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# Recovery of three types of gold in unconsolidated Pleistocene and Holocene alluvium of the Snake River drainage, southeastern Idaho

By

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## ABSTRACT

Prior and present studies show that flotation methods recover the greatest amounts of gold from unconsolidated Pleistocene and Holocene alluvial deposits in the Snake River drainage of Idaho. The amounts of gold recovered by flotation substantially exceed those amounts recovered by gravity-hydraulic methods by a factor of two to more than five, based on fire-assay analysis of concentrates obtained by flotation recovery and by gravity-hydraulic recovery methods, respectively.

We recognize three types of gold in these deposits: (1) "can-lid"-shaped grains of high fineness that have been reworked from paleoplacer conglomerate deposits in western Wyoming, (2) gold and silver minerals that are Au-Ag alloys and silver (major amount) and gold (minor amount) tellurides that include hessite, stuetzite and petzite of local origin, and (3) small grains of mercurian gold, so small that they are not recovered by gravity-hydraulic methods. This recently recognized mercurian gold is not recovered in barrel-amalgamation tests.

Data presented here indicate that the "can-lid"-shaped gold grains in these deposits represents only a minor part of the total amount of gold present, whereas the second and third types may be more important quantitatively, based on flotation-recovery studies. The presence of the "can-lid"-shaped gold grains has been known for about 100 years, and this type of gold was mined around the turn of the century; the other two types of gold have been identified only during the last three years, because they were not recovered by the gravity-hydraulic mining methods used prior to about the 1930's.


## INTRODUCTION

Three types of gold-bearing minerals occur in Pleistocene alluvial deposits of the Snake River between Blackfoot and American Falls Reservoir, in southeastern Idaho. Gold is most conspicuous as very small flakes that are readily pannable; their size is mostly less than 0.25 mm in diameter, their thickness is about one-tenth their diameter, and they have surface features indicating substantial distance of transport in a fluviatile environment. These "can-lid"-shaped grains were probably derived from Mesozoic and Cenozoic conglomerates in the upper reaches of the Snake River in western Wyoming (Antweiler and Lindsey, 1969). Most of these grains have a fineness of 900 or more.

A second population of gold and gold-silver minerals is from an upstream source that contributed silver tellurides (hessite and stuetzite), petzite and crystalline gold with grain surface ornamentation indicating a relatively short distance of transport in the fluviatile environment (Desborough and others, 1986). This gold and silver source is thought to be mercurian because mercurian gold-silver alloy mantles native gold. In addition, some hessite and stuetzite contain detectable mercury. Coloradoite and native tellurium have also been identified. Aggregates of intergrown native gold, hessite and stuetzite are present. Most of the native gold of this population has a fineness between about 600 and 850 (Desborough and others, 1988).

A third type of gold has been recognized only recently in these deposits; it consists of grains or grain aggregates (that have been recovered in flotation concentrates) of a mineral that contains only mercury and gold. Electron microprobe analyses show that amounts of gold are greater than 75 weight percent; the balance is mercury. The individual grains are mostly less than 5 μm in maximum dimension, but aggregates of these subhedral to euhedral grains are between 20 and 100 μm in length. These grains have a very high ratio of surface area to mass, and therefore they are not recovered by gravity-hydraulic methods; however this high ratio of surface area to mass makes them amenable to flotation recovery. The average mass of individual grains and grain aggregates is estimated to be in the range of 0.01 to 10 μg (micrograms). Because of the highly delicate ornamentation and high purity of these grains, and the fact that grains of this composition were not found intergrown with or attached to any of the other gold or silver minerals, we believe that they have grown in open space in an aqueous low-temperature system, that is, they are authigenic. None of these grains of Au-Hg have been recovered by either our field or laboratory gravity-hydraulic methods, except for a single aggregate of grains in a minus-35-mesh (<0.42 mm) table concentrate.

Recognition of these Au-Hg grains and grain aggregates may explain the higher recoveries of gold using flotation methods, in comparison with the lower values obtained for gold recovered by gravity-hydraulic methods in prior and present studies of these unconsolidated Snake River alluvial deposits.

In the late 1930's Fahrenwald and others (1939) reported relatively high values of gold in flotation concentrates obtained from Snake River gravels at five widely spaced localities along the Snake River (fig. 1) between Blackfoot and Grandview--a distance of more than 150 miles (250 km). Gold values for their flotation concentrates were two to eight times greater than any gold values reported for quantitative studies of placer gold using gravity-hydraulic recovery methods (Schultz, 1907) for these placer deposits.

This report compares results of laboratory studies of several samples using flotation + gravity, gravity-hydraulic, and amalgamation recovery methods.

## METHODS

Twelve samples from Beker drilling (reverse circulation) and six samples from backhoe sampling were used; their bulk weights ranged from 60 to 259 lb (27-117 kg). The material larger than 1 mm was removed by wet screening. The material smaller than 1 mm was split into four fractions using a Gemeni table; weights of each split were within 5 to 10 percent of each other. One split was submitted for flotation + gravity gold and silver recovery, the second was submitted for barrel amalgamation gold recovery, and a third was used to count the number of gold grains recovered by laboratory gravity-hydraulic methods that included use of a Gemeni table and a mechanical panning method (English and others, 1987). Fire assaying of concentrates was done independently by a firm that we considered reliable on the basis of numerous prior tests. For backhoe samples, gold grains were recovered by a Denver Gold Saver and panned in the field in order to count gold grains.

## RESULTS

Data for these studies are shown in table 1 and include bulk sample weight, weight percent of material larger than 1 mm diameter, gold and silver recovered from flotation + gravity concentrates, gold recovered by barrel amalgamation and the calculated number of native gold grains for each

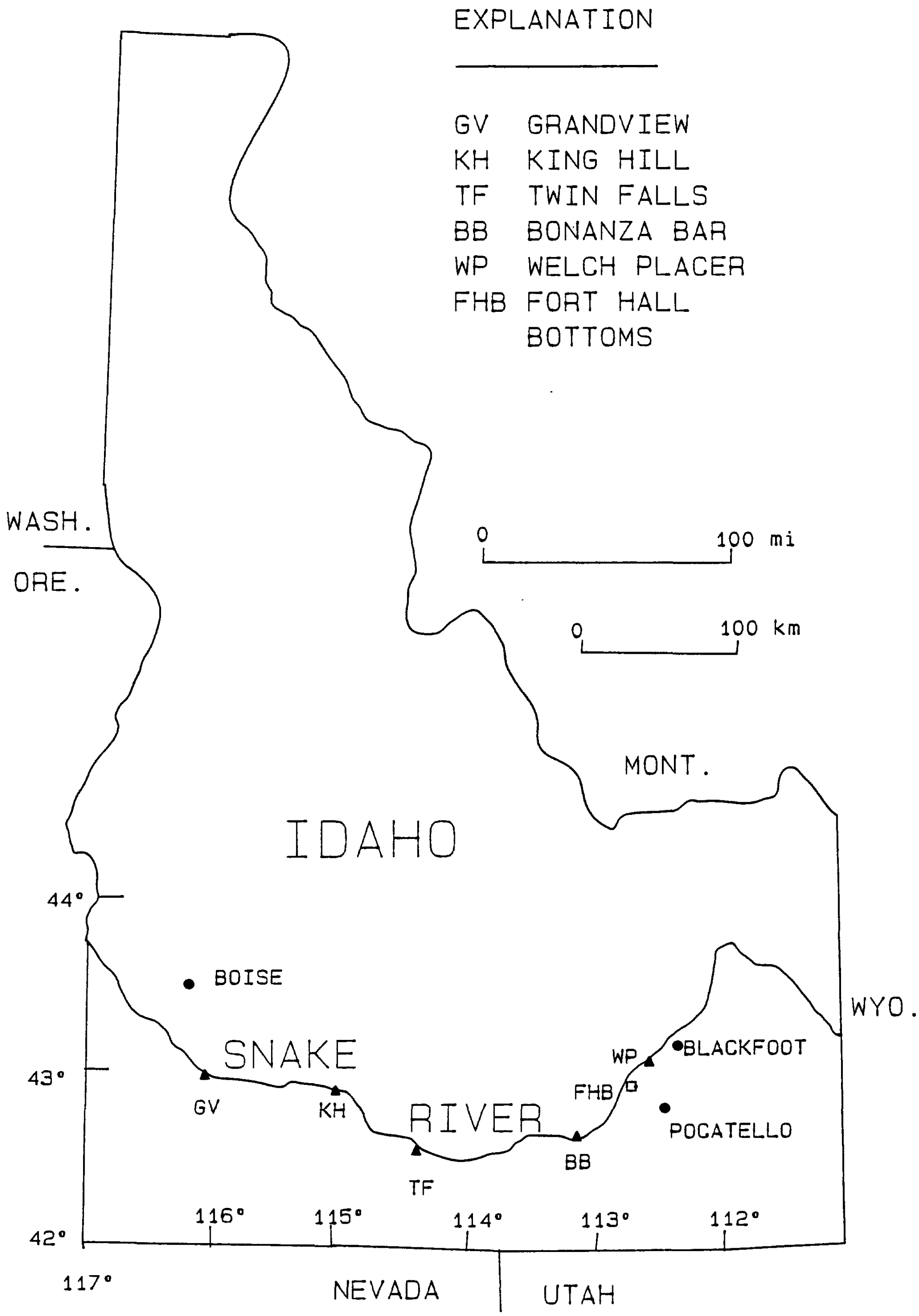


Figure 1.--Some placer gold localities along the Snake River in Idaho. Localities indicated are: GV = Grandview; KH = King Hill; TF = Twin Falls; BB = Bonanza Bar; WP = Welch Placer; FHB = Fort Hall Bottoms

Table 1.--Data for 18 placer samples from Pleistocene alluvial deposits in the Fort Hall Bottoms

| Sample No. | Bulk weight lb (kg) | Weight % of <1 mm fraction | Flotation + gravity, fire assay mg Au/yd$^3$ | Flotation + gravity, fire assay mg Ag/yd$^3$ | Amalgamation mg Au/yd$^3$ | No. of gold grains[1] |
|---|---|---|---|---|---|---|
| | | | Drill hole samples | | | |
| 14-16 | 144(65.2) | 33.3 | 44.1 | 42.8 | 16.2 | 90 |
| 16-18 | 159(117.3) | 29.5 | 46.5 | 21.7 | 14.2 | 172 |
| 18-20 | 169(76.5) | 20.2 | 69.1 | 43.0 | 14.2 | 70 |
| 20-22 | 76(34.4) | 51.6 | 150.0 | 56.4 | 27.1 | 116 |
| 22-24 | 62(28.1) | 9.0 | 43.0 | 38.2 | 3.9 | 58 |
| 24-26 | 68(30.8) | 44.7 | 73.1 | 37.5 | 6.9 | 60 |
| 26-28 | 69(31.3) | 19.0 | 773.0 | 987.0 | 14.6 | 84 |
| 28-30 | 60(27.2) | 27.3 | 837.0 | 2,220.0 | 5.4 | 40 |
| 30-32 | 68(30.8) | 47.8 | 728.0 | 592.0 | 2.3 | 16 |
| 32-34 | 73(33.1) | 45.8 | 113.0 | 103.0 | 0.2 | 12 |
| 34-36 | 86(39.0) | 78.6 | 22.2 | 31.2 | 2.1 | 20 |
| 36-38 | 79(35.8) | 71.2 | 373.0 | 98.0 | 3.4 | 25 |
| | | | Backhoe samples | | | |
| 37-2 | 79(35.8) | 79.7 | 103.7 | 114.3 | 24.0 | 56 |
| 38-2 | 70(31.7) | 50.0 | 54.6 | 20.4 | 31.0 | 98 |
| 39.2 | 79(35.8) | 69.6 | 43.3 | 24.2 | 16.0 | 48 |
| 41-2 | 75(34.0) | 68.3 | 109.8 | 27.8 | 119.0 | 330 |
| 42-2 | 71(32.2) | 71.8 | 70.0 | 36.7 | 36.9 | 66 |
| 44-2 | 76(34.4) | 69.7 | 86.4 | 56.3 | 69.2 | 90 |

[1]Number of gold grains was calculated using laboratory methods for drill hole samples and field methods for backhoe samples.

sample. The calculated number was based on the number of grains recovered by gravity-hydraulic laboratory methods for each split for drill-hole samples and number of grains counted by field methods for backhoe samples.

Figure 2 shows the relations of gold recovered by amalgamation versus the number of native gold grains calculated for each of 12 samples, based on laboratory counting of individual native gold grains in a split of each sample. The amounts of gold recovered by amalgamation and native gold grain counts indicate a computed average mass of about 4 $\mu g$ per native gold grain for 11 of the 12 samples. The dashed line on figure 2 shows the computed line for gold grains that have an average mass of 5 $\mu g$ per grain. These results are in good agreement with prior studies that showed average masses of native gold grains for this area to be about 3 to 5 $\mu g$ per grain for five samples using fire assaying on concentrates after counting of individual gold grains (Desborough and others, 1988, table 2).

Figure 3 shows the relations of gold recovered by flotation plus gravity, versus the number of native gold grains calculated for each of 12 samples, based on laboratory counting of individual native gold grains in a split of each sample. If the single sample with the lowest amount of gold recovered by flotation plus gravity on figure 3 is excluded, there is a general inverse relation between the amounts of gold recovered versus the number of native gold grains calculated for these samples. This indicates that the amount of native gold we recovered (counted grains) in gravity-hydraulic laboratory methods does not reflect the total amount of gold present in most of these samples.

Figure 4 shows the relations of gold recovered by flotation plus gravity, versus gold recovered by amalgamation for 18 samples. It is obvious that there is very low correlation between these two gold recovery methods. The amounts of gold recovered by these two methods was almost identical for only one of the 18 samples (table 1, sample 41-2). For the 17 other samples, the flotation-plus-gravity method recovered much more gold than the amalgamation method.

## CONCLUSIONS

Results of these studies show that we cannot account for the amounts of gold in concentrates obtained by flotation-plus-gravity recovery methods by using laboratory gravity-hydraulic methods that recover native gold grains with individual grain masses that are in the range of 1 to 10 $\mu g$.

In view of these results there may be several possible explanations. One is that gold-bearing minerals such as gold-tellurides or gold-silver tellurides are present as small grains that do not react with mercury. Another is that native gold is attached to or surrounded by tellurides of gold and silver, or by sulfide minerals that isolate native gold from reaction with mercury in amalgamation tests. Indirect evidence of these two possibilities is the coincidence of high values for both gold and silver for the samples in table 1 that were processed by flotation plus gravity for gold and silver recovery. Another possibility is that the very small grains of the subhedral to euhedral Au-Hg mineral that we recognized only recently, are abundant enough to contribute substantially to the flotation-recoverable gold. Because these grains are already mercurian, they do not react with mercury in amalgamation tests. We have exposed polished surfaces of these Au-Hg grains in direct contact with high-purity mercury, and there is no reaction.

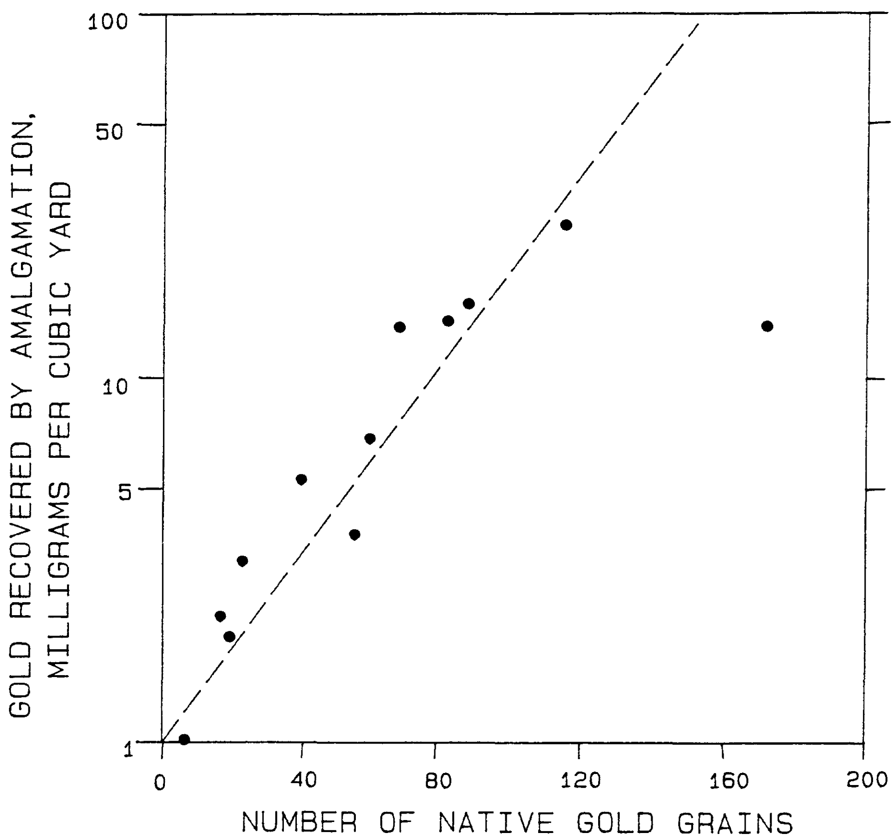


Figure 2.--Relations of gold recovered by amalgamation and the number of native gold grains in the sample based on counting. Dashed line is the relationship of gold concentration to the number of grains present if all grains weighed 5 micrograms.

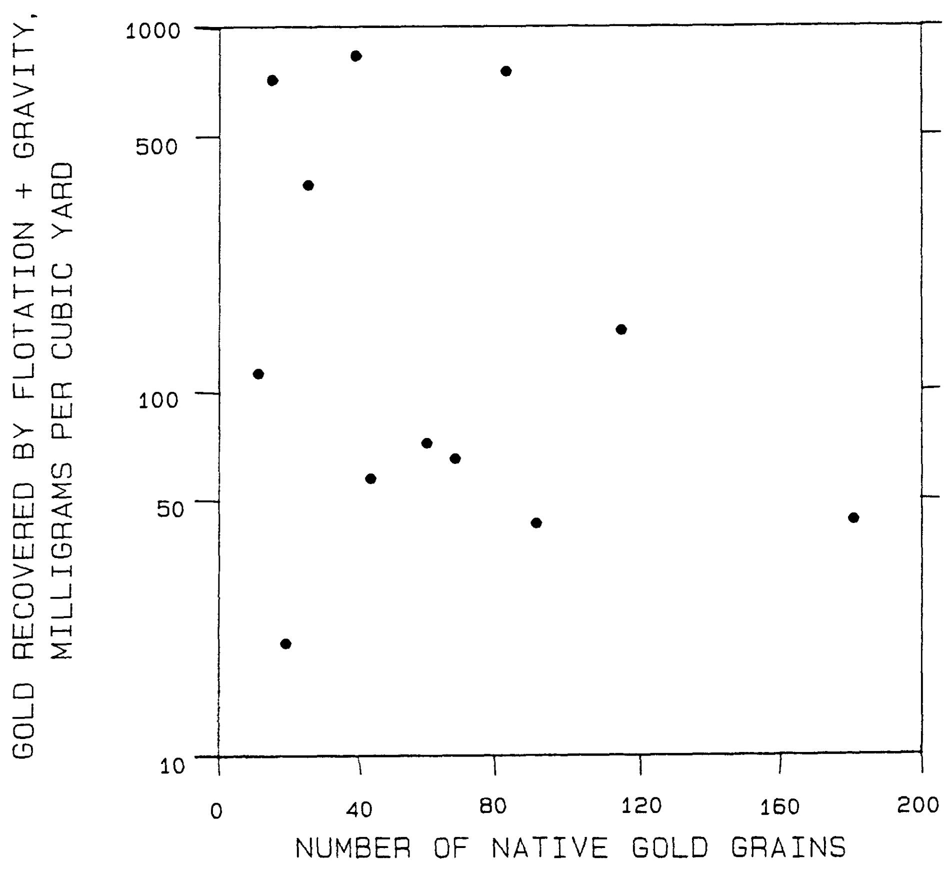


Figure 3.--Relations of gold recovered by flotation plus gravity and the number of native gold grains in the sample based on counting.

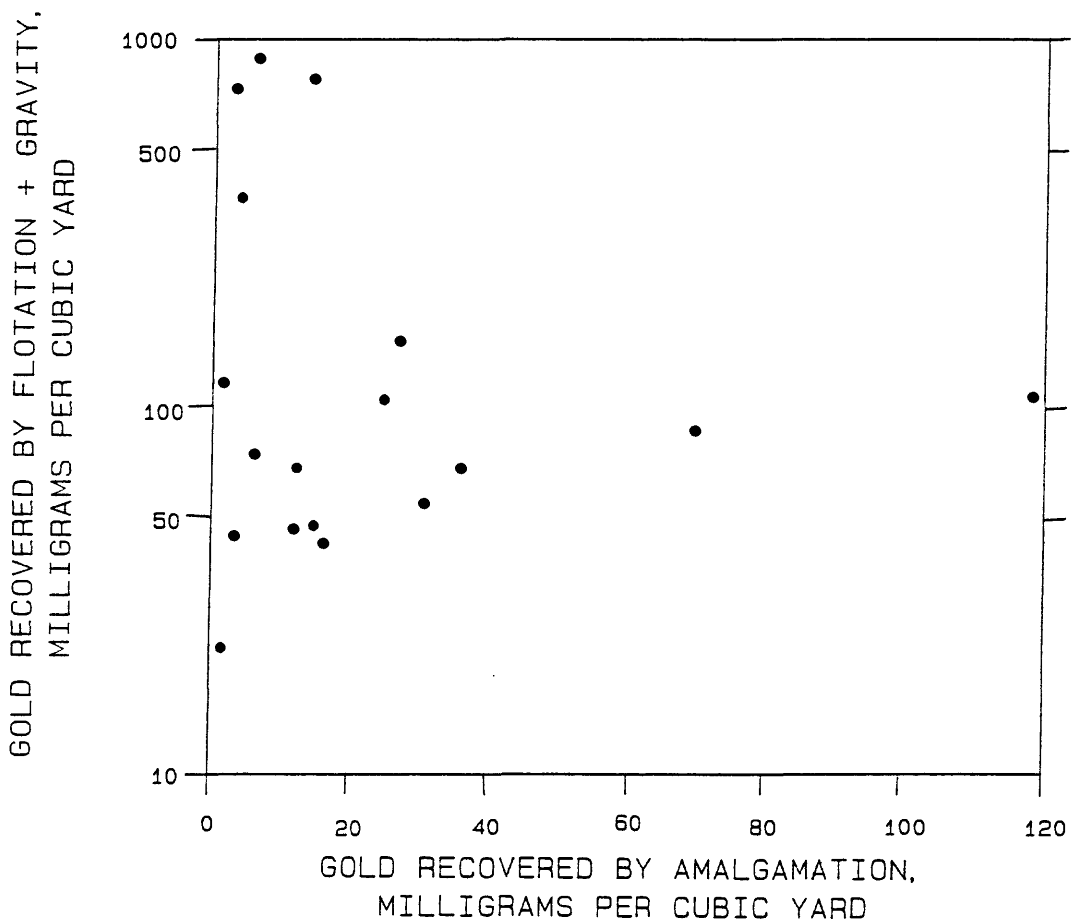


Figure 4.--Relations of gold recovered by amalgamation versus gold recovered by flotation plus gravity.

There is indirect evidence that some "invisible" gold was present in the Snake River placer gold that Fahrenwald and others (1939) recovered using flotation methods and fire assay analysis of the concentrates. Table 2 shows some of their data in columns 1 and 2, and our computed grade values (column 3) and our calculated average mass of gold grains for each sample (column 4), based on their data. Examination of the calculated average mass of gold grains (column 4, table 2) reveals that the average mass of gold grains required to account for the gold that Fahrenwald and others (1939) recovered by flotation is inconsistent with all prior results reported for the average mass of placer gold in the Snake River drainage in Idaho. The average mass of native gold grains calculated from the data of Fahrenwald and others (1939, table 2) is in the range of 11 to 35 $\mu$g; the average for the five samples is 23 $\mu$g (table 2). In several prior studies and in recent studies, as summarized by Desborough and others (1988, table 2), Snake River placer gold recovered by gravity-hydraulic methods has an average mass that ranges from 2 to 10 $\mu$g per grain. The computed values of average gold grain mass from the data of Fahrenwald and others (1939, table 2), as shown in table 2 (this report) are in the range of two to seven times greater than values reported by other investigations of the mass of native gold grains. Fahrenwald and others (1939) apparently thought that they could account for the fire assay gold values in their flotation concentrates by determining the amounts of gold recoverable by panning. We thought likewise in our initial studies.

We do not doubt the fire assay gold data of Fahrenwald and others (1939, table 2) that we have reproduced in column 2 of our table 2. However, we question their "Number of colors to have a value of one cent" (@$35.00/troy ounce for gold), because of the much higher average mass for gold grains that is required for consistency with their data regarding the relatively high amounts of gold recovered by the flotation method. In view of the present study and the data of Fahrenwald and others (1939), it seems obvious that the amount of gravity-hydraulic recoverable gold cannot account for the generally and significantly higher gold assays obtained for flotation, or flotation-plus-gravity concentrates for these Snake River alluvial deposits.

Table 2.--Placer gold data of Fahrenwald and others (1939, table 2) for five placer samples from the Snake River (columns 1 and 2 are from Fahrenwald and others (1939); columns 3 and 4 are calculated from their data)

| Locality | Column 1 Number of colors to have a value of one cent (@$35/troy ounce) | Column 2 Value in[1] dollars/cubic yd of gravel (fire assay, @$35/troy ounce) | Column 3 Grade milligrams/ cubic yard (based on column 2) | Column 4 Calculated average mass per gold grain (based on columns 1 and 2) (micrograms) |
|---|---|---|---|---|
| Grandview | 255 | $ 1.40 | 1,244 | 34.9 |
| King Hill | 605 | 0.36 | 320 | 11.4 |
| Twin Falls | 772 | 4.27 | 3,794 | 11.5 |
| Bonanza Bar | 383 | 1.44 | 1,279 | 23.2 |
| Welch Placer | 258 | 0.55 | 488 | 34.5 |

[1]The weight of a cubic yard of gravel was assumed to be 3,000 pounds.

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