

TERTIARY CHANNELS

by William B. Clark

FOSSIL RIVER BEDS, ONCE RIPPED
APART FOR GOLD, NOW
WORKED FOR SAND AND GRAVEL

The Tertiary channel deposits of the Sierra Nevada that have yielded vast amounts of gold in the past now yield sand and gravel which are sources of high-quality aggregate. Although mining for construction materials is underway, the aggregate potential of the channel deposits, is far from realized. The channel deposits are also useful as a source of silica which is contained in quartzitic sands and gravels.

Other mineral commodities that have been recovered are silver, platinum, clay, grinding pebbles, black sand, and petrified wood. In addition, a number of small diamonds have been found in several of the deposits.

As California's population continues to increase, the value of the Tertiary channel deposits as significant sources of raw material will likewise increase. If economic conditions become favorable for gold mining again, the deeply buried but undeveloped portions of these deposits may be the sources of large amounts of gold. A few have been worked for gold by hydraulicking on a small scale in recent years, and attempts are being made to work others with draglines or power shovels and stationary washing plants.

HISTORY

The chief period of gold production from the Tertiary channel deposits was from about 1855 until 1884. Much of the output was obtained by hydraulic mining, which was first done in the state in 1852 near Nevada City and at Yankee Jims in Placer County.

Hydraulicking consists of directing a jet of water under high pressure through a nozzle known as a "monitor" or "giant" against a bank to disintegrate it so as to wash the gravel through sluices. Hydraulic mining was a major industry in California in those years, and towns such as Cherokee Flat, La Porte, Howland Flat, North Bloomfield, Washington, Iowa Hill, Dutch Flat, Foresthill, and Michigan Bluff were major centers of population. Extensive systems of

reservoirs, ditches, flumes, pipelines, and tunnels were constructed to supply the vast amounts of water required for these operations.

As more and more material was excavated, the hydraulic pits became enormous. The tailings from these operations were allowed to flow into the rivers, which was alleged to cause flooding and silting of farmlands, eventually leading to litigation between the farmers who lived downstream and the miners. In a famous court case in 1884 (*Woodruff vs. North Bloomfield Gravel Mining Company* (16 Fed. Rep. 25)), Judge Lorenzo Sawyer issued an injunction prohibiting the company from dumping debris into the Sacramento and San Joaquin Rivers and their tributaries. Injunctions against other mines soon followed. Some mines constructed tailings dams or reservoirs and continued to operate, but on a smaller scale.

For a few years drift mining partly made up for the loss of production of placer gold from the hydraulic mines. After 1900 floating bucket-line dredges accounted for most of the placer gold produced in the state. Meanwhile many of the old hydraulic mines were abandoned. Large trees have since grown in the old pits. A few rusty pipes, an occasional monitor, and the remains of old sluice boxes are all the equipment that remains. The few hydraulic mines that have operated recently are licensed by the California Debris Commission of the U.S. Corps of Engineers in Sacramento. Most of the old drift mines also are shut down, and many have caved, although a few buildings and other structures remain at some of them.

With the explosive growth of California's population in recent years and the resulting increase in all types of construction, some of the more accessible Tertiary channel deposits have become valuable sources of aggregate material. For example, large amounts of hydraulic mine tailings derived from the You Bet and Dutch Flat deposits were used in the construction of the U.S. Highway 40 freeway in Placer County, tailings from the Cherokee mine were

MAP OF THE SIERRA NEVADA SHOWING TERTIARY CHANNELS AND PRINCIPAL GOLD-BEARING DEPOSITS

No.	Name	County	No.	Name	County
1	Altaville	Calaveras	39	Magalia	Butte
2	American Hill	Sierra	40	Meadow Valley	Plumas
3	Bangor	Butte	41	Michigan Bar	Sacramento
4	Blue Tent	Nevada	42	Michigan Bluff	Placer
5	Brandy City	Sierra	43	Minnesota	Sierra
6	Campo Seco	Calaveras	44	Mokelumne Hill	Calaveras
7	Camptonville	Yuba	45	Moore's Flat	Nevada
8	Canada Hill	Placer	46	Mooreville Ridge	Plumas
9	Cherokee	Butte	47	Morristown	Sierra
10	Chinese Camp	Tuolumne	48	Mountain Ranch	Calaveras
11	Columbia	Tuolumne	49	Newtown	El Dorado
12	Cottage Springs	Calaveras	50	North Bloomfield	Nevada
13	Damascus	Placer	51	North Columbia	Nevada
14	Deadwood	Placer	52	North San Juan	Nevada
15	Duncan Peak	Placer	53	Omega	Nevada
16	Dutch Flat	Placer	54	Pacific	El Dorado
17	Eureka	Sierra	55	Pilot Hill	El Dorado
18	Fairplay	El Dorado	56	Placerville	El Dorado
19	Fiddletown	Amador	57	Poker Flat	Sierra
20	Forest	Sierra	58	Port Wine	Sierra
21	Foresthill	Placer	59	Poverty Hill	Sierra
22	French Corral	Nevada	60	Pride	Sierra
23	Gibsonville	Sierra	61	Quaker Hill	Nevada
24	Gold Run	Placer	62	Railroad Flat	Calaveras
25	Gravel Range	Tuolumne	63	Ralston Divide	Placer
26	Howland Flat	Sierra	64	Rough-and-Ready	Nevada
27	Hunt's Hill	Nevada	65	San Andreas	Calaveras
28	Indian Diggings	El Dorado	66	Sawpit Flat	Plumas
29	Indian Hill	Sierra	67	Scott's Flat	Nevada
30	Iowa Hill	Placer	68	Smartsville	Yuba
31	Irish Hill	Amador	69	Smith Station	Tuolumne
32	Jackson	Amador	70	Table Mountain	Tuolumne
33	Jenny Lind	Calaveras	71	Todd Valley	Placer
34	Kentucky Flat	El Dorado	72	Vallecito	Calaveras
35	La Porte	Plumas	73	Volcano	Amador
36	Last Chance	Placer	74	Volcanoville	El Dorado
37	Lost Camp	Placer	75	Yankee Jims	Placer
38	Lowell Hill	Nevada	76	You Bet	Nevada



used in the rerouting of the Feather River Highway in Butte County, and gravels from Placerville and Diamond Springs have been used both in local construction and in the U.S. Highway 50 freeway. Some of the old reservoir and ditch systems are now parts of hydro-electric and irrigation systems.

CHANNEL DEPOSITS

Tertiary channel deposits are alluvial placers that were deposited by ancient stream channels during the Eocene, Oligocene, Miocene, and Pliocene epochs. Those of Eocene age are the most extensive and have yielded by far the largest amounts of gold, as well as the highest proportion of quartzitic gravels and sands. The channels had their origin during Cretaceous time when the streams flowed across subdued topography into a shallow sea that lay to the west. During Eocene time the climate was subtropical which permitted deep weathering of the bedrock. When the Tertiary Sierra Nevada uplift began the streams became loaded with quartz pebbles and quartzitic sand along with the gold that had been released by erosion of the gold-quartz veins. The finer clay particles were deposited farther west, the remnants of which are at such places as Lincoln and Ione.

Explosive volcanic activity which began at least as early as Oligocene time and continued through the Miocene epoch resulted in rhyolite ash falls that dammed up the rivers and formed numerous small lakes. The rhyolite ash deposited in these lakes was altered to what is commonly known in the mining districts as "pipe" clay or "chalk". Later, in Pliocene time, much more violent volcanic activity resulted in the deposition of vast amounts of andesitic detritus and mud flows. This forced the streams into new channels—essentially those that they occupy today. These later Tertiary channels are known as intervolcanic channels, those of the rhyolitic epoch commonly being referred to as "interrhyolitic gravels" and those of the andesitic epoch as "interandesitic gravels". The intervolcanic gravels contain less quartz than the Eocene gravels and nearly always are leaner in gold.

The oldest channel gravels consist of pebbles, cobbles, and boulders of white milky quartz and intrusive and metamorphic rocks. Most of the quartz fragments are well rounded and unless decomposed have a smooth and polished surface. These gravels often are referred to as "deep" or "blue" gravels and occur in the deepest part of the trough-like depressions in the deposits. The highest proportion of gold

occurs at or near bedrock in the oldest deposits. Natural riffles in the bedrock such as crevices, joints, and potholes hold much of the gold. Deposits that overlie limestone have been especially rich because the deep potholes in the limestone have been excellent gold traps. Such deposits are at Columbia, Volcano, Fairplay, and Indian Diggings. Some of these early gravels are well cemented with a sandy matrix.

When the cemented gravels were being concentrated in mining operations, it was sometimes necessary to send them through crushers and stamp mills. In a few cases such as at Cherokee or at a few of the mines at Iowa Hill, there are greenstone gravels near bedrock which have yielded significant quantities of gold.

Covering the deep gravels and in places attaining thickness of as much as 300 feet are the bench gravels. In places the bench gravels have spread out to widths of one or two miles. These gravels also contain much quartz, but the fragments are finer and there is more interstratified fine sediment including sand and "pipe" clay. Most of the bench gravels do contain gold, but it is not as abundant as in the deep gravels. In places the early gravels are overlain by intervolcanic gravels. Some of these older gravels are cut by younger gravel channels.

At Mokelumne Hill there is a complex series of eight distinct channels that range from early Eocene to late Pliocene in age, while at Last Chance there are three channels, the deepest of which is the youngest. The percentage of quartz present in the Tertiary channels varies from one deposit to another. The highest proportion of quartz appears to be in the You Bet and Mokelumne Hill districts, but quartz is also very abundant in the La Porte, Port Wine, Eureka, Indian Hill, North Bloomfield, Dutch Flat, and Iowa Hill districts. The gravels in places are overlain by thick beds of volcanic rocks, especially in the center of the long west-southwest trending ridges or "divides". Andesite of Pliocene age is the principal volcanic rock with smaller amounts of Miocene rhyolite. At Oroville Table Mountain the gravels are overlain by Pliocene basalt, while those underlying Tuolumne Table Mountain are capped by Pliocene latite. Where the volcanic capping was too thick for hydraulicking, the gravels were mined by underground drift mines.

At some districts such as Magalia, Damascus, or Altaville, most of the output was from drift mines. At others such as Michigan Bluff, Foresthill, or Iowa Hill the output was from both hydraulic and drift mines, and some individual mines were worked both

GENERAL VIEW OF MALAKOFF DIGGINGS



photo by C.E. WATKINS

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by drifting and hydraulicking.

The gold particles range from flour size to coarse nuggets weighing more than 100 ounces, but the most common size is fine to medium fine. The average grain size is about that of a mustard seed; flour gold is not abundant in the Sierra Nevada Tertiary channels. Most of the grains are flat, a result of the pounding of the cobbles in the gravel. Extremely coarse gold with individual nuggets weighing up to several hundred ounces have been recovered from some deposits, the most notable being at Forest and Minnesota in Sierra County; Magalia, Butte County; Remington Hill and Lowell Hill in Nevada County; Damascus, Iowa Hill, Michigan Bluff, and Foresthill in Placer County; and Columbia in Tuolumne County. The fineness of the gold ranges from 840 to more than 950. Placer gold from Vallecito has been re-

ported to have been as high as 987 in fineness. The gold is always associated with black sands that are composed chiefly of magnetite with smaller amounts of ilmenite, zircon, garnet, and occasionally pyrite. Also present are small grayish-white grains and nuggets of platinum, usually in very small amounts.

Small diamonds have been recovered from a few of the Tertiary channel deposits, the principal source having been the Cherokee hydraulic mine in Butte County. More than 300 diamonds have been taken from this mine, principally during the 1850s, 1860s, and 1870s. A few of the stones were up to two carats in weight and of good quality, but most were small with a pale yellow tinge. The largest diamond recorded from the state weighed $7\frac{1}{4}$ carats and was taken from the French Corral mine in Nevada County prior to 1867. Small diamonds also were found at Volcano and

Fiddletown, Amador County; Foresthill, Placer County; Smith's Flat near Placerville, El Dorado County; and Sawpit Flat, Plumas County.

DISTRIBUTION OF CHANNELS

The Tertiary channel deposits extend from the northern end of the Sierra Nevada in Butte and Plumas Counties to Tuolumne County on the south and from the lower western foothills nearly to the crest of the range. The most numerous and extensive deposits are located along the courses of the Tertiary Yuba and American Rivers, but major ones also occur along the Tertiary Mokelumne, Calaveras, and Tuolumne Rivers, and in a number of isolated channels such as Magalia, Cherokee, Mooreville Ridge, and Meadow Valley. The most productive deposits have been as follows: (1) The Magalia channel in Butte County which is of limited extent, but which contains a number of highly productive drift mines; (2) Cherokee, Butte County which has an estimated output of nearly \$13,000,000; (3) The extensive delta gravels at Bangor, Butte County; (4) The various branches of the Tertiary Yuba River in Plumas, Sierra, Nevada, and Butte Counties. These include the "diggings" at Sawpit Flat and La Porte in Plumas County the latter of which has yielded more than \$60,000,000; Gibsonville, Poverty Hill, Eureka, Howland Flat, which has yielded more than \$14,000,000, Poker Flat, Port Wine, Brandy City, Forest, and Minnesota, Sierra County; Smartsville, which has an output of more than \$13,000,000 in gold, and Camptonville, Yuba County; and Washington, Moore's Flat, North Bloomfield, North Columbia, North San Juan, French Corral, You Bet, Quaker Hill, Lowell Hill, and Scott's Flat, all in Nevada County; (5) The Tertiary American river in Placer and El Dorado Counties, of which the Dutch Flat, Gold Run, Iowa Hill, Foresthill, Last Chance, Damascus, Michigan Bluff, Volcanoville, and Placerville districts have been the richest. Placerville and Foresthill each have yielded more than \$25,000,000 in placer gold and Iowa Hill more than \$20,000,000 mostly from Tertiary channel deposits; (6) Branches of the Tertiary Mokelumne River of which the richest portions were Fairplay and Indian Diggings in El Dorado County and Fiddletown and Volcano in Amador County; (7) The Tertiary Calaveras River in Calaveras County where the most productive deposits were at Mokelumne Hill, Altaville, and Vallecito; and (8) The Tertiary Tuolumne River in Tuolumne County where productive deposits were at Chinese Camp and in the Gravel Range. In addition the famous Columbia "diggings" in this county are located near the intervolcanic

Cataract channel. Columbia, "gem of the southern mines", yielded more than \$87,000,000 between 1850 and 1875. It lies in a preserved Tertiary valley that is underlain chiefly by crystalline limestone. The limestone has numerous deep potholes and cavities which contained enormously rich gravels. The gravels were hoisted from the potholes and washed through long toms and sluices.

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