only: "Channel" refers to the deeper portion of the continuous trough-like bed of the river; "rim" to the sides of the trough, from the line above where the bedrock begins to pitch down, to the shore line of the bottom layer of gravel filling the channel; "upper lead," to an upper layer of pay gravel; "bench gravel," to a patch of an earlier deposit of gravel remaining in place after the greater portion has been washed away.

THE CHANNEL SYSTEMS.*

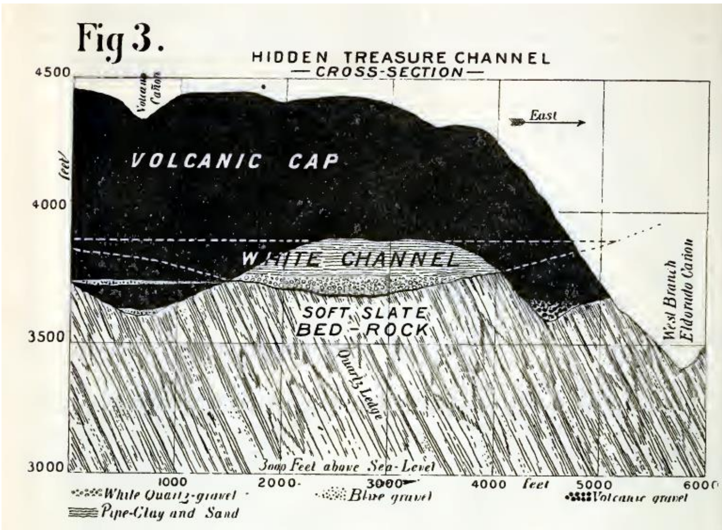
The network of channels under the volcanic cap is rather confusing. There are evidences of a number of channel systems, each representing a partial or complete displacement of the stream, a distinct cut, and a special deposit of gravel.

The series of volcanic eruptions in the high Sierras had a marked effect upon the watercourses and has enabled a ready grouping of the channel systems according to three important periods, covering the time before, during, and after the series of eruptions.

First Period.—Prior to the first important flow of volcanic' cement, this period is represented by a system of continuous valley-like depressions in the bedrock, from a thousand to several hundred feet in depth and several miles in width, and containing broad river beds filled with gravel to very considerable depths. The rivers, in eroding the bedrock and forming these depressions, left a succession of broad, flat benches with shallow accumulations of gravel.

*The term "channel system" herein refers to the beds of contemporary streams.

The channels naturally followed, to a great extent, the belts of soft slate. This slate is easily eroded, slacks readily, and is washed away in the form of a fine silt. Quartz is the only important material contained in the belts which is hard and permanent enough to resist the destructive action of the current. Owing to these facts we find in the filling of the channel, for long stretches, quartz gravel and quartz sand almost to the exclusion of other materials. The white channel of the Mountain Gate and Hidden Treasure Mines is a striking example. (See Fig. 3.)



The channel is filled to a depth of fifty feet, and a width of one third of a mile, almost exclusively with smoothly washed bowlders, pebbles, and sand of pure white quartz. On top of this, to a depth of one hundred and fifty feet or more, and an original width probably exceeding a mile, the filling is quartz sand and sandy pipe-clay.

The course of these belts of soft slate being south, or somewhat east of south, and not entirely continuous, and the general slope of the surface being to the southwest, the channels occasionally break across the harder belts of bedrock. The quartz gravel decreases in quantity, and there are substituted pebbles and bowlders of equally hard siliceous metamorphic rocks.

There appears no conclusive evidence of the occurrence, during this period, of any disturbances to cause a wide diversion of the watercourse, and the writer is unable to say whether the period is represented by one large channel system only, with its tributaries, upper leads, and benches on the valley slopes, or by several such systems.*

The first important volcanic eruption in the high Sierras changed the conditions. A mud composed of fine volcanic material was delivered to the river bed and washed down its course, spreading over the gravel to a considerable depth, solidifying and sealing the river deposit. The streams were diverted by the cement cap thus formed, and the first period came to a close.

Second Period, or period of the series of volcanic cement flows:—The capping of the older channel deposit occurred in a succession of flows. The watercourse was several times diverted by the heaping masses of volcanic materials. During the intervals between the periods of volcanic eruption both shallow and deep narrow channels were cut, sometimes following and partly obliterating the older deposit, sometimes crossing and leaving the deeper portion of the older bed altogether. Some of these later cuts are higher than the earlier; several of them, however, passed entirely through the older deposit and fifty to one hundred feet deeper into the bedrock. (See Figs. 3 and 4.)

The "blue channel" and the "volcanic gravel channel," shown in the section, represent two such cuts.

The "blue channel" contains, in its lowest depression, five to fifteen feet of bedrock gravel of a

*See Appendix A to this article.

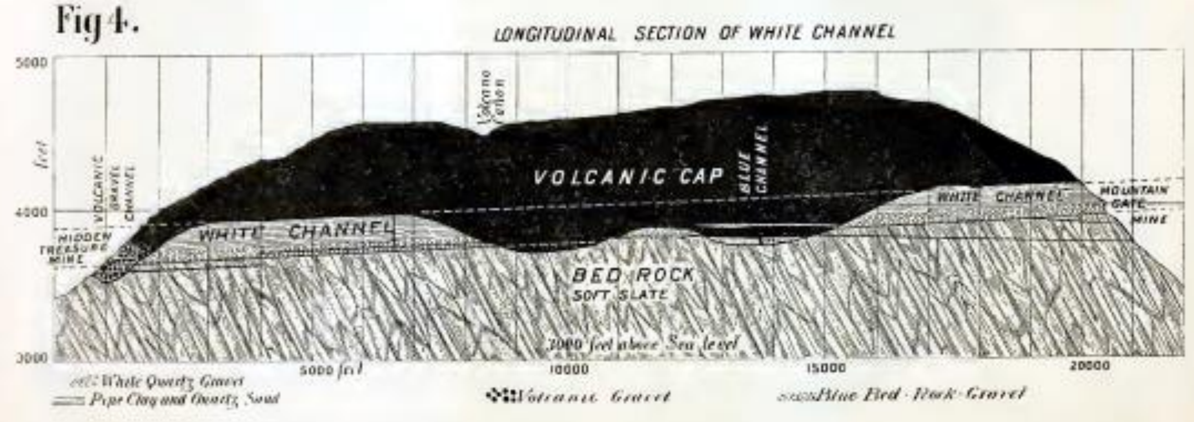
grayish blue color,* and on top of this eighty feet of cement, then a layer of four or five feet of bedrock gravel; and on top of this again, cement.

The " volcanic gravel channel " contains a large body of coarse gravel, composed mostly of volcanic rocks, and to a small extent only of bedrock.

These two channels represent distinct systems. The volcanic gravel channel is doubtless the later of the two; possibly the latest of the deep channels of the period.**

The final bed of the period was filled with coarser cements and conglomerates to a great depth. Volcanic eruptions in the high Sierras ceased altogether, and thus the cause of frequent diversions of the watercourse disappeared.

Fig 4.



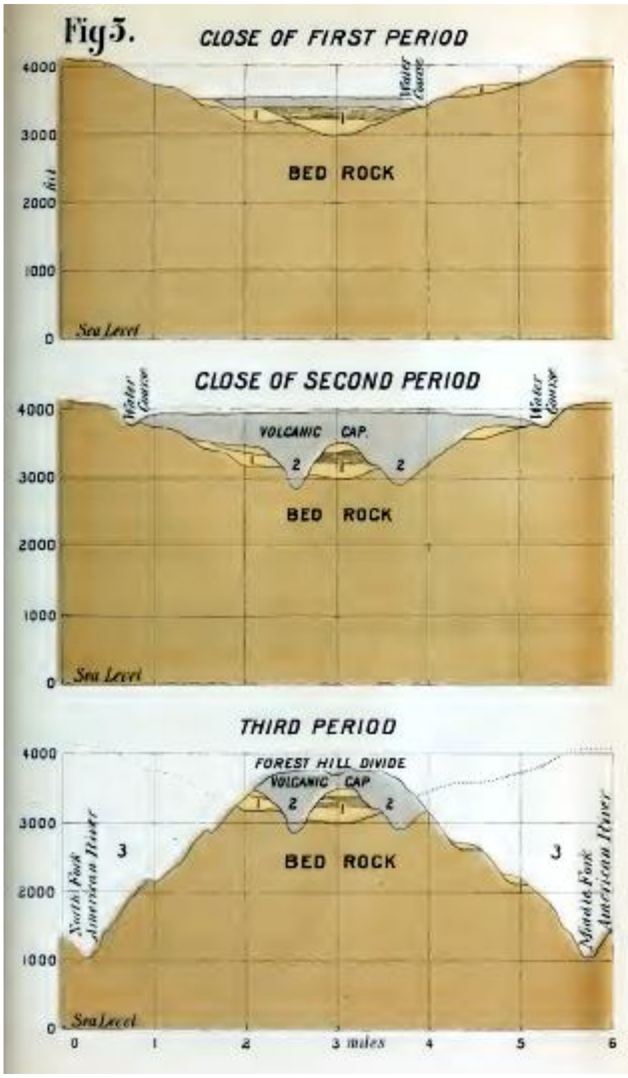
Third Period, immediately following the last important flow of volcanic cement and extending to the present time.—There still remains of the volcanic cap from three hundred to one thousand feet in depth. The ancient valley was filled to depths even greater than these, and there resulted a wider and more permanent diversion of the watercourses than heretofore. The streams started new channels, probably along the marginal lines of the cap, cutting across the cap at the juncture of tributaries of early periods, and ultimately obliterating the greater part of the deposits of the first period and a large part of the deposits of the second period.

These streams, undisturbed by volcanic activity, have continued to cut, forming eventually as the forks of the American River the deep canons of the present day. The following series of sections will illustrate this conception of the transformation of the original surface, and the extent of the cutting and filling of the three periods (see Fig 5). The surfaces marked 1 are sections of the gravel deposits of the first period, and those marked 2 are sections of the volcanic cement deposits of the second period.

Distinctive Features.—From the frequent displacement of the streams during the second period, there have arisen various complications in the channel systems. Although the mining developments are extensive in portions of the district, it still remains a difficult matter to separate the channel systems of the second period, and it is not always easy to distinguish between those of the first and second periods. In a general way, it may be said that the channels of the second period differ from those of the first as follows:

*In this article "bedrock gravel" means gravel composed of bedrock material; "cement," volcanic cement; "volcanic gravel," gravel composed of volcanic rocks more recent than the channel systems of the first period.

**See Appendix B to this article.



their beds are narrower, rims steeper, and accumulations of bedrock gravel incomparably smaller.

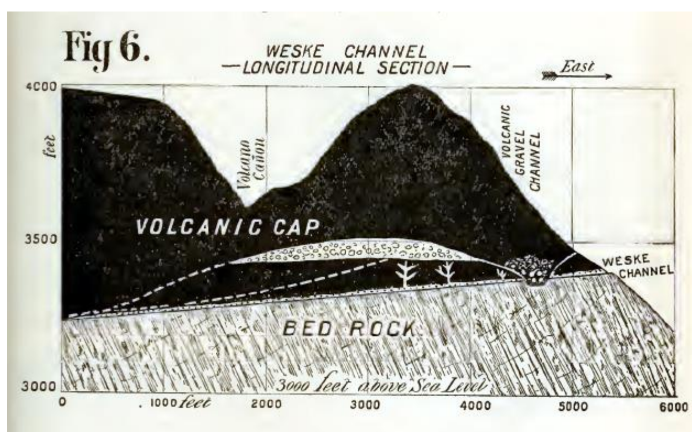
The following may be said concerning the gravels in the deeper channel bottoms, and their immediate volcanic cappings: The characteristic channel deposit of the first period consists of a large body of gravel of exclusively bedrock material, and a light cement capping; the characteristic channel deposits of the second period, either of a small body of bedrock gravel and a heavier cement capping, or of a large body of volcanic gravel and a heavy volcanic conglomerate and cement capping.

A continuous cap of so called pipe-clay generally indicates the first period.

Where one deep channel cuts across the deposit of another, the channel which does the cutting belongs, as a rule, to the second period. The channel which has been cut may belong to either period.*

Gravel Dislodged and Redeposited.—There occurs occasionally very large accumulations of bedrock gravel between the deposits of volcanic cement, which are evidently the result of the cutting and dislodgment of sections of the older deposit. (See Fig. 6).

The upper body of quartz gravel shown in the figure is such an occurrence. It has not been explored to any great extent, and the limiting lines in this section are conjectural.

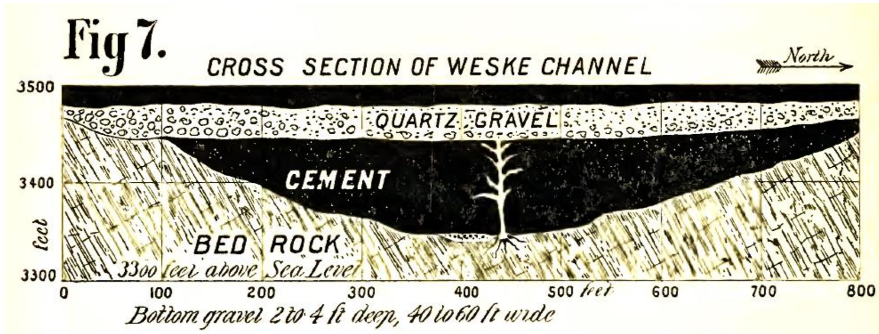


Buried Trees.—The section given in Fig. 6 shows an interesting occurrence. The cement filling the bed to a depth of one hundred feet is a more uniformly fine-grained sediment than is commonly encountered. It incloses a number of oak and cedar trees standing on the banks of the channel, with the roots intact in the gravelly soil and bedrock. One of these is a cedar nearly one hundred feet in height and four

*A careful study of the immediate volcanic caps of the gravel deposits by a competent specialist in petrography may lead to important criterions in classifying the channels. It will be evident that the writer's opportunities have been mainly for a study of the topographical features.

feet in diameter at the base, and stands perfectly upright, and, considering its age, is in a surprising state of preservation.

Similar standing trees are found also in the Bowen Mine, in the same channel. These trees are immediately on the shore line of the shallow deposit of gravel, and show that for a few centuries at least before the depositing of the volcanic material the stream was a small one. (See Fig. 7.)



These standing trees show also that the first flow of the cement was not torrential, though moving with a certain velocity. The existence of a current and its direction are plainly indicated by the structure of the deposit immediately surrounding the trunks of the trees.

The Weske channel is apparently one of the earlier channels of the second period. It is cut by a slightly deeper channel, which is filled to a considerable depth with a coarse, volcanic gravel, containing large waterworn bowlders of lava, mixed with a certain amount of coarse bedrock gravel. The whole is capped with hard cement and conglomerate. By following the course of the Weske channel on the map, it will be seen that it, in turn, cuts and recuts a channel of the first period, the Paragon and May Flower channels.

The Significance of the Volcanic Cap.—In certain districts in the State the ancient channel system, together with its dividing ridges, was completely covered by a broad lava-cap or mantle prior to the starting of the modern channel system.

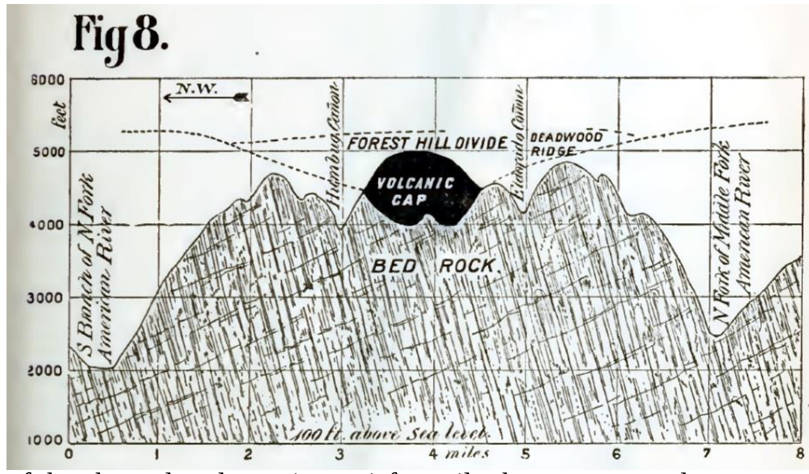
There appears no definite indication of such a mantle in the district herein described; on the contrary, the presumption is against it. Had the second period been closed by a broad, flat-topped lava mantle, completely covering the earlier divides, one should expect to find the modern channel, independent of the cement channel in its course, occasionally cutting and occasionally avoiding the same without a very definite guidance, and leaving as much of the old lava-capped divide as of the cement channel to form the present ridge. Such, however, is not the case on the Forest Hill Divide. The prospecting shafts and tunnels have invariably developed the existence of a trough-like depression under the volcanic cap. The ridge for twenty-six miles, from Tadpole to Peckham Hill, shows under the cap a practically continuous depression in the bedrock surface. There is good reason for regarding this as the main cement channel of the district.

It is difficult to establish satisfactorily the cause which led the modern river to avoid the older cement channel to so marked an extent. In picturing the periods, it has been assumed that the old river bed, or rather the valley, was filled with volcanic material to a level high up on its widespread rims, but not to actual overflowing; that the thick volcanic mud formed a more compact conglomerate of the heavier debris in the central line of flow, and a lighter and more sandy cement toward the shore lines; and that these conditions tended to divert the streams toward the marginal lines of the deposit. The streams would necessarily cut across the deposit at the juncture of the volcanic-capped tributaries.

There is offered no definite evidence in support of this assumption. It is made, in default of a better one, with the view of impressing the fact that the old cement channel has been avoided, to a notable extent, by the channel of the modern rivers.

It is plain, however, that the reconstruction of the ancient systems is very far from being so simple, as indicated in Fig. 5.

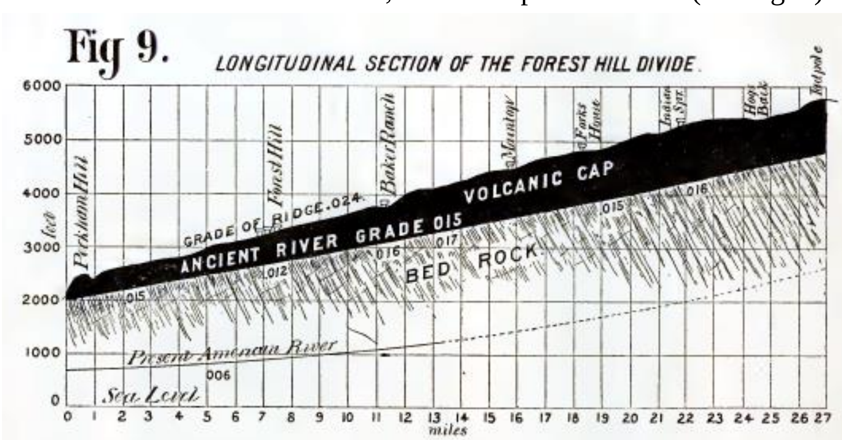
The following section (Fig. 8) shows the height of the present bedrock ridges. The rims of the old river bed must have been higher than these.



The section here given is taken across the Golden River and Eureka Claims. The existence of two deep channels is not absolutely determined. They are indicated by the pitching rims, but have not yet been developed.

The Grades of the Ancient Channels.—Owing to small irregularities there is required the development of a considerable length of the channel to determine satisfactorily the average grade. However, disregarding the smaller tributaries, the exposed sections show, as a rule, a fair uniformity of grade—certainly as great a uniformity as the modern river beds.

The accompanying longitudinal section of the divide shows the grades of the summit line, and of the ancient and modern channels, and the depth of erosion (see Fig. 9).



The course of the ancient river was somewhat more sinuous than that of the ridge line, hence the apparent grade in the section is somewhat greater than the actual grade. The grades are given in the form of the natural sine of the slope angle. The average grade of the ridge line is .024, or one hundred and twenty-seven feet to the mile; that of the ancient channel .015, or seventy-nine feet to the mile.

The grade line of the deep modern channel is curved to a marked degree; that of the shallower ancient channel to a scarcely perceptible degree.

In the following diagrams (Fig. 10) there are given the courses and grades of various patches of channel exposed in mining. The magnetic bearings of the down-stream courses are platted from a common point.

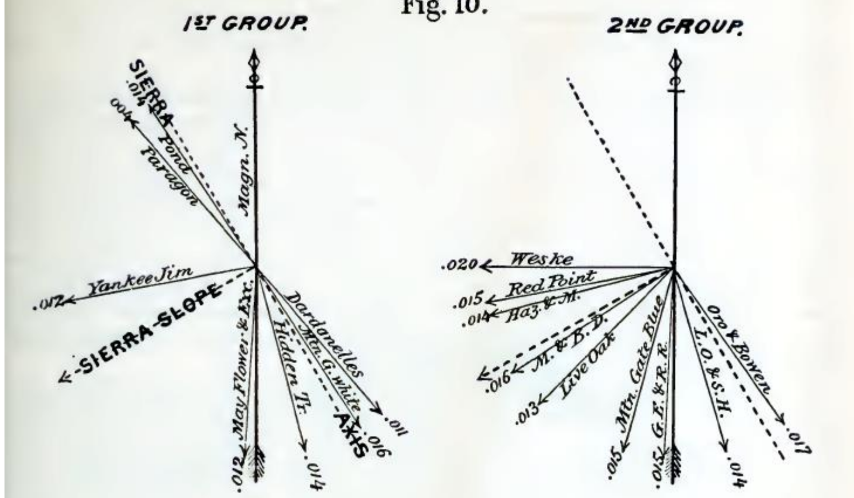
The first group represents the first period; the second group, the second period.

The Paragon grade is exceedingly irregular, the channel bottom rising and falling alternately on the down-stream course. The grades of the Dam, Mitchell, Rainbow, and Dix Mines, belonging to the second group, though determined, were not included in the diagram. They are as follows: Dam and Mitchell, south 50 degrees east .005; Rainbow and Dix, south 40 degrees west .005.

Professor Whitney, in his work on "Auriferous Gravels," after discussing the date of uplift of the Sierra, says: "We may assume that orographic causes may pretty much be left out of consideration in the discussion of what has taken place since the gravel was deposited."

Prof. Jos. Le Conte, in his paper on the "Old River Beds of California," attributes the cutting of the new channel, below the level of the old, to a considerable elevating of the Sierra Range, and increase of the mountain slope. The question on which the two authorities differ so widely in opinion is an important one in tracing the old channels. If, for example, Professor Le Conte's view is correct, and the bearing of the axis of upheaval is north and south, and the tilt to the west, one should expect to find, in following the sinuous course of the tilted channel: First, the original grade maintained wherever the course is north or south; second, a greatly increased grade wherever the course is west; third, little or no grade wherever the course is east. It is plain that a systematic study of the grades promises not only a settlement of the main question, but perhaps also the determination of the bearing of the axis, and the magnitude of the tilt, if any occurred.

Fig. 10.



The information furnished in the above diagrams (Fig. 10) is rather meager. More data are wanted to settle the question of tilting. However, it may be said that the evidence, as far as it goes,* is against any considerable increase in the slope of the Sierra flank—decidedly against an increase large enough to account per se for the two thousand feet deeper cutting of the modern river.

Local Disturbances.—There appears to have been very little local disturbance of the channels through faulting,** The writer has observed only one well marked case in the district covered by the map.*** A fault passes across the bed of the Yankee Jim channel. The strike is north 35 degrees west magnetic. The throw is to the northeast fifteen feet, and almost vertical, making the down-stream bed fifteen feet higher than the up-stream. The gravel has been washed away by hydraulicking, but it is plain that the fault extended through the gravel deposit, as the wall shows no wash and its edge is rough and angular.

Origin of Quartz Gravel.—The enormous accumulation of quartz gravel in the white channel of the Mountain Gate and Hidden Treasure Mines is a matter of some interest. A large number of the smoothly washed bowlders are from three to six feet in diameter, and weigh from one to ten tons each. One of the largest encountered had a smoothly washed surface and was between ten and twelve feet in diameter, weighing over fifty tons. It does not appear likely that the heavier of these moved very far after reaching the rough bottom of the river bed, and the surfaces were probably polished by the sharp quartz

* The Dam and Rainbow are forks of the same channel. Their grades disclose no tilt,

** This absence of local disturbance is a further indication that no marked uplift of the Sierra Range has taken place since the period of the ancient channels.

*** See Appendix C to this article.

sand in the swift current. Still the great mass of the material was doubtless derived from a source far above these sections.

In extracting the gravel and exposing the channel bottom there have been found a number of large quartz ledges. One of these measured thirty-four feet in width. Still the amount of quartz thus seen in the bedrock does not appear as sufficient to account for the filling of the channel. One is led to assume that the size of the quartz ledges, or their number, further up stream and perhaps nearer to the original surface, was greater than in the bedrock now exposed in the channel bottom.

Bench Gravel.—Numerous benches on the rims of the larger channels have been worked with profit. Owing, however, to the uncertainty regarding the extent of such benches when buried under the volcanic cap, there has been very little prospecting for them in the principal drift mines.

High up on the west rim of the present El Dorado Canon are a number of benches which have been hydraulicked with profit. Several of these are shown on the map. The Batchelder, Franklin, Drummond, and El Dorado Hill deposits are doubtless more recent than the ancient channels under the volcanic cap. The gravel of the Gas Hill and Big Gun pits is practically the same as that of the Mountain Gate and Hidden Treasure white channel—there is good reason for thinking that these are remaining patches of the same channel deposit.

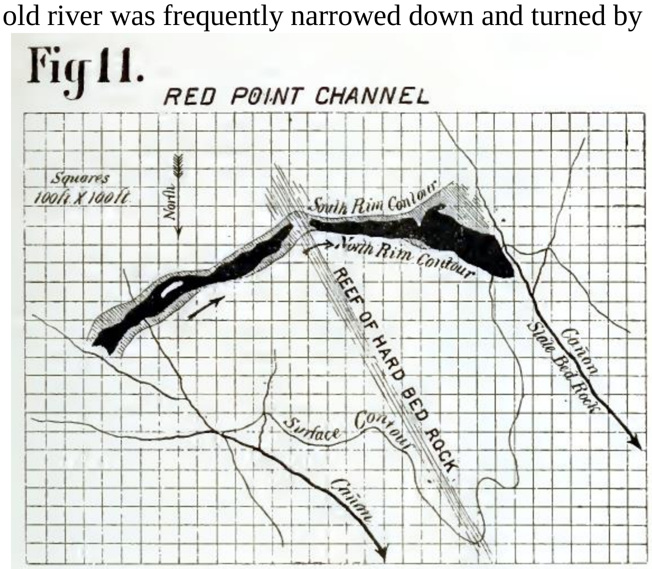
Courses of the Channels.—The courses of the channels placed upon the map appear to the writer as pretty definitely indicated by the data. The periods to which these channels are thought to belong are indicated by the coloring. (See note on map.)

In this connection attention is called to the "Review and General Discussion" of Mr. W. A. Goodyear, pp. 488 to 526 of Whitney's "Auriferous Gravels" Mr. Goodyear's foresight in outlining the courses of certain channels, at that time (1871) but imperfectly developed, is noteworthy. He indicated approximately the course of the Mountain Gate white channel several years before the discovery of the Hidden Treasure, and pointed out the probability of the bend in the Paragon channel many years before the May Flower discovery was made.

Depth of Gravel.—The depth of bedrock gravel wholly under the volcanic cap is, as a rule, from thirty to one hundred and seventy-five feet in the channels of the first period, and from a few inches to twelve or fifteen feet in the channels of the second period.

Width of Channels.—The character of the bedrock seems to have had Ian important influence on the width of the channel, the course, and pay. The old river was frequently narrowed down and turned by contact with belts of the harder of the metamorphic rocks.

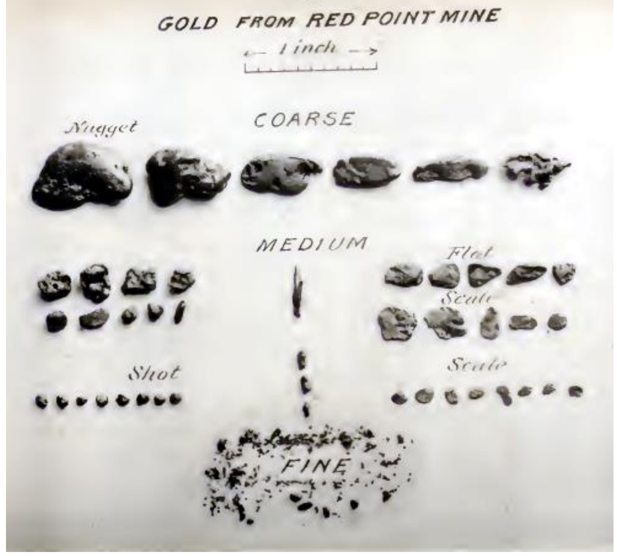
The following plan of the Red Point Mine is a good illustration of the effect of the hardness of the bedrock upon the width of the channel and the amount of gravel deposited:



The black surface represents the amount of gravel extracted, and practically the entire extent of gravel in the channel bottom. Where the channel crossed the hard reef it was narrow and contained no gravel, the volcanic cement resting immediately on the bedrock.

The Gold.—Fig. 12 gives a fair idea of the sizes and shapes of the ! gold nuggets and scales occurring in the gravel of the Red Point Mine. The fineness of this gold is about 0.930.

Fig. 12.



The greater portion of the gold is of medium size or fine and flat or scaly.

The gold from the blue channel of the Mountain Gate Mine, and from the Paragon and May Flower channel, is about the same as that from the Red Point. That from the white channel of the Mountain Gate and Hidden Treasure and from the Weske is somewhat coarser. Nuggets weighing one or two ounces are not uncommon; they seldom weigh as much as ten or fifteen ounces.

The distribution of the gold in the gravel is not always the same, though as a rule the bottom layer of gravel is the richest.

The Weske channel, it is stated, has yielded good pay on high benches. In one portion of the Dardanelles Mine, pay gravel was extracted in floors to a height of thirty-five feet above the channel bottom. The upper lead of the Paragon Mine—one hundred and sixty feet above the channel bottom—has yielded by drifting more per running foot of channel, though less per ton, than has the bottom lead. (See tabular statement.)

The gold is evidently derived from the bedrock traversed by the channel.

The fact is frequently commented upon that the quartz ledges in this district, though numerous, are usually too poor to pay the expense of working. This does not necessarily justify the conclusion that they were too poor to furnish the gold in the channels. Some of the ledges have shown gold enough to induce the investment of capital, and have at times paid a profit. It would not appear as over-sanguine to expect $2 or $3 per ton in a bottom layer of concentrates, representing a very small fraction of the mass of quartz broken and ground sluiced.

Finely laminated slates with quartz seams form good riffles in the channel bottom for the lodgment of the gold. The gold nuggets and scales frequently become imbedded in the softer slates to such an extent that it pays to remove the bedrock to a depth of several inches, or even a foot.

The effect of the swiftness of the current upon the pay is important. An underloaded current, i. e., a current charged with less detritus than it is well able to carry, is apt to cut its bed and prevent the accumulation of gravel. A greatly overloaded current will deposit too rapidly to admit of the concentration of the gold dust. It is apparent, therefore, that a suitable relation between the velocity of the current and the amount of material carried is an important factor in forming a streak of pay gravel. If such a relation exists, and is undisturbed for a considerable period of time, and the material passing over the riffled bed carries sufficient gold, a rich body of pay gravel may be formed.

An increase of grade, or narrowing of the channel, will cause an increase of velocity, and the same stream may be underloaded in a narrow, steep section, and overloaded in a broad, flat section. Furthermore, a stream may be underloaded in the center of the channel and overloaded on the rims; or it may be underloaded on the outer rim of a curve and overloaded on the inner rim.

Other conditions being the same, when the average grade of the channel is very great, one should expect to find the pay in the broad, flat sections, on the rims, and high up on the inner rim of the bend;

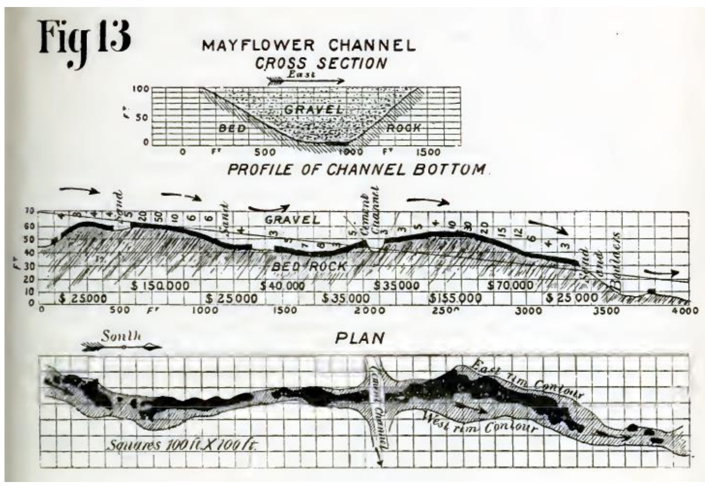
when the average grade is very small, rich gravel will be more likely to occur in the sections where the current is relatively swift.

In the Forest Hill District, where the average grades range from sixty to eighty feet to the mile, the general experience in working the bottom leads seems to be about as follows:

In the larger channels of the first period, the best pay is found on the brow of the steeper pitches on the down-stream course, and on the inner rims of a bend. The pay generally favors one rim for long stretches. Near and at the foot of steep pitches, and in very narrow sections, there occur potholes and the deposit is barren, consisting of round bowlders and sand. In the channels of the second period, there is a scarcity of gravel in the narrower sections, hence the broad, flat sections are preferred, even though the gravel may not be so rich.

The upper pay leads, such as the upper lead of the Paragon, probably represent long periods of comparative equilibrium between cutting and filling; while the poor strata are more likely to represent periods of rapid filling. A lack of stability in the beds of the upper strata militates against the frequent occurrence of rich pay leads in them.

Fig. 13 presents the average cross-section of the May Flower channel the plan and longitudinal section, or profile, of the bodies of pay gravel extracted (in black), and the plan of rim contours ten feet above the channel bottom. There are further given, in small figures, the total amount of gold extracted from various sections and the average yield in dollars per ton of gravel (ranging from $3 to $50) at intervals of one hundred feet. The average grade of the May Flower channel is twelve feet in one thousand.



Yield of the District.—The writer has been wholly unable to obtain a reliable estimate of the total yield of the district represented on the map.

Apparently it is about $30,000,000.

The following figures may be wide of the mark, as they are based on hearsay evidence, except in a few cases where comprehensive accounts were available:

Red Point, blue channel, drifting: $150,000
Mountain Gate, white channel, drifting: 600,000
Mountain Gate, blue channel, drifting: 175,000
Hidden Treasure, white channel, drifting: 1,150,000
Weske channel, drifting: 750,000
Michigan Bluff District, mainly hydraulicking: 5,000,000
Paragon, bottom lead, drifting: 850,000
Paragon, upper lead, drifting: 900,000
Paragon, hvdraulicking: 500,000
May Flower, bottom lead, drifting: 585,000
Forest Hill District, drifting and liydraulicking: 5,000,000
Dardanelles, hvdraulicking and drifting: 2,000,000

Todds Valley District, mainly hydraulicking: 5,000,000
Yankee Jim's District, mainly hydraulicking: 5,000,000

For special account of yield per running foot of channel, and per ton of gravel, see tabular statement.

The richest drifting channel on the divide was, doubtless, the Forest Hill channel, or series of parallel narrow courses under the town of Forest Hill, which, according to hearsay, yielded by drifting an average exceeding $1,000 per running foot.

Methods of Mining.—Many of the ancient channels and benches, especially those of the earlier period, have been exposed in complete cross section by the erosion of the modern streams.

For some time after the first discovery, in 1851, the mining of the district was practically confined to these exposed sections. The methods were naturally ground sluicing, hydraulicking, and drifting direct upon the richer layers. The drifting extended farther into the hill, and deeper tunnels were driven to drain off the water and facilitate the delivery the gravel.

The exposed and easily accessible deposits were gradually exhausted, and bolder enterprises were started. Shafts were sunk through the volcanic cap, and a deeper system of channels discovered. Large quantities of water were encountered, and this method of attack was found too expensive. At the present time all of the important mines of the divide are worked through deep drain and tramway tunnels, driven at great expense through the bedrock. Upraises to the channel bottom are made at intervals, and the richer gravel extracted. According to the firmness of the cementing substance binding the pebbles together, the gravel is either washed through sluices or crushed in a stamp mill.

The tunnels are driven either by hand or machine drills. By hand drilling the progress is from forty to seventy feet per month, and the expense $6 to $10 per running foot. By machine drilling the progress is from one hundred and fifty to three hundred feet per month, and the expense $12 to $18 per running foot. For details, see special descriptions and tabular statements.*

Details of Prominent Mines.—Four of the most actively operated mines at the present time are selected for detailed description. These are:

First—The Hidden Treasure, discovered in 1875 by Mr. William Cameron. This discovery is noteworthy, as the channel was not exposed anywhere near the point of attack, having been cut away by a volcanic gravel channel. Mr. Cameron based his calculations upon the similarity of the deposits at the Mountain Gate Mine and at Gas Hill, and started a tunnel, which passed through six hundred feet of volcanic gravel, and struck the white channel at precisely the right elevation.

Second—The May Flower, discovered by Mr. Chappellet. This was the first complete development of the covered portion of what was at the time called the deep back channel. This discovery in 1884 gave a new impetus to mining enterprise on the divide.

* For further information regarding the Forest Hill Divide, and general descriptions and comments upon methods of attacking the deposits, reference is made to W. A. Goodyear's notes in Whitney's "Auriferous Gravels," A. J. Bowie's work on "Hydraulic Mining," R. L. Dunn's and John Hays Hammond's articles in State Mineralogist's Annual Reports of 1888 and 1889.

Mr. Goodyear's "Review and General Discussion" presents the more important data leading to the ancient river theory, and discusses clearly the conclusions that may be based upon them. The publications of Mr. Bowie and Mr. Hammond present comprehensively the methods and results in working the deposits.

Third—The Paragon, discovered early in the fifties, and purchased by Messrs. Breece & Wheeler in 1865.

Fourth—The Red Point, or Golden River, opened under the direction of Messrs. De la Bouglise & Hoffmann.

At the Hogsback Mine a tunnel is being driven with machine drills. The equipment is similar to that of Red Point. The channel bottom has not yet been reached. Accurate accounts have been kept by the former Superintendent, Mr. W. C. Ralston, and show so close an agreement with Mr. Hoffmann's results in tunneling at the Red Point Mine, that it has not been deemed necessary to include the figures in the Statements which follow.

At the Gray Eagle Mine a tunnel is being driven very rapidly with the new Cummings air drill. The information is not at hand for a detailed description of the work.

The following descriptions and tabular statements will furnish the more important information regarding the four mines selected as types:

HIDDEN TREASURE.

Mine opened and worked under personal direction of principal owners, William Cameron and Harold T. Power.

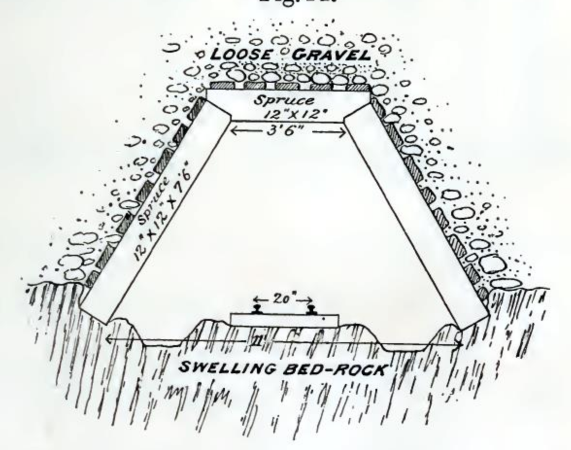
Pay Channel very wide, and unusually uniform in course, grade, and pay.

Gravel loose, involving the use of powder only in the breaking of large bowlders, and very little labor in breasting, but considerable expense in timbering. Free washing.

Bedrock very soft, involving the use of very little powder in breaking. Upon being exposed to the air it slacks and swells to an unusual extent, and requires close timbering.

Method of Attack.—The channel is reached through six hundred feet of tunnel in volcanic conglomerate. The tunnel is sinuous in its course, and somewhat irregular in grade. Its average grade is eighteen inches in one hundred feet. It follows the channel up stream, and is partly in gravel, partly in bedrock. Present length of the tunnel, from surface to gravel breast, eight thousand five hundred feet. The gravel is breasted by picking and caving, and is shoveled into cars having a capacity of one ton each. These cars are pushed by hand through short gangways to the main tunnel, and run thence by gravity to the dump house on the surface. One horse hauls a train of eleven empty cars into the mine.

Fig. 14.



Car Track, steel rails, thirty pounds per yard length.

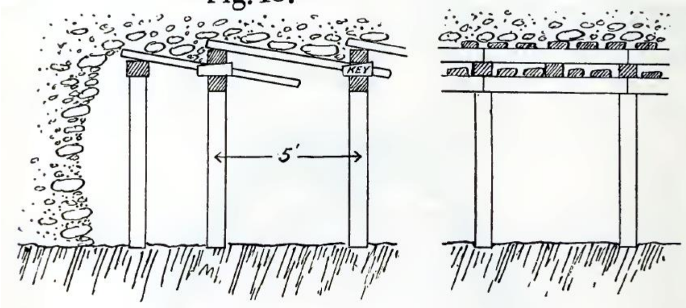
Tunnel Timbering.—The pressure from the gravel is not great, but the swelling bedrock has been a source of trouble, driving the legs of the timber-set inward and crushing the cap. After many unsuccessful attempts to overcome this difficulty, the legs were given an increasingly greater bottom-spread, until finally it was found that they remained stationary. The swelling bedrock is removed from time to time and the track adjusted. The accompanying cut shows the form of tunnel timber-set now used in bad swelling ground. (See Fig. 14.)

Sets are first put in four feet apart, and in the course of a few months center-sets are placed between these. Timber-sets on this plan have now been in place three years and are still in good condition.

In the eight thousand five hundred feet length of tunnel, there are about four thousand sets of timbers. Two men are kept constantly employed in easing and repairing the sets and adjusting the track.

Breast Timbering.—In breasting the loose gravel the ground is timbered closely as shown in sketch (Fig. 15).

Fig. 15.



The excavation is partly filled in or walled up with large bowlders to prevent extensive caving.

Powder, used only in small quantity in taking up bedrock and breaking large bowlders; total quantity about three thousand pounds No. 2 dynamite per annum.

Ventilation.—An air drift is run in the gravel, following the tunnel. By means of connecting drifts between tunnel and air drift, and with the assistance of a small furnace in the tunnel, a good circulation of air is maintained. There being very little powder used in the mine, this method of ventilating answers fairly well.

Washing the Gravel.—Storage capacity of dumping floor, four hundred tons. Size of nozzle, three inches. Water pressure at the nozzle, sixteen feet. The sluice boxes are eighteen inches wide and twelve feet long, and have a grade of eighteen inches to the box for the first six hundred and eighty-five feet, and twenty inches to the box thereafter.

The line of sluices is as follows, beginning at the dumping floor: One box Hungarian riffles; one hundred and ten feet flat and car-wheel riffles; eight hundred and seventy-two feet rock riffles, with occasional Hungarian riffles; grizzly and undercurrent with fall of fifteen feet; one hundred and forty-four feet rock riffles; drop of sixteen feet; one hundred and six feet car-wheel riffles; tailings accumulate in canon below. All but the Hungarian riffles are more or less charged with quicksilver.

Clean-up.—The upper box of Hungarian riffles is cleaned up daily; the one hundred and ten feet of flat riffles and car-wheels once in two to four weeks; the remaining riffles four times per annum. The tailings in the canon are sold to the highest bidder.

During the year 1889, under the management of Mr. Power, the total expense of the mine, or the difference between production and dividend, was 99 cents per ton of gravel washed.

For further details, see map and tabular statements.

MAY FLOWER.

Mine opened and worked by F. Chappellet, as Superintendent, for the May Flower Gravel Mining Company, of San Francisco.

Pay Channel fairly uniform in course, though irregular in grade and pay.

Gravel, hard cemented, involving the use of a large quantity of powder in breaking, and a small expense in timbering. Requires milling. Bedrock, hard slate, requiring considerable powder in blasting, but no timbering.

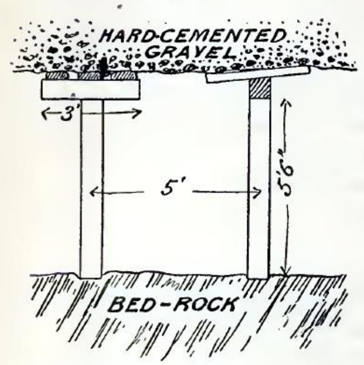
Method of Attack.—The channel is reached through four thousand six hundred and forty feet of straight bedrock tunnel (with uniform grade of three inches in one hundred feet), seven hundred and sixty-five feet of incline (with up-grade of eight in one hundred), and a bedrock gangway under the channel with twenty to forty feet upraises to the channel bottom. Present distance trammed from gravel breast to mill, eight thousand five hundred feet. The gravel is breasted by drilling and blasting, and is shoveled into small cars having a capacity of one thousand three hundred pounds each. The cars are pushed by hand to a chute. Larger cars, having a capacity of one ton each, are loaded at the chute and pushed by hand through the bedrock gangway to the head of the incline, and from the foot of the incline are hauled by mules to the mill dump on the surface. At the incline the empty cars are lifted by the loaded. One small mule will haul ten or twelve empty cars into or loaded cars out of the tunnel, with about the same facility.

Car Track, steel rails, sixteen pounds per yard length.

Bedrock Gangway.—Size, seven feet by seven feet. The channel rises and falls alternately, sometimes ten or fifteen feet in a length of three or four hundred. There is, in places, considerable water in the gravel. Owing to these conditions the driving of the bedrock gangway, even though a matter of large expense, is essential to the successful working of the mine. There are two gangways, one following the channel up stream, one down stream. In order to push these ahead fast enough to keep pace with breasting, a compressor plant is maintained to drive air drills. Two air drills are run in the face. Blasting with No. 1 and No. 2 dynamite powder. Very little timbering. Expense of gangway, about $13 per foot length. Progress, from one hundred to two hundred and fifty feet per month, as required.

Compressor Plant, located at mouth of tunnel. One boiler forty-four inches by twelve feet; one boiler fifty-four inches by fourteen feet. Two Burleigh compressors, eighteen-inch cylinders, twenty-inch stroke. One five-foot Pelton waterwheel to run one compressor during winter and spring. Compressed air pipe six inches, four inches, and two inches. Three air receivers thirty-six inches by twelve feet—one in compressor-room, one halfway in tunnel, one at head of incline. Two three-inch Ingersoll air drills, and four three and one half inch.

Fig. 16.



Gravel Breasting.—Drilling single-handed. Blasting with No. 2 dynamite powder. Timbering with short caps and posts five or six feet apart. (See Fig. 16.)

Excavation in great part filled in with bowlders. A gravel breast, seventy-five feet wide and six feet high, is driven ahead along the length of the channel at the rate of eighty to ninety feet per month, and there are required two such breasts to keep the twenty-stamp mill running at full capacity. Prospect drifts, in gravel, cost $2.50 to $3 per foot length.

Powder.—The amounts of dynamite powder consumed are as follows: In bedrock gangway, four pounds of No. 1 and four pounds of No. 2 per foot of length, at cost of $1.70. In gravel breast, one half pound of No. 2 per ton of gravel delivered, at cost of 8 cents. Total quantity, about thirty-five thousand pounds per annum.

Ventilation.—In part by compressed air, in part by connection with air shaft.

Gravel Mill.—Twenty-stamp mill located at mouth of tunnel. Four batteries of five stamps each. Stamp, eight hundred and fifty pounds; seven and a half inches drop; one hundred drops per minute. To each battery there is an automatic feeder (Challenge), a grooved wooden table, an oscillating rubber (Eureka), and a box of riffles. For screens, punched iron plates are used, two tenths inch holes, six or seven holes to the square inch.

The mill is run by steam power in the summer and fall, and by water power in the winter and spring. There are provided for this purpose one boiler, forty-eight inches by sixteen feet; one engine of seventy-five horse-power; one five-foot Pelton waterwheel.

Amalgamating plates have been discarded. The horizontal grooves across the table are one and one half inches wide, three fourths of an inch deep, and about twenty inches apart. The mortars and grooves are charged with quicksilver.

The gravel, as it enters the feeders, is picked over by two assorters, who throw out the large clean pebbles and bowlders. About 9 per cent of the mass is assorted out in this way and is washed down the sluices without passing through the mill.

The tailings pass through eight hundred feet of sluice boxes.

The stoppages in the mill during a run of one hundred and forty days amounted to ninety-two hours for small repairs and adjustments, and forty-four hours for clean-up—about one hour in twenty-four altogether.

Clean-up.—Upper groove, daily; mortar, two, three, or four times per month; lower grooves and rubber, monthly; tailing sluices, three or four times per year. Most of the gold is collected in the mortar and upper groove. (See tabulated statement.) The oscillating rubber collects a certain amount of quicksilver, but its usefulness scarcely appears proportionate to the amount of power absorbed.

For further details, see map and tabular statements.

PARAGON.

Mine worked under joint direction of owners, A. Breece and J. Wheeler. Present Superintendent, W. H. Grenell.

Pay Channels.—A complete cross-section of the channel is exposed by hydraulicking, at a point where the present Volcano Canon has cut and swept away a great portion of the deposit. The channel is the same as the May Flower. The bottom lead, immediately on the bedrock, and the upper lead, one hundred and fifty feet above, have both been worked. The bottom lead is irregular in pay and very irregular in grade. The upper lead is more regular in grade and pay.

Gravel.—The gravel of the bottom lead is the same in character as in the May Flower, requiring blasting and milling. The gravel of the upper lead is not so strongly cemented, and is breasted by picking, but is nevertheless worked by milling. The width of pay gravel is several times greater in the upper than in the bottom lead.

Bedrock, mostly hard slate, same as in May Flower Mine.

Method of Attack.—The bottom lead is followed direct from the surface exposure into the hill by means of a bedrock tunnel and upraises to the channel bottom. The course of the tunnel is sinuous, and its grade irregular; average, six inches in one hundred feet. Present length from gravel breast to surface, seven thousand six hundred feet. The bottom gravel is breasted by drilling and blasting, and is shoveled into cars and trammed by hand to the chute; thence by hand, in cars of one ton capacity each, to the mill dump on the surface. The upper lead was worked out to a point where it was cut off by a cement channel.

Car Track, mostly of scrap-iron.

Bedrock Tunnel.—Drilling, double-hand. Powder, No. 1 dynamite. Progress, twenty-five to sixty-five feet per month. Cost per foot length, $7 to $12; average, $8.

Gravel Breasting, in bottom lead, same as in May Flower; No. 1 dynamite in bedrock tunnel, and No. 2 in gravel breast.

Ventilation, by means of No. 4 Baker blower, driven by overshot waterwheel at mouth of tunnel. Air pipe, seven inches.

Gravel Mill, located at mouth of tunnel. Same plan as May Flower Mill. Ten stamps. In place of punched plate, a coarse wire screen is used with twenty-five openings to the square inch. Mill runs twelve hours per day, putting through thirty tons of gravel in that time. Power, steam. Fuel per twelve hours, one and a half cords of wood (pine, spruce, and cedar).

Clean-up.—Upper two grooves, daily; mortar, weekly; rubber, two or three times per year; sluices, once or twice per year.

For further details, see map and tabular statements. In the tabular statements, two figures are given regarding length of channel worked and yield. The upper figure is based upon the known yield since March 1, 1866, under ownership of Messrs. Breece & Wheeler; the lower figure is based upon the estimated yield under prior ownership.

RED POINT.

Mine opened and worked by Charles F. Hoffmann, as Superintendent for the Golden River Mining Company of Paris.

Pay Channel, fairly uniform in general course and grade, though irregular in width and depth of gravel and in pay.

Gravel, cemented, though not so hard as that of the bottom lead of the May Flower and Paragon, involving the use of a large amount of powder in breaking, and a small expense in timbering. Gravel worked by washing, though not so free as Hidden Treasure gravel.

Method of Attack.—The channel is reached through two thousand feet of bedrock tunnel, and upraises twenty to forty feet to channel bottom. Grade of tunnel, uniformly three inches in one hundred feet. Present distance trammed from gravel breast to washing floor on surface, four thousand feet. The gravel is breasted by drilling and blasting, and is shoveled into cars and pushed by hand to the chute. Cars having a capacity of one ton each are loaded at the chute and hauled by horses to the washing floor at the mouth of the tunnel.

Car Track, steel rails, sixteen pounds per yard length.

Bedrock Tunnel.—Size, seven feet by eight feet. In order to push the tunnel ahead rapidly, a compressor plant is maintained to drive air drills. Two air drills are run in the face. Blasting, with No. 2 dynamite powder. Very little timbering. Mr. Hoffmann has prepared a tabular statement showing the cost of labor and supplies per foot length of tunnel, from which the following is extracted:

Cost per Running Foot of Tunnel.

Labor: $7.35
Powder: 170
Fuse and caps: 17
Wood: 71
Charcoal: 21
Candles: 19
Foot-planks and ties: 09
Timbers for about 10 per cent of length: .03
Steel rails: .33
Air and water pipes: .35
Horse feed: .18
Oil and tools: .45
Freight: .64
Total, exclusive of management: $12.40

Average progress, about two hundred and fifty feet per month when required.

Compressor Plant, located on a flat, about two hundred feet above, and three hundred feet distant from the mouth of the tunnel. One boiler fifty-four inches by sixteen feet. One Ingersoll straight-line compressor, sixteen inches by twenty-four inches. Three three and one half-inch Eclipse air drills. Compressed air-pipe, three inch. The plant is well adapted for the purpose of tunneling. Cost, including substantial building, etc., about $8,000. When running bedrock tunnel with two drills, the consumption of fuel is two and one half cords of wood (mixed pine, spruce, and cedar).

Gravel Breasting.—Usually the entire body of gravel is breasted from bedrock to volcanic cement, the latter forming a clear roof to work to. Drilling, single-hand. Blasting with No. 2 dynamite powder. The method of timbering is the same as in the May Flower. Sets six or seven feet apart. Where the gravel is deep and the pay does not warrant the removal of the entire quantity, the timber is closer and heavier, to prevent the upper layer of gravel from flaking or slipping at the contact-surface with cement.

Powder, used in large quantities, both in driving the bedrock tunnel and in breasting the gravel. The amount used in the bedrock tunnel may be figured from the table above. The amount used in the work in the channel is one half pound per ton of gravel delivered; cost, 8 cents.

Ventilation.—No. 4 Baker blower run by small steam engine in compressor building. Air-pipe, eleven inches; cost, 45 cents per foot.

Washing the Gravel.—Length of dump house, fifty feet. Depth from car track (tunnel level) to washing floor, thirty feet. Storage capacity, four hundred tons. Size of nozzle, three inches. Water pressure at the nozzle, twenty-five feet. The sluice boxes are eighteen inches wide and twelve feet long, and have a grade of eighteen inches to the box.

The line of sluices is as follows, beginning at the dumping or washing floor: Two hundred feet Hungarian and flat riffles; drop, thirty feet; twenty-four feet wooden block and rock riffles; sixty-five feet ground sluice; one hundred and forty feet block, rock, flat, and Hungarian riffles; six hundred and eighty feet canon bed; drop, twenty feet; seventy-five feet ground sluices; drop, six feet; forty feet ground sluices; eighty feet twenty-four-inch flume; three hundred feet ground sluices; dam; forty feet double thirty-inch flume; grizzly and undercurrent, with fall of fifteen feet; tailings accumulate in canon below.

The lower riffles are charged with quicksilver.

Clean-up.—The upper four boxes are cleaned up two or three times per week; the following three hundred and forty feet of riffles, once a month; the balance four or five times a year. The tailings in the canon are sold to the highest bidder.

The total cost of surface plant and improvements, including compressor plant, boarding house, office, and dwelling, blacksmith shop, stable, powder house, wood shed, framing shed, snow sheds, one and one half miles of graded wagon road, trails, graded yard, dump house, tank, sluices, one and one half miles of seven-inch pipe for water supply, four horses, etc., about $22,000.

For further details, see map and tabular statements; also, article by Charles F. Hoffmann, published in the " Mining and Industrial Advocate" of San Francisco, March 10, 1887; also, R. L. Dunn's article in annual report of State Mineralogist, 1888.

The following tabular statement gives in round numbers the results of the working of the four mines:

Tabular Statement

	Hidden Treasure	May Flower	Paragon	Red Point
1. Character of pay gravel: Bottom Lead Upper Lead	Loose Not known	Hard, cemented Known but not worked	Hard, cemented Slightly cemented	Med., cemented Not known
2. Material of pebbles and bowlders predominating –Bottom Lead Upper Lead	Quartz	Metamorphic R	Metamorphic R Quartz	Metamorphic R
3. Color of pay gravel—Bottom Lead Upper Lead	White; red	Gray; blue	Gray; blue Red	Gray; blue
4. Material overlying pay gravel—.Bottom L. Upper Lead	Loose gravel &sand.	Cemented	Cemented Gray sand	Volcanic
5. Average width of gravel breasted, Bottom L Upper Lead	250 feet	75 feet	50 feet 225 ‘	120 feet
6. Depth of gravel breasted—Bottom Lead Upper Lead	4 to 7 feet	2 to 14 feet	2 t0 7 feet 6’	2 to 12 feet
7. Portion of gravel breasted, consisting of large bowlders left in mine-- Bottom Lead Upper Lead	25%	35%	25% 20%	30%
8. Total length of channel worked-- Bottom L. Upper Lead	7,700 feet	8,900	5,400; 1,400 2,000; 1,000	2,300
9. Portion of this length yielding pay— Bottom Lead Upper Lead	100%	66%	66% 75%	66%
10. Average fall of channel, feet per mile	70	60	Uncertain	75
11. Manner of breasting, Bottom Lead	Picking & caving	Drilling & blasting	Drilling & blasting	Drilling & blasting
12. Manner of extracting gold from gravel	Sluicing	Milling	Milling	Sluicing
13. number of tons of gravel delivered per 24 hours, active operation	275	130	30	100
14. Number of men employed in mine and on the surface during active op.—White men Chinamen	35 85	85 45	27	25 25
15. Average daily wage per man	$2.15	$2.75	$2.70	$2.40
16. Average cost of labor and supplies in mining and milling, or sluicing, per ton of gravel delivered, during active operation	$1.10	$3.25	$3.25	$2
17. Total gross yield to date, August 1880, By Drifting Bottom Lead By Drifting Upper Lead By Hydraulicing	$1,500,000	$585,000	$675,000+$175K $600,000+300K $245,000+250K	$150,000
18. Dividends	$340,000		$600,000	
19. Average gross yield per lineal foot of channel—Bottom Lead Upper Lead	$150	$150	$125 $300	$70
20. . Average gross yield per ton of gravel delivered to surface—Bottom Lead Upper Lead	$1.75	$7	$10.00 $4.50	$2.50

Note: 6 footnotes are shown on the original copy

Men Employed during Active Operation upon Average Gravel Breast.

	Hiddden Treasure	May Flower	Paragon	Red Point
Clerk	1	1		
Mine foremen	2	1	1	1
Mill and outside foreman		1		
Compressor engineers		2	1	2
Mill engineers		2	1	
Blacksmiths	3	2		1
Blacksmith helpers	1	2		
Carpenters	1	2		
Timbermen and rock-pilers	12			
Trackmen	2			
Shift bosses		4	1	2
Gravel washers				
Miners in tunnel or gangway	12	12	4	7
Miners in gravel breast	86	44	16	28
Drivers	2	2		6
Dumpers	2	2		2
Teamsters		2		
Outside laborers	1	3	1	
Mill hands—amalgamators		2		1
Mill hands—assorters		4		
Total number, excluding management	126	130	27	50

Milling and Sluicing Returns.

	Hidden Treasure	May Flower	Paragon	Red Point.
1. Manner of extracting gold from gravel	Sluicing	Milling	Milling	Sluicing
2. Number of stamps in mill		20	10	
3. Loss of weight in melting bullion, per cent	1.43	1.0	1.25	2.0
4. Fineness of bullion after melting	0.928	0.880	0.870	0.931
5. Per cent of total production obtained:				
From upper box, 12 feet	80			
From upper four boxes, 48 feet				85
From remaining sluices	18			13
From sale of tailings	2			2
	100			100
From mortars		66	75	
From upper grooves		32	24	
From lower grooves, rubbish boxes		1.5	0.75	
From tailing sluice		0.5	0.25	
		100	100	
6. Number of tons of gravel milled per stamp per 24 hours		6.5	6.0	
7. Number of cubic feet of water used for washing or milling per ton of gravel	(?)	325	325	175
8. Portion of pound of quicksilver lost per ton of gravel	0.003	0.1	(?)	0.003
9. Cost of milling per ton of gravel				
By water power.		$0.25		
By steam power		0.25	$0.50	

APPENDIX A.

The Hidden Treasure, Paragon, Pond, and Yankee Jim channels are all indicated on the map as belonging to the first period. It is plain that if these were the channels of running streams at the same time, they must have been forks of one and the same river. But this appears very unlikely. The gravel of the Hidden Treasure differs so greatly in character from that of the Paragon, that it is difficult to imagine the former merging into the latter in a distance of a few miles only. Further more, the Hidden Treasure and Pond channels are apparently higher in level than the Paragon and Yankee Jim channels.

The information points to the conclusion that these four channels were formed and filled with large accumulations of gravel prior to the first important flow of volcanic cement in the district described. There is, however, no exposure of an intersection or of a juncture of any two of them, and the writer is wholly in doubt with regard to their relation.

APPENDIX B.

That the Mountain Gate "blue channel" belongs to the second period is inferred, but not as yet established by direct evidence. The gravel contains pebbles of porphyritic rocks, but, as far as learned, none of volcanic rocks so recent as the immediate cap of the white channel which it cuts. This is not surprising, as the first cement cap of the earlier system is, as far as the writer has observed, fine grained and loose to form pebbles. The cements containing fragments and bowlders of lava were first introduced as a capping of the gravel deposits of this blue channel. The volcanic gravel was of a later origin, resulting doubtless from the erosion of the cap. There is wanting in this section in exposure to show the cutting of the light cement cap of the earlier system, to establish conclusively that the formation of this blue channel was due to a diversion of the stream, caused by a cement flow.

That the volcanic gravel channel belongs to the second period is directly shown by the character of the gravel.

The longitudinal section of the Weske (see Fig. 6) and Paragon channels (see map) furnish more definite evidence of the existence of at least two deep channel systems belonging to the second period. The cross channel, cutting both the gravel deposit and the white cement cap of the Paragon and the May Flower, belongs to a system earlier than the volcanic-gravel channel.

Just how many channel systems of the second period are represented by the various patches exposed it is difficult to say. Two such are virtually established, and one more is less satisfactorily indicated. It is practically shown that during comparatively recent geological epochs, the streams of the district have cut their channels at least three or four times to a depth of several hundred or a thousand feet, and once to a depth of three thousand feet.

APPENDIX C.

In the hydraulic pit of the Dardanelles Mine there is exposed a long fissure crossing the channel, and apparently faulting the bed to a slight extent. The strike is about south 75 degrees west magnetic, and the pitch steep to the north. The fissure is crossed by the bedrock tunnel, and is filled at that point with a fine, light gray sediment, apparently of volcanic origin and inclosing seams and bunches of quartz. The
edge, thus constituted, is said to have passed entirely through the gravel but not into the volcanic cement cap. A portion of this cement cap is similar in appearance to the filling of the fissure below, but coarser and more granular in structure. The gravel is washed away by hydraulickng and there is no opportunity of verifying the statements made with regard to it. It appears not unlikely that the formation of this fissure was directly due to the volcanic activity which led to the first important flow of cement.

Tenth Annual Report of the State Mineralogist, 1890, Pages 435 to 465