CALIFORNIA STATE MINING BUREAU

FERRY BUILDING, SAN FRANCISCO

FLETCHER HAMILTON — State Mineralogist

San Francisco] BULLETIN No. 85 [August, 1918

Platinum and Allied Metals

IN

California

CALIFORNIA STATE PRINTING OFFICE
SACRAMENTO
1919

CALIFORNIA STATE MINING BUREAU

FERRY BUILDING, SAN FRANCISCO

FLETCHER HAMILTON — State Mineralogist

San Francisco] — BULLETIN No. 85 — [August, 1918

Platinum and Allied Metals

IN

California

BY

C. A. LOGAN

CALIFORNIA STATE PRINTING OFFICE

SACRAMENTO

1919

CONTENTS.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

To His Excellency, the Honorable William D. Stephens,
Governor of California.

Sir: The attached report represents the result of several months' field work which was begun at the request of George Otis Smith, Director of the United States Geological Survey, and was carried on during the summer and fall of 1917 in co-operation with geologists of the Survey. It is anticipated that the report will ultimately be published by the above organization as part of a report on our domestic platinum resources.

Meanwhile, the inquiries which come to this Bureau daily on the various phases of platinum production, indicate that there is immediate need of a comprehensive and up-to-date report on the subject. The domestic production of the platinum-group metals is limited, California's placer gold mines and dredgers are the principal contributors, and the largest domestic reserves of the metals are also found in this state. The present report is intended to answer the numerous questions of those who are alive to the nation's need of an increased supply of these metals, but who have been unable to find any exact or exhaustive treatment of the subject in recent technical literature.

Respectfully submitted.

Fletcher Hamilton,
State Mineralogist.

August 20, 1918.

INTRODUCTION.

Purposes and Scope of the Report.

The field work for this report was undertaken for three main purposes. It was desired to gather and make readily available all the information to be had regarding production of platinum metals in California, to bring home to the owners of properties where these metals occur the absolute necessity of saving and marketing, for urgent domestic uses, every ounce mined; and to reach some definite conclusion regarding the future of platinum production in this state. The work was made necessary by the serious conditions caused by an unprecedented demand for platinum, occurring at a time when importation has been interrupted. Old sources of supply in Russia have failed us, and new fields have been called on to satisfy the needs of the acid manufacturers, the chemist and experimenter, and the maker of electric apparatus. It was necessary to take stock of our resources in this metal, which has become so important in industries vital to our success in the serious work on hand in Europe.

The work was done at the request of the United States Geological Survey, in co-operation with geologists of that organization. Every active mining district in California, where platinum is found, was visited. Because of the fact that it occurs in gold placers, and its recovery involves only a little extra care in addition to that required for saving the yellow metal, there is not much justification for failure to save it. There are few placer properties in the districts visited, where the sale of platinum metals recovered would not more than pay at present prices for the labor involved in getting them out of the black sand. This is true alike of dredgers and hydraulic mines. This work can be postponed in most cases till spare time is available, so it need not interfere with routine duties.

Most small operators were found to be unacquainted with the simplest methods of increased efficiency in this line and were not doing as good work as is desirable. Both hydraulic mining and dredging are big-scale operations, carried on to handle large yardages at low cost. There are losses of finely divided gold and platinum in both cases which are unavoidable and are expected. In hydraulic mining the loss occurs in the sluices because of the inability to save. With the dredgers, it occurs principally where the bedrock is hard or uneven, and can not be cleaned by the buckets.

The territory covered was so large that attention had to be limited quite closely to the main purposes of the trip, which were immediately practical in character. The result was that extensive or systematic

geological work could not be carried on. It must be understood, that such notes as occur herein on the geology of the districts visited, represent the impressions gained by hurried reconnoissance work. In the northwestern part of the state an effort was made to study certain districts far enough to give basis for an intelligent opinion regarding the origin of the platinum. This directed attention to the distribution of serpentine especially, and resulted in the mapping and outlining of serpentine occurrences, with an inquiry into the possible relationship of serpentine and the platinum metals. In general, it may be said that the results of the work confirm strongly the hypothesis that the platinum had its origin only in basic igneous rocks of the peridotite type. There were certain conditions observed which might be interpreted as contradictory to this hypothesis, and which ought to be examined more closely before a final statement is allowable.

No complete survey of the state's platinum metal resources has been made in the past. David T. Day made an investigation about 20 years ago with especial reference to the occurrence of osmium in northern California placers. Day's work was reprinted as a part of Bulletin 193 of the United States Geological Survey. The occurrence of platinum-group metals is mentioned in a casual way by Lindgren in his exhaustive work on Tertiary Gravels of the Sierra Nevada. These metals are also mentioned in various reports of the State Mineralogist of California, but nothing very definite has ever been known of them in California, beyond the fact that they occur widely distributed, in very small quantity. The writer of the present report has attempted to make definite statements only where based on results which have been obtained on a working scale.

A large number of properties reputed to be platinum producers were found, as a result of visit and investigation, to have no claim to the title. Similarly, reports of platinum ores in place in minable quantity have proven without foundation, although there are several apparently authentic cases where the metal has been identified in very small amount. The tendency of promoters to capitalize the credulity of their acquaintances and to sink money in search of these precious metals in places where failure is forecasted by all conditions, is especially deplorable now. In addition to the loss involved, the public is made distrustful and loses interest in legitimate mining enterprises, being often unable to distinguish a project with merit from a wildcat proposition. A consideration of our known platinum resources as described in the following pages does not indicate the presence of any undeveloped mining property which could be profitably exploited solely for its platinum metals content. There are, however, certain districts where the platinum metals and gold occur together in amount sufficient to

invite close investigation, and where the value of the ground for gold mining is greatly enhanced by the presence of platinum metals.

Our greatest reserves of these metals are no doubt locked up in Sierra Nevada gravels of Tertiary age. That in the dredging fields of Central California, and in the Quaternary gravels of the northwestern counties, is more readily available and is the present source of supply. Some of the first class of deposits are now being reopened, but anti-debris requirements are so stringent that no extensive hydraulic work in the Sierras is probable. The possibilities of our dredging fields and of the terrace deposits of the northwest are covered very fully in this paper.

ACKNOWLEDGMENT.

The writer takes pleasure in thanking the owners and operators of mining properties for the courteous and hospitable reception given him, and the keen interest shown in the subject. Their co-operation made it possible to obtain many details which, it is hoped, will make the report of interest to the practical miner and the prospector, the men to whom we must turn at last for aid in all ventures looking to the development of our mineral wealth.

Special thanks are also due to Louis M. Prindle and Henry G. Ferguson, geologists of the United States Geological Survey, with whom the writer co-operated in much of the field work. The cordial friendship and active assistance given by these gentlemen did much to make the season's work pleasant and successful.

Properties, Uses, and World Supply of Platinum Metals.

Platinum with a hardness of 4 to 4.5 and specific gravity of 21.5, never occurs pure in nature, being alloyed with varying percentages of osmium and iridium and smaller amounts of the other platinum group metals, of gold, of iron and sometimes copper and nickel. The typical modes of occurrence in California show it associated with considerable amounts of the first two metals, traces of palladium and rhodium, and one or two per cent of gold, with iron in such subordinate quantity that the crude platinum seldom responds to the magnet. Analyses of California platinum made years ago by Deville and Debray have been widely quoted and are still published as representative. They give 85% of platinum as the content of typical California crude platinum. As far as the writer knows, there is only one occurrence where such a high grade product is obtained in this state. Two-thirds or more of the crude platinum marketed from this state will not carry over 65% platinum.

Its insolubility in acids, its malleability and ductility, its coefficient of expansion (nearly equal to that of glass) and its high melting point (1791° C) are qualities which make platinum hard to replace, and

indispensable for many urgent uses. Among these are the manufacture of chemical and physical apparatus, in the oxidation process for the manufacture of nitric acid from ammonia, in magneto points and other electrical apparatus, and as a catalyzer in the manufacture of sulphuric acid, expediting the interaction of the chemicals without itself being consumed.

G. F. Kunz[1] estimated that the world's supply of platinum in 1917 was about 4,000,000 ounces, with 400,000 ounces of other platinum-group metals. Kunz divides this as follows, with regard to the principal uses to which it was put:

Catalyzing	400,000 ounces
Dental	1,000,000 ounces
Chemical and physical apparatus	1,000,000 ounces
Electrical devices	500,000 ounces
Jewelry	500,000 ounces

Of the world's total, he considered there were 1,000,000 ounces in the United States, of which 200,000 ounces were used for catalyzing, an amount equal to that used by England, France and Germany for this purpose. Of the remainder, a large part of that used in dentistry is permanently withdrawn. An increasing amount of that used in electrical work is going back into trade channels as scrap metal, instead of going to the junk pile with worn-out equipment. The metal required in catalyzing and in laboratory equipment is used over and over, very little of it being lost. The increased amounts required in these lines is because of the enormous expansion of business made necessary by the war. In the face of such need, no one can justify the use of platinum in dentistry or jewelry where other metals can be made to serve.

Iridium is superior in hardness and specific gravity to platinum, and at present commands a higher price. Its complete separation from osmium is a slow and expensive process and is a task avoided by many refiners, who prefer to buy the alloyed metals as osmiridium, estimating the relative percentages of the two. When sellers insist on exact returns for iridium, the osmium is not paid for, the explanation being that it is lost in the refining process. California platinum metals run from 30% to 90% combined osmium and iridium and in some localities, notably along the American River, the percentage of iridium nearly equals that of platinum. (See table of analyses). This metal is valuable for manufacturing of standard weights and measures, for fine tools, for knife-edges in sensitive balances, and for tips on fountain pens. Less important applications are for use as coloring in photography and ceramics, and in jewelry. Alloyed with platinum (10% iridium and 90% platinum), it gives a hard alloy which is useful in manufacturing electrical goods.

[1]G. F. Kunz—Platinum with especial reference to Central America.

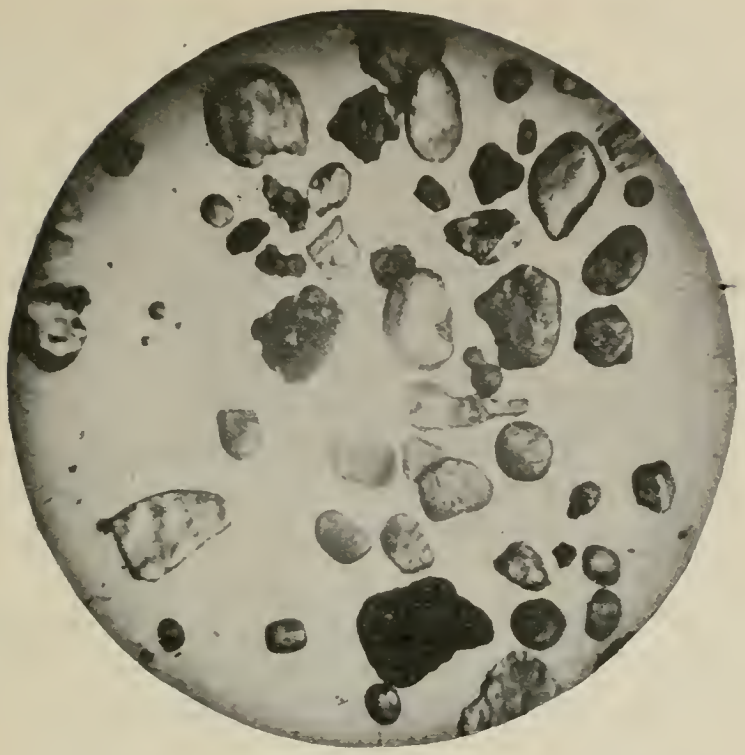


Plate I (a). Photomicrograph of platinum metals from Clear Creek, Shasta County. Recovered on Gardella dredge. Typical product obtained on dredgers. Principally platinum, with osmiridium in very subordinate amount. Magnified 30 diameters. The black grain is gold. Photomicrograph by S. A. Tibbetts.

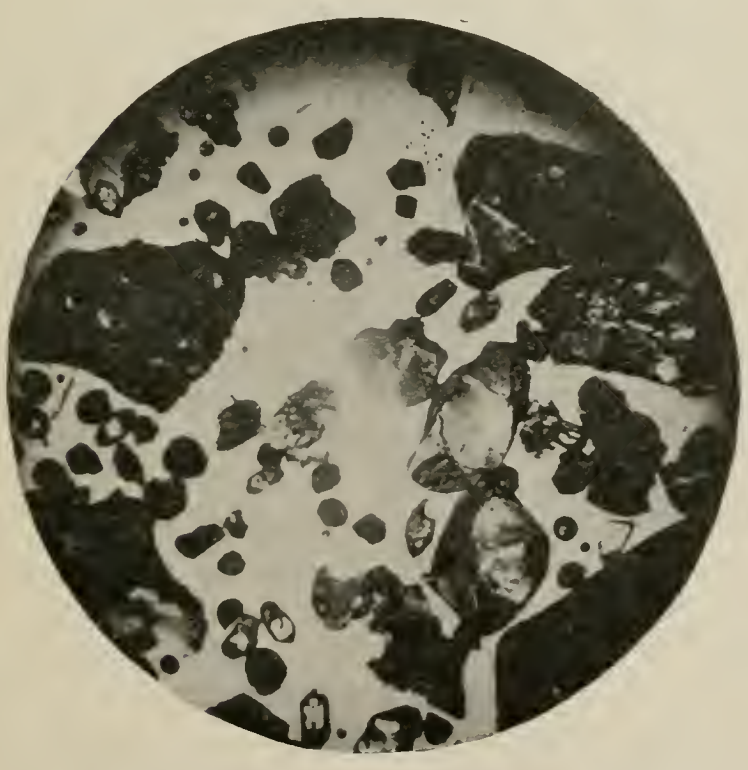


Plate I (b). Platinum metals recovered by cleaning bedrock of hydraulic mine at Sawyers Bar, on a bench of Salmon River, Siskiyou County. This material assays high in osmiridium, with less than 5 per cent platinum. Note the sharp, unworn character. Sample donated by Wm. Wike, Sawyers Bar. Photomicrograph by S. A. Tibbetts. Magnified 30 diameters.

Osmium is insoluble in acids or aqua regia and is practically infusible. It is used largely as osmiridium in pointing pens and in fine tools, and has also been employed in a certain type of electric lamp. It occurs in rather high percentage in practically all California crude platinum, and appears to be alloyed usually with iridium. The large nuggets of the Trinity and New River districts have been shown to consist principally of this alloy, bound together by small percentages of platinum and soluble iridium. California osmiridium is very much in favor for tipping fountain pens. The California alloy of these metals occurs as coarse pieces, larger than most of the imported material. This makes it easier to work up and grind, it being desirable to get pieces which can be shaped and cut. In tipping the pen the piece of osmiridium is soldered on the pen, and is then dressed and split on a fine wheel coated with diamond dust.

None of the other platinum group metals occur in California deposits in sufficient quantity to be commercially important. Traces of palladium and rhodium have been noted in several analyses.

Geography.

Two distinct areas in California are covered by this report. The first is the northwest portion of the state, comprising Del Norte, Siskiyou, Humboldt and Trinity counties. The streams of this district drain westward directly into the Pacific, and the region is one made up almost wholly of mountains. Here the Coast ranges of California blend with the Klamath and Cascade mountains in a tangle of confused chains lacking entirely the orderly arrangement and symmetry of the Sierra Nevada. The other area includes the western foothill slope of the Sierra Nevada, from upper Sacramento River to Merced River, particular attention having been given to a study of those dredging districts which are situated on every river where the stream escapes from its rocky mountain cañon and spreads out over the fringes of the great valley, dropping its load as it loses velocity and forming rich placer deposits. A small detached area on the Russian River watershed in Mendocino County was studied. Some work was also done on Beegum Creek, on the Shasta-Tehama counties line. The former is a Coast Range locality; the latter is on the west side of the Sacramento Valley.

The boundaries of the northern counties are determined by natural features. Del Norte County facing the Pacific, comprises practically the entire Smith River basin and is bounded on the east by the high crest of the Siskiyou Mountains. Smith River enters the ocean about four miles south of the Oregon line, and the Klamath flows into the Pacific about the same distance from the Humboldt County line.

Siskiyou County west of the railroad includes the Klamath River drainage. The present report deals with two sections of this extensive

NEVADA
NEWLANDS
TRUCKEE
CARSON
TRUCKEE RIVER
CARSON RIVER
LAHONTAN RESERVOIR
LOVELOCK
FALLON
FERNLEY
RENO
SPARKS
CARSON CITY
DAYTON
VIRGINIA CITY
GOLDFIELD
TONOPAH
HAWTHORNE
YERINGTON
MINDEN
GARDNERVILLE
STATELINE
LAKE TAHOE
CALIFORNIA
OREGON
IDAHO
UTAH
ARIZONA


CALIFORNIA STATE MINING BUREAU
FLETCHER HAMILTON
STATE MINERALOGIST
OUTLINE MAP
OF
CALIFORNIA
SCALE
SHOWING
LOCATIONS
OF
PLATINUM DEPOSITS
AUGUST
1918
ACCOMPANYING BULLETIN No 8
OREGON
NEVADA
PACIFIC OCEAN
MEXICO
DEL NORTE
HUMBOLDT
SISKIYOU
MODOC
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YUBA
NEVADA
PLACER
YOLO
EL DORADO
SONOMA
NAPA
SOLANO
AMADOR
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
FRESNO
INYO
SANTA CRUZ
SAN BENITO
MONTEREY
TULARE
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

rea—the main Klamath River from Somes Bar to the Southern Pacific Railroad, and the Salmon River district. Each of these is a unit, and ogether they include all the platinum producing properties of the ounty.

Trinity County, like Del Norte and Siskiyou, consists of an extensive iver basin. Trinity River drains every portion of it, and the multi-ude of perennial streams make this a good county for the placer miner. The auriferous gravels here have proven richer and more extensive than n any of the neighboring counties. The zenith of hydraulic mining as been passed here in the Weaverville and Junction City districts; arge quantities of equipment lie idle and valuable water rights have apsed, while in other regions, notably around Douglas City and near he mouth of South Fork, there are extensive and valuable gravel eposits undeveloped because water is lacking. Good dredging ground s being worked along the upper Trinity. Platinum production is mited to the vicinity of Junction City on the main Trinity, and to the egion near the mouth of South Fork on and a few miles east of the Humboldt County line.

Humboldt County is largely a lumbering and agricultural territory. Two areas are covered in this report, one on Trinity River near Willow Creek postoffice, and the other on the Klamath from Weitchpec to omes Bar.

Field work was done in the foothill belt on the west slope of the ierra Nevada, in the dredging fields of upper Sacramento River; on Feather River at Oroville, on the Yuba at Marigold and Hammonton, nd on the American at Natoma. Besides these larger fields, the Cosumnes, Mokelumne, Calaveras, Merced and Tuolumne River dredg-ng districts were covered. This entire district is a unit as regards eography, climate, physiography and geology. The dredgable ground n each river begins at the western end of the rocky cañon and extends estward down stream till values fade out and the ground becomes too ow grade to mine.

elief.

Because of the extensive field covered in this report, it is best to iscuss each district as a unit. In this way it is possible to obtain reater coherence, and to bring each region more vividly to the reader's ttention. In a general way, however, it may be said that the con-rolling feature of northwestern California's relief is an old peneplain, amed by Diller the Klamath peneplain, and described in his excellent ork, "Topographic Development of the Klamath Mountains." This ld peneplain is now tilted gently westward, and the modern streams ave deeply dissected it. Remnants of the ancient surface are visible

at many places. Larger panoramas of mountain ranges bring out clearly this feature, showing striking uniformity of elevation along chains of peaks whose summits once formed part of a continuous surface of subdued relief. There are only a few mountain ranges which stand out independently of this peneplain. Chief among these are the Salmon Mountains in Central Siskiyou County and the Siskiyou Mountains between Del Norte and Siskiyou counties.

Some attempts have been made to separate the mountains of this region into different systems. The Cascades, between the Sierra Nevada and Coast ranges, are east of the district being considered. The Klamath and Coast ranges can be separated in some places by topographic differences. Rounded, gently sloping hills, devoid of timber and separated by broad shallow valleys carrying tiny streams which fade away in summer, are characteristic Coast Range features. Such topography is seen in Humboldt County on the road from Korbel over Bald Mountain toward Willow Creek. North and east of that divide the term Klamath Mountains has been applied. The distinction between the two systems is based largely on geological grounds. Topography does not always offer a dividing line, as the Klamath type is developed at places in the Coast Range where intrusive and metamorphic action have been violent, and the Coast Range type is in evidence at places in the Klamath Mountains where Cretaceous and Tertiary sediments are preserved.

As has often been remarked, the streams of this section show a nearly uniform direction of flow northwestward in their lower courses. Eel, Mad, South Fork of Trinity, Klamath and Smith rivers exhibit this characteristic where they flow parallel to the strike of the sedimentary formations on the coast side. But in their upper portions they have carved deep cañons through the metamorphic rocks, flowing in narrow trenches with practically no level land. This action of the streams has made Trinity County a succession of cañons and mountain tops except on the upper reaches of the main river and on the Hayfork, where the country takes on an open, gently rolling aspect with low grade streams. The Klamath between Happy Camp and the mouth of the Trinity keeps to a deep narrow trench 3000 feet below the flanking mountains. The only flat land in this distance is the Orleans basin, scarcely a square mile in area. The river bars and terrace deposits in this section are only a few acres each in area at most, and the material of the cañon sides stands at such a steep angle that sliding is common.

Climate, rainfall and character of timber growth vary greatly on the two sides of the mountains which mark the limit of ocean influence. The lower courses of the rivers are open for the passage of moist winds and fogs, and the rainfall is heavy. This, with the rich soil in the river

bottoms, offers ideal conditions for the majestic redwoods which thrive n western Humboldt County and in the Smith River basin westward rom the mouth of South Fork to the edge of the sandy coastal plain. Rain in this section may set in heavily in September and is apt to total louble that received east of the mountains. The heavy vegetation regulates the flow of water so well that streams are perennial and there s an abundance of springs. Eastward of the coastal chain, the redvoods disappear and Douglas fir is the commonest conifer, with a very few sugar pines sometimes found in small clumps, and with the noble ir occurring in the higher mountains above 5000 feet. The bright nued madroña is also much in evidence. Underbrush, which is often mpenetrable on the coast side, thins out somewhat, but travel away rom the beaten trails is usually neither pleasant nor easy except in the erpentine belts, which support little vegetation.

PLATINUM PRODUCTION OF CALIFORNIA.

The annual production and value of platinum metals in California since 1887, have been as follows:

Year	Ounces	Value	Year	Ounces	Value
1887	100	$400	1904	123	$1,849
1888	500	2,000	1905	200	3,320
1889	500	2,000	1906	91	1,647
1890	600	2,500	1907	300	6,255
1891	100	500	1908	706	13,414
1892	80	440	1909	416	10,400
1893	75	517	1910	337	8,386
1894	100	600	1911	511	14,873
1895	150	900	1912	603	19,731
1896	162	944	1913	368	17,738
1897	150	900	1914	463	14,816
1898	300	1,800	1915	667	21,149
1899	300	1,800	1916	886	42,642
1900	400	2,500	1917	610	43,719
1901	250	3,200	1918	571	42,788
1902	39	468			
1903	70	1,052	Totals	10,722	$285,248

DREDGING.

INTRODUCTION.

The annual production of platinum metals from dredging operations in California is so small compared to the gold yield, that it is overlooked by the ordinary observer. Nevertheless, dredgers produce the principal portion of the annual recovery of these metals. This, of course, is because of immense yardages handled, as a study of the dredging fields shows clearly what is meant when we speak of platinum as a 'rare metal.' The metals of the platinum group are produced in California only where gold can be mined at a profit. Therefore, in discussing their occurrence and the possibilities of their future production in this state, a good deal of space has to be given to the subject of gold placers if any intelligent conclusion is to be reached.

A survey of our dredging fields shows a remarkable uniformity in practice and equipment. Close-connected buckets and revolving screens have everywhere replaced open-link buckets and shaking screens. Electricity is used exclusively for power, costing from 3/4¢ to 1¼¢ a kilowatt hour. From the time the bucket line dumps its load, till the final cleanup, gold-saving methods vary only in the degree of care exercised. The fine material passes over riffle tables of standard grade and type. Fine tailing goes directly to the pond by sluices, and coarse

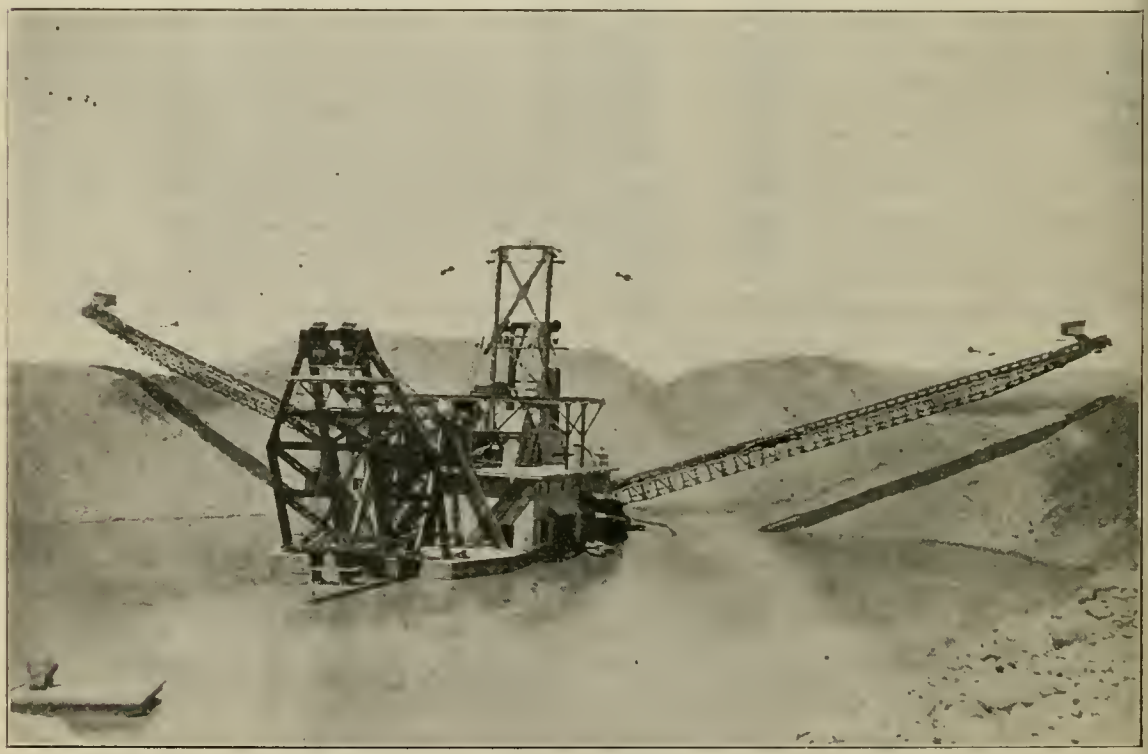


Photo No. 1. Dredge No. 16, Hammonton. Equipped with 2 stackers to comply with regulations requiring a clear channel.

ocks which have travelled inside the screen pass from its lower end nto a belt conveyor which elevates and stacks them. The problem of ailings disposal has been responsible for the chief variations from the tandard. Boats working in stream channels on or tributary to navi- able rivers are amenable to debris legislation, and are required to eave a clear channel. To do this, double stackers are used, one dump- ng to each side, leaving an open lane between. One such dredger s in operation on the Yuba River, and one on the Calaveras. Another ariation is the resoiling dredger, on which the long belt conveyor tacker is replaced by two very short ones, which dump coarse rocks ear the boat and spread them more uniformly. The fine tailing is arried back farther than usual in long sluices, so that it spreads over he coarser boulders and approximates original conditions. Such dredgers were designed to meet the complaints of those who objected o the destruction of farming land. Several are in use near Fair Oaks.

The Neill jig, first introduced on the Yosemite dredger, has more ecently been installed on boats near Natoma, to recover rusty gold. Each of six dredgers there are fitted with ten jigs, five on a side, with Hardinge Mill on each side to grind the sand preliminary to jigging. This installation costs about $12,000 on each boat and requires the ervices of an extra man.

Prospecting Ground for Dredging.

Shafts give more reliable results than the Keystone drill, but the atter has been used universally where shaft sinking was impracticable. Misleading returns with the drill may be due to (1) careless drilling, (2) spotted ground, or (3) hard or uneven bedrock, from which the dredger can not recover all the values. The drill, in a new unprospected ield, is probably as useful for the light which it throws on conditions nderground, as for the indication of values. Results near Hammon- on are said to average 80% of drill indications. Great care is taken here to prevent pumping below the casing when drilling.

At Marigold, squares of 200 feet are drilled at a cost of $2 a foot. A rocker six feet long is carried with the drill rig and the sand from each foot of drill hole is pumped and washed separately. The size and number of gold colors is noted and recorded for each foot. No. 1 size s smallest, No. 2 about the size of a pinhead and No. 3 the largest. The total gold content for the entire depth is found by actual recovery nd weighing and not by fire assaying. Special care has to be exercised when drilling through the pay streaks.

Prospecting with shafts was going on in the terrace gravel above Calaveras River near Jenny Lind in November, 1917. C. F. Hellman of the Butte Dredging Company has a novel washer to replace the ordinary rocker. The latter can not be used because the upper ground

is principally stiff clay. The dirt from the shaft is shovelled into a pipe 20 feet long by one foot in diameter, which has a grade of one-half inch to a foot and turns 20 times a minute. Water plays into the pipe and helps loosen the clay which is given a rotating motion by longitudinal strips in the pipe. The cylinder discharges into a tray 10′ x 5′ where the dirt is washed and puddled till throughly broken up. From here the dirt is scraped into a long-tom rocker 8′x 1′, which moves through a six-inch stroke 110 times a minute. The bottom of the rocker bed is covered by riffles, followed by cocoa matting under screen. The cylinder and rocker are both operated by a 1½-horsepower motor. A ton of sticky clay gravel can be washed in five hours.

FEATHER RIVER DISTRICT.

This was the pioneer dredging field of California and here were worked out the steps which had to be taken between the building of the early Risdon dredges and the perfection of the modern steel-hulled giants with buckets of 18 cubic feet capacity. The total area of dredgable ground in the Oroville district was 6450 acres. This took in part of Oroville townsite and extended southward along the Feather River about seven miles, with an average width over one mile. Besides this, there were smaller adjacent areas on streams tributary to the Feather. Wyman's Ravine District, four miles southeast of Oroville, contained about 680 acres and Honcut Creek about the same area. In 1902[2] there were 35 dredgers being operated by twelve companies, and the gold yield that year was over three million dollars. In February, 1918, seven boats were in operation and only four companies were left in the field. It is estimated that the dredging ground in the district will be exhausted within two years, and production from now on will decrease rapidly. One dredger was shut down in October 1917, one discontinued work in January, 1918, and two others are expected to be out of commission within twelve months. There remains after that, the possibility that some of the ground may be redredged, but at the present time the feasibility of this is entertained by very few, and no plans looking to such work have been made so far as known, except by Natomas Consolidated of California.

Some of the ground around Oroville has proven very rich, and early profits from dredging led to the payment of nearly any price for land. One company paid $1,500 an acre and some property is said to have brought as high as $3,000 an acre. Portions of the townsite have been dredged and subsequently graded for use as building lots.

Ground has been drilled to a depth of 500 feet in this district without striking true bedrock. The last bedrock as one descends the river is at

[2]California State Mining Bureau, Bull. No. 57, Gold Dredging in California.

the bridge outside Oroville, from which point the waters have spread over the plain. A typical section of dredging ground shows a top layer of 6 to 16 feet of fine soil, followed by the pay gravel with a depth of 20 to 50 feet. This rests on a bed of greyish volcanic ash, 3 to 8 feet deep, which forms the bedrock for dredging operations. It seems to be the consensus of opinion that the gravel below the ash is not pay gravel. Values as a rule are in the lower portion of pay gravel just above the volcanic ash.

The earlier operations were carried on with small dredgers which were unable to reach the best values on bedrock in some cases, so that there is no doubt a good deal of pay left in places under the old tailing piles. It is this possibility which raises the question of redredging. There were also the less easily located losses arising from the failure of the winchmen to dig to bedrock, when they could show greater yardage by shallow work. This practice was more prevalent ten years ago than now. While it could not be counted on as a definite factor in considering redredging, it would serve as a margin of safety. Cost per yard is cut down by the large up-to-date dredgers, recovery is improved, and the nature of the dredged ground would permit increased capacity, with proportionately lower unit expense. There is one such large dredger now in the district and it is the writer's judgment that it will continue work for some years after the new ground is exhausted.

Natomas Consolidated of California operates two dredgers, one with 15 cubic foot buckets and one having 7½ cubic foot buckets. They recover widely varying quantities of platinum from year to year as the platinum content of the ground varies directly with the gold values. The platinum is fine and high grade. An assay of a recent shipment of several ounces showed 68.3% platinum and 20.53% osmiridium. This company's production of precious metals will decrease about 25% in 1918 because of the retirement of one dredger.

Oroville Dredge Limited operated two dredgers near Thermalito. They were both equipped with 7½ cubic foot buckets and dug 20,000 to 30,000 cubic yards each a week. The ground is shallow and the dredgers dug to a depth of 26 feet. The platinum production over a period of two years has averaged one ounce for 160,000 cubic yards of ground dredged. This gravel was low grade in both gold and platinum, being situated quite a distance from the main channel and on high ground. This company finished its ground late in 1918.

The Pacific Gold Dredging Company has one dredger on the Feather River seven miles below Oroville. This boat handles 140,000 cubic yards of ground a month and produces less platinum than is recovered by the dredgers in the upper part of the field; as nearly as could be learned it takes considerably over 225,000 cubic yards of ground to

give a recovery of one ounce of platinum. This company in November, 1917, reported enough ground to keep the dredger in operation two years.

The American Gold Dredging Company retired a dredger in August, 1917, and began operations with a new one, the A. J. Holton No. 4, late in October, 1917. They have 250 acres of ground on the river seven miles below Oroville and estimate that about one-half of it is dredging ground. This will furnish several years work. The platinum production is the same as obtained from the ground near Thermalito.

Lawrence Gardella has been operating a dredger at Kentucky Ranch on Honcut Creek ten miles southeast of Palermo. He has paid no attention to platinum and has recovered only a few ounces in all. The dredger is old, and the ground contains some big boulders. This dredger is not apt to make any important production of platinum during the short span of activity remaining to it, as the clean-up methods used are not refined.

Upper Feather River.

The Feather River in its upper course, drains large areas of serpentine, amphibolite and granite. Wide belts of serpentine cross the watershed with a northwest trend. Chromite deposits occur at a few places, but they are relatively small, and production has been on a small scale. Neocene and Pleistocene gravel areas lie all along the river from the higher Sierras to the Oroville dredging fields, and prominent among them are some large lacustrine deposits, like the Meadow Valley beds. There are many gravel bars along the river which are of more recent origin. These bars, and the courses of tributary streams which often make up into steep cañons and drain older gravels, are mined in a small way by a number of 'snipers,' mostly old men who may be found working alone with rockers and long toms in summer, all the way from Oroville to the high mountains. Many of them save platinum and bring it into Oroville in the fall. A mining man of that place who has handled a good deal of this material, estimates that there is annually produced in this way from 12 to 15 ounces of platinum metals.

There is some placer mining on a larger scale on the upper Feather, but operations are hampered by lack of water and lack of grade. There is no record of production of platinum from these hydraulic properties.

Résumé.

The production of platinum will decrease from now on in the dredging district of the lower Feather, because of the rapidly approaching exhaustion of new ground. Redredging will not produce much platinum. Production for 1917 was about 94 ounces of crude metal, including that taken out by small placer miners. Four dredgers which

participated in this production have ceased operations and one, (the largest in the district) is working part of the time in ground dredged before. It seems, therefore, that a decrease of from 25% to 50% in the production of gold and platinum metals in this field may be looked for in 1918.

YUBA RIVER DISTRICT.

This district is on the river from the point where it issues from its cañon to one mile west of Marigold townsite, about seven and one-half miles. . The width dredged averages about one mile but there is partially

Photo No. 2. Detail of bucket line, Dredge No. 14, Hammonton. Buckets hold 17 cu. ft. and weigh 2 tons each.

proven ground back from the river which will give a total width of about two miles. There has been a total area of 2000 acres dredged in this field to the end of 1917, and there remains an equal area of proven ground. Work began here in 1903 under the direction of W. P. Hammon and R. D. Evans, whose interests were taken over in 1905 by the Yuba Consolidated Goldfields, a corporation of which W. P. Hammon has since been managing director. The Marysville Dredging Company began operations in 1906 and the Pacific Gold Dredging Company obtained some land on the extreme upper end of the field, just below the mouth of the cañon, and began dredging in 1916.

The trend in this field has been toward big scale operations and the holdings are mostly in the hands of the Yuba Consolidated Goldfields who had 2800 acres of proven ground, and the Marysville Dredging

Company with about 1000 acres of known ground controlled. The maximum annual gold yield so far attained was in 1910 when $3,172,476 were recovered with fifteen boats in operation. The total reported yield to the end of 1918 is somewhat in excess of $36,000.000.

Pioneer work in the Oroville field indicated what errors should be avoided, and the nature of the ground itself in the Yuba River District led to the construction of boats with increased yardage and depth capacity. The tendency now is to retire the smaller boats, with 7½ cubic foot buckets, and standardize on boats with 18 cubic foot buckets. There were operating in December, 1917, in the Yuba River field a total of eleven dredgers. Two dredgers with buckets of 7½ cubic foot capacity have recently been retired by the Yuba Consolidated and their capacity will be more than equalled by a new boat with 18 cubic foot buckets which began operations in December, 1917. Another of equal capacity has been contracted for. This company is using three boats with 7 cubic foot buckets and five with 18 cubic foot buckets. The Marysville Dredging Company operates two dredgers with 9 cubic foot buckets and one with 16 cubic foot buckets, but the rated capacity of this latter is considerably higher than the large boats of the Yuba Consolidated. The Pacific Gold Dredging Company operates one dredger with buckets of 9 cubic foot capacity and with a digging ladder capable of digging 70 feet below the water line. All the dredgers now working in the Yuba River field are equipped to dig from 68′ to 92′ below water level.

The upper portion of the gravels in the flood channel, to a depth of 40 feet, consists of old tailing from the hydraulic mines operated in years past on the upper Yuba watershed. This is low grade, containing about six cents a yard in gold. The ground varies in depth from 45 feet on the fringes of the lower end of the field to around 100 feet on the upper end. The bedrock under the pay-gravel is the typical volcanic ash of the Sierras, altered and consolidated in some cases by pressure. As in the Oroville district, drilling has not revealed the true bedrock. The last true bedrock outcrop is of greenstone on the Yuba Consolidated land near the river at Daguerre Point. The river is subject to sudden floods and has a swift current in winter. While it is often stated that values are not concentrated on bedrock, it is nevertheless the case that when digging is done during periods of flood, there is apt to be considerable loss because the dredgers are floating too high to dig to any great depth. This has been demonstrated to the satisfaction of the operators. Drillers who have worked in the district believe there are two pay channels south of the present river, the older of which runs southwest. Between this and the upper channel, which

appears to trend northwest, there is a poor streak. The gravel is generally medium to fine, with nothing in it to render digging difficult, and dredging conditions are nearly ideal. Values vary markedly in the different sections of the field. The richest ground of course, is in the up-stream section nearest the mouth of the cañon; but the ground is excessively deep and recovery not as complete as desired. Parts of the middle portion of the field run as high as 40¢ a yard, with an average stated to be about 16¢. From here values taper down rather sharply and it is believed that there is little if any dredgable ground below the holdings of the Marysville Dredging Company.

Platinum occurs in very small ratio to the gold content, but the total platinum production in the field is large because of the immense yardage handled. One ounce of platinum to 50,000 cubic yards dredged is the recovery obtained in the middle part of the field. In the lower ground, the platinum values decrease more rapidly than the gold. About 380,000 yards of gravel are dredged there for every ounce of platinum recovered. The metal is all very fine and as might be expected, is high in platinum and low in osmium. The greater portion of the assays indicate from 62% to 69% platinum and an average of 15% osmiridium. Some assays tend to show that iridium forms most of this 15% and prices paid for the osmiridium are nearly twice the value of osmium. The study of platinum in this district is interesting from the standpoint of comparison with other platinum fields, as regards geological relations and comparative values of platinum recovered. Platinum has been noted in the concentrates at several of the old hydraulic mining districts in the county but there has evidently never been any production of it from these sources, except in one case noted elsewhere. There is a marked difference between the relative amounts recovered on the Yuba and on the adjoining Feather and American rivers. Chromiferous serpentine areas are prominent on the American watershed not many miles above Natoma, where platinum metals are found in much greater proportion to gold than on the Yuba.

The total yardage of gravel handled annually by the dredgers now operating in the Yuba River field will be approximately 25,000,000 cubic yards which will yield, at the present rate, about 215 ounces of crude platinum metals. Of this total there will be 125 ounces of pure platinum, basing the estimate on actual returns for a portion of the current year. There will also be slightly over 30 ounces of osmiridium.

The only ways in which platinum production in this field can be increased are (1) increased yardage, (2) closer saving of values from the black sand concentrate, and (3) saving values now lost in tailings. With present conditions prevailing, there is no reason to expect any

enlargement of operations. One large dredger contracted for will do little more than replace the two smaller boats which are approaching the end of their usefulness. Scarcity of steel for peaceful purposes the past two years have made it very difficult for dredger companies to procure even large repair parts, and cost and scarcity of materials of construction and skilled labor, alike render new construction impracticable and inadvisable from a business standpoint.

As regards increased recovery, anything that could save even a part of the platinum now going to waste would give appreciable results when applied to such an immense tonnage. The Yuba Consolidated dredgers alone produce monthly 60 to 70 tons of a concentrate composed principally of black sand, which is the residue left after saving the amalgam in the long toms. The treatment applied to this sand for the recovery of gold and platinum is taken up in detail under the head of Methods of Recovery. The increased value of platinum will no doubt cause more care everywhere in its recovery. In applying refined methods of saving in any metallurgical process, a point arrives where the increment of saving does not justify the increase of cost necessary to attain it. Such a case arises when the concentrates cost more to treat than they appear to contain. The company mentioned above has now a system of treatment which seems to have reached this point.

The only record of recent platinum production on the upper Yuba is of a small recovery from Tertiary gravels on the South Yuba watershed near Nevada City. An Indian had been doing assessment work there for years on the Illinois Bar and Ah Moon claims in the Blue Tent district. In 1911, as nearly as can be learned, he noticed some metal grains in the gold clean-up which excited his curiosity and an assayer who was sought for advice identified them as platinum. The Indian's tribal brethern swore him to secrecy, which he kept faithfully for five years, not even advising the owner of the small quantities of platinum which he was mining and selling annually. In the fall of 1916, John Barleycorn unlocked his lips in the hearing of a local reporter, and it developed that he had sold $400 to $500 worth of platinum. This is said to have come from the Blue Tent tunnel and must have been the result of small operations, as assessment work usually implies the minimum legal amount of labor. This showing would seem to justify the hope that re-opening of hydraulic mines in that county will help platinum production. Arrangements are now under way to resume hydraulic mining on this property. The results of hydraulicking this gravel will give us the first definite idea of platinum yield to be expected from Tertiary Sierran gravels, as the owner has been brought to a realization of the necessity of saving the metal.

AMERICAN RIVER.

Lower American River (Folsom-Natoma District).

The dredgable land in this district extends from the old Blue Ravine placer diggings, six miles above Folsom, along the American River to nine miles below Folsom, and is three miles wide in places, with virtually all the good ground on the south side of the river. Dredging is carried on at two levels in old terrace gravels of the American. The ground varies in depth from 20 to 70 feet. The upper portion is hard, tenacious clay, which calls for heavy digging machinery and offers difficulties not met with in dredging the loose stream gravels of Yuba and Feather rivers. Water has to be pumped into the ponds. Rusty gold is common, and Neill jigs are used on six of the dredgers to recover it, as discussed more fully elsewhere under Mining.

The pioneer dredger was put in operation in this field in April, 1899, by the Colorado-Pacific Gold Dredging Company. It was a Risdon boat with 3¼ cubic foot buckets. Four companies followed and worked till January, 1909, when they were consolidated under the corporation name of Natomas Consolidated of California. The Ashburton Mining Company finished its ground in 1913. The only other remaining company, the Wilkes-Barre Dredging Company, sold its dredger, etc., to Natomas Consolidated in March, 1916, leaving that firm alone in the field.

Natomas Consolidated in December, 1917, was operating ten dredgers in this field. Three have buckets of 15 cubic foot capacity and are each rated to dig 200,000 cubic yards of gravel a month using over 1100 horsepower, as compared with the same company's Feather No. 3, a 15 cubic foot boat which digs about 200,000 cubic yards a month near Oroville and is stated to use 735 horsepower. Two dredgers are equipped with 13 cubic foot buckets and five with 9 cubic foot buckets. Natomas No. 2, another 9 foot boat, is being rebuilt. The bucket lines on the large dredgers carry 83 buckets and can dig 60 feet below water level. The gross gold yield of Natomas Consolidated in 1917 was $2,303,544, of which probably $1,700,000 came from the American River field. In the past year 27,106,000 cubic yards were dredged, about 20,000,000 cubic yards of which came from this field. The company claims to have 247,200,000 cubic yards of proven ground left, or enough for nine years.

Parts of this field are rich agricultural land, a factor which has led to the evolution of the reclamation dredger. This type varies from the ordinary dredger principally in the construction of the machinery used to dispose of the tailings. The coarse tailing is dropped near the boat from short stackers. The fine tailing from the gold tables goes farther back through long sluices which distribute it over the top of

the coarse cobbles, so that the resulting pile is left at nearly the same level as before digging. The land, if originally suited for agriculture, is left in condition such that it is easily prepared for planting trees and vines. The company has large fruit land holdings, and besides the large acreage of overflowed lands which it has reclaimed for farming, it is also planting some of the dredged ground from which precious metals have been extracted.

Platinum metals are recovered in this district in considerably higher proportion than in the Yuba River field. A reference to the geology[1] of the American River watershed constitutes apparently a strong argument for those who favor the theory that these metals in California have their origin in basic igneous rocks, and particularly in chromiferous serpentine. Large areas of serpentine cross the watershed in several belts, trending slightly west of north. One such belt extends, with interruptions, from the Cosumnes River through Latrobe, outcropping again on Green Spring Creek (on the South Fork of American River watershed) for several miles. Another, a mile wide and three miles long, lies a mile south of Salmon Falls, and still another crosses the South Fork and runs nearly to the North Fork near the old Zantgraff mine, having a width of nearly a mile and a length of four miles. Farther north and east other such belts occur over the entire watershed of the river. Chromite occurs frequently in these serpentine areas and is being mined now in many places, notably near the Zantgraff mine in El Dorado County, and in the vicinity of Iowa Hill, Butcher Ranch and Towle in Placer County.

The tenor of the crude platinum is such as to make us believe that it has not undergone such a long trip from its source or been subjected to erosive action as long as were the platinum metals of the Feather and Yuba rivers. The average of five assays made on lots of from 30 to 80 ounces each, showed 43.49% platinum and three of these showed 22.57%, 23.13% and 25.17% iridium. Osmium was not paid for and the percentage of it was not shown. The loss, less about 10% representing dirt, etc., or about 30%, is undoubtedly osmium. The material is thus seen to closely resemble in character the Trinity River metals recovered by the Valdor dredger.

There is a meager record of platinum production in this field, and the retirement of so many firms makes it impossible to get any such statistics for years past. The figures available, indicate production for only a few years past. The rate of production in 1914, 1915 and 1916 was about 150 ounces per annum. This represents the product from 16,000,000 to 18,000,000 cubic yards of gravel moved. One company now retired from the field, reports 35 ounces of platinum from 7,000,000

[1]U. S. G. S. Folio No. 5, Sacramento Quadrangle.

cubic yards. This is noticeably higher in proportion to gold yield than recovery from the Yuba and Feather River districts. Natomas No. 7 dredger which worked on Willow Creek back of the Natoma shops, is said to have recovered as high as one ounce platinum for $1000 in gold, as compared with .4 oz. platinum for $1000 in gold at Oroville, and less from the Yuba River.

UPPER AMERICAN RIVER.

This section of the stream has a swift current and is subject to sudden and severe floods. The cañons of the North and Middle forks are narrow and the streams flow on rough beds of hard rock. Dredging as described below has been confined to river bars made up principally of old hydraulic tailings which often cover virgin areas of ground. The chief difficulties in dredging are the rough hard bedrock and big boulders. Above Folsom the river flows through a cañon carved in granodiorite. The contact with amphibolite on the east crosses the river two miles above Rattlesnake Bar. A small area in the granodiorite near Rattlesnake Bridge, was dredged several years ago by Edward Gaylord. There is very little ground, if any, that could be dredged on the balance of the stream between Rattlesnake and the forks of the river. Some claims are being held with the expectation that they will prove dredgable, but the acreage is too small to justify construction of a boat and the bedrock is hard and rough.

On the Middle Fork, a dredger with 3½ cubic foot buckets has been operated intermittently since March, 1914, by the El Dorado and Placer Counties Gold Mining and Power Company. The digging is in river bars composed chiefly of old tailings covering some new ground. The Pacific Gold Dredging Company operated a larger dredger with 7½ cubic foot buckets just down stream from the last named boat. After over four years successful operation they are at present (January, 1918) moving this dredger's machinery to the North Fork of the river, where work will start about three miles above the junction of the North and Middle forks. The ground which has been worked was reported to run about 10¢ a yard through the gravel, but the slate bedrock was worth several times that wherever it could be reached. Care has to be taken during the winter storm periods to keep the boats out of the reach of the current. This ground yields well in platinum metals. The last run on new ground gave one ounce and a half a month for the one boat and the assay showed the content of iridium practically equal to platinum, with a trace of palladium and rhodium. Platinum was not saved here till quite recently.

There is a great deal of black sand in this stream which makes the recovery of fine gold difficult. The bulk of the gold in the upper

gravel is in flakes thinner than paper and floats readily if dropped on water. This gold comes in large part from old hydraulic mines. The upper gravels which are in reach of the current are sorted and washed during high water and the shape and location of gravel bars is constantly changing. The fine gold in them is often concentrated in rich streaks in coves or on the sides of bars. These streaks run as high as $2 a yard or more. The reported recovery of 10¢ a yard from the gravel dredged represents, no doubt, only a portion of total gold content. The fine flakes also appear to be hard to amalgamate. If tailings from rockers or sluices are panned they often show that only 60% to 70% of the values are being saved. The statement of one dredging man who has been familiar with dredging on the upper American for years, is that the bulk of the concentrate worked will stop on a 30-mesh screen. But much of the fine gold is so small that a streak of it gives the impression of a smear of paint. The conclusion is inevitable that a large percentage of this escapes. This is true of the platinum in greater degree than of the gold, because the former will not amalgamate, and is uniformly finer than the gold. The American River has long been a fertile field for experimentation with all manner of 'black sand' devices.

COSUMNES RIVER.

There is a small area of dredging ground on this river between Bridge House and Michigan Bar. It is estimated that there remains undredged 160 acres, which have been drilled and proven workable, and 40 acres of this have been bought and are being dredged. Farther upstream, near Michigan Bar, a small acreage has been dredged. The boat which was operated there was floated down the river and began work two miles west of Michigan Bar on the south side of the river, on July 18, 1917.

The topography is subdued, being characterized by low rolling hills and a shallow bedrock which rises gently from the river southward, outcropping near the county road. The gravel has been mined a great deal in this vicinity, but because of its thinness the operations have been on a small scale. Where dredging is going on, there is a bank 30 feet high, of which 15 feet is a barren overburden of sticky reddish clay. This bakes to a hard 'adobe' in the dry season and makes heavy digging. It is softened somewhat by running streams of water along the face of the cut. The gravel is found to be very 'spotted' because of the old drifting and surface mining, but is stated to have averaged 10¢ a yard for the past year.

The Indiana Gold Dredging Company is the only operator in the field. Their dredge contains the machinery of one of Oroville's

oldest boats. It has chain and sprocket wheel drive with 75 buckets of 4 cubic feet capacity. It can dig 27 feet below water and is stated to have a capacity of 60,000 yards a month, but considering the ground it handles, there is doubt if it disposes of over two-thirds that amount. Its horsepower rating is 210. Table space for gold saving is small. There is sufficient ground owned by the company to keep the boat busy two years, and land for an additional year's work has been examined, though not yet purchased. Probably the dredge will be in condition to retire by the end of the three years.

No definite idea of the exact platinum yield of the present operations is obtainable as the ground has only been worked since July, 1917. Past production one and a half miles upstream was at the rate of 12 ounces a year. The usual long tom is used to clean up. The black sand concentrate remaining in the long tom after recovering the gold, is panned down by hand and is sent to one of the company's other dredgers for final recovery of the platinum. The assay indicates 33.3% platinum and 41.97% osmiridium, of which about one-half is iridium.

MOKELUMNE RIVER.

The dredgable land on this river extends from the mouth of the cañon, four miles above Comanche, a distance of nine miles, to within four miles of Clement. The gravel is from 6 to 35 feet deep, with an average depth of 20 feet, carries a heavy overburden, and lies on the typical lava-ash 'bedrock' of the western Sierra slope. There is a total dredging area of 450 acres which will furnish work for the three dredgers in the field for four years longer. Field cost per yard dredged has run $1\frac{1}{8}$¢ lower than for the same company's ground in the Oroville district, but the average yield for the total yardage handled has also been considerably lower.

The American Dredging Company, formerly The Oro Water, Light and Power Company, controls all the ground in the district which they consider will pay to dredge. They are operating three dredgers at present, having begun in 1904 with one. At Lancha Plana, the upper end of the field, a boat with buckets of 6 cubic foot capacity is working. Another of similar size, and one with 9 cubic foot buckets, operate in the middle and lower portions of the field respectively. The smaller boats handle as high as 170,000 cubic yards a month. The larger one does not handle a proportionately larger yardage. It was the first dredger commissioned there but developments have shown that it was not as well adapted to the shallow ground as the smaller ones. The dredgers are called the Comanche No. 1, 2 and 3. The last boat was commissioned November 1, 1916.

The platinum production varies with the gold content of the gravels, and is somewhat lower in proportion than on other streams to the north. An assay of the platinum recovered here could not be obtained. The selling price of $47 an ounce, as against $61 obtained by the company at the same time from the same buyer for Oroville platinum, which assays about 68% platinum, would indicate the platinum content to be about 50%. The company at present is paying more attention to the recovery of platinum metals, and the production in 1917 was higher proportionately than in 1916. Present indications are that annual production will be 20 to 25 ounces during the next four years. Exact figures of production can not be published in a case like this, as there is only one operator in the field, and it is not the policy of the State Mining Bureau to reveal exact details of private business without the express permission of those interested.

CALAVERAS RIVER.

Dredging near Jenny Lind has been carried on in the bed of the Calaveras River and on the river terrace lying possibly 60 feet above the present channel. Considerable ground has been turned over along the river from the mouth of the cañon to the center of Jenny Lind townsite, and dredging is now progressing downstream from the town. Dredgers first started work here in 1903. There were in all about 600 acres of gravel in this field, of which the major portion has been worked. Depth to bedrock does not exceed 40 feet probably anywhere in the district and some of the gravel is only 18′ to 20′ deep. The material in the river is loose and easily dredged, being made up in part of old hydraulic tailings covered by fine sand. This ground is stated to run about 10¢ a yard. The terrace gravel carries an overburden of as much as 15 feet of 'hardpan' or hard tenacious clay, which carries no values, and with the small dredger used had to be blasted, at an added cost of 3¢ to 4¢ a yard. There remain undredged about 200 acres of the low grade river gravel, but the terrace gravel has been worked out as far as prospected.

The Calaveras Dredging Company finished its ground in the field and retired in May, 1916. El Oro Dredging Company has a dredger with 4 cubic foot buckets which is now on the terrace. It was idle and under repairs in November, 1917. The company's present holdings are about worked out, but there is a chance that new ground will be developed as the result of prospecting under way. The gravel on this terrace costs 10½¢ to 11¢ a yard to work, including cost of blasting, according to the statement of El Oro's superintendent, Mr. Hellman. Their dredger can handle 35,000 cubic yards a month of this gravel. (This company has retired from the field since the writer's visit.)

The Isabel Dredge, Ivy L. Borden, owner, is working in the river gravels, which reach a maximum depth of 40 feet and are easy digging. The dredge was commissioned in June, 1917, an older boat having been retired in March, 1916. It is equipped with 5 and 7 cubic foot buckets, and digs 27 feet below the water, handling 123,000 cubic yards a month. There are two tailing stackers to comply with debris regulations which require a clear channel. It is possible that the stackers may later be shortened and sluices lengthened in order to do resoiling. The ground being worked by this dredger includes portions of that formerly handled by the Calaveras dredge, with spots of new ground covered in places by tailings, and bedrock that was not always reached by the smaller dredge. It is estimated that there are 200 acres which will yield about 10¢ a yard.

The platinum production in this field is unimportant now. The Borden Company formerly saved 9 or 10 ounces yearly when working in ground that averaged 30¢ a yard, but the present output will amount to scarcely one-third that. The output from the Butte Dredging Company's ground has been only eight ounces in five years. There does not appear to be any prospect of the annual output amounting to more than four or five ounces per annum for the few years life left in the field.

TUOLUMNE RIVER.

La Grange Gold Dredging Company operates a dredge with 7 cubic foot buckets near La Grange on Tuolumne River. The ground is said to average 35 feet in depth, and consists of rather coarse gravel overlain by 8 feet of clay, and resting on a soft volcanic ash bedrock. This company makes a practice of saving the black sand and concentrating it on a Huelsdonk Submerged Table Concentrator (see under Methods of Recovery). The recovery of platinum metals here for given yardage is equal to that at Oroville. The company estimates they have enough ground for 12 years' more work. The platinum metals sold in 1917 averaged about 72% platinum and 18% osmiridium.

MERCED RIVER.

The Yosemite Gold Dredging and Mining Company operates a small dredge near Snelling in the gravels and overflowed land of Merced River. From the standpoint of platinum production, this company's work is of especial interest because of the experiments which have been carried on lately in concentrating the tailings and thus saving platinum and gold which have heretofore been lost. This phase of the subject is covered fully under the heading, "Possibilities of Increasing Platinum Production" (see page 105). The holdings of the above company comprise 400 acres and they have been working since 1907. The ground

is thought to average 16.5¢ a cubic yard, and is said to cost 6.5¢ a cubic yard to work.

Summary of Newer Dredging Fields in California.

As the present dredging fields are being worked out, exploration becomes more and more active, recovery is improved, and ground that was turned down once as "too low grade to dredge," is taken up again for consideration. California's best ground is either being dredged now, or is under control of dredging companies. No areas equal in size or as well adapted to dredging as the Feather, Yuba and American River districts, remain in the state. The physiography and geology of the region where the Sierra foothills merge into the great central valley gave ideal conditions for this class of mining. Escaping from their narrow rocky cañons, the streams have spread their sediments over a broad floor of soft volcanic material. This condition is not duplicated on the rivers in northwestern California, which have rocky cañons through most of their courses. There are some small isolated areas on many of California's rivers which could probably be dredged at a profit, some which are being dredged and a few which have been investigated and rejected. A summary of these with such mention of operating companies as will throw light on local conditions, is perhaps desirable, because California's platinum output is dependent on the development of gold placers.

Trinity River.

Trinity River has been the scene of most exploration and exploitation in the northwest. The Pacific Gold Dredging Company installed a dredge on upper Coffee Creek, but they were forced to abandon this ground on account of the heavy rocks and depth to bedrock and have moved their dredger farther down stream to near Carrville. This venture was a gamble and the dredger was put in its first location on the chance that it could be operated in spite of the boulders, as the bedrock is rich. There is considerable ground in this region known to be rich in coarse gold, but heavy boulders have prevented working it.*

Near Trinity Center, the Alta Bert Dredging Company has operated a 7½ cubic foot boat since 1903. The Alta Bert Company sold to Estabrook Gold Dredging Company in 1916. It is a peculiarity of these northern streams that they are often aggraded by ponding in their upper courses. This gives rise to broad flats of gravel and alluvium. Such a flat surrounds Trinity Center and extends downstream some miles. This company has met with success and has a

*It is reported that operations were started again during December, 1918. The Yukon Gold is operating on dredging property about half way between Carrville and Trinity Center.

onsiderable reserve of ground. Mr. Walker, superintendent, advises ney have some platinum and will market a small amount. Other rms have investigated the territory, but have not installed dredgers. ravel is 15′ to 40′ deep. Oroville Dredge, Limited, is now prospecting round on Stuarts Fork above Lewiston (June, 1913).

Four miles above Lewiston, the Trinity Gold Dredging Company has een dredging since 1912. They have made a good recovery of gold ut get no platinum. They had originally 900 acres of ground. The ravel is loose and reaches a depth of 40 feet, with a slate bedrock. etween this dredger and Douglas City there is a large acreage of round which might prove susceptible to dredging but is inactive at resent. As far as known it has not been drilled. On the Trinity iver upstream from Junction City about two miles, there is an area possibly 500 acres of land now being farmed, which might prove od for dredging. It has not been drilled, but was viewed as a possi- lity by local operators. The Valdor Dredge has been in operation on rinity River five miles below Junction City since November, 1916. he total proven area is small, only 74 acres, but adjacent ground will, doubt, be added soon to this. The bed of the river and gravel bars nd alluvial flats are being dredged. The bedrock is limestone and rpentine and the gravel has an average depth of 24 feet. The round embraces old placer diggings and has proven spotted and full holes. Otherwise dredging conditions are apparently fair and an verage of about 125,000 cubic yards a month has been handled. This roperty, as mentioned elsewhere, is the largest producer of platinum Trinity County.

The Trinity flows in a box cañon most of the way from North Fork New River. About three miles above the mouth of the South Fork the main Trinity, a dredging company drilled some bars and flats 1916. This ground was rejected because it was said to be too deep r a small dredger and too small in area for a large one. The Hoopa alley Indian Reservation includes several thousand acres of gravel id to average 25 feet deep, part of which could no doubt be dredged, mining were allowed, but the exploration of this tract is out of the uestion at present.

The Hayfork of Trinity is aggraded in its upper course. In the einity of Hayfork town there is a broad valley of possibly 10,000 res, of which two-thirds are reported to be gravel. This flat has been rospected by several dredging companies but none have attempted to ork it. The attitude of the residents is not particularly favorable to redging, as they fear it will spoil farm lands adjacent to the stream. he failure of the companies to make satisfactory deals with owners, nd the natural disinclination to pioneer in an untried district, have

probably been instrumental in retarding developments. The tributaries of the Hayfork supported a multitude of miners at one time; about 3000 Chinese are said to have worked there. As mentioned elsewhere, the platinum content of the gravels in this basin was very high in proportion to gold.

Klamath River.

On the Klamath River there appears to be little ground fit for dredging. Below Weitchpec, the government reserves unalienated lands for the Indians. From Weitchpec to Orleans the river cañon is steep. At Orleans, a change in the character of bedrock and in the direction of the river, led to the widening of the cañon. The town of Orleans is on a pleasant flat which is the lowest of six old river terraces formed by the Klamath in its cañon cutting. The highest of these terraces is 850 feet above the stream. The gravels at the different levels have been partially hydraulicked and the bed of the river has been mined with profit. Water for hydraulic mining being scarce, the idea of dredging the flat around the town was advanced. The ground was drilled four years ago by The Oro Water, Light and Power Company. They abandoned it, giving cost of transportation and general risks of pioneering as reasons. The flat, together with several hundred acres of adjacent high bench gravels, belongs to one company, and the desire to dispose of these holdings in one parcel is apt to retard dredging operations. The gravel is from 35′ to 55′ deep and lies on slaty schist bedrock which has been crushed and faulted a good deal. The gravel is in general medium, but there are some large boulders. The floor of this bench averages 10′ or 12′ above low water level. There are a few detached areas near Orleans which might be dredged in conjunction with this, but are too small to be taken alone. Dredging here should yield considerable platinum.

From Orleans to Happy Camp the river flows across the strike of the formations and the result is a V-trench in which the only gravel deposits are on narrow benches. These are nowhere large enough for dredging nor are they suitable for it. In the vicinity of Hamburg Bar a small suction dredger was operated some years ago without success. A small dredger operates irregularly on the Klamath near Oak Bar but is not reported as highly profitable.

El Oro No. 3, formerly El Oro No. 1 dredger of Oroville, is operated near Yreka on Greenhorn Creek, which drains into the Klamath through Yreka Creek and Shasta River. This ground does not produce any platinum; only an occasional grain of it is observed. The gravel averages 18 feet in depth, with slate and 'porphyry' bedrock and rarely is any serpentine encountered. The dredger carries 89 buckets of 6 and 6¼ cubic foot capacity and has a 16-foot extension on the digging

adder which permits digging 38 feet below water. The gold is coarse nd is caught on the first four tables. There is a short supply of ater in summer in spite of the elevation (about 3000 feet). In inter snow and freezing cause trouble, and a 28 horsepower boiler is sed for making steam to keep frost from the stacker belt. This redger has an area three-fourths of a mile long and possibly one-fourth f a mile wide remaining to work. The gold yield is satisfactory.

cott River.

The Siskiyou Dredging Company operates a dredge on McAdams reek, a tributary of Scott River near Fort Jones. The ground here is s much as 50 feet deep and there is a quartz porphyry bedrock. This redge gets no platinum.

Two small dredgers were operated for a time near Callahan on Scott iver, but neither one was a success, probably because they were too nall for the ground. One of them cost $45,000 and cleaned up a total f $10,000 in 26 months. No platinum recovery was reported.

acramento River.

Some dredging has been done along this stream in the neighborhood f Redding, but operations have been on a small scale, and the region emains today the largest undeveloped dredgable field in the state. he ground is generally favorable for dredging, running from 20′ to 40′ eep, and being composed of medium-sized clean gravel on soft volcanic sh bedrock. The ground along some of the tributaries is rich bottom nd, valuable for farming, so that in some cases dredging may be revented by disinclination to destroy such sources of perpetual income. ntroduction of extensive irrigation systems in the Upper Sacramento alley is also enhancing the value of farm lands.

In the vicinity of Redding several suction dredges were tried years go without success. Attempts were also made to get at the gold on edrock by the use of pneumatic caissons, but apparently no satisfactory sults were obtained in this way.

Late in 1917 the American Gold Dredging Company took an option n the Menzel Ranch, which lies along the north bank of the Sacramento iver opposite Redding and just outside the city limits. The results of rilling this property were so encouraging that they closed their otion on February 5, 1918, the price reported being $80,000. The mpany will begin the construction of a new dredger at once. It will ave buckets of 6 cubic feet capacity and will be designed to dig 40 feet low the water level. The property, which contains 1000 acres, has ot been entirely prospected, but enough ground has so far been eveloped to keep one dredger working for its entire life. This prop- ty, like the ground on Clear Creek, had been previously drilled and jected by another company.

Clear Creek.

This tributary enters the Sacramento a short distance below Redding.

William Desilhorst[1] did pioneer work in dredging here. He operated a steam scoop for several years, and although it is said to have cost 20¢ to 25¢ a cubic yard, profitable results were obtained. In 1906 the Shasta Dredging Company began operations and continued work for several years on a parcel of about 700 acres, nine miles from Redding. Subsequently many of the Oroville dredging companies drilled adjacent areas and were unanimous in rejecting it.

After this verdict had been passed, Lawrence Gardella took hold of the land, did a little prospecting and installed a dredger. Results have been satisfactory from the first. Gardella claims to be working this ground at about one-half the cost of dredging in the Feather and Yuba fields. This is due in part to the fact that he maintains no head office force, and in part to the exceptionally favorable ground. The gravel averages about 20 feet deep, carries no large boulders and is ideal for dredging. The entire acreage of dredgable land on the stream is not definitely known. Gardella states he has enough ground to keep three small dredgers at work fifteen years. He is moving the machinery of the old Oroville Union dredger to Clear Creek, and is also bringing in from Placer County the machinery of the dredger which he operated near Gold Hill, and which was closed down in July, 1917. Near Gardella's land, which is seven miles from Redding, the American Gold Dredging Company holds 250 acres, of which two-thirds is considered dredging land. This field is said to average about 10¢ a yard in gold.

So far, platinum production here has been discouragingly small, due no doubt in large part to lack of care in cleaning up. Only about 3½ ounces were saved in a year's work. Better results are looked for when the three boats are at work.

Cottonwood Creek.

Cottonwood Creek enters Sacramento River from the west, forming the county line between Tehama and Shasta Counties and receiving the drainage from the extensive area of Cretaceous rocks on the Shasta-Trinity divide. The Shasta Dredging Company operates a dredger on the stream near Cottonwood. The production of platinum metals here in 1917 was small, and sales indicated about 33% platinum and 50% iridium, with osmiridium approximately 17%, but not paid for. The operators hope to increase the production of platinum and iridium in 1918.

Butte Creek.

This stream enters Sacramento River west of Marysville. The Pacific Gold Dredging Company is operating a dredger on this creek and has

[1]Mines and Mineral Resources of Shasta County, Cal. State Min. Bur., 1915.

enough ground left to keep at work two years longer. The dredger handles from 100,000 to 120,000 cubic yards a month. The platinum yield is slightly higher than in the Oroville district and amounts to about eight ounces a year. The El Oro Dredging Company has enough ground along Butte Creek to operate a 6 or 7 cubic foot boat for four years, but the present high costs and difficulties attending the building of a dredger, preclude the probability of operations there in the near future. The cost of dredging on Butte Creek is placed at 3½¢ a yard.

Bear River.

Two small Risdon dredgers were installed on this stream near Wheatland in 1901[1] but the ground proved too heavy for them. The property came into the hands of the Oroville Dredging Company in 1907 and a boat with 7 cubic foot buckets and able to dig to bedrock was built. They operated for ten months at a cost of 5.4¢ a yard in ground that was said to average 7¢ a yard. The property was abandoned and has been idle since. There were about 1000 acres originally taken for dredging. The ground was heavy and clayey and the gravel small to medium, averaging 40 feet deep. On Bear River near Colfax there are some areas of gravel thought to be dredgable, which have not been drilled. This ground is similar in character to that which has been worked on the upper American River. It is largely in river bars, covered by hydraulic tailings and lying on a slate bedrock. If it can be worked, it ought to prove good, as the ground mined thereabouts has paid well.

Other Streams.

In the Gold Hill District, Placer County, a dredger was operated by Lawrence Gardella of Oroville for about two and a half years. The ground adjoins Auburn Ravine and consists of stream gravels and alluvial deposits which have been worked by shallow placer mining in the past. It is shallow and only about one-third of it carries pay. Gardella quit work here in July, 1917, because returns were unsatisfactory, and has moved the dredger to Clear Creek. There was no platinum found here.

In Yuba County, near Sucker Flat, one-half mile north of Smartsville, a stock company undertook some years ago to work a high bank of gravel by combined hydraulicking and dredging. They were going to hydraulic the bank which is 210 feet high, then scoop up the broken ground with a dredger, and store the tailings with an aerial tramway. A big slide is said to have put a stop to operations after several hundred thousand dollars had been invested. A stationary dredger with 7½ cubic foot buckets, made by the Yuba Construction Company was

[1]Bulletin 57, California State Mining Bureau, p. 163.

installed, as well as other expensive equipment. This project had apparently been abandoned at the time of the last report.[1]

There are some areas of ground in the Sierras which have been mentioned from time to time as dredging possibilities, but have not been developed. Among these are the holdings of the Mountain Meadow Dredging Company of Chicago, who proposed[2] to install a dredger two years ago. Their plans have evidently failed to mature. They had 3000 acres in the Mountain Meadow region in Plumas County. These gravels, which are at a low elevation near the present streams, are Quaternary alluvial deposits. There are several such, including deposits in Indian and Genessee valleys. There are also large areas of Tertiary gravel ten to fifteen miles southwest of Susanville, on the mountain tops at elevations of 5000 to 7000 feet[3]. Both these classes of gravel have been mined with profit. Hydraulic mining on the Quaternary gravel is limited by lack of grade in the lower ground, and on the higher portions of the Tertiary deposits it is difficult to get any water for hydraulicking.

Three miles south of Bucks Ranch, and 23 miles from Quincy, Plumas County, the Gold Mountain Hydraulic and Dredging Company of Los Angeles has 440 acres of land which has been hydraulicked recently. This ground is largely silt and sand with some quartz gravel on slate bedrock. The last reported run is said to have given $4,800 from 7500 yards mined.

There are other areas of gravel tributary to the upper waters of the Feather River, which have not been investigated so that no judgment of their availability for dredging can be passed. The same is true of the upper Yuba above Nevada City, and of other rivers of the Sierras. It is probable that exploration for new dredging fields in California will turn in this direction and no doubt some small deposits will be opened.

As far as known there has been no good dredging ground revealed yet in Southern California. Two companies who have prospected deposits there recently, one near Los Angeles and another in San Bernardino County, were both disappointed. Sandy gravel at the head of Gold Creek Cañon, east of San Fernando, has been prospected somewhat, as has also similar ground in Soledad Cañon, north of Lang Station. The promoters of these projects planned to grind the sand and gravel in ball mills and extract the gold and platinum, but apparently their inability to finance the venture led to its abandonment for the time being. Both localities are in Los Angeles County.

---

[1]Waring, C. A.: Cal. State Min. Bur., Mines and Mineral Resources of Yuba County, 1916.

[2]MacBoyle, E.: Mines and Mineral Resources of Plumas County. Cal. State Min. Bur. (in press).

[3]Diller, J. S.: U. S. G. S. Bull. 353, p. 116, Geology of Taylorsville Region.

SEA BEACHES.

Platinum in association with gold has been identified along the California coast from south to north,[1] but in general there has been no commercial production of either from such sources except in the northern beach mines in Humboldt and Del Norte counties. The recovery has usually been insufficient to pay wages. Gold and platinum are both very fine and hammered to the thinnest flakes. Many have held the opinion that a big plant, capable of handling large tonnage, would give a profit from these sands. Actual results have not sustained this theory. There often is a small profit possible from washing the superficial layer of black sand, which is concentrated in bands along the beach particularly during winter storms from the northwest. The practice of gathering this sand and taking it beyond the reach of the tide for washing in long tom or rocker, proved profitable years ago in Humboldt County at Upper and Lower Gold Bluffs and at Big Lagoon and Little River. Beach sands were also worked in a small way along the coasts of Santa Cruz and San Mateo counties. About 1884, there was a rush of beach miners to Laguna de la Merced, on the coast of San Francisco County, and for a time 200 men were attempting to mine gold there. A very few are said to have made a little profit.

Del Norte County.

A mile south of Crescent City, Del Norte County, a beach mine was operated in the 90's by one Yates,[2] who employed a few men to wash the sands, which were run over a series of plates. Working on this small scale, a fair return was reported. The most ambitious attempt ever made to mine beach sands in California for gold and platinum was launched by the Oro del Norte Company, incorporated for $1,000,000 by Theodore Heintz, a mining engineer. This company built a plant said to have cost over $125,000, on the beach two miles south of Crescent City. The plant and the process used are described in the chapter on Mines and Mineral Resources of Del Norte County, Report of State Mineralogist 1913–14[3]. It took this company a considerable time to satisfy themselves that the values they could save would not pay for the cost of extraction. The plant operated for over a year, but was closed down in 1914 and has been dismantled.

Humboldt County.

Another recent installation for extracting gold and platinum values from black sands is at Big Lagoon in Humboldt County. This lagoon contains eight to nine square miles of brackish water and is separated

[1] An enumeration would include practically every coast county in the state.
[2] Cal. State Min. Bur., Report XII, 1894.
[3] Also, in Report XIV, pp. 375–379.

from the ocean by a sand bar one-half mile wide. As mentioned above, the sands here have been washed profitably in a small way. The Big Lagoon Mining Company has a barge here which they have fitted with a centrifugal pump for raising the sand from the bottom of the lagoon. Driftwood and coarse material is removed by screening to 20 mesh and the fine sand flows over a double set of wooden riffles to give a rich concentrate. The equipment can handle 30 cubic yards of sand an hour and 300 cubic yards are required to give one ton of concentrate, at a cost of $15, according to the owners' statements.

An assay of this concentrate tended to show that it was worth $100 a ton, with a content of two and one-half ounces of gold and one-half ounce platinum a ton. This would mean that the original sand carried 33⅓¢ a yard. Such assays as this are of little value, when the gold and platinum occur as 'free' metals in grains and flakes. One small flake, more or less, in the portion assayed, may make a difference of as much as $20 a ton either way in the indicated values, depending on the size of the sample tested. Every assayer is familiar with the difficulty of assaying quartz rich in free gold, or concentrates carrying 'free' values. The only reliable way of testing this sand would be to wash quantities of it taken from different depths, in long toms or rockers.

Results of work done on beach sands indicate that the main body of sand in depth does not contain values enough to repay mining. Workable sand is found along the water-line where heavy constituents have been concentrated by waves and wind. This concentration has been carried to such an advanced point that the rich layer of beach sand may be 50% heavy black sand. The difficulty of extracting the values completely from this is readily appreciated when we consider that two or three per cent of such black sand in an auriferous gravel renders recovery of fine values practicaly impossible, and has led to the failure of many companies. It becomes necessary to remove perhaps 1000 pounds of this material from each ton to get the few cents in gold and platinum. The reverse process, or removal of the platinum and gold, would be preferable if commercially applicable to such low grade material. The fancied riches to be obtained from mining beach sands on a big scale have never been realized yet, and there appears to be no equipment applicable to this class of ground which will handle a large tonnage at a profit.

Laws Affecting Land Under Tide Waters.

In connection with the subject of beach placers a short statement of the law regarding ownership of lands under tide waters ought to be interesting. The following extracts are taken from paragraph 429, Vol. 2, Lindley on Mines:

"There is no principle involved in the consideration of the public land system better settled or more clearly enunciated than that lands under tidal waters and below the line of ordinary high tide are not public lands. * * * Title of such land

is in the state in landlocked bays from headland to headland and from the line of ordinary high tide on the shore of the open ocean seaward to the distance of three miles or a marine league.

"Where lands of this character form part of the territory acquired under treaties of cession and purchase which for the time are not included in the boundaries of any state but are in territories or insular dependencies with the temporary form of government. * * * the United States holds them in trust for the benefit of such states as may ultimately be carved out of them. It has been the policy of the government to leave the administration and disposition of the sovereign rights in navigable waters and in the soil under them, to the control of the states, respectively, when organized and admitted into the Union. At the same time the Supreme Court of the United States has the power to grant such title to soil under the high-water mark of tide waters. A mining claim can not be so located as to extend below the line of ordinary high tide.

"By Act of March 25, 1909, the California legislature forbade the sale of land between high- and low-water mark, and over which the tide ebbs and flows. In the case of oil taken from such land below high tide at Summerland, the state has not interfered. It is held, however, that a littoral owner may bring suit to abate a nuisance if such entrance on land below high tide should result in obstructing his passage to or from the open ocean."

It is thus seen that no title can be obtained to such lands, either from the state or federal government. The operator of a mining enterprise in such a location is liable to prosecution by the United States if he interferes in any way with navigation, or he may be liable to ejection by the state government.

Analyses of California Black Sands.

From time to time the attention of mining men turns to the problem of our black sands and to the possibility of extracting from them not only the precious metals, but also other minerals of industrial value. At the time of the Lewis and Clark Exposition the U. S. Geological Survey carried on an extensive investigation of black sands of the entire Pacific Slope. The following analyses of heavy black sands from representative California localities are taken from Bulletin 285, U. S. Geological Survey. All these except one are beach sands. The results shown were obtained from analyses of samples taken in most cases by local miners under varying conditions, and probably are of value chiefly in showing the relative proportions of the different constituents, rather than absolute quantities.

Figures represent pounds per ton, except gold and platinum.

Location	Magnetite	Chromite	Garnet	Olivene	Monazite	Zircon	Quartz	Dollars Au. and Pt.
Smith River (beach)	840.6	508.9	83.3	363.9	----	17.45	238	[1]2.45
Gold Bluff	244.5	75.2	171.6	818.6	----	16.94	593	6.01
Crescent City	480.8	109.4	503.1	574.2	56.03	43.55	132	0.24
San Mateo County	356.6	1022	14.2	290.0	----	110	215	Trace
Yuba River (Marysville)	562	122	10.7	176.0	Trace	3	714	0.97

[1]No platinum.

OTHER OCCURRENCES.

MENDOCINO COUNTY.

An interesting occurrence of platinum metals in this county was recently brought to notice, thirty-five years after the last miner had ceased work on the property. The writer spent two days in the district, and also spent a few hours in a locality about twenty miles distant, where there is a similar deposit properly to be considered as a unit with the above.

The first named property is about two miles east of Hopland, a station on the Northwestern Pacific Railroad 100 miles north of San Francisco. About 1880 Mr. Howell, proprietor of the Duncan Springs Resort, and a partner, worked two gulches on this land by placer mining with rockers and sluices. The surviving partner reports that they recovered about $1500 in gold and an equal weight of platinum metals, or about 75 ounces, in two seasons. Noting the recent enhancement in value of platinum, this man, now too old to mine the ground, called it to the attention of Howell's sons, who bought 256 acres, embracing the principal part of the deposit.

The section in question forms the eastern side of Russian River Valley. The gravel has been preserved in a chain of rounded hills which trends northwest for about two miles in accordance with the strike of the principal sedimentaries. The hills reach a maximum elevation of 860 feet, which is 373 feet above the present valley floor at Hopland station. McDowell Creek, flowing into Russian River from the east, has cut a broad valley through the hills, and many of its tributaries have carved gulches in the deposit. All except two of these are simply rainwater gullies, and go dry immediately after a storm. The sections exposed by these gullies, taken in connection with a consideration of the rocks enclosing the deposit, give a good idea of the geological conditions just preceding and accompanying the deposition of the pay gravel.

The area is one made up of many members of the Franciscan group. From the detritus of Franciscan metamorphics and igneous members a thin layer of gravel carrying gold and platinum metals has been laid down. This deposition appears to have occurred in Tertiary time. It is covered by only a thin layer of soil.

On the southwest side of the deposit reddish Franciscan jasper heavily stained by manganese oxides, strikes N. 55° W. and dips 70° W., forming part of the boundary. In contact irregularly with the chert near the Burns reservoir and surrounding the gravel to the east and

southeast are various outcrops of greenstone showing stringers of quartz. Some chlorite-mica schist also occurs here and one gulch exposes the sandstone which is so prominent to the eastward, and has furnished material for the underlying gravel. Farther north, along the west side of the deposit, occasional small outcrops indicate a boundary of igneous and metamorphic rocks with the greenstone phase prominent. About midway of the deposit near the west edge, a crosscut tunnel had been started northeast but was inaccessible. East of it, part way up the hill, a shaft had lately been sunk 17 feet and a hole from the bottom of this was bored 20 feet deeper. This shaft and boring penetrated, (1) 2 feet of red soil; (2) 1½ feet of yellow clay; (3) 12 feet of gravel, thinning toward the west and carrying no pay; (4) 21 feet of clay shale dipping 20° to 30° NE.; (5) small fragments of a hard rock, evidently a phase of the igneous rocks to the west and probably the west rim-rock. About 400 feet northeast, on the hill top, a shaft has been sunk 86 feet. This passed through a thin layer of the auriferous gravel near the surface but for the balance of the distance traversed a uniform brownish gravel composed entirely of pebbles of the sandstone. This sandstone gravel was practically barren of gold and platinum.

One of the larger gulches on the northeast side empties eastward into a branch of McDowell Creek and has cut a rather deep trench across the gravel, giving a V trough with a hill on each side. The banks show a considerable thickness of the last described sandstone gravel with occasional small lenses of light colored clay and some darker shale. This series shows marked uniformity in character and an entire absence of igneous and metamorphic rock fragments. At the head of this gulch a crosscut tunnel has been driven southwest 170 feet, presumably in search of a pay streak. This crosscut is entirely within the sandstone gravel. The pebbles in the gravel are small and all of brownish sandstone. At intervals there are lenses of fine grained soft sandstone and clay, about a foot in thickness and all dipping 40° to 45° E. The orientation of the pebbles in the gravel is in the same direction, indicating an eastward tilting of the deposit as a whole after its deposition. The gravel in this tunnel apparently carried little or no gold.

We come now to the pay gravel, which appears as a distinct layer 1½ to 3 feet thick, overlying the sandstone gravel. This pay gravel is composed entirely of igneous, metamorphic and clastic rocks. Among its constituents were noted: boulders of curly amphibolitic schist, mica-garnet schist, greenstones, quartz in considerable quantity alone, and also inclosing broken fragments of the red Franciscan jasper previously mentioned. This gravel is coarse and the quartz is often angular, indicating little travel. There are occasional pebbles of chromite and man-

ganese oxides. Cinnabar is found in pieces the size of a small bird's egg. Gold is occasionally found attached to rose quartz. There is considerable coarse black sand. A fresh contact could not be observed, so it can not be said positively that the pay gravel lies conformably on the sandstone gravel, but conditions indicate that it does. The gold and platinum, which can be panned from this pay-gravel stratum anywhere along the sides of the gulches, represent without doubt a reconcentration. No prospecting has yet been done in the gravel away from the gulches. Good values in gold and platinum metals can be panned, it is claimed, in every gulch traversing the gravel.

The pay gravel is clearly derived from the Franciscan metamorphics and from serpentine and later intrusives piercing the Franciscan. A trip was made to the east and south for some miles, but no gravel equivalent to it was observed, although many terrace deposits at high levels were seen. These are clearly stream deposits, and are often identified at once as stages of present streams. None of them are even similar in character or associations to the deposit under discussion. Prospecting in this direction has not revealed any minable gravel. The boundary of chert and greenstone to the south and southwest appears to be a definite one. To the east thick beds of brownish sandstone strike northwest and dip 70° NE. With this there are numerous interbedded strata of dark clay shale. These are exposed in an abandoned railroad cut which crosses the high ridge just east of the road to Lake county. On the basis of hurried field observations only, this formation is tentatively considered as lower Cretaceous. To the west, across the present Russian River valley, Duncan Peak rises to a height of about 1800 feet, the dominating elevation thereabouts in the coastal chain. In place on its eastern slopes occur greenstones, serpentine, hornblendic and micaceous schists representing Franciscan metamorphics and intrusives. Serpentine is the principal rock around the Duncan Springs resort buildings and narrow ridges of it extend eastward down the slope, with some sandstone float. Time could not be taken to trace the sandstone to place, but it probably outcrops higher up as the westward extension of the Cretaceous (?) described above.

The local derivation of the auriferous gravel is emphasized by an inspection of the gold-bearing gravel near Calpella. This, as mentioned, is geologically a unit with the Hopland deposit, although erosion has removed the intervening link, which has been traversed by Russian River. The gravel hills lie just west of the river south of Calpella. Gold Gulch, emptying eastward into the river, cuts through the gravel stratum which carries the gold and platinum, showing it to rest on a sandstone gravel with occasional clay and shale lenses, identical with the gravel at Hopland, but dipping only 20° NE.

The elevation of the westward (upper) edge of the auriferous gravel was 835 feet (aneroid), only 25 feet below the equivalent point at Hopland. The black sand is very fine-grained here, and there is considerable fine quartz sand. No coarse pieces of chromite, cinnabar or manganese oxide were seen. The gold and platinum grains are noticeably finer and more water-worn than at Hopland. All the observations possible in the short time spent here indicate that it is the downstream extension of the Hopland deposit. Further work to the north would be required to prove that the old stream once had such a direction, opposite to that of the present river.

There is no exposure of a cross-section in either locality which shows the presence of a pronounced stream channel. Such a channel may have existed on the east, however, where the gravel is partly eroded and partly buried by the gravels of one branch of McDowell Creek. The thin, broad blanket character of the deposit indicates deposition in a broad estuary, such as might have existed there in Tertiary time, when the coast-line was approximately in that neighborhood.

The manner in which this gravel has been saved from destruction by erosion, is of interest. This may have been brought about by folding or by the faulting down of a block, which has been preserved, while the southeastward portion has been eroded away. Or it may be that the gravel in a syncline has been partly mantled and preserved by Quaternary alluvium. The final tilting came after the deposition of the gold-platinum bearing gravel, giving the eastward dip, and differentiating the deposit from Quaternary stream terrace gravels which can be seen only a few miles east.

Recent hand mining with pan and rocker in two of the gulches draining the deposit gave surprising returns, attributable to the concentration of values in the little stream beds. Over two ounces of platinum metals were taken out in this way. One test gave 190 grains of gold and 160 grains of platinum. The platinum metal shows the rough crystalline character of osmiridium, little affected by wear. An assay by A. A. Hanks indicates 49% iridium, 32% osmium and 10% soft platinum. Unfortunately, the deposit at Hopland is so situated that there is no water supply of sufficient size readily available for mining it. The only streams nearby are too small to be of service except during storms. A branch of Burns Creek has been restrained by a dam near the southeast end of the deposit, but the flow here, which would have to be pumped, is too small and torrential in character to be of any use. Russian River is 375 feet below the deposit at the nearest point. The property would have to be thoroughly prospected in order to show whether or not the installation of a pipe line several

miles long would be justified. The present showing is such that extensive exploratory work by means of shafts and trenches is fully warranted.

If such prospecting confirms as wide distribution of gold and platinum as the richness of the wash in the various gullies indicates, the pay gravel could be stripped of soil and mined at slight expense. In the absence of adequate water supply, a preliminary concentration by dry washing ought to be practicable. Enough water for final concentration could probably be developed by sinking wells into the gravel on the east side and pumping.

TEHAMA-SHASTA COUNTIES.

Beegum Creek.

A small area along Beegum Creek, from the crossing of the State Highway to the beginning of the box cañon, a distance of about one mile in all, attracted some attention in 1917–1918 when several ounces of platinum were taken out. The writer spent two days in the district with the idea of finding out definitely the manner of occurrence of the platinum and the size of the area which could be worked profitably.

The creek here forms the county line between Tehama and Shasta counties. The slopes are gentle, there being a gradual ascent from Beegum Creek at the Selvester Ranch to the divide between the Sacramento and Trinity watersheds, a distance of thirteen miles. Beegum Creek has formed a gravel flat here which has been mined somewhat in the past for gold, but is now under cultivation. The stream is sluggish in this graded portion, but less than a mile below it enters a narrow cañon and gains grade. Its upper branches drain the serpentine area around Tedoc Mountain to the south, and its northern fork reaches into the Trinity Mountains, but carries an insignificant amount of water in summer. Beegum Peak, the prominent natural feature of the neighborhood, is so named because of its profile, resembling the rounded outline of a bee-hive. It is covered by conglomerate, which appears to be made entirely of chert pebbles from the size of shot to 1½ inch in diameter. This chert is the rock encountered for a distance of eight miles on the road to the Tedoc chromite deposits, giving place to the conglomerate one-fourth mile from Beegum Peak. On the Selvester Ranch near the highway, the creek enters a bed of alternating thin laminations of dark shale and sandstone. These strike about N. 10° E. and dip 45° E. and the stream has cut a wide V-shaped trench through them. The stream bed in a distance of one-fourth mile begins to pick up grade, and becomes narrower, flowing over slate which dips at a low angle and is broken up into thin sheets. In the miniature cañon the stream has formed a flood deposit of sand and gravel 1 to 2 feet thick, but in the summer the water is only 12 to 15 feet wide and runs near the south bank.

Panning in the gravel of Beegum Creek on the upper part of the Selvester Ranch shows only an occasional color of platinum. The creek bed is for the most part choked with detrital material and the grade is so low that mining would be difficult in it. There is probably a certain amount of platinum in the stream here, but it is so situated under a mantle of barren sand that it is doubtful if mining it would be profitable. This is the case because of the small scale methods that would be used. At the lower end of this property the stream takes on grade enough to clear its bed of sand. Panning here of the material taken from the crevices in the slaty creek bed at the summer water level gave a surprising prospect of platinum. The following shows the results with a $\frac{1}{2}$ size pan:

(1) 13 colors platinum; 3 colors gold.
(2) 4 colors platinum; 5 colors gold.
(3) 15 colors platinum; 3 colors gold.
(4) 6 colors platinum; 4 colors gold.
(5) 8 colors platinum; no colors gold.

The platinum colors ranged in size from a pinhead down to 'flour.' In striking contrast, several pans taken from the flood-stage gravels which lie to one side of the summer channel and mantle the slate bedrock, failed to yield any colors of platinum. About one-fourth of a mile below this, panning the material from the flat crevices in slate at the water's edge gave the following:

(1) 20 colors platinum; 2–3 colors gold.
(2) 8 colors platinum; 4 colors gold.
(3) 11 colors platinum; 2 colors gold.
(4) 55–60 colors platinum; 4 colors gold.

Panning the gravel on the bedrock 10 feet back from the water's edge failed to show any platinum or gold.

Downstream 200 yards from this point the stream enters the chert, which has occasional limestone lenses with it. No colors of platinum were found here and it is not thought that mining where the creek crosses this rock would yield a profit. The chert does not offer a riffle for the platinum, but on the contrary would tend to scour out clean during high water. There is an exposure of gravel lying on indurated clay shale adjacent to the creek near the chert contact. One or two minute grains of platinum can be obtained in nearly every pan from the lower two feet of this gravel. The writer came to the conclusion that the area which could be mined with a profit here was confined to the slate bedrock of the creek for a distance of about one-half mile and a width of about 12′ to 15′. There appeared to be no values in the gravel or on the bedrock away from the edge of the stream. This gravel had been mined off to bedrock and the latter carefully cleaned from the water's edge to the wall of the miniature cañon. In order to determine whether my conclusions regarding the deposit were correct

I sought out the owner at a later date. It developed that the area 100 feet long and 20 feet wide, back from the stream, had yielded practically nothing, but that about 5 ounces of platinum with a little gold, had been recovered from a very small area of the stream bed where the slate had been dug up and the crevice filling washed in sluices. This was in addition to unknown small quantities mined surreptitiously by people who had no right on the ground.

The platinum here appears to be the result of concentration from the adjacent gravels through which the stream has cut. In the gravels themselves the concentration of platinum is apparently not sufficient to pay. The slaty bedrock has offered an exceptionally good riffle for detaining the metal and the creek has been a natural sluice in times of high water. Time could not be taken to trace the platinum down the stream, but parties who had mined at the mouth of Beegum Creek reported gold and platinum in very small quantity, not enough to pay wages for hand mining. The boundary of the gravel is half a mile above the highway bridge, and as far as reported, no platinum had been found above this gravel. An assay of platinum from Beegum Creek was made some years ago by Shapeleigh. It is shown in the appended table.

Since the district was visited, other claims have been staked near the stream above the Selvester property, and the district is being prospected to determine whether or not development work will be justified.

YOLO COUNTY.

Platinum occurs in gravel near the mouth of Putah Creek, just west of Winters in Yolo County. George T. Ruddock[1] reports that when prospecting here some years ago, he obtained from 2 to 11 coarse colors of platinum with a subordinate amount of gold in practically every pan.

The gravel prospected was taken from the little gullies which carry off rain water during the winter season, but are dry most of the year. Probably there has been considerable concentration of platinum here; the gravel on the hillsides away from the gullies has not been prospected.

The deposit is described by Ruddock as a conglomerate dipping northeast and containing cobbles of quartz, granite and diorite. He cites the presence of granite as evidence that the gravel came from the Sierra Nevada side. Nevertheless, it is possible that close investigation would result in connecting this conglomerate with other areas of Cretaceous conglomerate which are so prominent to the north on the west side of the Sacramento Valley, or with the Tertiary gravels of shore origin which overlap the Cretaceous beds. The presence of

[1]Mining Engineer, Insurance Exchange Bldg., San Francisco. Personal interview.

granitic cobbles in the conglomerate is in no way conclusive, as granitic wash can be found in several deposits in the northwestern counties which contain platinum, and granite bosses of varying size underlie a large part of the Klamath Mountains.

The conglomerate near Winters has an area of several square miles, sloping up on the west in a gentle fold. It is thought that it would be possible to work only the weathered surface portion, as in depth it becomes cemented. The total thickness has not been determined, but is known to be great. Plans for dredging it were once entertained. Water could be pumped from Putah Creek; a lift of 150 feet to a reservoir would put the supply high enough to be used in sluicing the dirt down the gullies, and would also give sufficient supply to fill a dredge pond lower down. Inability to reach an agreement with the owners led to abandoning the project.

HYDRAULIC MINING.

Hydraulic mining practice today varies little from that followed twenty-five years ago. The long fight of the Sacramento valley farmers, which resulted in the disruption of this branch of mining in the Sierra Nevadas, left only the northwestern California counties open to hydraulicking. The man with a giant and long string of sluices has been content to save such gold as lodged between blocks and riffles and has paid little or no attention to values lost with the tailing. He recognizes that his method is at best very crude. Its advantages are its cheapness of installation and operation, and the large yardage that it handles. Even such refinement as an undercurrent is frowned on by most operators because they claim it takes too much water from the sluice.

The La Grange mine in Trinity County has worked on a larger scale than any other property and at the same time has paid more attention to saving than most, as the gravel there has been of low grade. This company's operations are well described by MacDonald.[1] The great success in saving fine gold there is ascribed to the eddying action in the sluice which is caused by the shape of the steel rails which are used for riffles. The grade of the sluice is seven inches to twelve feet in the upper portion, and eight inches in the lower portion, and the boxes are four by six feet, the insides being lined with the bases of the rails which have had the tops worn away in the sluice while being used as riffles. The curve of settlement for gold of different sizes has been investigated at this mine. The coarsest pieces, larger than 10 mesh, which form over one-half the total gold, stop principally in boxes 11, 5, 12 and 13, the first named receiving more than the others and the amount decreasing rapidly from box 13 onward. From 10 to 50-mesh gold stops largely on the way to box 12 and that box marks the maximum recovery of these sizes. The bulk of gold finer than 50 mesh stops in the first 13 boxes; box 22 is another period in the recovery, as the gold of all sizes which passes it does not seem to settle so rapidly beyond it, but spreads out over the remaining boxes.

Few of the hydraulic mines of northwestern California are adequately equipped with water. The La Grange in Trinity County, the Forks of Salmon River mine on the Salmon, and the Davis and Siskiyou mines at Happy Camp are the only properties able to operate continuously. The La Grange has 29 miles of ditch, flume and tunnel and gets 2000 miner's inches, but even with this splendid supply they ran short in the fall of a dry season like 1917. The Forks of Salmon River mine

[1]U. S. G. S. Bull. 430, p. 51. (This property is now idle.)

diverts practically the entire summer flow of the North Fork of Salmon into their mining ditch, which is five miles long, and furnishes enough water for steady operation. But the balance of the hydraulic properties operate over a period not exceeding six months and in many cases only three months of the actual storm period, January to April. The

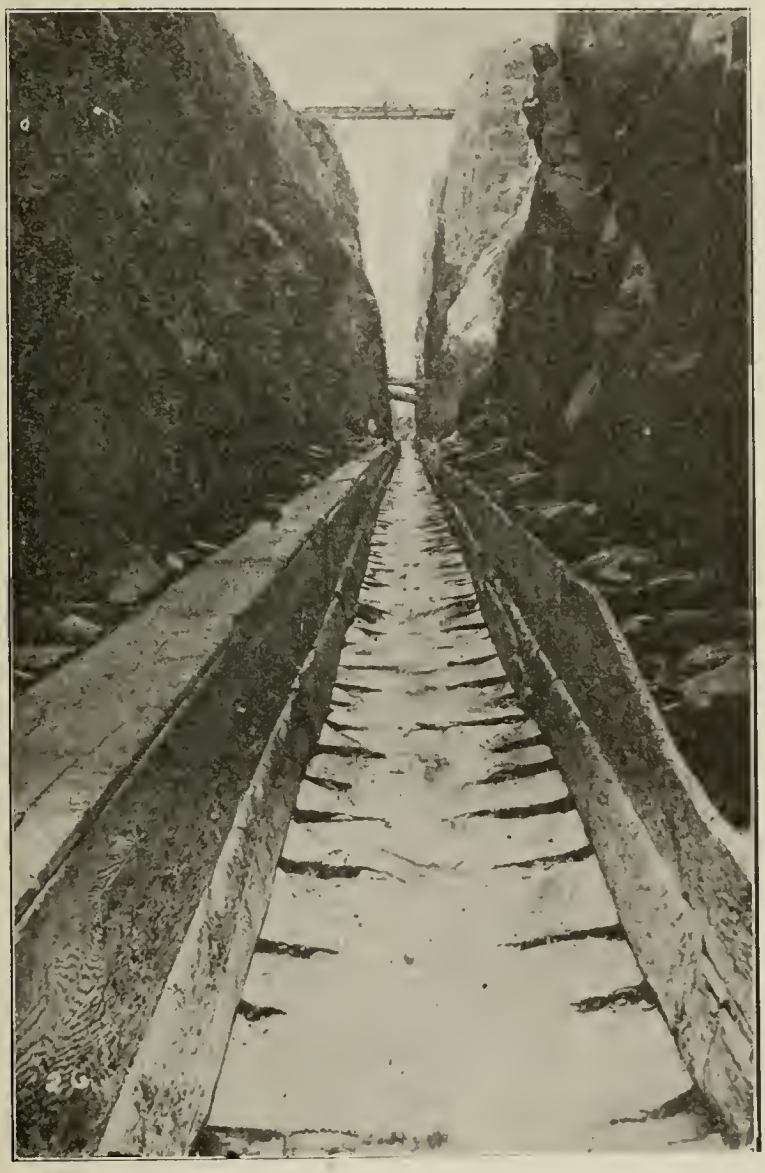


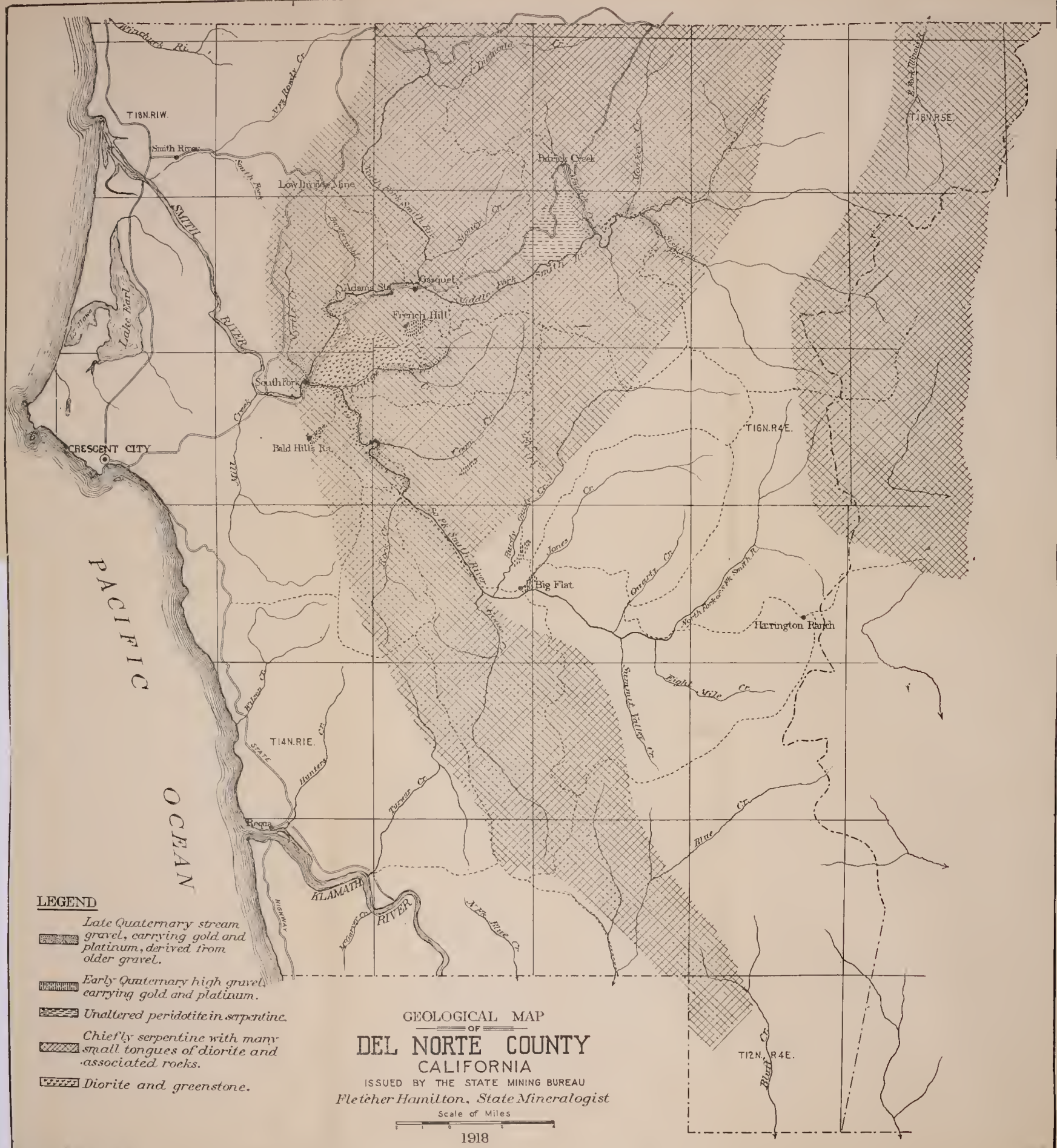
Photo No. 3. Bedrock cut and sluice, Orleans Bar Hydraulic Mine, Humboldt County.

expense of digging and maintaining a long ditch is, of course, too heavy for the average small property to stand. Their production does not warrant it. The area of ground worked yearly at the smaller hydraulic mines is seldom over an acre and the annual clean-up is from $1,000 to $5,000. There are several properties big enough to justify the installation of a water system comparable to the La Grange equipment, but no one with the capital and the breadth of vision needed, has yet taken hold of them.

Bedrock sluices vary with the size of the property. Some gravel deposits are situated so that they give good natural run off and the sluice boxes can be carried nearly up to the gravel face. Others with broad, nearly level benches like the mines near Junction City require long bedrock cuts 60 feet or more deep. The putting down of such a cut is an expensive and slow job and requires rich gravel to justify it. Strings of sluices in most mines are probably rather short to give best results. The La Grange mine carries 3000 feet of sluices with a fork in the lower portion to permit the diversion of the gravel and the cleaning of the lower boxes on one side of the fork, without stopping mining. A few properties have as much as one-fourth of a mile of sluices but the majority have not over 500 feet. Pine blocks are used almost entirely for riffles. Some of the mines are equipped with saw-mills but for the most part they are hand sawed. Sprinkling a little quicksilver among the blocks completes the preparation for mining.

The ordinary practice requires bedrock sloping down to the sluiceway. There are a few properties where the ground has to be attacked from the opposite direction and it then becomes necessary to pipe up to the boxes. This requires hard work and a big head of water, with an extra giant. A property of this kind is being operated near Weaverville.

The Ruble elevator has been successfully used to mine ground which is too nearly level to offer grade for sluices and dump. These elevators are used entirely by the Michigan-Salmon Mining Company, on the South Fork of Salmon River. The elevator is 90 feet long and 8½ feet wide and with sides 6 feet high. It is essentially a long sluice box, set at an inclination of 17° and the gravel is driven through the box against this grade in order to elevate it. The bottom of the box for 62 feet is a grizzley fitted with cross riffles of 2 by 4 timber, iron-faced and set 2 inches apart. Under the grizzley and at right angles to the length of the elevator there is a wide sluice 50 feet long which receives the material under two inches coming through the grizzley. This is the only sluice used and is said to make an excellent recovery. This good work is probably due to the removal of the coarse material, and to the wide sluice with plenty of water. The ground mined is especially adapted to this method of operation as there is no soil overburden and no very large boulders. In mining, three No. 3 giants with 457 feet head are used. One giant is used exclusively for driving the gravel through the elevator. The coarse gravel which will not pass through the grizzley is driven over the upper end of the elevator and piles up in stacks resembling dredger tailings. Extra stacking height can be gained by increasing the length of the elevator. The elevators cost about $5000 each to install, have a long life, and are moved around the diggings without much trouble. They require a large amount of



LEGEND

- *Late Quaternary stream gravel, carrying gold and platinum, derived from older gravel.*
- *Early Quaternary high gravel, carrying gold and platinum.*
- *Unaltered peridotite in serpentine.*
- *Chiefly serpentine with many small tongues of diorite and associated rocks.*
- *Diorite and greenstone.*

GEOLOGICAL MAP
OF
DEL NORTE COUNTY
CALIFORNIA

ISSUED BY THE STATE MINING BUREAU

Fletcher Hamilton, State Mineralogist

Scale of Miles

1918

Accompanying Bulletin No 85

water under heavy pressure and handle from 1000 to 2000 cubic yards of gravel in 24 hours.

Prospecting of hydraulic mining ground may begin by tracing the trail of gold colors up a cañon side. This method sometimes discloses the presence of good terrace gravels which may be entirely mantled by slide debris.* To determine the availability of a deposit for hydraulic mining, the situation of ground as regards grade for sluices and room for dump must be determined. It must be under water which can be delivered in sufficient quantity at high enough pressure. The amount of overburden barren of values, must be known, so that the yardage of dead wash, which must be moved to get at pay gravel, can be figured. The physiography of the country must be considered. The grade of a cañon superjacent to a gravel deposit may equal the angle of repose, or the material may be especially susceptible to sliding, like serpentine, so that the gravel is kept covered by debris as fast as it is cut by the water. This latter condition is also of prime importance in establishing a water system. There are numerous small bodies of gravel on the Klamath River which can not be hydraulicked advantageously on account of interfering slides. Flumes and ditches across this sliding ground give a great deal of trouble and there is annually great loss and delay due to interruption of water supply in stormy weather. Such delays are at times unavoidable, and must be figured in the cost of the season's run. If there is a heavy cement, it may prevent piping, and if boulders are so large as to require much blasting or a derrick, cost is appreciably increased. Gravel mantled by too heavy overburden, or by volcanic material too hard to pipe, is not hydraulic ground. Such ground becomes susceptible to drifting if the gravel on and within six feet of the bedrock is rich enough. All these conditions are easily appreciated, and most of them are determinable during preliminary investigation; yet it is true that they are constantly ignored in the exploitation of hydraulic mining properties.

The actual sampling of gravel has often been done by running prospect drifts into the deposit. These can be made to show the breadth of the deposit, the location of pay streaks, and amount of gold a yard, the nature of bedrock, grade of channel and other features liable to affect mining.

DEL NORTE COUNTY.

Topography and Relief.

The boundaries of Del Norte County are nearly coincident with those of the Smith River basin. The coastal plain has a width of about five miles near the river's mouth and extends south to four miles beyond

*One of the best-paying, small bodies of terrace gravel opened in recent years on Salmon River was uncovered in this way. It was concealed by slides and had been overlooked for 50 years.

water under heavy pressure and handle from 1000 to 2000 cubic yards of gravel in 24 hours.

Prospecting of hydraulic mining ground may begin by tracing the trail of gold colors up a cañon side. This method sometimes discloses the presence of good terrace gravels which may be entirely mantled by slide debris.* To determine the availability of a deposit for hydraulic mining, the situation of ground as regards grade for sluices and room for dump must be determined. It must be under water which can be delivered in sufficient quantity at high enough pressure. The amount of overburden barren of values, must be known, so that the yardage of dead wash, which must be moved to get at pay gravel, can be figured. The physiography of the country must be considered. The grade of a cañon superjacent to a gravel deposit may equal the angle of repose, or the material may be especially susceptible to sliding, like serpentine, so that the gravel is kept covered by debris as fast as it is cut by the water. This latter condition is also of prime importance in establishing a water system. There are numerous small bodies of gravel on the Klamath River which can not be hydraulicked advantageously on account of interfering slides. Flumes and ditches across this sliding ground give a great deal of trouble and there is annually great loss and delay due to interruption of water supply in stormy weather. Such delays are at times unavoidable, and must be figured in the cost of the season's run. If there is a heavy cement, it may prevent piping, and if boulders are so large as to require much blasting or a derrick, cost is appreciably increased. Gravel mantled by too heavy overburden, or by volcanic material too hard to pipe, is not hydraulic ground. Such ground becomes susceptible to drifting if the gravel on and within six feet of the bedrock is rich enough. All these conditions are easily appreciated, and most of them are determinable during preliminary investigation; yet it is true that they are constantly ignored in the exploitation of hydraulic mining properties.

The actual sampling of gravel has often been done by running prospect drifts into the deposit. These can be made to show the breadth of the deposit, the location of pay streaks, and amount of gold a yard, the nature of bedrock, grade of channel and other features liable to affect mining.

DEL NORTE COUNTY.

Topography and Relief.

The boundaries of Del Norte County are nearly coincident with those of the Smith River basin. The coastal plain has a width of about five miles near the river's mouth and extends south to four miles beyond

*One of the best-paying, small bodies of terrace gravel opened in recent years on Salmon River was uncovered in this way. It was concealed by slides and had been overlooked for 50 years.

Crescent City, where it gives way to the Sherwood peneplain.[1] This plateau fronts steeply on the ocean, but descends more gradually to the Klamath, which enters the ocean about five miles north of the Humboldt County line. This river is wide and sluggish in its lower course, meandering over a low plain for some distance.

Going eastward from Crescent City toward the South Fork of Smith River, one crosses the beautiful Redwood belt, covering the lower hills. These trees require much moisture and good soil, and they disappear at the divide which cuts off the ocean fogs and marks the beginning of the rockier mountain spurs. The old peneplain surface is preserved in many flat topped mountains along the whole length of the county. High Plateau at the north has a maximum elevation of 3500 feet and has a cliff-like, unpassable front on Smith River's northern fork, 2500 feet below. French Hill, between the South and Middle forks near their junction, has for several miles a nearly level surface near the 2000 foot contour. This flat exhibits a gentle slope to the south and west. Similarly, Lower Coon Mountain and Big and Little Rattlesnake mountains show long, flattish tops, from about 3000 to 3500 feet in elevation.

The forks of Smith River and their tributaries have deeply dissected this peneplain. Cañon sides are sometimes very steep, and the streams flow in narrow rocky trenches. The cañon of the Middle Fork, viewed from the road from Adams Station to the Oregon line, is especially picturesque, showing the river as a bright ribbon, 2500 feet below some of the mountains to the south, which are remnants of the old surface. The main axis of the Siskiyou Mountains runs nearly north and forms the eastern boundary of the river basin and the county. The upper waters of one branch of Illinois River drain the extreme northeastern corner of the county. Many peaks over 6000 feet in height stand along the county line, and the country is rough and practically uninhabited.

Drainage and Water Resources.

Smith River drains most of Del Norte County and some of its northern tributaries extend into Oregon. Its basin is separated from that of the Klamath by the Siskiyou Mountains which are from 4000 to 7500 feet high, on the east and south. The Illinois River watershed lies to the northeast, beyond mountains which reach a maximum height of 5000 feet. The portion of the Smith River basin lying in California is very nearly 700 square miles in area.

The North Fork rises near South Red Mountain in southern Oregon and flows south past the steep scarp of High Plateau, entering the Middle Fork opposite Gasquet Stage Station at an elevation of only

[1]Diller, J. S.: U. S. Geol. Surv. Bull. 196. Topographic Development of the Klamath Mountains.

376 feet. The Middle Fork, with its main branch, the Siskiyou Fork, drains the mountainous area from Sanger Peak to Doe Flat Saddle. It flows most of the way in a steep cañon, with only an occasional narrow bench of flat ground, till it approaches its junction with the North Fork, where it flows through a pleasant valley about one-half mile wide and five miles long. The South Fork heads against Doe Flat Saddle, with its source close to the upper waters of Siskiyou Fork. It flows south for twelve miles, then west and northwest for twenty-five miles, entering the other branch at Christensen's Ranch, elevation 260 feet. This fork is a beautiful stream of crystal clearness flowing for considerable distances in a box cañon with only occasional deposits of bench gravel. From the junction at South Fork, the river flows northwest through a redwood forest and enters the ocean in an estuary about four miles south of the Oregon line.

This stream maintains a good flow in summer, having many tributaries which reach into the high mountains. Grades are steep. There is ample water available for working the gravels which lie near the river, but there are a few of the older and higher deposits which would require ditches five to ten miles long to get an adequate supply. There are no deposits of gravel in Del Norte County which compare in size with the bench gravels of the counties to the south, and the question of water supply is never going to be a pressing one. Mining operations are likely to be only on a limited scale. Very little of the available water supply has yet been appropriated. Rainfall is heavy, being about 100 inches per annum along the coast belt, and summer is cool, so that the streams give a perennial supply capable of serving any mining needs apt to arise.

Geology.

The coastal plain from Smith River southward past Crescent City shows few outcrops of rock in place. Diller ascribes the low plain to the softness of the Neocene formations. Farther inland, a belt of Franciscan rocks traverses the county. This is bounded by the Redwood Mountain fault and is succeeded by a zone of eruptive rocks which increases in width toward the north, covering an area of over two townships where it crosses the state line into Oregon. This belt is made up of serpentine and peridotite chiefly, but there are many tongues of gray-green 'diorite' intruded in it. The peridotite is prominent in the northern part of the county. The road from Smith River to Patrick Creek traverses a wide stretch of it which extends north. It forms rocky, forbidding slopes, weathering to a soil which supports only scrubby brush. Here it is not entirely serpentinized, but serpentine is prominent along the river, forming bedrock in the hydraulic mines on both forks and to the east of the

South Fork, as well as on French Hill. This serpentine belt is of great importance because the principal deposits of chromite, gold, copper and platinum are situated near its edges, owing their genesis probably to magmatic segregation from the serpentine or diorite. The chromite deposits at Low Divide and French Hill, which have been producing large tonnages of high grade ore during the past year, are both located near such contacts. The best copper prospects are also located near similar contacts. The same action is considered by the writer to be responsible for deposition of gold, found typically in Myrtle Creek. Besides the chromite properties mentioned, recent prospecting has revealed promising deposits on High Plateau just east of the North Fork, and to the east and south of French Hill for a distance of fifteen miles.

South and west of the serpentine is an area of metamorphics named Weitchpec schists by some previous observers, because of their occurrence near Weitchpec village on the Klamath River in Humboldt County. The geology of the country thence eastward to the county line has never been studied except casually. O. H. Hershey indicates the extension northward of igneous rocks of undetermined age, in a belt from the Klamath. A belt of slates, presumably equivalent to the Mariposa, according to Hershey, extends from the Klamath River northward far into Del Norte County east of the serpentine zone, and is bounded on the east by the Orleans fault. Hershey also indicates that a narrow belt of old schists borders the fault on the east. Volcanics forming the higher Siskiyous near the county line are succeeded by a second serpentine-'diorite' zone, having the same characteristics as the west belt. This zone runs the length of the county along and just outside the county line. It extends eastward beyond the Klamath and some miles up the Salmon River.

High gravels have been deposited at many places on the eroded peneplain at elevations approximating 2000 feet. Such deposits are best seen on French Hill, between the South and Middle forks, but similar bodies have been hydraulicked at Big Flat, Bald Hills and elsewhere. These deposits are typically thin, and of such age that their equivalence with the oldest of the Salmon River deposits is probable. The newer deposits of gravel on the benches near the present streams have been derived from these old beds. They are usually thin layers reaching, however, a maximum depth of 25 feet in one case.

Distribution of Platinum.

Very little production of platinum has been reported from the stream itself, but certain of its tributaries produce a very small quantity as do also the older high gravels of French Hill. Deposits of same age as the French Hill gravel have without doubt been the source of the

platinum found below in the South Fork and its laterals. On the Middle Fork of Smith River there are some areas of auriferous gravels which have been mined, and some which have never been tested on a working scale. Certain of the latter are held to be too low grade for profitable mining and others carry too great an overburden.

The Elkhorn mine at the mouth of Patrick Creek has been mentioned as a platinum producer, but as far as could be learned, the property has made little production of gold and none of platinum. It has been idle for years except for occasional short-lived efforts. The gravel is low grade in gold. The latest work has been on the second bench above the river, near the mouth of the creek. There is a six foot bank of gravel carrying heavy boulders, and having a steep serpentine bedrock. An elaborate undercurrent, evidently installed recently, contained considerable black sand. This sand carried a few colors of fine gold, but no platinum was present. The holdings of this company originally comprised 2560 acres.

The George Washington placer claims and the Monkey Creek mine comprise 480 acres along Monkey Creek near its mouth. The former has never been worked beyond the prospecting stage, and the latter has been ground-sluiced, but no platinum has been reported. It is stated that platinum can be panned sparingly in gravel near the mouth of Siskiyou Fork. There is little possibility of mining being resumed in this locality as it is believed that the Chinese worked the best of the ground in early days.

Coming downstream, the river cañon opens upon an extensive gravel flat as we approach Gasquet and Adams Stage stations. Several hundred acres here have never been mined but prospecting has shown it to be low in gold content. The land is farmed now and there is little probability of any mining there. Two and a half miles below Adams Station considerable hydraulic mining has been done by Geo. Cook on benches on both sides of the river. The gravel is on 'diorite' bedrock and has a depth of about 25 feet. There was a total yield of slightly over two ounces of platinum with a moderate quantity of gold. No work has been done here for years and there is not apt to be any renewal of operations this season.

At the mouth of Myrtle Creek and extending along the river and up the creek for possibly a mile, are twenty-seven mining claims formerly held by the Myrtle Creek Placer Mining Company, now defunct. The deposit is on benches, the first of which is only a few feet above the present stream. The gravel and overburden form a bank nearly a hundred feet high but the values are stated to be on and within two feet of the bedrock. No work is at present being carried on in this bench gravel. Some attempts were made to work it, but the recovery

is reported to have been insufficient to pay for handling the immense, practically barren overburden. The gravel is medium sized with a streak of blue gravel. There is a stratum of very tightly cemented gravel on portions of the bedrock in these claims. The bedrock is serpentine. The contact between serpentine and diorite crosses Myrtle Creek a mile and one-half above the mouth and crosses Smith River one-fourth of a mile above South Fork.

The shallow placer diggings in the bed of Myrtle Creek have proven very rich in coarse gold. The largest nugget taken here was reported worth $1200 and the ground is said to have paid $100 a day to a man. Even at this late date, the miner in charge of operations claims to be making good wages. The creek bed is being sluiced, great care being taken to clean the serpentine bedrock thoroughly. A 'self-shooter' is turned loose at intervals in the creek and a No. 3 giant is also used to loosen up the gravel but not in driving. Three men are employed. The gold obtained is uniformly coarse and roundish, showing little erosion. No platinum has been observed in the clean-ups from the creek but it is said to be present in the bench gravel. The source of the coarse gold is probably in pockets along the locus of the serpentine-diorite contact; it is claimed in fact, that the contact marks the limit of the coarse gold in going up-stream. A former report[1] stated that "the black sands carry platinum in considerable quantity." This could not be substantiated, but the amount of bench gravel mined was apparently too small to permit any judgment of the platinum content. Considerable panning here by the writer failed to show platinum.

On the opposite side of the river in the area bordering the south bank of the South Fork, is the Nels Christensen hydraulic mine. There are two benches of gravel. The first bench is about twenty feet above the present river. The face shows six feet of gravel containing very heavy boulders. The gravel is made up principally of fine-grained igneous rocks both acid and basic and the big boulders are all that distinguish it from the other bench gravels in the district. It is loose, and lies on a serpentine bedrock. The owner claims to be able to make little better than wages in this ground, which he works a short time each winter. He has never made any recovery of platinum, but the metal was panned by the writer in the sluice and called to the attention of the owner who planned to save it. The proportion of platinum to gold is small and the grains of the former are very fine. There are 174 acres in this property, most of which is bench gravel which is being farmed. These benches may represent former levels of the South Fork, which at present enters the other branch of the river farther up-stream through a steep rock-cut cañon about thirty feet deep. If this is the case, the platinum

[1]Cal. State Min. Bur. Mines and Mineral Resources of Del Norte County, 1915; also Report XIV, p. 375.

is no doubt referable to high gravels which occur at several places on the South Fork watershed.

Turning now to the South Fork of Smith River, we find that considerable mining has been carried on along the stream near the mouths of the different tributaries.

Jones Creek, a tributary entering from the north, was several years ago the scene of a sad disappointment for a company of French people. They were attracted by the noticeable amount of a heavy grayish metal which they found when prospecting the gravel. They were led into the belief that the metal was platinum and they became so enthused that they made a considerable investment in plant. Local history has it that they did not discover their mistake until they attempted to market their first clean-up and found it valueless. The name of the disappointing metal is not recorded, but it may have been either awaruite or iron.

The Big Flat deposit lies at an elevation of 2160 feet on the ridge between Jones and Hurdy Gurdy Creeks. Old reports[1] indicate considerable activity here prior to 1889, and the production of coarse gold pieces worth $3 to $5 common. The last operators were Chinese, who worked the property till 1906. It is said to have yielded a good gold return, but there is no record of platinum there. This deposit has a slate bedrock. Local people have been holding the ground by location for years, but have done no mining. Prospecting for gold and platinum was going on in October, 1917, at the mouth of Hurdy Gurdy Creek. A prospector told the writer that in 1904 he made a sensational find of platinum in gravel there, and had returned but recently to see if he could not rediscover it. His work had given no positive results up to the time of the writer's visit.

Haines Flat, on the divide between Gordon Creek and Coon Creek, has a narrow gravel deposit trending southwest. There has been no recent attempt to work here, and platinum was not reported. Years ago an attempt to mine the deposit resulted in disaster when a miscalculation was made in the depth of an expensive bedrock cut.

From the mouth of Rock Creek to Coon Creek, about three and one-half miles as the river flows, there are small areas of bench gravels at intervals along the river. These are of later origin than the high gravels and are near the present river, where the cañon is more spacious than the box-like trench to which the South Fork is usually confined in this region. The cañon sides are steep and are heavily covered by brush and trees here, so that there may easily be sections of bench gravels completely covered by slides and vegetation. Three benches, 15 to 25 feet apart, have been noted. The lowest, as exposed opposite the mouth of Coon Creek, shows serpentine bedrock, and there are lenses

[1]Cal. State Min. Bur., Report XI, p. 196; XIII, p. 127.

of tightly cemented conglomerate frozen to it in places. This gravel pans some gold and platinum. The gravels of these benches have been mined in a small way by drifting and sluicing. Locations were recently filed on 1000 acres here and in October, 1917, preparations were under way to begin hydraulic mining. Trouble has heretofore been experienced in saving fine gold, as this section of the South Fork carries a high percentage of black sand, attributable to the erosion of serpentine. Mr. Gordon Land, in charge of work for the new company, planned to meet this by using a magnetic separator of his own invention. He claims that the practical value of this apparatus has been fully proven. This property ought to develop into the principal gold and platinum producer of the county. However, no production was made up to the beginning of 1919 so far as could be learned.

High gravel on the Bald Hills, west of the mouth of Coon Creek, formerly yielded wages. This deposit is about six feet thick and at an elevation of 2050 feet. Similarly, Lower Coon Mountain between Coon Creek and Craigs Creek was worked, but has been idle since 1900.

French Hill is a portion of the Klamath peneplain between the South and Middle Forks of Smith River. It is nearly level on top, having an average elevation of 2000 feet for about four miles east and west, with a maximum width of two miles. Serpentine and diorite mantle the north and south sides of the mountain. The exact character of the bedrock in some of the hydraulic pits could not be determined as weathering had profoundly altered it. Copper prospectors who have explored the north slope above Adams Station, have found only small bunches of high grade secondary copper ores and heavy black iron oxides in the serpentine. Valuable chromite mines were operated during 1917 and 1918 on the south side in a diorite-serpentine contact. The old surface, now covered with gravel, sloped gently south and west. Small mines have been opened in the gravel at several places, but the principal workings are those of J. M. Darnell. He works two pits with giants and has been making a small annual recovery of platinum for many years. The northeasterly opening shows the bedrock covered by only two to four feet of gravel, thinning to the northeast. The other pit, one-third of a mile southwest, has a face of gravel 20 feet thick, with two feet of blue gravel near the bottom apparently carrying the best values. There is said to be an ounce of platinum for about each $1000 in gold. It is all very finely comminuted. No analysis of it was obtainable.

South of French Hill, Craigs Creek and its tributaries have eroded deep trenches to keep pace with the South Fork. The gravels accumulated in the creek trough are similar in character and age to the low gravels along the river, but have apparently proven richer in both gold

and platinum. They are evidently reconcentrated directly from the French Hill deposit. The sketch map of the geology shows that the creek crosses alternating areas of diorite and serpentine. Some low benches have been cut above the present stream. Craigs Creek was mined by the pioneers, who left only small areas untouched. The operations of the present owner have proven profitable whenever he could find such virgin ground. One such place was on the creek two miles above Kaus' cabin and six miles from South Fork. Here the creek bed, which is in serpentine, was cleaned for a length of 200 yards and a width of 20′ to 40′. The gravel was only one to three feet deep. At the same time a small area on the bench above the creek was cleaned. The total yield was 25 ounces of gold and 2¼ ounces of platinum. The largest nugget of platinum weighed only five grains. Kaus believed the bench gravel was richer in platinum and that the amount of platinum increased up-stream. Several pans taken by the writer from the bench gravel gave five or six colors of gold and half as many very small platinum colors each, but the serpentine itself yielded nothing. This place was only a short distance from the Tyson chromite mine, which deposit is on a contact of true diorite and serpentine.

A miner who worked on Craigs Creek twenty years ago states that the yield was good, the largest gold nugget found being worth $92, with one-fourth-ounce pieces common. Platinum was seen in considerable quantity but never saved. Just west of Kaus' cabin, and about 50 feet above the present stream, a tributary entered from the north. The gravel in it is coarse, entirely fine-grained igneous (locally called 'diorite') and on a 'diorite' bedrock. It yielded coarse gold but no platinum.

Origin of the Platinum.

From what has been written above, it is seen that platinum occurs in the older gravels which have been deposited as often as not on the eroded surface of the serpentine. This has led to a confusion of thought on the part of some miners, who cite the fact as conclusive evidence that the platinum could not have come from the serpentine. In passing this judgment they fail to visualize the great planing down carried on by the Smith River. The erosion of serpentine has been pronounced and the deposition and reconcentration of gravels has been coincident with it. All the platinum in Smith River basin appears to have travelled considerable distances. The gravel resembles in mineral character the Klamath River terrace deposits and the two were derived chiefly from equivalent formations. The remnants of the old peneplain, which stand at elevations of 3500 to 5000 feet, give a good idea of the erosion in Quaternary times.

The Smith River terraces are not as well or regularly developed as on the neighboring rivers; and conditions of rainfall and deposition have been different, but the series as a whole is contemporaneous. The resources of this basin in gold and platinum metals are much less promising than on the Trinity and Salmon, and the deposits are very small in comparison. The inaccessibility of the country has retarded development seriously and will continue to operate to the disadvantage of those interested.

KLAMATH RIVER.

Platinum is recovered in hydraulic and drift mining operations along the Klamath from Weitchpec, just below the mouth of the Trinity, to Hamburg Bar. It is known to occur, but is not saved on a commercial scale, at practically every other camp on the Klamath.

At Weitchpec, the metal is gained from hydraulicking the first bench just above the water. There is a slate bedrock on this claim and the rough upturned edges of this formation, crossed nearly at right angles by the river, have proven a good riffle for the precious metals. The ground is so near the water that a rise of a few feet in the river stops work in the mine. The Klamath in rainy weather is apt to rise as much as two feet in an hour and has risen at Weitchpec as much as 75 feet above low-water mark. The lower end of the sluice boxes are in the water in summer and have to be moved with the beginning of the rainy season. The owner plans to move his sluices to higher ground and pipe up to them. The gold varies in size from flour to $\frac{1}{4}''$ and is nearly all flaky, although some of it shows rough edges, suggesting its derivation from the quartz seams which cut the slate in great numbers along the strike. The platinum grains are uniformly fine, varying in size from dust to two pin heads, and exhibit differences which indicate two sources. That portion of it which comes from the Trinity River retains its crystal shape and is prevailingly coarser than the Klamath River platinum which is more water-worn and flaky.

The yield of platinum from this property is noticeably higher than from mines on the Klamath above the junction with the Trinity. This is due not only to the greater richness of the Trinity basin in platinum metals, but to the ideal trap which the slate bedrock forms. The gravel on this lowest bench is coarse, carrying boulders occasionally as large as 3 feet in diameter, and has a maximum thickness of 30 feet. There is a second bench directly above it not considered as good ground as the first. Values are reported to be almost entirely upon and within 3 feet of bedrock.

Going up the Klamath from Weitchpec, the next mining properties are the Klamath River mine and two small adjacent properties situated

on the river about 3 miles above Weitchpec. The sides of the cañon here are so steep that one's first impression when looking across the river is of looking at a painting. The benches are relatively narrow and the grade of the hillside equals the angle of repose, so that debris is constantly sliding into the hydraulic workings and obliterating the ditches and flumes if they are in its path. This condition is intensified by the character and condition of the country rock. The latter is badly broken mica schist. It slides down into the workings at times in huge blocks which require blasting. The Klamath River mine has produced considerable gold from the lower bench, but mining at present is on the upper ground. The gravel is rather coarse and the gold prevailingly fine. Platinum metals occur with it in the ratio of about one ounce to $3,000 gold. The bedrock in these mines resembles closely the mica schists of the Mother Lode. It carries a small amount of gold which is readily distinguished from the placer gold of the gravels by its roughness. The platinum has associated with it a considerable quantity of metal which looks like the platinum but is of inferior specific gravity and is highly magnetic. Work was planned in 1917 on high ground which consists principally of country rock slide material with very little gravel. There is a great deal of black sand in the mines along the Klamath and this becomes a serious obstacle in recovering the fine gold and platinum. An undercurrent is to be installed at the Klamath River mine in order to make a higher saving of these fine values.

At the adjoining Florence mine, which is next above the Klamath River mine, the conditions are the same, but work is done on a small scale and as far as known no platinum has been marketed. Opposite these properties is the Cavanaugh mine where mining in a small way is carried on. Platinum metals in very small quantity are found here.

Reference to the table of assays will show that the percentage of platinum in the material from this district is very low, and of osmiridium, very high. The material might properly be called osmiridium as these combined metals make up 72% and the platinum only 25% of the mixture. As far as known, it has not yet been determined whether the three metals form an alloy, or are associated as mixed grains of platinum, osmiridium and platiniridium.

Between Weitchpec and Orleans platinum metals have been mentioned as occurring at different properties which are now either idle or working on such a small scale that platinum production is entirely negligible.

The Salstrom mine, located one and a half miles west of Orleans, has yielded three ounces of platinum in six years past. To procure this small quantity an area of approximately two acres has been mined to a maximum depth of 30 feet. No undercurrent has been used here

and the opinion of the owner is that he has been saving only 10% of the platinum metals. He has no definite basis for this figure, but there is no reason for doubting that a considerable loss of fine flaky platinum occurs, as a big head of water is used and the giant works close to the box in driving. Mining on this property is limited to an annual season of about seven weeks, because of scarcity of water. The gravel is easy to mine, being of small size with few rocks; and it is ideally located. There is in places an overburden of from 30′ to 60′ which is considered to be devoid of values. The bedrock is mica schist, dipping gently southeast. The gold output is very satisfactory and there is a reserve acreage of gravel which will permit hydraulic mining for a long period. There

Photo No. 4. The Orleans Basin, Klamath River, Humboldt County.

is in addition an area of about 60 acres of possible dredging ground on this property as mentioned elsewhere in this report.

There are at the present time no important mining operations going on in the immediate neighborhood of Orleans. A great deal of hydraulicking has been done in the Orleans Basin and there remains there an immense acreage of high bench gravels and low river bars. This area is to be classed as a possible resource rather than a present producer and is accordingly taken up in another portion of this paper.

The Bondo mine and a few other hydraulic properties which lie on the Klamath as one travels upstream from Orleans are worked each winter, but there is no platinum marketed from them as far as known, although it has been found in the concentrates from several mines. The season is short because of scanty water supply.

Seven miles above Orleans at the Rosalina mine on the northwest ank of the river, platinum has been recovered in small quantity, but ining has been practically suspended for several years. The cañon f the Klamath is very steep here and the country rock is principally erpentine. Whenever piping has been attempted, the country rock as slid in, covering the gravel and making it necessary to pipe off an ndless supply of barren material before any pay gravel can be reached. his has led the owner to attempt stripping the gravel back to a point here sliding will be less bothersome. A sample of sand residue from ie clean up of this mine was assayed by the U. S. Geological Survey nd gave a high return in gold and platinum.

Just below the mouth of the Salmon River on the southeast bank of ie Klamath, drift mining is being carried on because the position of ie gravel is too low to permit piping and dumping. There is a bed f gravel sixty feet thick, which is said to be good pay through its ntire depth, but of course the drifting takes only the dirt near bed- ock, which has yielded as high as $7 a cubic yard. The ground can nly be worked during low water from July to November. The owner eports the platinum content to run about one ounce for each one ousand dollars gold. Production to date has only been nominal.

Two and one-half miles above the mouth of the Salmon, on the pposite bank of the Klamath, platinum has been noted in small uantity from time to time at the Ten Eyck mine, but was never saved or sale before the season just past. A small shipment was made in ctober, 1917. The analysis indicated $8\frac{1}{3}\%$ platinum and $91\frac{2}{3}\%$ smiridium. Two benches of gravel have been mined on this property nd there is a third higher bench which has not been piped. The owest bench is about 50 feet above low water. The bedrock here is ate and the gravel is loose. While there is considerable overburden, is not as troublesome as at properties farther down the river, because ie cañon side is graded down here considerably by the waters of Ten Eyck Creek. The gold is coarse and the property a good producer. he second bench lies 300 feet above the first and has a serpentine edrock with a finer average run of gravel. The owner states that ight years ago he did some mining on this upper bench which yielded qual quantities of fine gold and platinum. Work there was suspended ecause tailings dumped from this upper ground would cover up the ill unmined portion of the lower bench. Twelve pans of dirt washed rom this gravel showed two colors of a silver gray metal which was ighly magnetic and inferior in luster and specific gravity to most lacer platinum. It is classed as magnetic iron pending further xamination of similar grains found in the concentrates of the Klamath iver mine. If it contains platinum it must be low grade. (Refer to

analysis above.) The serpentine extends westward, up the slope giving place to an area of 'diorite' (meta-gabbro of Hershey) which is of small extent and is followed by another extensive serpentine area. The present owner of the Ten Eyck has prospected the slope above the second bench and has found many small gold pockets, which probably owe their origin to contact phenomena around the 'diorite' and serpentine contact. The largest of these pockets yielded about $1400 in gold.

One mile and a half above the Ten Eyck mine a small platinum production was made last season from the Mann and Ross drift mine. The work here is on the lowest bench, which is some 20 feet above low water. The bedrock is slate and the gravel quite coarse, the cobbles being chiefly of slate, amphibolite and granodiorite. Drifting had to be resorted to in order to avoid the sliding overburden, which covered the gravel and came into the pit whenever piping was done. Drifts total 460 feet in length. The gravel yielded a very satisfactory gold return, but the ratio of platinum to gold was low—about one ounce platinum to $3600 gold. The assay of this material was not available, but the price paid indicates a higher percentage of platinum and less osmiridium than properties farther down stream.

Continuing up the Klamath River, the production of platinum is observed to maintain a low ratio to gold. At the Blue Nose mine the 1916 clean-up of platinum netted less than ten dollars. This mine is 18 miles above Somes Bar and the geological relationship is said to be the same as at the Ten Eyck mine. There is a slate bedrock in the mine opening and there are four benches of gravel. An undercurrent is used only when there is an abundance of water and very little pains are taken to save platinum, which is uniformly fine. Between the Mann and Ross mine and Happy Camp the mining is mostly on a small scale.

THE SALMON RIVER DISTRICT.

Topography and Relief.

There are only two or three small areas of arable land in the basin. The remainder is a jumble of mountains deeply dissected by streams, clothed with impenetrable masses of brush for the most part, and carrying very little merchantable timber. Except for a few high meadows in the northern part, the district is not good for stock range, as the growth of grass is sparse, even where the surface is free from brush.

The South Fork of Salmon takes its course parallel to the Orleans Mountains, a spur of which trends southeast from the Klamath River to the Sawtooth Range, separating the Salmon from New River and the North Fork of Trinity River with a divide having many peaks

Photo No. 5. The Salmon Mountains, looking east from Crapo Mountain toward Mount Shasta. Photo by Irving Eldredge.

nearly 7000 feet in elevation. This divide is deeply carved by the streams but shows remnants of the old peneplain surface in many of the long ridges which reach out from the axis of the divide toward the river. A fine example of this phase of the topography is the ridge between Methodist and Knownothing creeks. One can walk here for over three miles along a narrow spur at an elevation varying little from 3700 feet.

Between the South Fork and the North Fork of Salmon lies the Blue Ridge, the summit of which averages about 5000 feet and culminates in a peak 5938 feet high. This slopes gently toward the South Fork, but on the north presents a steep front, cliff-like in places, with the North Fork winding around its base. The North Fork marks a topographic boundary as sharp as the geologic contact. North, east and south, the Salmon Mountains half enclose the basin within a rough gigantic crescent. The higher peaks of the range are well over 7000 feet and the road from Sawyers Bar to Etna Mills has to climb by many curves to 6159 feet before it can pass the barrier. These mountains are harsh, rough, rocky piles stretching beyond the reach of vision in a succession of brushy spurs often bare of timber. Cupped in such rocky basins are the little lakes lying at elevations of 6000 feet or more, which give origin to the Little North Fork.

Drainage and Water Resources.

The Salmon River drains a watershed of about 750 square miles, being bounded on the west by the Orleans Mountains, on the south and east by Trinity Summit and on the north and east by the Salmon Mountains. On all sides, except northwest toward the Klamath, the mountains are high and the Salmon basin is effectually isolated. Orleans Summit is over 6100 feet high and the chain on that side exceeds 5000 feet in most places till the Sawtooth Range is reached, where the highest point, Thompson Peak, reaches an elevation of 8936 feet. The Salmon Mountains offer a barrier which is deeply drifted with snow in winter, and in severe seasons the mail has to be carried in by men on snowshoes.

The North Fork of the Salmon rises in the Salmon Mountains and after flowing north, east and south, finally breaks out of the high mountains and receives Russian Creek, one of its chief branches, a few miles east of Tanners Peak. Here it turns west. Its other main tributary is the Little North Fork, a beautiful stream whose upper course is little known. This enters North Fork from the north five miles below Sawyers Bar.

The South Fork has two main branches, one flowing southwest and the other northwest from the perpetual snow banks of Thompson Peak. From their junction at Cecilville the stream flows northwest, receiving

the drainage from the Orleans-Trinity summits on the southwest and from the Blue Ridge on the northeast.

Both forks and their tributaries have steep grades. From the peak near Summit mine, elevation 6320 feet, across the South Fork to the top of Blue Ridge, 5938 feet, is ten and one-half miles, with the South Fork at an elevation of 1500 feet. A profile across the North Fork from the summit of Blue Ridge to the summit above Garden Gulch, 6777 feet high, is only five and one-fourth miles, with the river flowing in a deep notch 1700 feet above sea level. The North Fork shows a

Photo No. 6. Hancock Lake, elevation 6317 feet. Type of snow-fed basins which lie at the sources of streams in the Salmon Mountains.

grade of about 51 feet a mile from Sawyers Bar to forks of Salmon, which is 11 feet a mile more than on the South Fork. From the confluence at forks of Salmon, the river turns northwest and holds a crooked course over a rocky bed for nineteen miles, entering the Klamath at an elevation of only about 525 feet, showing an average grade of 38 feet to a mile in this distance.

These steep grades have favored the hydraulic miner so that he can get a six to eight months water supply with plenty of fall from a ditch usually not over five miles long, if he is mining the lower deposits. One property has a perpetual supply with a five mile ditch. The flow of both forks of the river has been appropriated by companies operating near their confluence, and hydraulic properties at the mouths of the principal tributaries farther up use the main part of the water which enters the lower courses of the two forks, between Sawyers Bar and forks of Salmon on the North Fork and to a considerable distance up the South

Fork. The water supply is adequate to work the gravels. The streams are perennial in flow, having their sources in springs where they do not reach back into the region of perpetual snow.

Geology.

The writer made the trip up the Klamath on foot from Orleans to a point several miles above Somes Bar, thence across the Klamath, back to the Salmon and over two spurs of the Orleans Mountains to forks of Salmon. The trip was in the nature of reconnoisance, with the idea of surveying in a general way the areas of platinum production, with the possibility of more detailed work being done later. Therefore, it was not possible to map the areal geology in detail or to make the field studies necessary for a proper correlation of details.

Serpentine is prominent on the river at Somes Bar bridge and for about three miles upstream. This is the eastern portion of the extensive greenstone-serpentine belt which follows the Klamath northward past Happy Camp, crosses into Oregon and extends westward into Del Norte County. From the time the trail leaves the river to cross the mountains, no more serpentine areas are seen. Diorite, and related porphyry ('birdseye porphyry' of the miners) are prominent among the igneous rocks of the ridges. No platinum has been produced on this part of the Salmon and no mining is going on there now. The river flows in a crooked box cañon cut for the most part in amphibolitic schists, the origin of which may be attributed to metamorphism of the diorites and similar rocks to the south.

Because of the interesting conditions noted in connection with the occurrence of platinum on the two forks of the river, the writer spent several days in a study of the region from Sawyers Bar southwestward to Gilta, and from forks of Salmon to Black Bear. The geology was noted here in a general way, but particular attention was given to the location of serpentine and to the properties where platinum has been found. The sketch map of the areal geology indicates definitely the distribution of serpentine, but other formations are not as precisely placed.

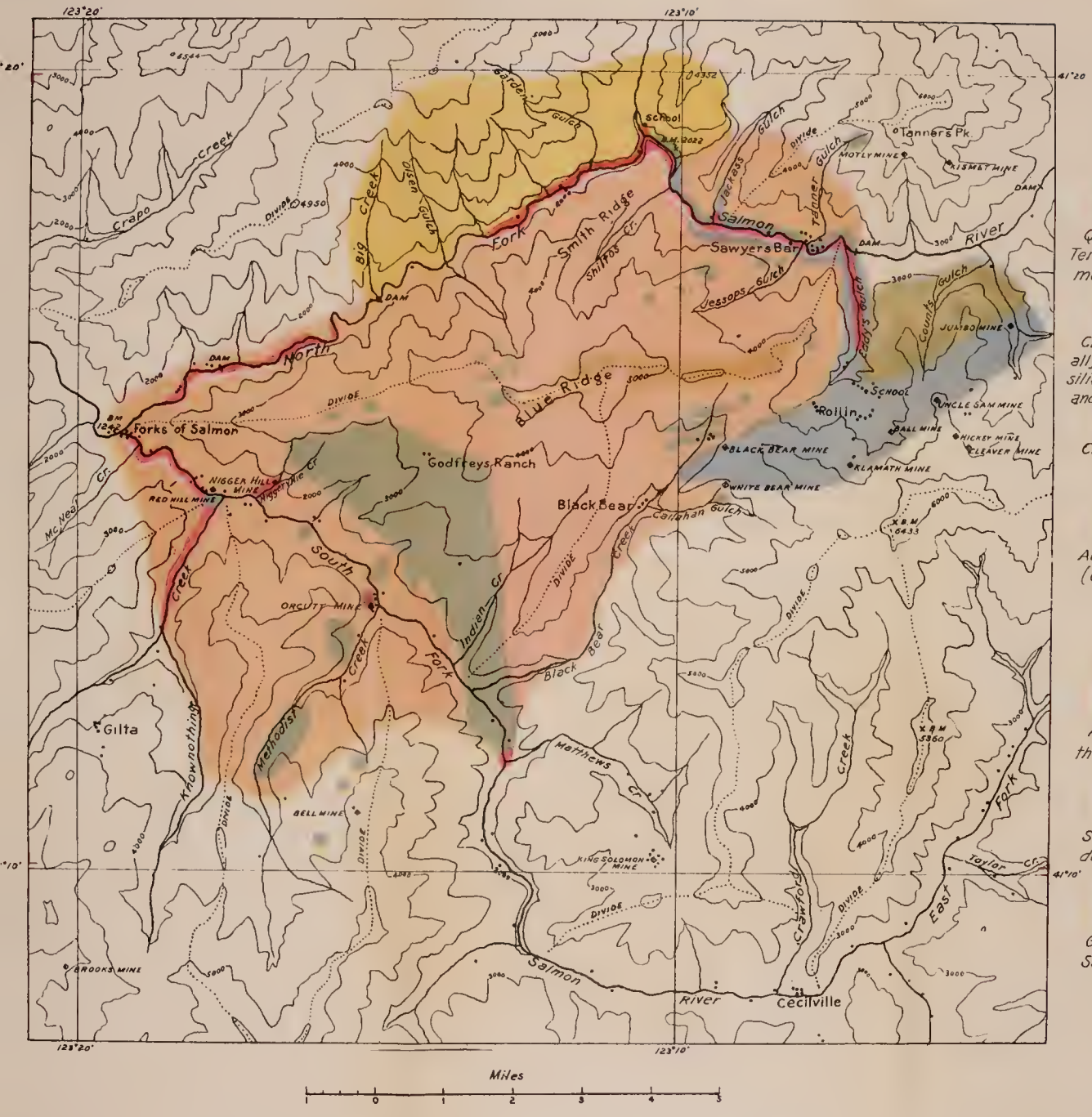
This region is made up of a great variety of metamorphic and igneous rocks, mingled in a complexly folded and faulted mass having a high ridge with a northeast trend. It is called the Blue Ridge. Its north side is steep enough to suggest a fault scarp, but the slope to the South Fork is gentle.

Unaltered sedimentary rocks were not seen here. Rocks originally sedimentary have been altered by pressure, folding and the action of igneous intrusives. Probably the whole series including both igneous

[1]Cal. State Min. Bur. Unpublished work on Geology of Central Siskiyou County.

GEOLOGICAL MAP
OF THE CENTRAL PART OF
SALMON RIVER DISTRICT
SISKIYOU COUNTY, CAL.

Geology by C.A. LOGAN.



Topography from U.S.G.S. advance sheet, Sawyer's Bar quadrangle.

STATE MINING BUREAU; SAN FRANCISCO, CAL., JUNE 10th, 1918.
Accompanying Bulletin No 85

and metamorphic members, is the same as described by J. P. Smith[1] to the east of this area under the name of 'greenstone series.' He considered the age of that series indeterminate, but not later than Lower Devonian. Smith's work extended only as far west as Russian Creek.

Rocks Originally Sedimentary.

Slate occurs as bedrock in several of the hydraulic mines, notably around Sawyers Bar and Eddy's Gulch. There is also a small outcrop of it on lower Knownothing Creek. It occurs as one wall, and sometimes as both, in most of the quartz mines in the district. In the Black Bear and Klamath Mines it forms both walls of deposits which occur as lenses and stringers, and is often mixed with quartz as the filling of crushed zones. The Black Bear deposit is strikingly similar to the 'stringer leads' of some Mother Lode properties, but there is no prominent cropping of quartz to correspond to the 'bull quartz' veins of Calaveras and Tuolumne counties. Slate also occurs as hanging- or foot-wall in contact deposits with diorite or quartz porphyry intrusives as the other wall. The Gilta Mine is an example. The slate strikes northeast and dips southeast commonly at an angle of about 40°, but at times reaches a 60° dip because of intrusives. The uniformity of dip and strike at properties rather far apart shows there was originally a long belt of this rock, which has everywhere been broken and interrupted by the entrance of intrusives. There has not been enough work done to indicate the thickness of the slates, but in the Sawyers Bar quadrangle it, no doubt, was once continuous along the strike from the New River divide northeast to the Salmon Mountain axis.

Chert outcrops occur at several places, but usually only as small areas. The best exposure noted was on the summit of the nearly level divide between Methodist and Knownothing Creeks at an elevation near 3500 feet. Here one inch layers of chert are interlaminated with thinner partings of calcareous shale. The formation strikes N. 20° E. and dips 45° NW. On the top of the Blue Ridge massive chert occurs in place at an elevation of 5630 feet (aneroid) and strikes northwest. Associated with it are oxides of manganese, but all the outcrops seen were too siliceous to be worth mining. Just west of the slate belt at the Black Bear Mine at the roadside, chert interbedded with thinner layers of shale occur, showing marked distortion. Thus there are evidently two characters of chert here, near each other. The interbedded chert-shale formation is strikingly similar to deposits near San Francisco Bay which Lawson has classified as Monterey (Miocene). The only other similar deposit was described by the same writer in the same field as Franciscan. The presence of manganese here in association with the massive chert seems to favor the supposition that this may

[1]Cal. State Min. Bur. Unpublished work on Geology of Central Siskiyou County.

and metamorphic members, is the same as described by J. P. Smith[1] to the east of this area under the name of 'greenstone series.' He considered the age of that series indeterminate, but not later than Lower Devonian. Smith's work extended only as far west as Russian Creek.

Rocks Originally Sedimentary.

Slate occurs as bedrock in several of the hydraulic mines, notably around Sawyers Bar and Eddy's Gulch. There is also a small outcrop of it on lower Knownothing Creek. It occurs as one wall, and sometimes as both, in most of the quartz mines in the district. In the Black Bear and Klamath Mines it forms both walls of deposits which occur as lenses and stringers, and is often mixed with quartz as the filling of crushed zones. The Black Bear deposit is strikingly similar to the 'stringer leads' of some Mother Lode properties, but there is no prominent cropping of quartz to correspond to the 'bull quartz' veins of Calaveras and Tuolumne counties. Slate also occurs as hanging- or foot-wall in contact deposits with diorite or quartz porphyry intrusives as the other wall. The Gilta Mine is an example. The slate strikes northeast and dips southeast commonly at an angle of about 40°, but at times reaches a 60° dip because of intrusives. The uniformity of dip and strike at properties rather far apart shows there was originally a long belt of this rock, which has everywhere been broken and interrupted by the entrance of intrusives. There has not been enough work done to indicate the thickness of the slates, but in the Sawyers Bar quadrangle it, no doubt, was once continuous along the strike from the New River divide northeast to the Salmon Mountain axis.

Chert outcrops occur at several places, but usually only as small areas. The best exposure noted was on the summit of the nearly level divide between Methodist and Knownothing Creeks at an elevation near 3500 feet. Here one inch layers of chert are interlaminated with thinner partings of calcareous shale. The formation strikes N. 20° E. and dips 45° NW. On the top of the Blue Ridge massive chert occurs in place at an elevation of 5630 feet (aneroid) and strikes northwest. Associated with it are oxides of manganese, but all the outcrops seen were too siliceous to be worth mining. Just west of the slate belt at the Black Bear Mine at the roadside, chert interbedded with thinner layers of shale occur, showing marked distortion. Thus there are evidently two characters of chert here, near each other. The interbedded chert-shale formation is strikingly similar to deposits near San Francisco Bay which Lawson has classified as Monterey (Miocene). The only other similar deposit was described by the same writer in the same field as Franciscan. The presence of manganese here in association with the massive chert seems to favor the supposition that this may

[1]Cal. State Min. Bur. Unpublished work on Geology of Central Siskiyou County.

be Franciscan. Some outcrops of limestone occur on the west side of Knownothing Creek several miles above its mouth, but time could not be taken to determine their relation to the chert.

Quartzite is reported from some of the gold mines as forming one wall of contact deposits, but it is not of wide occurrence or particular importance in this discussion.

Altered Igneous Rocks.

Serpentine outcrops on the North Fork drainage only in small plugs, and is often thoroughly weathered to a reddish material forming a layer one or two feet thick. The miners call this 'porphyry'. They often penetrate it while prospecting, and find the characteristic greenish phase of serpentine below, from which they have drawn the erroneous conclusion that serpentine underlies the entire Blue Ridge. The sketch map shows that serpentine is widespread over the South Fork drainage. The largest area forms the chief portion of the basin of Niggerville Creek, its western contact crossing the South Fork diagonally at Indian Creek. Here the river has cut a deep notch in it. The South Fork side has evidently been largely spared the later intrusions and the accompanying upheavals which went on along the summit of Blue Ridge to the north. There is probably a wide distribution of serpentine mantled by soil on the South Fork. Near the Black Bear Mine several outcrops of serpentine have the aspect of sills which may have been injected along the strike of chert beds. The general impression gathered by observation is that the serpentine has originally been surrounded by larger areas of chert. The serpentine is deeply eroded, but shows practically no chromite content. The surfaces are usually light green, but one small area was black. Original peridotite occurs in one area as a prominent dike.

A few of the serpentine areas have yielded notable gold pockets. The largest one reported was on Graham Gulch and is said to have yielded over $12,000. A small area at the head of Jessops Gulch near Sawyers Bar produced coarse gold, some of the nuggets being worth $50. This gold, no doubt, was originally deposited near contacts of intrusive diorite or similar rocks with the serpentine. J. P. Smith mentions such small deposits in the 'greenstone series' to the east, as being the result of such intrusive action.

Of interest geologically, but of less importance in the present paper, are the other altered rocks of the greenstone series. These rocks include members which can not be determined in the field usually, but are of widespread occurrence in the northern Coast Range. They are distinguished on one hand from the deep-seated granodiorites and granites, and from the fairly fresh unaltered volcanics of Tertiary age on the other.

Granodiorite forms the Salmon Mountains, and every stream from Big Creek to Jackass Gulch on the north side of the North Fork, carries only granitic detritus and boulders. Apparently a small boss of such

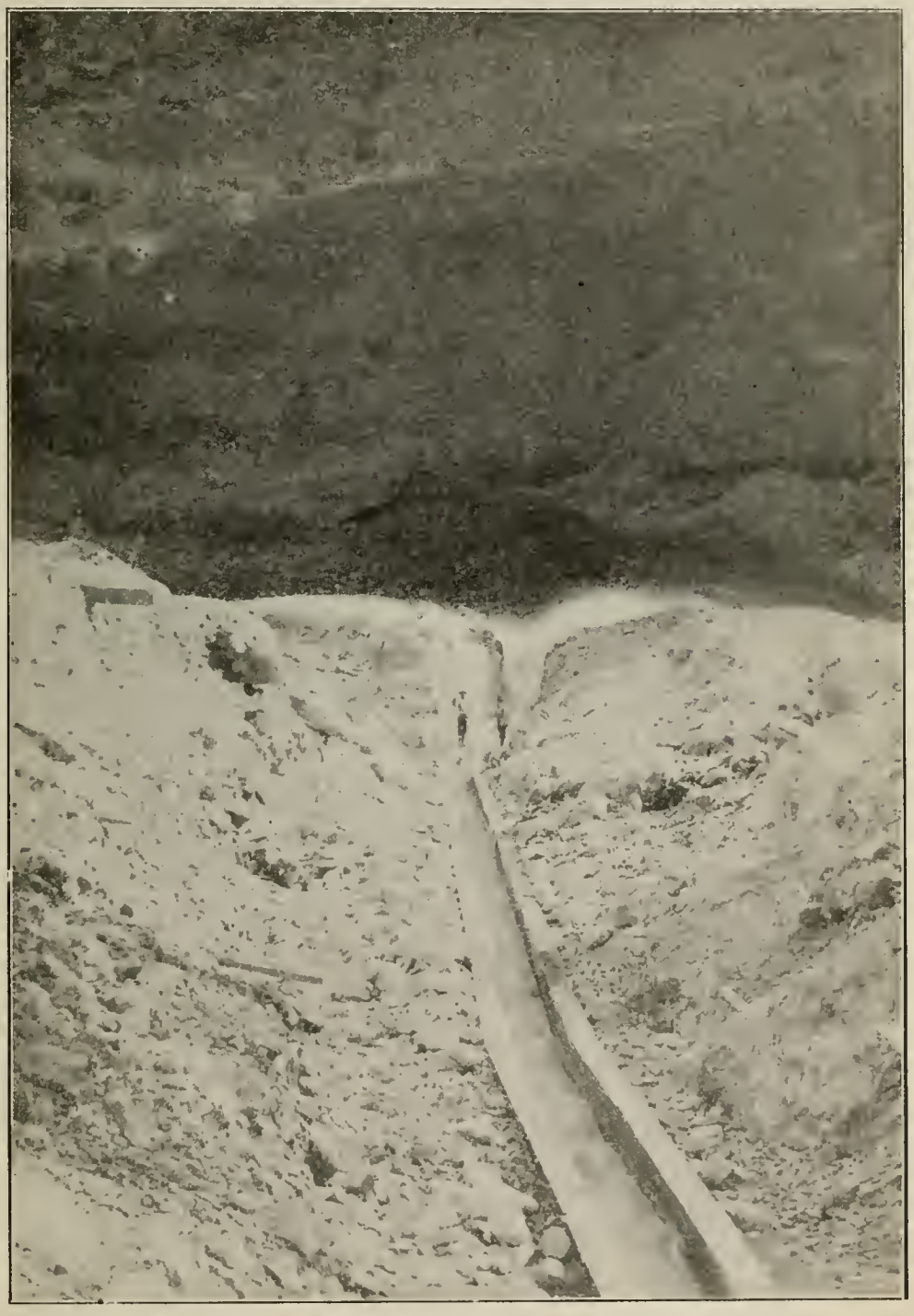


Photo No. 7. Bank of pay gravel and overburden, Bloomer Mine, on Salmon River 5 miles below Forks of Salmon, Siskiyou County. Photo by Irving Eldredge. Typical quaternary terrace deposit.

rock underlies Blue Ridge, but it outcrops only in a narrow area on the summit. No other outcrop was observed south of the North Fork.

Prominent on the upper slopes is an acidic eruptive rock, fine-grained almost to the glassy stage, showing principally quartz and feldspar.

It covers the mountain sides with rough sharp-edged blocks and is apparently the youngest formation in the district.

Old River Terrace Deposits.

The hydraulic mines of the Salmon basin, like those of the Trinity and Klamath, are chiefly located in gravels on the old river terraces. There has not been, however, such an extensive development of the terraces here. Hershey[1] has identified five old channels on the South Fork of Salmon near Summerville and places the highest at an elevation of 250 feet above the river. Thus it is seen that the cutting action of the stream has been less pronounced than on neighboring rivers during the Pleistocene. Hershey believed that a considerable arching of the country occurred in the late Neocene[2] and that a fold along a north-south axis crossed the present course of the Salmon between the forks of Salmon and the Klamath, and that this fold is responsible for the nature of the Pleistocene Cañon cut through it.

The old channels in the district under discussion, reach their highest elevation of 300 feet above the South Fork on the Blue Ridge side at the Nigger Hill Mine. On the opposite bank bench gravels have been hydraulicked at several levels around the mouth of Knownothing Creek. Old deposits were laid down on terraces cut by the latter stream at different levels as far as six miles upstream from its mouth. These have been mined in a small scale. On both sides of the North Fork from the forks upstream, but more particularly as we approach Sawyers Bar, a similar series of terrace deposits have been laid down in old channels. The youngest of these is only a few feet above the present stream. Most of the development of these deposits has been on the north side of the river, but there is one mine on the south side on the lowest bench at Sawyers Bar, one on the south bank seven miles downstream from Sawyers Bar, which has an elevation of 90 feet above the stream, and another bench, evidently the highest and oldest, is 200 feet vertically higher, or 500 feet on the incline. Terrace deposits were also prominently developed upstream beyond the Sawyers Bar District but proved not rich enough to mine where they were worked in the vicinity of Finley's Camp.

Origin of Placer Gold.

The origin of the gold in the bench gravels on the North Fork of Salmon was without doubt in the series of rich gold-bearing quartz veins which traverse the slate and other metamorphics. These strike uniformly north and northeast, forming a belt which, in the area considered, has been mined with profit from White's Gulch to Gilta.

[1]Hershey, O. H.: Journal of Geology, Vol. 11, No. 5.
[2]Hershey, O. H.: Journal of Geology, Vol. 11, No. 2.

In the left fork of White's Gulch the Lanky Bob Mine made a good yield. The owner of that property subsequently opened an extension of the same vein in the right fork of the gulch, calling his new mine the Slim Jim. The vein here swells and pinches with considerable regularity, varying in width from two inches to two feet, and has averaged $20 a ton. It strikes nearly north. Similarly, the Uncle Sam, Gold Ball and Klamath veins were all good producers. They lie on the North Fork side and are crossed at right angles by Eddys, Counts and Whites gulches and other tributaries of the North Fork. Hydraulic miners in Eddys Gulch recover now a considerable quantity of rough quartz carrying gold nuggets, broken by erosion of such veins. The placers on the North Fork from a short distance above Sawyers Bar to forks of Salmon are estimated to have yielded about $26,000,000. The famous Black Bear lode, credited with nearly $3,000,000 production, has been opened on the South Fork divide, but extensions of it have no doubt contributed to the wealth of the North Fork. To the northeast, beyond the area of this report, some sensationally rich quartz mines of pockety character were opened. The Highland and Homestake have been the chief producers among these. The lode has been traced both ways far beyond the district.

The South Fork placers have been enriched in the lower part of the stream by erosion of veins forming the southwesterly continuation of the same lode which fed into the North Fork. The best producers among the quartz mines opened on this side were the Gilta on upper Knownothing Creek and the King Solomon above Matthews Creek. At the Michigan Salmon mine at the mouth of the former stream, rough nuggets with quartz attached are often found. The upper placers in the vicinity of Cecilville were not as rich as those from Matthews Creek downstream. The gold in that upsteam section probably came from the erosion of veins lying in a parallel belt passing through the region of Thompson Peak. Some of these placers were operated at a loss. Glaciers once occupied the upper South Fork basin, moving from Thompson Peak, They deposited a good deal of morainal material poor in gold. The perpetual snowbanks on the north side of Thompson Peak now, are reminders of these ice fields and are sometimes called glaciers.

Occurrence of Platinum.

All the evidence obtainable in the field leads to the conclusion that the occurrence of platinum in the district was coincident with the presence of serpentine. As noted elsewhere, there are only a few small areas on the North Fork drainage where this rock has been exposed to erosion. The principal outcrops of it are on the South Fork side. The field work was not carried beyond Matthews Creek, but as far as could be learned that stream marks the southeast boundary of the serpentine

belt. Hershey emphasized the absence of serpentine on the South Fork from the neighborhood of Cecilville for many miles upstream and described the few boulders of it which he found in the gravels there, as erratics, which he believed came from the Coffee Creek (Trinity County) side, when the upper waters of South Fork encroached upon and captured a part of the Coffee Creek watershed, during the glacial epoch.[1] This portion of the river is of minor interest in the present discussion, as there is practically no mining there and no record of platinum occurrence. The point that attracts attention is the fact that platinum metals are produced in noticeable quantity at each of the three operating mines which are within the serpentine belt on the lower

Photo No. 8 Two giants working under pressure of 457 feet. Red Hill (Michigan-Salmon) Mine, South Fork of Salmon River.

South Fork; but on the North Fork, where dozens of properties have operated for a long period, and where gold production was immense, only a few pennyweights of these metals were recovered.

The Michigan Salmon or Red Hill Mine takes in two and a half miles along the South Fork at and near the mouth of Knownothing Creek, beginning a mile and a half above the forks. In past years the high benches have been worked but operations now are confined to the lower gravels, which are mined by the aid of Ruble elevators, as described under Hydraulic Mining. The ground handled is the gravel of the lowest and youngest bench, only a few feet above the summer level of the stream which must partially flood it during high water. A large

[1]Hershey, O. H.: Journal of Geology, Vol. 11, No. 5.

yardage is handled yearly. Little attention has been paid to platinum metals in the past because of their cheapness, but there is an annual production of several ounces. Probably a large percentage of that present has been lost, as no great care seems to be given to its recovery. The bulk of the metal is in small scales and nuggets but there are many larger pieces, the biggest one saved weighing 1/8 ounce. The small scales are bright but the larger pieces are rough and coated with a blackish film. Pits in the nuggets are often filled with rusty, powdery coatings and one little cavity had a bit of quartz in it but this might have been a grain of sand which it had picked up. This platinum showed little of the smoothing wear of erosion. The nuggets were of various irregular and angular shapes, as if they had come to a resting place in the gravel not far from their matrix. An analysis of a recent shipment of 3.787 ounces of the metal from this property indicated only 0.117 ounce platinum and 3.675 ounces osmiridium. This means that it carries slightly under 3% platinum and is apparently nearer to being pure osmiridium than any other occurrence in California. It is not magnetic, so could not contain a very high percentage of iron.

The Nigger Hill hydraulic mine has been opened on both sides of Niggerville Creek nearly half a mile upstream from the river. Two benches have been mined. The highest deposit is about 300 feet above the Salmon, and is the oldest gravel in the basin. No doubt it corresponds with the oldest of the five benches near Cecilville which is 250 feet above the river. There is a bank 90 feet high, containing 30 feet of gravel at the base, overlain by 60 feet of a distinctly red, clayey overburden. The creek cuts across the terrace, and has eroded a deep trench to keep pace with the river. The heavy red clay overlying the gravel is no doubt a torrent fan poured out delta-fashion during stormy weather in the days when the creek entered the river here. The boulders in the gravel are medium sized and have the appearance of great age. The bedrock is also soft and highly altered, apparently igneous.

Previous to last season platinum was never saved at this property, though considerable ground has been hydraulicked. Last year several nuggets of a metal looking a good deal like dirty lead were picked out of the box at clean-up time and put aside. The man who leased the property recognized them as platinum metals. Closer attention was paid thenceforth to saving the material. The largest nugget was reported to weigh one-half ounce, and the bulk of that saved was in nuggets from a pennyweight upward. Mining was done here in a small way for about three months with one giant and a scanty water supply, but the recovery of platinum metals apparently equalled the season's production at the Michigan Salmon Mine where at least ten

times as much ground was moved. This metal has not been sold yet so the analysis is not obtainable.

The Orcutt hydraulic mine is operated on a small scale at the mouth of Methodist Creek, about seven miles from forks of Salmon. There is a small annual recovery of platinum here. The largest nugget recovered weighed slightly over four pennyweights. Serpentine occurs prominently here and at intervals along the creek basin to the top of the divide. Prospectors who had mined the upper creek with sluices claimed that some platinum was always noticed in the boxes, but no attention paid to it. A nugget of platinum metals weighing ½ ounce is said to have been found by a prospector near the head of the creek in 1912.

On the North Fork, platinum has been found in a very small amount at two properties. One of these is the Peterson mine in Eddy's Gulch about three miles from Sawyers Bar. There is a slate bedrock here, striking northeast and diping 40° SE. This gulch is wide and U-shaped, in striking contrast to the other stream cañons of the district. The material filling it is mostly rough and angular. There is a bank 60 feet thick, of which 25 feet is apparently pay gravel. There is a high percentage of rocks, and black sand is almost entirely absent, in contrast with the high percentage found in the river. While no time was taken to verify the supposition, it is thought that Eddy's Gulch is undoubtedly an old glacial trough, although some of the material now filling it probably came from landslides. The gold found here is rusty, rough and coarse, often with quartz attached. The few pieces of platinum saved are rough and covered with a black and rusty coating. This material shows few signs of erosion. The largest nugget weighed 23 grains. The nuggets have flat, angular shapes and are probably osmiridium. Eddy's Gulch has produced a great deal of placer gold, and is still yielding well, although Peterson is the chief operator and he mines only about 5000 yards annually. Several productive quartz mines were formerly operated in its upper branches where the spacious U-shaped cañon is very pronounced. Evidently no small stream like the present one could have done such work. The only outcrop of serpentine visible in this trench is a small body lying at an elevation of 3500 feet on the trail to Black Bear Summit.

The only other producer of platinum on the North Fork was the bench mine at the mouth of Jessop's Gulch. William Wike and a partner took a contract here many years ago to clean the bedrock after hydraulicking was suspended. They made $6 a day each in gold for nearly a year, but their saving of platinum metals amounted to only about ½ ounce in all. This was loaned to the writer. The largest piece weighs __ grains. This nugget shows a rounded surface but most of

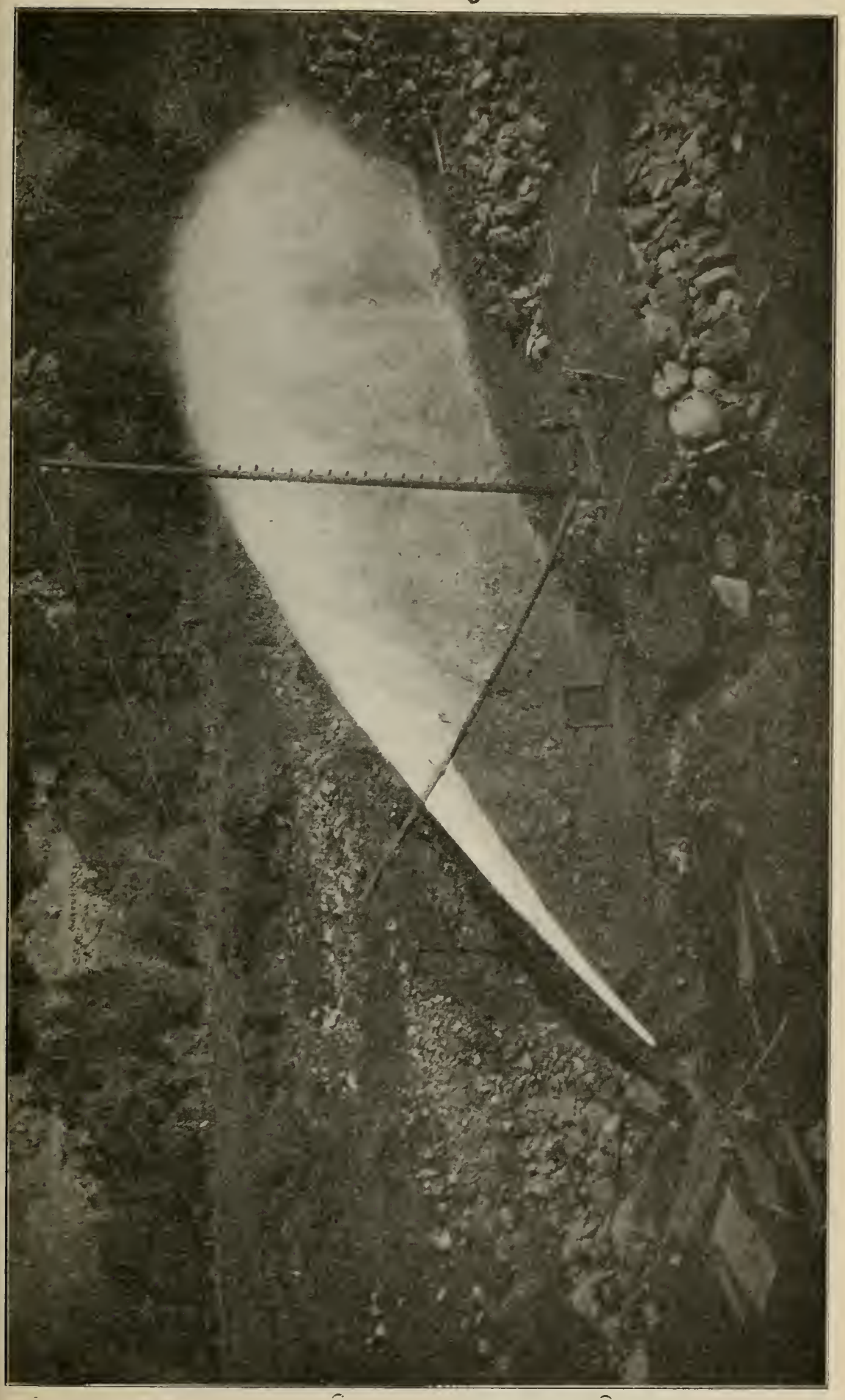


Photo No. 9. Hydraulic Mining near Sawyers Bar, Siskiyou County. Photo by Irving Eldredge.

the metal is in irregular unworn nuggets and in jagged scales exhibiting perfect basal cleavage faces, indicating osmiridium. Boiling in concentrated acid readily removed the black coating and accentuated the sharp, unworn character of the material. (See Plate I.)

JUNCTION CITY DISTRICT.

This is usually the first region thought of when platinum production in California is mentioned. The distinction is due to the occurrence of numerous nuggets of mixed platinum metals which have been saved here. These nuggets are the largest of the kind ever found in the state.* The district, which is confined to Trinity River and the lower courses of its tributaries, is bounded upstream by the mouth of Dutch Creek and the downstream limit is placed at North Fork or Helena, for the purposes of this report, because there is such a small production and so little mining activity between there and the South Fork.

An automobile road runs from Weaverville to North Fork via Junction City, and from the latter place a road crosses the river and runs as far as Dutch Creek. The numerous perennial streams have cut deep cañons in reaching the river, which in turn has left a number of terraces carved on the cañon side to mark its earlier Quaternary channels. At present, the river is overloaded with sand and gravel tailings of the La Grange hydraulic mine. Most of the hydraulic ground in the district is exhausted and a good part of that remaining can not be worked until water is supplied. There is one dredger below Junction City which produces nearly all the platinum saved in the region.

Geology.

No systematic study has been made of the geology of this immediate district, and such study was outside the province of the present paper. The rocks of the region have been roughly grouped under two heads by J. P. Smith on his Geological Map of California, published by the California State Mining Bureau. The older series, or 'Pre-Cambrian Metamorphics,' is one in which gneiss, hornblende schist and mica-schist are the dominant rocks. This series lies mostly east of the river, but the contact is badly warped and crosses the stream several times. The younger rocks lie principally west of the river. Smith groups them under the title of Paleozoic Metamorphics, Undifferentiated. This classification is useful to contain all the rocks of sedimentary origin, including shaly cherts and limestones, the age of which has not been determined because of a paucity of fossils; here also are grouped the

*The Placerville Republican of January 29, 1917, reported that a nugget of platinum valued at $105 had recently been recovered one-half mile from Fairplay, a small camp near the Middle Fork of Cosumnes River, in El Dorado County. There is no other record of platinum nuggets being recovered from that region.

many areas of serpentine found in association with the chert and various rocks of igneous origin which have undergone the chloritic or 'greenstone' form of alteration.

The older series is exposed typically on the southwest slope of Weaver Bally. Here hornblende schist shows evidence of much folding and crumpling, having been compressed by contraction along a northwest-southeast line. This compression is shown in its larger aspects in the La Grange fault about five miles south where Tertiary gravels lie thrust upon a rim of schist, with slate to the south. Schistosity along a northeast direction is plainly developed in this formation where it appears along the river in the bedrock of the hydraulic mines. Mica schist is prominent west of the river near Dutch Creek and actinolite schist in the bedrock of mines near Mill Creek.

The chert and limestone of the younger series have been crushed so that the chert is badly broken up and the limestone largely changed to gray marble, but the original strike of the beds to the northwest is usually traceable. It is evident this series has escaped much of the metamorphism felt by the older schists. The rather extensive beds of limestone suggest a Devonian deposit. Serpentine areas are in general enclosed by chert which is interlaminated with thin partings of shale. There are some small outcrops of shale a few feet in width.

Granodiorite makes up the higher portion of Weaver Bally. Younger igneous formations ranging in character from very acid to basic, are of frequent occurrence in dikes.

The bench gravel deposits which have yielded the gold and the nuggets of platinum, are derived from the erosion of older gravels, but the origin of these is a mooted question. It seems simple enough to trace them upstream to the Minersville district, but the problem is complicated by a survey of the field. The gravel on the benches in the district bounded upstream by the mouth of Dutch Creek is without doubt different in origin from the gravel farther upstream on the river. The wash between Dutch Creek and the Jacobs mine is characterized by enormous boulders which have evidently not come downstream, as they are not seen above Dutch Creek. Neither is platinum noted in the La Grange mine, although there are numerous boulders of large size in the gravel there. The disappearance of heavy wash and platinum nuggets above Dutch Creek is coincident, suggesting their common origin. This origin may be in the immediate vicinity; the boulders may represent fault breccia, landslide material, or glacial debris brought from the northeast, from the region of the Sawtooth Mountains. Insufficient study of the geology has been made to defend or disprove either hypothesis.

Production of Platinum.

Chief among the producers of platinum here is the Valdor dredge. This is working on the Trinity River about five miles below Junction City, on what was formerly known as the Hertevant mine. The machinery of the dredge is principally of Union Iron Works manufacture and the hull is built from timber sawed on the company's land nearby. The bucket line carries 69 buckets of 7 cubic foot capacity. The boat can handle 5000 cubic yards a day. It is 100 feet long and carries about 1550 square feet of gold saving tables. Electric power is bought from a company which has a generating plant just below Junction City. Cost per yard to work this ground is only a fraction of a cent higher than at Oroville, but of course the cost of bringing in machinery from Redding, about 65 miles distant over steep roads, was heavy. The dredge is at an elevation of 1424 feet and in August, 1917, was working on the north bank of the Trinity, although the possibility of crossing the river was being considered. Dredging began here November 18, 1916. Up to July 1, 1917, about 900,000 cubic yards had been dredged.

The ground consists of river gravels and alluvium which has been laid down in one of the few places where the cañon widens out. When visited, only 74 acres had been proven as dredging ground, but there is no doubt a considerable area in the region upstream and across the river. The ground was worked by surface and drift mining from the '50's onward and on the opposite bank a great deal of hydraulic mining has been carried on all the way upstream to the mouth of Dutch Creek. All these hydraulic properties were rich in gold and produced considerable platinum, so that it was reasonable to look for rich ground here. The average depth to bedrock is 24 feet with extremes of 15 and 33 feet, but the bedrock often contains deep holes which the buckets can not clean. Every hole drilled showed either serpentine or limestone bedrock. The actual results obtained by dredging in many cases were exactly opposite to drill indications. Ground which drilled as high as 40¢ a yard was dredged at a loss of several cents a yard, and some ground which prospected 2¢ or 3¢ a yard proved very rich. A typical section in a hole 33 feet deep shows (1) 12 feet of soil; (2) 9 feet loose fine gravel; (3) 6 feet hard coarse gravel; (4) 2 feet loose gravel; (5) 3 feet medium loose coarse gravel. The gold is found on and within three feet of bedrock. Usually a foot or more of bedrock is dug. Nearly all the gold is saved on the first two tables, but there are few nuggets found.

More careful and systematic work in saving platinum has been carried on here than anywhere in the northwestern counties. The location of the property, only about nine miles downstream from the celebrated Chapman mine, and nearer to other hydraulic mines where

platinum nuggets were found, also makes the property of special interest. Platinum metals occur as fine flakes and as crystalline, sharp edged pieces. The former, no doubt, are platinum, the latter osmiridium. Over a period of several months, the ratio of platinum metals to gold (by value) averaged about 1¼ : 100. This gravel yields from five to six times as much platinum metals per yard as the dredging ground on the Yuba, Feather or American rivers.

The platinum is recovered principally by hand panning of the long-tom concentrates. A small part is saved with the hard amalgam. The black sand from the dredger is brought to the clean-up house. To reduce the bulk it is run through a long tom several times. This long tom is 11 feet in length and 1 foot wide and is made of 2 inch lumber. It has a grade of 1½″ to a foot, and the bottom is covered with riffles. The dredger product enters through a hopper which screens out coarse pebbles and base metal over ¼ inch. Hard amalgam with a little platinum is first recovered. Continued panning of the sand saved in the long tom gives in the following order: Mercury and soft amalgam; base metal carrying some amalgam, which is saved in a base bar; free platinum concentrate, carrying about 90% platinum metals; and No. 1 black sand concentrate. The main body of sand is saved and the coarse material over ¼″ is examined, although nuggets of gold are rare, the largest found in nine months weighing about ¼ ounce. No platinum larger than a wheat grain has been found.

Various tests have been made on the black sand concentrate after panning out as much as possible of the gold and platinum. Tabling tests indicated that one ton of the sand carries .112 oz. gold, .016 oz. platinum, and .014 oz. osmiridium. Only five tons of such sand were accumulated, however, in dredging nearly 1,000,000 cubic yards, so that the loss is not serious if these tests are correct. Screen tests of the residual black sand showed that 93% of the gold and all the platinum remaining in it is finer than 10 mesh. Assays vary considerably. The last one furnished the writer showed 43.2% platinum, 47.5% osmiridium and 1.3% gold, leaving 8% of the 'crude platinum' without value. Another lot of over nine ounces carried 30.5% platinum, 54.2% osmiridium and 1.72% gold. The gold also varies greatly in fineness, running from $16.15 to $18.76 an ounce.

LOWER SOUTH FORK AND MAIN TRINITY RIVER.

This area includes the main river from the end of the cañon near the mouth of New River to Willow Creek, and the South Fork of Trinity from Big Oak Flat to the mouth, with the gravel which has been deposited on the series of benches between the two streams.

The mines here are located on terrace gravels which have been opened in different properties from near the level of the river to an elevation of 840 feet above it. A careful study of this region ought to shed much light on the history of the Trinity Cañon. The series of benches appears to be preserved better in the small area around the mouth of the South Fork than anywhere else on the Trinity River. There is a striking similarity between this series of terraces and the series studied by Hershey[1] at Orleans, Humboldt County. However, Hershey stated that the highest bench at Orleans is 850 feet above the present Klamath River. The highest terrace noted at the place mentioned on the Trinity is about 1000 feet above the river. Considering that the two terrace systems represent probably the same time period it is evident that Trinity River has maintained a uniformly faster rate of cañon cutting in Quaternary times than the Klamath, due to differences in stream grades, and in directions of flow with respect to the strike of underlying formations.

The complete set of gravel-covered benches appear on the Hammer property, sometimes known as the South Fork Gold and Platinum Mining Company, of which P. P. Hammer of Willow Creek is principal owner. These holdings comprise 885 acres lying between the main Trinity and its south fork, with a length of $\frac{7}{8}$ mile up the main stream. The highest or sixth bench, 1000 feet above the river, is unprospected, but there is probably $\frac{1}{2}$ mile of it here. The fifth bench is 841 feet above the water and has been traced for about one mile. It has been mined a little; about $\frac{1}{4}$ acre has been hydraulicked by Mr. Hammer and has proven to be good ground. The fourth bench has not been worked or thoroughly prospected. Its edges show occasionally as a bare rocky platform on the road up the South Fork. The third bench has been extensively prospected and has been mined on the Hammer property and on the adjoining properties lying on the east bank of the South Fork. This channel has a length of $\frac{3}{4}$ mile and has proven to be productive ground. The gravel is 47 to 50 feet deep with no overburden. The floor of this bench is about 450 feet (aneroid) above the river. The bench is prominently developed clear across the area between the two branches of the river. The second bench has been tested by shafts and tunnels and found to carry from 8¢ to 20¢ a cubic yard. This bench passes under the house of an adjoining landowner, who contested the mineral character of the land. The suit brought out evidence showing that the entire Hammer holdings are mineral land. Some samples from the second bench went as high as $3 a cubic yard. This bench has been mined in a small way on the opposite side of the river from the Martin house, and yielded satisfactorily. The first, or lowest

[1]Hershey, O. H.: River Terraces of the Orleans Basin, California. Bulletin of Dept. of Geology, Univ. of Cal., Vol. 3, No. 22.

bench, has not been mined on this property, but higher upstream has been proven productive. This bench is well developed around the mouth of the South Fork, where the present stream flows in a steep cañon cut in the rocks to a depth of 60 to 70 feet below the first bench. These six terraces are thought to represent the entire series of stages of the downcutting Quaternary Trinity River. Not all of them, probably, occur so conveniently situated for observation anywhere else on the river, although as many as three or four can be seen at places like Junction City.

As little known as these bench gravels are, they have been mined enough to indicate that they are probably richer in platinum than any other known area of mining ground in the state. The platinum on the Hammer ground is coarser than would be expected so far downstream, and evidently contains a large proportion of osmiridium. As noted above, Hammer is operating two small hydraulic mines on his holdings. One is on the fifth bench, where Dutchman's Gulch cuts through the gravel. One-fourth acre of ground has been mined here, which Hammer says has yielded $6,000, and has given as much as four ounces of platinum for $1,000 in gold. In one 50-hour run with a 6-inch pipe and 3-inch nozzle, nearly one ounce of platinum was saved. The gold is flat, ranging around the size of wheat. Platinum flakes the size of two pinheads are common, and both gold and platinum are clean and bright. Nearly 15 ounces of platinum are said to have been produced from this ground. The very high proportion of the platinum to the gold can be realized when it is remembered that 15 ounces represent the average yearly production of platinum from two California dredgers handling from 200,000 to 240,000 cubic yards a month.

On the South Fork, possibly a mile upstream from the mouth, Hammer has opened a mine in the gravel of the third bench and has found ground which has yielded well. The bedrock is slate. Where now working, the gravel is 30 feet deep, but increases to 47 feet nearby. There are two strata of gravel in the bank, colored red and blue; the latter is the richer, and has shown a value of 37¢ a cubic yard as against 18¢ for the red phase, where they were prospected by shaft. The recovery from the ground actually mined has exceeded these prospects as Mr. Hammer claims to have realized over 60¢ a yard. The gold is in flakes of medium size, seldom smaller than No. 2. Platinum colors can be easily panned on the bedrock. They range from very fine to No. 2 size. The amount of ground moved here has been small, because very little water is available.

These Hammer holdings no doubt contain as good grade of gravel as remains unworked in California. Failure to work them on a larger scale has been due to lack of water, and adverse claims of agriculturists

who for many years have contested the character of the land. The problem of water supply has been the chief difficulty. There are no streams nearby high enough to put water on the fifth bench. The only water now available there is the run-off during the winter rains. Two miles of ditches have been dug to encircle the hill 80 feet above this bench, and these ditches serve as reservoirs which permit washing with one giant during wet weather. It is estimated that a water supply sufficient for six months steady piping anywhere on the 885 acres could be obtained from Eltapom Creek, a branch of the Hayfork, by building 18 miles of ditch and flume. For a full year's supply, it is thought that it would be necessary to tap the Hayfork at a distance of 34 miles. A siphon from Campbell Creek would furnish a supply for the third bench gravel. This compares favorably with the La Grange property, where it was found necessary to go 29 miles for a water supply, and where the gravel has never approached in richness the prospects reported on the above property. The gravel is loose and easily worked and there is ample grade with plenty of space for dump.

An interesting prospect was opened in the gravel of the third bench on the **Koon Ranch**, on the South Fork about one mile above Hammer's property. There are possibly 50 to 60 acres of gravel here, averaging 25 feet deep. The bedrock is slate and the gravel is medium to fine, with a blue color throughout. One winter Mr. J. A. Koon, the owner, hydraulicked a little of this gravel, handling in all about 2200 cubic yards. The gold recovered amounted to $150, and Koon estimates that he also cleaned up between three and four ounces of platinum. Unfortunately, he was unacquainted with this metal and discarded all of it except 1¼ ounces which he now has on hand. There is no reason to doubt the accuracy of Mr. Koon's statement. This was a remarkable yield, and strongly corroborates the figures of platinum yield and the writer's observations at other properties nearby. The gold and platinum in this gravel are fine and flaky.

Continuing up the South Fork, we reach a considerable bend in the river at Sec. 26, T. 6 N. The bend surrounds, on three sides, an area of about 100 acres of high gravel, known as Big Oak Flat. This is considered by those most familiar with the region, to be the limit of the Main Trinity River wash, as distinguished from South Fork material. At any rate it appears to be the limit of pay gravel as we ascend the stream. A number of years ago, this flat was quite thoroughly prospected by shafts and tunnels. The average value was determined to be 6¢ a cubic yard, according to the man who had charge of the prospecting. The idea of hydraulicking it was consequently abandoned. An unsubstantiated report was made at one time that platinum occurs on the Carpenter property, Sec. 12, T. 5 N., R. 5 E., in the ratio of

4 or 5 parts to one of gold, but it is believed that the gold content there is too low for mining profitably.

Little is known about the gravel which may lie on the west side of the South Fork. No claims have been located there yet, although a face of gravel has been noted several hundred feet above the stream.

On the main Trinity between the mouths of South Fork and New River there are several hydraulic properties which for the most part have been operated for a short season during the winter. There has been considerable friction here between miners and agriculturalists and land probably more valuable potentially for mining than for farming is being held in some cases by homesteading.

(This district was covered by H. G. Ferguson of the U. S. Geol. Survey but the following notes obtained by the writer are given here because they may contain some items of information in addition to that obtained by Ferguson.)

Gem Placer, Teal and Perigot, owners, has yielded possibly 20 ounces of platinum. There are 400 acres in these holdings. Season averages six months. Platinum to gold ratio of one to ten by quantity.

Top Notch Mine, F. Ranney, owner. This property was mentioned in a former report[1] as producing platinum in the ratio of one ounce to six ounces gold. Ranney states this figure is too high; some of the lowest and richest ground made a small yield at rate of one ounce platinum to ten of gold. The mine is not being worked now.

Hawkins Bar, Jerry Smith, owner. Located in Secs. 28, 29, T. 6 N., R. 6 E., and contains 340 acres. This property is equipped for mining and has made some production in the past, both of gold and platinum. It is not now being worked.

The Henderson Mine, in Sec. 13, T. 6 N., R. 5 E., contains 60 acres and is equipped for hydraulicking. It is a small producer of gold and platinum.

All these properties are able to make only a short season's run on account of water scarcity.

The Corona de Oro Mine is located on the Trinity River in Secs. 17 and 20, T. 6 N., R. 6 E., six and one-half miles from the mouth of the South Fork. There are several benches of gravel on this property, the highest of which is about 800 feet above the river and probably corresponds to the fifth bench on the Hammer property. The gravel has been opened in one of the lower benches with satisfactory returns in gold and platinum, but troubles among the stockholders and difficulty in applying proper mining methods have retarded progress.

[1]Cal. State Min. Bur., Mines and Mineral Resources of Trinity County, 1915.

Six hundred fifty inches of water is taken from Cedar Creek, a branch of Horse Linto Creek, through 10 miles of ditch and tunnel, and a five-inch giant working with 260 feet head is used in hydraulicking. Use of large quantities of water and the attempt to put through a big yardage are thought by some of the stockholders to have resulted in loss of considerable fine gold and platinum, but nevertheless the reported recovery has been at the rate of 28¢ a cubic yard in gold. At the current rate paid for Trinity River platinum metals, there has been a yield of 4.6¢ a yard for the platinum saved, making a total of nearly 33¢ a yard. With more careful manipulation and the installation of an undercurrent, it ought to be possible to increase largely the recovery of both fine gold and platinum. The largest gold nugget so far found was worth $5.00, and the platinum is said to be all fine. The gravel is medium and easy to work. It contains a large amount of pyrite, probably derived from the erosion of the slate which is the commonest bedrock material in that district. The longest continuous run yet made was 12 days. This property ought to be capable of producing 15 to 20 ounces of platinum each season if the proportion indicated by past recoveries can be maintained, and if mining can be kept up for three to four months each season. The width of the gravel has not been determined. Tunnels 200 and 125 feet long respectively, were entirely in gravel. The mine is owned by the Corona de Oro Mining Company, Eureka, California.

HAYFORK OF TRINITY RIVER.

Hayfork Creek or the Hayfork of Trinity, as it is frequently termed, has a uniformly broad, well-graded valley. It has two forks, the larger of which heads near the upper waters of the South Fork of Trinity and of Beegum Creek and is separated from those streams by a mountain divide of about 5000 feet, which is largely serpentine, forming as it does the widest portion of the serpentine zone which extends from Tedoc Mountain northwest.

These three streams are all notable as platinum producers. The Hayfork, in the region of the town, has produced large amounts of the metal. As we go toward the headwaters of Hayfork the results appear to be less definite. On the East Fork of Hayfork there is at present little mining going on. There are some small areas of gravel which pan promisingly for platinum, but in the greater part of the stream there is no particular promise of platinum production. The Hayfork is today a low-grade stream, and the broad valley is preserved to within three or four miles of the sources of the two forks. Its south fork at Wildwood flows in a broad trough filled with fine sediments.

The eastern slope of this valley leads over an alluvial surface of gentle grade to the top of the divide which separates the Hayfork from the Cottonwood Creek drainage. There is no outcrop of rock in place on either side of the road till one passes to the Cottonwood side. On the road to Harrison Gulch, slate in place occurs about one mile below the summit and is prominently shown on the dumps of all the gold prospects in the neighborhood of Harrison Gulch.

Wilson Creek, a tributary of Hayfork a mile north of the highway, cuts through the alluvial mantle and shows it to consist chiefly of greenish clay. On the Geo. H. Knight Ranch, which lies on the highway, one-half mile from Green's Wildwood Hotel, a small branch flowing west into Hayfork has cut through the clay to a bedrock which has the appearance of highly weathered granite or granodiorite. There is a stratum of greenish clay some three feet thick under which a thin layer of angular wash, containing considerable quartz, lies directly on bedrock. Mr. Knight has put a short sluice in this branch and has cleaned a very few square yards of the bedrock scooping out the dirt from beneath the clay. The clean-up was interesting, more because of its character than its value. The gold was heavy and round, and had traveled a very short distance. There was a notable proportion of platinum which was bright, angular and coarse. The clay is probably a portion of the deposits brought into the Hayfork basin when the latter was a ponded stream.[1] Three or four colors of platinum can be obtained in a pan of this wash; but panning the gravel and scraping bedrock along the Hayfork here rarely or ever gives a color; in fact, only one color was found in a distance of several miles on the main stream.

Ascending the Hayfork, that stream begins to take on a steeper grade two miles south of the highway. Here a lens of tightly cemented conglomerate seven feet thick lies on a very hard basic igneous bedrock. The conglomerate is apparently derived from the bedrock. It contains boulders up to three feet in diameter. There is a large body of serpentine just to the west of the creek here. Chromite has been mined and shipped here recently, and there are some small bodies of it still in evidence. Large areas of igneous rock rich in pyroxene flank the Hayfork to the east and form steep rock strewn hills on that side. Stringbean Gulch, a tributary of Hayfork to the east, flows through this formation for about two miles. Another similar outpouring of basic eruptives of the same character but apparently not continuous with this area extends from the Hayfork northwest, being in evidence on both sides of the highway, and forming prominent hills across the upper basins of Salt Creek and Hayfork. This rock is very slightly

[1] U. S. Geol. Survey Bull. 196.

serpentinized as a rule. It weathers to a reddish soil and on the weathered surface has a somewhat darker shade than terra cotta. No platinum could be panned in this section of the stream.

A trip was taken from the highway at Wildwood to the upper waters of Prospect Creek, which is a tributary of the South Fork of Trinity River. Serpentine is a prominent rock in this region, forming the bare ridges which separate the two drainages with an elevation of 5000 feet. The serpentine appears in association with cherts through this area till one reaches the watershed of Prospect Creek. Serpentine is also prominent between Dubakella Mountain and the State Highway and around the headwaters of many tributaries which empty into Hayfork farther downstream. It is thus seen that serpentine and related basic rocks are the prevailing formations in the Hayfork watershed. There are, however, no evidences of benching or gravel deposits on these upper portions of the streams. The 5000 foot divide is a nearly level ridge which can be travelled for miles on horseback, as the serpentine supports practically no timber or brush. There are no peaks of superior height in the region, nearer than North Yolla Balla. The gravel of South Fork of Trinity River carries a very little platinum in the vicinity of Prospect Creek.

Platinum occurrence along the Hayfork and its tributaries is apparently limited to the older stream gravels in the lower courses of the streams, and can not be traced to a definite source in the headwaters, above the level of the gravel deposits. Carrier Gulch in Sec. 23, T. 31 N., R. 11 W., is credited with a large but indefinite production in the old days, but there has evidently been no platinum recovered there in recent years. Kingsbury Gulch, which empties into Hayfork at the town, has been mined for gold in both veins and placer gravels. Two ounces of platinum were saved there in 1916 with $1500 in gold from a gravel mine. The platinum was fine and flaky.

Platinum occurs on the Hayfork at the mouth of Little Creek. The gravel bed here is from two to four feet deep. It is made up of coarse wash mostly granitic and the bedrock, also, is a decomposed granitic rock. Two or more colors of platinum can be obtained from every pan taken from the bedrock, upon which the platinum values seem to be concentrated. Roy Peterson has located a claim here and has done a limited amount of work, cleaning bedrock and shovelling into sluices. No sales have been made as far as known, but a small output is possible.

Platinum occurs in a similar way from the mouth of Jud Creek to Bear Creek, on the Beebee claims. Beebee says the proportion of platinum to gold is 1 to 6 in quantity. The work done so far has not shown the amount of gravel which can be mined. Water can be made

available by a pipe line 750 feet long to Jud Creek. Two claims are held by location. Only a little hand shoveling has been done.

If one is to believe the stories of the early days, there must have been a heavy production of platinum. The metal at the time was worth only $2 to $3 an ounce and few wanted to buy it at that price. The white miners probably threw away what they found of it, but the Chinese were more frugal. It is said to have been recovered at the rate of six or seven ounces for $3,000 gold. The Chinese had a pigment in which they colored the platinum yellow. It was then dried and mixed with the gold, which was sold whenever possible at night to local merchants in order to avoid too close examination. Hayfork gold thus came to have a poor name, and could command only about $16 an ounce.

PLATINUM IN PLACE.

Most of the information available regarding platinum metals as constituents of veins in California is hearsay, not supported by subsequent development or even proven by reliable assays.

Shasta County.

The only well established case is that of platinum metals recovered in the electrolytic refining of blister copper from the Iron Mountain mine of the Mountain Copper Company in Shasta County. Ledoux & Company of New York sampled blister copper for the above company at the eastern refinery. They reported in September, 1917, that their analyses showed that the blister copper carried platinum at the rate of .001 oz. per short ton.

Palladium was not recognized in 50 A. T. samples. This figure is much lower than the estimate quoted[1] by Eilers. It is worth noting that assays made on copper ores from other Shasta County properties have failed to show the presence of platinum.

Twenty years ago considerable excitement was caused in Harrison Gulch, Shasta County, by the reported discovery of platinum in ore from a tunnel near the roadside between Wildwood and Harrison Gulch and only a short way below the summit of the divide between the two counties, just within the slate belt. This property was abandoned long ago, and no definite information is available about it now. Extensive work in the slate belt at Harrison Gulch, where millions in gold have been taken out, has not produced any platinum as far as known, so the authenticity of the above find is open to question. It should be noted, however, that platinum was panned by the writer about three miles from this prospect near Wildwood, and that it was impossible to connect this platinum with the extensive areas of basic igneous rocks on the upper Hayfork watershed.

[1]Trans. A. I. M. E., Vol. 47, page 217.

San Bernardino County.

Platinum in association with lead carbonate is reported[1] to have been found on the 150 foot level of the West End mine, near Cima, San Bernardino County. Some assays are said to have indicated 7.61 oz. platinum and palladium in addition to considerable amounts of gold and silver. The ore occurs at contact of limestone and granite. Inquiries addressed to this company remain unanswered.

Del Norte County.

Platinum in chromite from Del Norte County was reported in "The Mining and Scientific Press" for June 30, 1917. The ore came from the northern part of the county, southwest of Monumental. The reported assay indicated .04 oz. platinum per ton of chromite ore. When the writer visited the district in September, 1917, no one would claim responsibility for the report, and those acquainted with the facts stated the story was without foundation.

Trinity County.

Circumstantial reports of the discovery of platinum in veins in serpentine at the mouth of Bell Gulch near Soldier Creek in the Junction City district of Trinity County, came to the attention of the party members while in Weaverville. Color was lent to such reports by the fact that the largest nuggets of platinum metals ever found in California came from the bench gravels of Trinity River in this immediate locality. Accordingly, the party, which included L. M. Prindle and H. G. Ferguson of the U. S. Geological Survey, and the writer, spent some time in a careful reconnoissance of the district. A camp was established near the mouth of Maple Creek. Careful and persistent work here failed to indicate the presence of any platinum other than a few grains found with placer gold in the bench and stream gravels. The rock locally called serpentine, is in many cases a highly altered greenstone which occurs as bedrock in many of the hydraulic mines. It is schistose and often quite soft, being possibly best described as an amphibolite equivalent of serpentine. Areas of this rock and all the areas of serpentine in the vicinity were carefully panned and examined closely. Several days were spent in panning the wash of the numerous streams from Browns Creek to Connor Creek. The results of this work were entirely negative. These creeks themselves have no gravel deposits in their upper portions and have never been mined with success.

The gold and platinum in the district are confined to the deposits on the terraces formed by the Trinity River, and had their origin no doubt in veins a long way north of the river. The nuggets of platinum metals

[1]Mining and Scientific Press, August 25, 1917.

are worn smooth usually on all sides, except one, which has evidently been protected. The finding of these nuggets has been so infrequent that no definite knowledge of their original location in the deposit is to be had. The fact that they are sometimes picked out of crevices in the bedrock signifies nothing.

The serpentine areas in this region usually carry very little chromite. On the divide between the upper Hayfork and the South Fork there is notably more chromite, but no traces of platinum could be found there.

Maple Creek, in the same district, has been mentioned as a place where platinum and gold associated in a quartz vein were found lately by the same prospector who claimed to have found platinum previously in Bell Gulch. Our party carefully prospected this stream and its branches over its entire course. Adjacent serpentine areas were likewise panned thoroughly, but no color of platinum was found except in bench gravels left by the retreating river at a point which no doubt was once at the junction of creek and river, but is now some distance upstream on Maple Creek. Similarly, platinum is obtained near the mouth of Dutch Creek from gravels formerly mined on the high terraces now some distance up Dutch Creek. The finding of platinum in the terrace gravels near the mouths of these streams has given a certain plausibility to the argument that the platinum originated in the country rock within the immediate basins of those streams. The deposition of gold and platinum at these places may well be ascribed to slowing down of the river currents or to eddies, or curves in the river channel, which are known to often be responsible for the deposition of gold at certain points along water courses. If the platiniferous rock has been brought south by glaciers it might also be said that the erosion of the morainal material by streams would result in concentration of gold and platinum at the mouths of the streams where retarding of the current reduces its power of transportation. Sorting of this alluvial fan material by the river during high water stages would result in the concentration of precious metals on the bedrock, especially in the case of larger nuggets.

San Luis Obispo County.

Traces of platinum in peridotite from the Santa Lucia Mountains near Santa Margarita in San Luis Obispo County are reported by A. A. Wheeler to have been found in analyses made by Baker and Company. The western slopes of this range are largely covered by serpentine areas in which large deposits of chromite are widely distributed. Small bodies of copper ores are also of frequent occurrence.[1] On the east slope, near the summit of the range, native copper occurs in serpentine as fine wires and bands. Some small rich bunches of

[1]Cal. State Min. Bur., Mines and Mineral Resources of San Luis Obispo County, 1916.

copper ore have been encountered where assays indicated several dollars a ton in gold and silver, but no mention has been made of platinum in such cases, although it may reasonably be expected in such an association.

Platinum and gold occur in the beach sands of the county, but no profit has been realized from the attempts to recover them. There are no minable gold-bearing gravels in the Santa Lucia serpentine areas.

Conflicting reports have been made on the occurrence of platinum at the La Plata claim, near the Liberty Hill mine's debris dam on Bear River in **Nevada County.**

Small amounts of platinum may be reasonably looked for anywhere in California where large areas of serpentine occur. This rock is usually found to be a poor one for mineral deposits. The irregularity and lack of persistence of any ore in serpentine is well known. It is emphasized by the behavior of all our Coast Range deposits of chromite, and of quicksilver where the wall rocks are serpentine. Gold deposits in serpentine are uniformly small and 'pockety,' and if platinum is ever found in place in such serpentine areas, we are justified in expecting only the smallest of stringer leads, elusive and discontinuous in character.

During the most productive period of Trinity, Siskiyou, Shasta and Plumas counties' hydraulic and placer mines, there was a yearly recovery of nearly 200 ounces of platinum metals at the San Francisco Mint from the refining of gold from those counties. Although the recovery is much less now, the amount is still considerable. Practically all of this was from placer gold, there being only one or two reports of traces of platinum in gold from quartz mines.

RECOVERY OF PLATINUM FROM CONCENTRATE.

Hydraulic Mining.

The hydraulic miners of most districts have as a rule thrown away platinum for years. Some of them did this because the price obtainable up to a few years ago was not considered worth the trouble necessary to get the metal. Others did not know platinum when they saw it, and threw it away with the black sand after amalgamating the gold. Today the high price and the urgent need in this country for every ounce that can be produced, are going to stimulate production as never before. Those who have saved platinum from the hydraulic mines have had only small quantities to deal with and have saved it simply by panning as much of it as they could out of the black sand concentrate left after the gold amalgam was saved. It is hard to get either clean platinum, or to remove all the platinum from the sand by ordinary panning. Better results are obtained if the concentrate is screened and each

screen size panned separately for its platinum content. The platinum product shipped by the hydraulic miner is classed as 'crude platinum.' In addition to the native platinum group metals, it contains 1% to 2% of gold and considerable black sand. Even with rather careful work, from 10% to 15% of the 'crude platinum' is composed of impurities without value.

Dredging.

The long tom is in universal use on dredgers to clean up. Sometimes a portion of the platinum is directly recovered in the long tom with the main part of the amalgam, but most of it is in the residual black sand concentrate, which also contains amalgam, rusty gold, scrap iron and lead. This concentrate is run down to small volume usually in the long tom. The base metals are separated and saved. They contain some amalgamated gold which is recovered by running the metal into a bar and shipping to buyers, or sending in the accumulated base metal periodically for smelting. The platinum is recovered by panning the final long tom concentrate several times. Its separation from the small amount of gold is easy because it will not amalgamate without special treatment, but the panning is slow and must be carefully done. In many cases the black sand receives no further treatment, but is stored so that it is available for the application of any improved methods of recovering the values remaining in it. This outlines roughly the practice of many dredging companies, but each of the larger companies has its special methods for the treatment of the black sand after the recovery of the main batch of hard amalgam, and these processes will be described.

Methods Used in Feather River District.

At Oroville, the Natomas Consolidated gold man collects the black sand concentrate and amalgam in a box on each dredger and runs it through a long tom till it is reduced to one-half a small water bucket full. The long tom used is one foot wide, twelve feet long and rests on the gold tables so that it has a grade of one inch to a foot. The upper four feet of the long tom are covered with small iron riffles in solid sections one foot long, the cross riffles being an inch apart and sloping back. Below these, the bottom of the box is lined with cocoa matting under expanded metal. From this long tom the concentrate is taken to the clean-up room. The bulk of the amalgam is separated easily and is retorted. The black sand containing platinum and a little amalgam and rusty gold is washed several times in a miniature long tom and the bulk is reduced to about one pint. This contains the gold and platinum group metals. The surplus quicksilver is drawn off, and the concentrate is subjected to a 'boiling' motion, which is imparted by

pouring it back and forth between two ordinary crockery bowls. This removes nearly all the black sand. Concentrated nitric acid is applied to remove any base metal and to brighten the rusty gold so that it will amalgamate. The platinum can be finally cleaned by magnet and blower to remove the remaining black sand. All the black sand is saved for future treatment.

Some of the clean-up men at Oroville have made use of the Kellogg black-sand machine to recover the platinum from the long-tom concentrate. In principle, this device is an inverted funnel with pockets around the circumference. The sand and water are poured down the sides and the concentration is brought about by the boiling action when the mixture flows into the pockets. This gives a very rich concentrate, about 50% metal. The machine appears to be a good saving device. A recent clean-up made with it gave $4\frac{3}{4}$ ounces platinum. The residual black sand from the clean-up was treated chemically and was found to contain only 90 grains of platinum. This would indicate a recovery of slightly over 95% with the appliance.

A. H. Sherwood of Oroville has for several years used a chemical method for recovering platinum on a small scale from black sand concentrate. His process consists of two stages: (1) putting the mercury and platinum in condition to amalgamate, and amalgamating them; (2) separating the amalgamated gold and platinum. A patent has been granted him for the second stage, but not as yet for the initial process. As his rights have not been clearly defined, it is not thought advisable to fully describe the process. It is a new application of a well-known law of chemical solutions, and appears to do all that is claimed for it, giving a beautifully clean platinum and a perfect recovery which would be impossible by purely mechanical means.

The process has not been perfected to the point where it can be used on a large scale, but this is because of the lack of apparatus, and not because of any defect in the method.

Platinum in this district, as well as in the other central California dredging fields, is uniformly fine, either as flakes or grains. It is probable that the best results are not obtained in the ordinary practice where panning and the long tom are used. The pan tubs used by Oroville Dredge, Ltd., gave up after careful final cleaning 12.2% of the annual platinum yield, which had escaped during the monthly clean-ups. How much more platinum remained after this last panning is problematical. The dredging superintendents generally are satisfied with any results which approximate the usual yield of platinum. They reason that the platinum is in such small quantity at best that more careful work is not justified.

Methods Used in the Yuba River District.

Yuba Consolidated Goldfields has devoted considerable attention to the treatment of the black sand concentrate obtained on their dredgers. Their investment in plant and labor for this work is justified when it is remembered that each of their large dredgers gives three tons of sand concentrate a week and a total of 60 to 70 tons of this product is treated monthly. The sand handled is the black sand from the long toms, one of which is used on each dredger to recover as much gold and platinum as can be gotten in a rich concentrate of small bulk. The handling of this residual black sand concentrate does not differ materially from the practice described elsewhere for other properties, but the work done in the sand plant is different from the methods followed elsewhere.

The sand is ground in batches for two hours in a steel ball mill, with a very weak cyanide solution to brighten the rusty gold. The slime is then discharged into a well from which it is pumped into a small settling tank and is subjected to cyanide treatment in a miniature plant which is housed in the same building. Leading from the ball mill is a string of sluices 40 feet long and one foot wide, with a grade of one inch to the foot. This offers the following impediments to the escape of precious metals. (1) Mercury trap; (2) two feet of silvered amalgamating plate; (3) three feet of iron cross-riffles such as are used in long toms; (4) five feet of cocoa matting; (5) eight feet of wooden riffles loaded with mercury; (6) balance of sluice covered by cocoa matting under expanded metal. After drawing off the slime the mill is run open and the sand discharges into this sluice. The process gives about $40 a ton in gold and platinum. The extraction of gold is said to be nearly perfect, but assays of the sand tailing from the sluices indicate 50¢ to 75¢ a ton in platinum still remaining. In spite of the good recovery, the tailing is left where it can be gotten and the employes are constantly on the watch for any possible improvements in treating it.

Clean-ups made by the Marysville Dredging Company give much finer-sized platinum than that at Hammonton. After the recovery of the hard amalgam in the long tom on the dredger, the black sand is sacked and brought to the clean-up room. It is first run through a long tom 12 feet long which is fitted with iron riffles. Most of the amalgam is saved here. The sand is then rocked in a common rocker. It is next ground in batches of about two buckets for one-half hour in a three-foot arrastre. A little sulphuric acid is used to brighten the rusty gold, most of which is caught in the arrastre. The sand is finally washed through a Colorado amalgamator, which is said to get the remaining values. The concentrate from the long tom, rocker and arrastre is panned three times to get out the platinum.

Methods Used in Natoma District.

There is a high percentage of black and rusty gold here in some of the old terrace gravels remote from the present stream. The operating company states that most of the platinum saved is caught in the base trap of the long tom which is used on the dredger to recover hard amalgam and base metals. It is stated that the Neill jigs do not save any platinum, although successful in gold saving. The final recovery of platinum from the sand is largely in the Senn Pan-Motion Batea. A small Hardinge mill is used to grind the sand. From this mill it passes onto an amalgamated plate two feet wide and ten feet long and thence to the Senn machine. This is operated at 160 r. p. m. The concentrate given is 10% to 30% black sand. The gold is practically all amalgamated on the Batea and the platinum is caught in the bowl at the center. This machine was modified according to the ideas of E. E. Strouse, the company's gold man, and the bowl is larger and deeper than on the stock machine. In finally separating the platinum, the Batea concentrate is screened. It is found to be much easier to get the platinum from sand of its own screen size, than from sand of all sizes. Some sand stops on a 40-mesh screen; some of the platinum and sand grains are fine enough to pass 100 mesh. The material entering the Hardinge mill carries about $75 a ton in values, and the tailing from the Senn Batea is said to assay $1 gold and $1 platinum. If these figures are correct, the process saves 97% of the precious metals.

La Grange Method.

The Huelsdonk Submerged Table Concentrator has been used (see Photo No. 10) successfully for four years in recovering platinum, gold, amalgam and mercury from black sand concentrates at the La Grange dredge. The concentrator works under still water in a box or trough which is 16 feet long, one foot wide inside, and about one foot deep, being made from two-inch planks. A small gas engine mounted on the sluice furnishes power for shaking the screen and the concentrator, and for pumping water. The shaking motion is given by an eccentric with $\frac{3}{4}$-inch travel. The screen moves on a single bolt support on each side, and the power is applied against springs. From the screen the sand and water pass on to an apron which extends one-half the length of the sluice and is perforated at regular intervals so as to distribute the sand along the table proper. This apron and the table are bolted together and are shaken at the rate of 180 r. p. m. They travel on rollers along the bottom of the sluice, and require little power. The table proper is essentially a long narrow galvanized-iron covered trough, extending the full length of box, and tapering at the lower end to a groove scarcely $\frac{1}{4}$-inch wide and deep. The sand enters the groove at the upper end and as the shaking motion forces it along the lighter

constituents are crowded to the top and forced over the side, falling into a bottom compartment which shakes with the table and which can be used to give a middling, or to discharge tailing. The concentrate travels the length of the groove and is tapped off through a spigot at the end. Middling and tailing are tapped from the side near the end.

Huelsdonk claims the unit can handle two cubic yards of gravel or one ton of mill tailings an hour. Twenty cubic yards of gravel give two gallons of concentrate. The concentration with mill tailings is said to be 100 to 1. At the La Grange dredge 8 tons of black sand

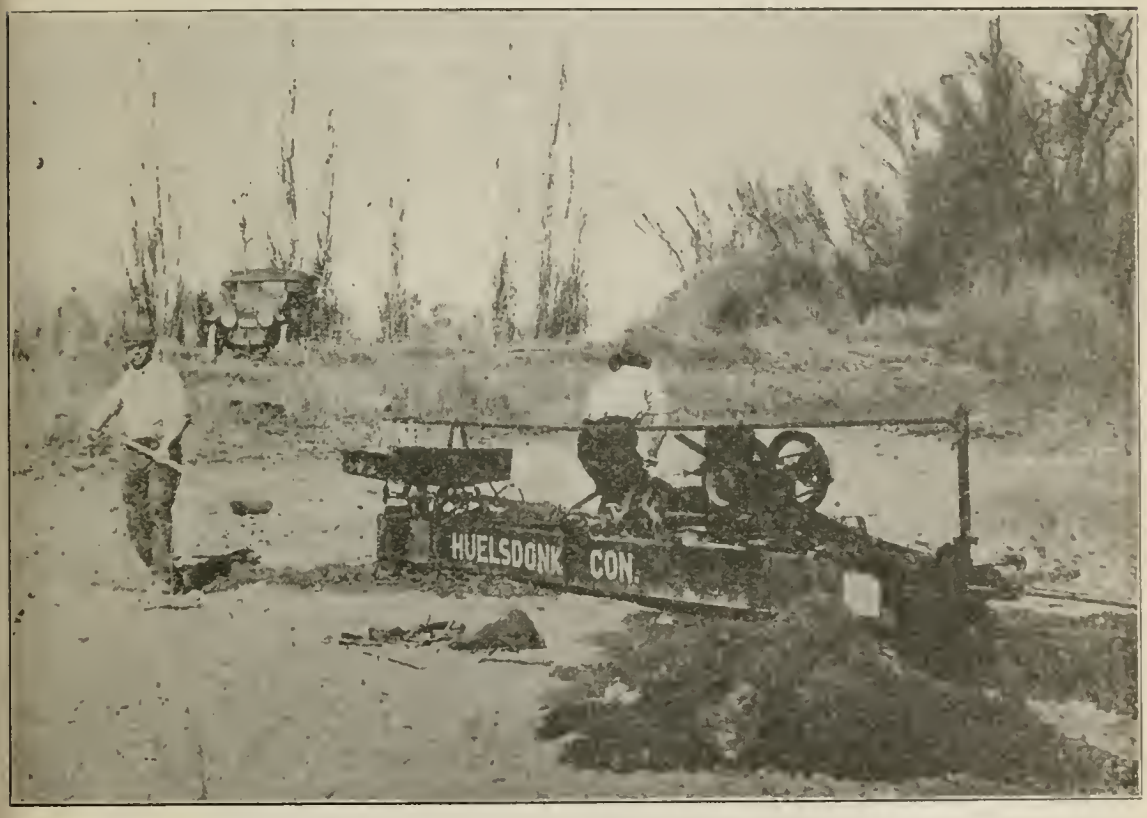


Photo No. 10. Huelsdonk Submerged Table Concentrator.

concentrate were reduced to about one-third of a gold pan full, which contained the year's output of platinum. Only ⅓–horsepower is said to be required for the concentrator. The demonstrating model has a 1½–horsepower engine, which is claimed to be more than ample for pumping water and operation. A one-inch centrifugal pump gives an ample supply of water.

The saving by this machine appears to be very satisfactory, and the concentrator seems to have a wide field of application, but ought to appeal especially to the small miner or the man who wants a portable outfit which is easy to operate and requires little water. The installation complete, including engine and pump, weighs 600 pounds, and the heaviest part is the engine. Two men are required to run the outfit where hand shoveling is done.

IDENTIFICATION AND METALLURGY OF PLATINUM METALS.

Detection.

Many of the tests which are available for the detection of platinum metals require the metallic grains to be tested free from other minerals which are often associated with the platinum and which would give interfering precipitates. Careful use of the gold pan will indicate the presence of platinum metals in placer deposits, even in cases where these metals are present in very small quantity. They are easier to save in a pan than gold and because of higher specific gravity will lag somewhat behind it. Metals or compounds capable of being confused with platinum metals are rare. In a very few northern streams, the chief one of which is Smith River in Del Norte County, fine grains of silver gray metal, highly magnetic and noticeably lower in specific gravity than ordinary placer platinum, have been confused with platinum. These grains are mostly iron, although awaruite,[1] Ni_3Fe has also been identified in the sands of this river. Similar grains from the Klamath River gravels give no reaction for nickel. Part of the metal saved as platinum at Klamath River properties is magnetic; other grains are not magnetic. Analyses of the mixed 'crude' platinum from these properties show it to be about 45% platinum metals and balance without value. Most California crude platinum shows no magnetic content except the accompanying black sand.

Simple tests for the identification of platinum metals by chemical means are summarized below:

The Glow Reaction.[2]

The substance to be tested is brought into solution by any of the common methods (in hot aqua regia, for example) and about 0.2 c.c. of this solution is absorbed in a piece of thin asbestos paper by alternately dipping the paper into the solution and heating until the required volume has been absorbed. The moist paper, held by one end in a pair of tongs, is heated to redness in a Bunsen flame, then removed; after redness has ceased, but while the paper is still hot, it is brought into a stream of mixed illuminating gas and air from a Bunsen burner. If platinum is present the asbestos paper will begin to glow. The glow must last for some time and can be brought back after it has once died out by again heating the paper and holding it in the stream of gas. The burner must be arranged to supply a fairly good mixture of gas and air, and the pressure must not be too great. For the greatest sensitiveness of the test the solution should not be too acid, the asbestos paper must be very thin, and the glow is intensified by having the gas warm.

---

[1]Cal. State Min. Bur., Minerals of California, Bulletin 67, p. 23.
[2]Curtman, L. J., and Rothberg, P.: Reprint in Trans. American Metallurgical Society from Journal Am. Chem. Society.

This test shows the presence of as little as 0.002 mg. of platinum, .005 mg. iridium, .0005 mg. palladium or .0009 mg. rhodium; but does not reveal osmium or ruthenium. The test may be applied successfully to black sand concentrates or to solutions without preliminary separation of other substances.

The glow reaction depends on the catalyzing action of the finely divided platinum compound, which hastens and intensifies the oxidation of the hydrogen particularly, in the illuminating gas.

Another simple method,[1] which can be followed in the field, calls for three chemicals, nitric and hydrochloric acids to form aqua regia and potassium iodide. A few grams of the material to be tested is dissolved in a casserole by means of aqua regia, then evaporated to dryness on the water bath (or by gentle and uniform heat). The residue is heated gently till every trace of nitric acid is expelled, as indicated by disappearance of the choking, acrid fumes. The residue, containing platinic chloride, is dissolved in water and filtered. A few drops of potassium iodide solution added to the clear liquid gives platinum iodide, which dissolves, producing a deep rose-colored liquid resembling cobalt nitrate.

Another method provides for dissolving the residue from the aqua regia solution in hydrochloric acid and evaporating by boiling till thick, but not dry. This thick mass is diluted with distilled water and a few drops of sulphuric acid and a little potassium iodide are added. The resulting solution is wine red if considerable platinum is present, or red-pink with less platinum.

Again, a solution of ammonium chloride added to the aqua regia solution gives yellow crystals of ammonium-platinic chloride if platinum is present.

It must be borne in mind that these last two tests are apt to be obscured by other elements, so the tests are best made on metallic grains.

Osmiridium, in which form California osmium occurs, is practically insoluble in a single acid or in aqua regia so is not susceptible to the tests used to detect the soluble members of the group. Osmiridium occurs in crystalline pieces with hardness of 6 to 7 and with sharp or ragged edges, brilliant tin-like luster and perfect basal cleavage faces; being thus easily distinguished from the soft, thinner, well-worn and duller colored platinum flakes. The nuggets of platinum metals found in California are composed principally of osmiridium. These are distinguished from platinum first by their extreme hardness, as they can not be scratched by a knife or an ordinary file. Osmium compounds when heated at high temperature form poisonous oxides with pungent odor like chlorine gas. Such compounds boiled in excess of nitric acid give off the tetroxide, OsO_4.

[1]Ohly, J.: Analysis, Detection and Commercial Value of the Rare Metals, p. 61.

Iridium occurs in soluble form alloyed with platinum and as an insoluble constituent of osmiridium. Soluble iridium separates as a fine black powder when the iridium sulphate solution containing alcohol is exposed to sunlight. This powder is distinguished from platinum black because it has a much more energetic action in oxidizing gases. Iridium black, placed on a paper saturated with alcohol, causes the paper to ignite.[1]

The identification of iridium in osmiridium by chemical means is too involved for the ordinary prospector or experimenter. The test consists essentially of putting the alloy in the form of soluble chlorides by fusing with zinc and ammonium chloride. The zinc is removed with sulphuric acid, leaving mixed double chlorides of osmium and iridium as a powder. This powder is dissolved in water, concentrated by evaporation, acidulated with nitric acid and distilled. The osmium passes over and the iridium salt remains in the residue. This salt can be concentrated and the iridium precipitated as double chloride by adding ammonium chloride solution. Spongy or powdery iridium is obtained by igniting the double chloride.

Metallurgy of Platinum.

Most of the Russian platinum has been marketed in years past as a rich concentrate. Mining has been carried on by a multitude of placer miners working alone or in small groups, using crude hand methods and operating on a very small scale. The platinum concentrate thus obtained is quite similar to our California 'black sand,' carrying many of the same heavy minerals such as zirconium, chromite and magnetic iron oxides. The Russian 'crude platinum' carries a higher percentage of platinum and correspondingly less osmiridium than the California product. It is also said to usually carry enough alloyed iron to be magnetic, which is the exception with the domestic material.

Only a small part of the Russian product was refined at home; two plants in St. Petersburg before the war handled a few hundred pounds of concentrate, and the balance was exported to England, France and Germany. The war led first to a curtailment of exports, and finally chaotic conditions in the interior did a great deal toward stopping production, and marketing through the normal peace time channels, which had centered in the capital city. Methods of refining have been kept secret by the refiners, but the principles of both the wet and dry methods used commercially are based on the well known chemical properties of different metals of the group.

The wet method is in commonest use, and its application depends on the different degrees of solubility of the metals. Gold is first dissolved out by aqua regia. Platinum and the small percentage of soluble

[1]Ohly, J.: Analysis, Detection, etc., of the Rare Metals, p. 79.

iridium alloyed with it can next be removed by solution in stronger aqua regia, sometimes used under pressure. Osmium and iridium, as the alloy osmiridium (sometimes called iridosmine) remain in the insoluble residue. The rarer metals of the group will at this stage be present in very small quantity, possibly only as traces, in both the platinum solution and the osmiridium residue. It is probable that the amount of them in most California crude platinum is not enough to have a noticeable effect on the platinum itself. Iridium alloyed with the platinum makes it harder, but the alloy is suitable for many uses, and hard platinum has been quoted lately several dollars higher per ounce than soft metal.

The separation of osmium and iridium is made by volatilizing the osmium as previously outlined. The entire process of separating platinum, osmium and iridium requires two to three weeks. When buyers offer payment in full for all values in 'crude platinum' on delivery, it may be safely inferred that they are simply estimating the percentages of the various precious metals, and are no doubt careful to avoid any overpayments. Another rather unsatisfactory practice of buyers is their tendency to pay for osmium and iridium as osmiridium, arbitrarily estimating the percentages of osmium and iridium without separating them. On account of the high price established by the government for iridium, $175 an ounce, it behooves sellers to see that the separation is made, except in cases where the amount of 'crude platinum' involved in too small to warrant payment of the charge for treatment.

The dry method does not give as clean a separation as does the wet, and is not used much. For dry treatment the ore is smelted in a reverberatory furnace with an equal weight of galena. Borax and silica are used as fluxes. The platinum forms an alloy with the lead from the galena; litharge is used to oxidize the sulphur, and osmiridium, which does not alloy with the lead, settles to the bottom of the charge. This process is much faster and cheaper than the wet method. It can be applied on a small scale by any competent assayer equipped with a good furnace, as the lead-platinum alloy forms at a temperature much below the melting point of platinum.

For those desiring to learn more of the working details of assays of platinum group metals, the following references are given:

Mining and Scientific Press, May 16, 1914, and June 20, 1914.
Mining and Engineering World, July 13, 1912.
Ohly, J.: Analysis, Detection, etc., of the Rare Metals.

Possibilities of Increasing Platinum Production.

A review of conditions with which placer miners in California now have to contend shows that we are not justified in expecting any notable

increase in platinum production from hydraulic mines. The efficiency of recovery methods and the scale of operations in our active hydraulic mining districts, are limited by lack of water and size of deposits. Many of the bench gravel bodies of the northwest which carry platinum are too small in area to justify any large outlay for adequate, perpetual water supply or installation of equipment to give maximum recovery. Working as they do, with such water as is obtainable nearby, their operating season is limited to five or six months at best. Saving devices such as blocks and pole riffles, with quicksilver sprinkled between, help to detain the coarser gold. Platinum metals are uniformly smaller in grain size than gold and there is no doubt that the amount of these metals saved in hydraulic mining is only a small fraction of that entering the sluices. While in the case of small properties more care in saving may not be practicable, there are some large and promising gravel deposits on Trinity River, notably near the mouth of its South Fork, where there appears to be ample acreage to justify an installation comparable to that of the La Grange mine.

Resumption of hydraulic mining to any general extent in the Sierra Nevada would call for a much greater outlay of capital than is apt to be available for some time. In addition to the outlay necessary to restrain tailing from entering the rivers, difficulties regarding water supply would arise. Many long and expensive ditches which were built to convey water to hydraulic mines have either fallen to decay or have been acquired by hydro-electric companies. Water entering such streams as the Feather, Bear and American rivers is being appropriated at such a rate for irrigation and electric power generation that the time is nearby when there will be no unappropriated water in any of these streams in summer.

Consideration of these points directs our attention to the possibility of increasing production from the main source of domestic platinum, the California dredgers. Dredging has often been described as a branch of mechanical engineering rather than of mining, because so many of the difficulties have been problems of mechanical design and construction. Gold-saving equipment has been standardized; steel covered wooden riffles are largely used and are set commonly at a grade of $1\frac{1}{2}''$ to the foot. A good head of water is required to keep the riffles from packing with sand; and to get the full advantage of the eddying action induced by the overhanging edge of the steel. Under these conditions dredger men are prone to claim recovery of 90% or better and in general are satisfied to keep digging without bothering to experiment with improved methods of recovery.

With ample gold-saving table space, it is likely that a satisfactory recovery is made of gold which will amalgamate. The same can not

be said of 'rusty' gold or of platinum metals, on which plain quicksilver has no effect. The installation of Neill jigs in the Natoma district, where 'rusty' gold is plentiful, has been the result of failure of standard gold tables to save such gold from a gravel which costs more than usual to dig, and where the margin of profit had to be increased. If the more fortunate operators of the Yuba and Feather River districts had been confronted with similar difficulty, our exact knowledge of precious metals lost would be sufficient to base a definite opinion on. To date, however, profits have been so satisfactory that improvements have not been required. As regards platinum especially, the total amount present in the gravels has been considered too trifling to merit serious attention. Tests were made by various companies in the Oroville district to determine the platinum content of the ground and the loss of platinum in dredging operations.[1] The loss of platinum, while admitted to be appreciable, was held to be insufficient to warrant the installation of concentrating machinery to recover it. Such tests were made at a time when platinum was worth only one-fifth or one-sixth its present value. All the platinum of the central dredging fields in California is fine in size and most of it is in such thin flakes as to be easily floated on water. It is only reasonable to assume that more platinum goes back into the pond than remains on the tables.

The only recently reported investigation of such losses was made by James Neill on the Yosemite dredge, near Snelling. This dredger is a small one, containing machinery from the old Indiana No. 1, which was wrecked in March, 1907, after six years service in the Feather River district.[2] Neill states that in 22½ months,[3] platinum to the value of $3438 was recovered on that dredger, indicating a monthly average of $150. Samples taken by Neill from the tailing after passing the Neill jig, represented an entire cut across the pond. He found the tailing carried 35,037 lb. dry weight of sand in a 22-hour day. A test of the tailing by the General Engineering Company of Salt Lake City on a Wilfley table, gave 1.81% concentrate and 7.25% middling. The concentrate was refined by Shreve & Company of San Francisco, who reported half an ounce of platinum metals a ton. An analysis of a recent shipment of the platinum metals from this ground showed 97.7% platinum and 2.3% osmiridium, a remarkable degree of purity for placer platinum, and the highest grade ever reported from a California producer.

Basing his calculations on these tests, Neill went further, and figured that during an average month the dredge was losing 9.5 tons of concentrate carrying 4.75 ounces of platinum metals, or about three-fourths of

[1]Cal. State Min. Bur., Bulletin 57, p. 81.
[2]Cal. State Min. Bur., Bulletin 57, p. 117.
[3]Recovery of platinum in gold dredging. Mining and Scientific Press, Dec. 8, 1917.

all the platinum in the gravel handled. In spite of the predictions of experts who forecasted failure, he installed a one-half size Wilfley table on the upper deck of the dredge. The tailing from the jigs is elevated by a Krogh sand pump to a tank on the upper deck, going thence to the Wilfley table. The table is said to work well under normal digging conditions.

The application of such tests to the tailing from dredgers in the three larger districts on the Feather, Yuba and American rivers would be timely now, and there appears to be no logical objection to the tests from the standpoint of cost. If the same encouraging results were obtained, the added saving of platinum would be no small item to the producers and to the country at large. While of course unsafe to generalize too freely, it may be said that the rate of yield of platinum from our various dredging fields in central California does not vary widely, and percentage of recovery is probably also comparable where saving equipment is ample and where working conditions are alike, as regards bedrock and quality of gravel. Such considerations justify the assumption that results of the tests at the Yosemite dredger might be duplicated elsewhere.

The relative merits of the different types of concentrators which might be used for this work can only be established by working tests. The capacity of a large modern dredge is such that it would require an immense amount of equipment to take care of the tailings with tables unless the volume could be first cut down by a rough preliminary concentration.

Analyses of Platinum Group Metals from California.

Location	Authority and date	Percentage platinum*	Percentage osmiridium	Percentage iridium	Percentage gold[1]	Percentage other metals[2]
Klamath River Mine, Klamath River	Baker & Co., 1916	25.5	72.1		1.20	
Klamath River Mine, Klamath River	Baker & Co., 1917	26.59	72.2		1.13	
Valdor Dredge, Trinity River	C. R. Luckhardt, 1917	43.2	47.5		1.30	
Valdor Dredge, Trinity River	Returns from sale	40.74	57.96		1.36	
Crescent City	Bull. 193, U. S. G. S., after Shapleigh	8.0–11.0	46.0–83.0			
Michigan-Salmon Mine, Salmon River	1917 sales, Wildberg Bros.	2.95	97.05			
Beegum Creek	Bull. 193, U. S. G. S., after Shapleigh	13.5–20.0	79.0–84.0			
Hayfork of Trinity	Bull. 193, U. S. G. S., after Shapleigh	30.0–73.0	18.0–58.0			
Oroville, Feather River	Natomas Cons., 1916	68.3	20.5		1.04	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	67.5	16.0		3.00	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	69.15	18.5		2.50	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	65.81	14.67		9.10	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	66.90	14.90		6.20	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	69.04		16.37	4.67	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	61.53		15.27	10.21	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	62.79	15.29		8.41	
Hammonton, Yuba River	Vogelstein & Co.—Various dates	60.48	15.35		10.98	
Marigold, Yuba River	Ledoux & Co., 1915	67.52	16.55		3.43	
Marigold, Yuba River	Ledoux & Co., 1915	66.20	18.96 (Osmium)		2.67	Pa and Rh traces
Mendocino County	A. A. Hanks, 1918	9.87	35.60	49.20		
Natoma (Lower American River)	Ledoux & Co., 1916	40.88		23.13	0.09	
Natoma (Lower American River)	Ledoux & Co., 1916	45.54		15.88	0.49	
Natoma (Lower American River)	Ledoux & Co., 1916	42.55		17.30	0.14	
Natoma (Lower American River)	Ledoux & Co., 1916	46.51		22.57	0.35	
Natoma (Lower American River)	Ledoux & Co., 1916	41.50		25.17	0.15	
Mammoth Bar (Upper American River)	Pacific Gold Dredging Co., 1917	37.22		31.72	28.02	Pa and Rh traces
Michigan Bar, Cosumnes River	White Dental Co., 1917	33.3	41.97	18.88	13.58	Ag 1.56
Jenny Lind, Calaveras River	Shreve & Co., 1916	56.5	30.0		4.0	
Yosemite Dredger, Yosemite River[3]	Shreve & Co., 1917	97.7	2.3			

*Figures are parts in 100.

[1]In most cases this is probably black or rusty gold which will not amalgamate.

[2]Commercially, tests are seldom made for the other platinum group metals which are usually present only as traces.

[3]Mining & Scientific Press—12-8-1917.

Producers of Platinum Metals in California, 1917. (Alphabetically arranged by counties.)

Name of property	Operator	Class*	Address of operator	County	Remarks
Boston Nos. 3 and 4	Oroville Dredge, Ltd.	Drg.	Mills Bldg., San Francisco	Butte	2 dredgers near Thermalito.
Feather Nos. 1, 2, 3	Natomas Cons. of Calif.	Drg.	Forum Bldg., Sacramento	Butte	3 dredgers on Feather River.
Fliedner Claims	Wm. Fliedner	Sluice	Oroville	Butte	
A. J. Holton No. 4	American Gold Dredging Co.	Drg.	Sharon Bldg., San Francisco	Butte	1 dredger on Feather River.
Kentucky Ranch	Lawrence Gardella	Drg.	Oroville	Butte	1 dredger on Honcut Creek.
Pacific No. 4	Pacific Gold Dredging Co.	Drg.	582 Market St., San Francisco	Butte	1 dredger on Feather River.
Isabell Dredge	Ivy L. Borden	Drg.	417 Montgomery St., S. F.	Calaveras	1 dredger on Calaveras River.
Camanche Nos. 1, 2, 3	American Gold Dredging Co.	Drg.	Sharon Bldg., San Francisco	Calaveras-Amador	3 dredges on Mokelumne River.
Christensen Mine	Nels Christensen	Hyd.	South Fork via Crescent City	Del Norte	Small mine on Smith River.
Darnell Mine	Jack Darnell	Hyd.	South Fork via Crescent City	Del Norte	Small mine on French Hill.
Kaus Mine	Antone Kaus	Sluice	South Fork via Crescent City	Del Norte	Small mine on Craigs Creek.
Land Mine	Gordon Land, Supt.	Hyd.	South Fork via Crescent City	Del Norte	Small mine on Smith River.
Gist Mine	J. C. Gist	Hyd.	Weitchpec	Humboldt	On Klamath River.
Klamath River Mine	Jno. Profitt, Jr., Supt.	Hyd.	Weitchpec	Humboldt	On Klamath River.
Salstrom Mine	Jonas Salstrom	Hyd.	Orleans	Humboldt	High bench near Klamath River.
Wilder	Geo. Wilder	Drift	Orleans	Humboldt	Low bench near Klamath River.
Howell and Glatt	Howell Bros. and T. Glatt	Sluice	Hopland	Mendocino	High tertiary gravel.
Yosemite Dredge	Yosemite Gold Dredging and M. Co.	Drg.	Snelling	Merced	Dredger on Merced River.
Blue Tent Tunnel	Miss Eleanor Hoeft	Drift	Nevada City	Nevada	Deep tertiary gravel.
American Dredge	Pacific Gold Dredging Co.	Drg.	582 Market St., San Francisco	Placer	Dredger on American River.
Cosumnes Dredge	Pacific Gold Dredging Co.	Drg.	582 Market St., San Francisco	Sacramento	Dredger on Cosumnes River.
Natomas District	Natomas Cons. of Calif.	Drg.	Forum Bldg., Sacramento	Sacramento	11 dredgers near Natoma.
Iron Mountain	Mountain Copper Co.	Smlt.	332 Pine St., San Francisco	Shasta	Platinum from electrolytic ref.
Blue Nose Mine	Donald McPherson	Hyd.	Blue Nose	Siskiyou	Old bench, Klamath River.
Davis Mine	R. A. Davis	Hyd.	Happy Camp	Siskiyou	Old bench, Klamath River.
Mann and Ross Mine	E. Mann and N. Ross	Drift	Orleans	Siskiyou	On Klamath River.
Michigan-Salmon Mine	L. E. Taggart, Supt.	Hyd.	Forks of Salmon	Siskiyou	On South Salmon River.
Nigger Hill Mine	Bennett Co., Geo. Smith, Mgr.	Hyd.	Forks of Salmon	Siskiyou	Bench of South Salmon River.
Orcutt Mine	Alvin Orcutt	Hyd.	Forks of Salmon	Siskiyou	Bench of South Salmon River.
Petersen Mine	J. R. Petersen	Hyd.	Sawyers Bar	Siskiyou	In Eddys Gulch.
Ten Eyck Mine	Luther Hickox	Hyd.	Orleans	Siskiyou	Bench of Klamath River.
La Grange Dredge	La Grange Gold Dredging Co.	Drg.	La Grange	Stanislaus	Dredger on Tuolumne River.
Beegum Creek	Jos. Moore et al.	Sluice	Knob, Shasta County	Tehama-Shasta	Beegum Creek near Beegum.
Beegum Creek	Ike Selvester	Sluice	Beegum, Tehama County	Tehama-Shasta	Beegum Creek near Beegum.
Beebe Claims	J. L. Beebe	Sluice	Hayfork	Trinity	Hayfork Creek.
Chapman Mine	Geo. Chapman	Hyd.	Junction City	Trinity	High bench, Trinity River.

Corona de Oro Mine Company	H. S. Dinsmore, Supt.	Hyd.	Willow Creek, Humboldt Co.	Trinity	High bench, Trinity River.
Ferris Claims	W. W. Ferris	Sluice	Care Geo. Lewman, Junction City	Trinity	On Dutch Creek.
Gem Placer	Teal and Perigot	Hyd.	Gus Perigot, Blue Lake	Trinity	Bench of Trinity River.
Gilzean Mine	J. A. Gilzean	Hyd.	Junction City	Trinity	Bench of Trinity River.
Hawkins Bar	Jerry Smith	Hyd.	Burnt Ranch	Trinity	South Fork Trinity River.
Henderson Mine	Ferguson and Henderson	Hyd.	Burnt Ranch	Trinity	South Fork Trinity River.
Kingsbury Gulch	Chas. Farmer	Hyd.	Hayfork	Trinity	Near Hayfork.
Lewman Mine	Geo. Lewman	Hyd.	Junction City	Trinity	Bench of Trinity River.
Montezuma Mine	W. W. Wilson	Hyd.	Junction City	Trinity	Bench of Trinity River.
Red Hill Mine	H. Jacobs	Hyd.	Junction City	Trinity	Bench of Trinity River.
S. Fork Gold and Plat. M. Co.	Hammer & Kahlke	Hyd.	Willow Creek, Humboldt Co.	Trinity	South Fork of Trinity River.
Valdor Dredge	Valdor Dredging Co.	Drg.	Junction City	Trinity	On Trinity River.
Marigold Placers	Marysville Dredging Co.	Drg.	Marigold	Yuba	Yuba River.
Parks Bar	Pacific Gold Dredging Co.	Drg.	582 Market St., San Francisco	Yuba	Yuba River.
Yuba Goldfields	Yuba Consolidated Goldfields	Drg.	Hammonton	Yuba	Yuba River.

*Drg. denotes dredger; Hyd. denotes hydraulic mine; Drift denotes drift mine.

INDEX.

46903 2-20 1M