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A Mechanical Panning Technique for Separation of Fine-grained Gold and Other Heavy Minerals

By

Brian L. English[1], George A. Desborough[1], and William H. Raymond[1]

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[1]Denver, Colorado

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ABSTRACT

A simple mechanical panning technique using a Wilfley[1] table and gold pan, developed for the recovery of fine-grained gold, separates fine gold from either concentrates or unprocessed samples of alluvium, usually in less than 15 minutes. Further, this technique has been used to obtain high purity separates of native mercury, native amalgam, sulfide minerals, and zircon, and may partially replace use of heavy liquids for some samples in the mineral separation laboratory.

INTRODUCTION

The difficulties of recovering the fine-grained gold (90 percent passes through a 230-mesh sieve) from the Snake River sediments has frustrated scientists and prospectors for a century. Egleston (1889, p. 598) described the difficulties encountered when panning this gold:

"The heavier pieces of basalt, the black sand, and the fine gold remain persistently together . . . after the black sand has been separated by the magnet, the fine particles of gold float, while the gray sand sinks . . . after much trouble the surfaces are wetted and the gold is got under the water and on to the top of the sand, the first wave from the other side of the pan over the sand floats the gold again." Later, Antweiler and Love (1967) reported experienced panners recovered only about 18 percent of the total free gold analyzed in gravels of the upper Snake River in Wyoming.

Hill (1916) described similar difficulties when other gravity techniques were applied. He reported that two gravity concentrates "from which all gold has been removed by the churn process" yielded 8.75 and 29.98 ounces of gold per ton when fire assayed.

The mechanical panning technique described here has proved to be the most efficient method of recovering fine-grained gold for mineralogical and morphological studies.

EQUIPMENT REQUIRED

1. Black plastic gold pan(s) with dimensions:
   - rim diameter 27 cm
   - base diameter 15 cm
   - height 5 cm
2. Laboratory scale Wilfley table and motor
3. Binocular microscope (6X-40X magnification)
4. Hand magnet
5. Nonmagnetic fine-tipped probe
6. Disposable Pasteur pipets (146 mm long x 7.0 mm O.D.) and 10 ml suction bulb

The 27 cm diameter gold pans are more efficient and easier to work with than larger standard gold pans. The plastic gold pans have several advantages over metal gold pans of the same size:

1. The plastic pans do not damage the surface of the Wilfley table.
2. The black surface provides a sharp color contrast for most of the minerals to be separated.

[1]Use of brand names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

3. The plastic pans are less likely to slide off the inclined table surface.
4. The slightly uneven interior surface of the plastic pan greatly improves the efficiency of the recovery.
5. Plastic pans can be cleaned with either water or acid, greatly reducing the possibility of cross-contamination.

A major disadvantage of the plastic pans is that their soft interior surfaces scratch easily. Scratches adversely affect the separation efficiency and are a possible source of sample cross-contamination, because grains become wedged in scratches.

The Wilfley table is operated at 240 oscillations per minute with a stroke of 1.25 cm. The table needs to have a side slope that can be manually adjusted from -25 to +25 degrees from horizontal. A table surface 1.0 x 0.5 meters readily accommodates three 27 cm diameter gold pans.

The binocular microscope needs a large focal distance, a large base, variable magnification up to a minimum of 40X, and an intense light source. The large focal distance allows examination of the sample while underwater in the gold pan. The large microscope base facilitates examination of all areas of the gold pan. The high magnification permits examination of grains only a few microns in diameter. A fiber optic light source with variable brightness controls is recommended.

The hand magnet, nonmagnetic probe, and Pasteur pipets are used to separate the mineral species or phases. Disposable pipets are preferred; thereby eliminating the possibility of cross-contamination of samples.

TECHNIQUE

1. Sieve or crush the sample to less than 35 mesh.
2. Place up to 25 grams of sample and 700-750 ml water in the gold pan, ensuring all the grains are wetted and have sunk. (Note: Wetting of the grain surfaces may be accomplished by adding one drop of a detergent which acts as a wetting agent.)
3. Set the side slope of the Wilfley table at -10 degrees and place the gold pan on it. Start the table and allow it to oscillate for 2 minutes; thereby concentrating the sample in one area of the gold pan, ready for separation (fig. 1).
4. Change the slope of the table through the horizontal to +10 degrees. Start the table and allow it to oscillate for 2 minutes.
5. Rotate the pan 35 degrees clockwise, allowing the sample to move up the slope of the table. Start the table and allow it to oscillate for 2 minutes. Results are shown on figure 2.
6. Transfer individual separated gold grains or other desired heavy minerals to another container using pipet.
7. Repeat steps 5 and 6 several times until no more gold can be separated easily.
8. Remove the magnetic fraction from the heavy mineral fraction using the hand magnet. The magnetic fraction should be transferred repeatedly through several containers to ensure no gold or other nonmagnetic mineral is removed with the magnetic fraction.
9. Repeat steps 5, 6, and 7 with a reduced oscillation time of 1 minute. The result will be a heavy mineral plume containing an occasional entrained gold grain (fig. 3). The gold grains can be moved to a clear area of the pan using the probe and removed using the pipet.

Figure 1. Sample in gold pan and ready for separation. The Wilfley table slopes away from the viewer.

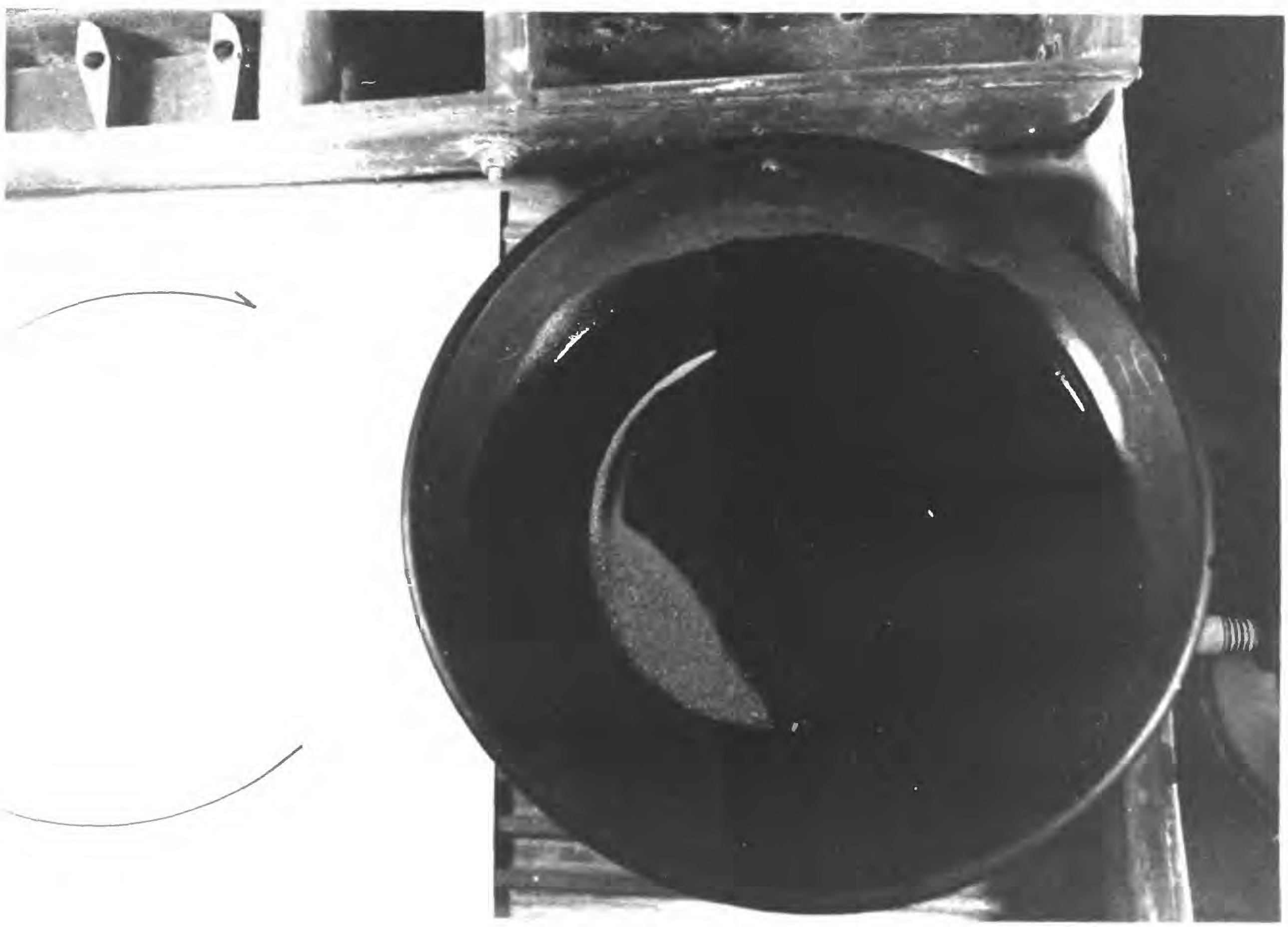

Figure 2. Sample after a single clockwise pan rotation of 35 degrees and 2 minutes of oscillation of the Wilfley table. Note how the grain size of the separated gold increases in a counter-clockwise direction.

Figure 3. Sample after most of the gold has been removed. The heavy mineral plume at the top consists primarily of zircon, pyrite framboids, and ilmenite. The dark material is obsidian.

10. The heavy mineral plume may be cleaned up by rotating the pan clockwise in increments of 10 degrees and oscillating briefly (20-30 second intervals). When formed properly, the heavy mineral plume will consist almost entirely of minerals with a specific gravity greater than 3.35 (less than 1 percent of the grains from the heavy mineral plume float in methylene iodide-S.G. 3.35). The heavy mineral plume can then be transferred to a separate container for drying and further processing.

This mechanical panning technique also can be used to reduce the amount of material from a concentrate prior to processing with heavy liquids. Simply add the concentrate to the pan, follow steps 1-7 above, and remove the lightest grains from the toe of the sample (fig. 3).

The method outlined above is the standard procedure used on a "typical," unconcentrated, minus 35-mesh fraction of a Snake River gravel sample. Several procedural variations may be introduced depending on the nature and size of the sample. A partial list of these variations include:

1. Amount and size fraction of the sample
2. Amount and temperature of the water
3. Side slope of the Wilfley table
4. Amount the pan is rotated each time
5. Length of time the pan is oscillated

A gravity concentrate (obtained by panning, tabling, or other methods) can be processed in 30 to 35 gram aliquots because removal of the magnetic fraction will reduce the aliquot weight below the 25 gram limit for effective separation. A sample that consists of crushed rock or unprocessed fine sand must be processed in smaller quantities.

The range of grain sizes, in part, determines the effectiveness of the separation. If the gold is less than 500 micrometers in diameter, a restricted size range will enhance separation. Equidimensional or round gold grains larger than 500 micrometers cannot, in general, be easily separated by this technique because of their tendency to remain buried in the lowest part of the pan.

The amount of water can be varied within reasonable limits. If insufficient water is used, the pan will slide off the table. If too much water is used, the motion of the Wilfley table will splash any excess water out of the pan. Except with very small samples, the procedure seems to work best with a "maximum" amount (750 ml) of water in the pan.

The temperaure of the water has a significant effect on the efficiency of the separation. Taggart (1956) defined the concentration criterion (C) as:

$$\frac{(SH-R)}{(SL-R)} = C$$

where SH is the density of the heavy mineral, SL is the density of the light mineral, and R is the density of the separating liquid, in this case water. Separations are facilitated by higher values of C. Because the density of water varies inversely with temperature, cold water enhances the separation. This rule holds true unless there is a significant amount of dissolved air in the water (more true for cold water than hot water) that exsolves in the gold pan during an attempted separation. Such gas bubbles adhere to all surfaces of the gold pan and prevent effective separation.

The proper side slope setting of the Wilfley table is essential to the separation process. A slope between 3 and 5 degrees will separate the largest (i.e. those >250 micrometers) heavy mineral grains, but the heavy mineral plume will contain abundant light minerals. Too great a slope will result in either the pan sliding off the table or no heavy mineral plume. A slope of between 5 and 15 degrees has proven most effective in separating most minerals with a specific gravity greater than 4.0.

The shape of the mineral grains to be separated determines both the amount the pan is rotated and the duration of oscillation on the table. In general, non-equidimensional grains with either large crystal faces or large cleavage surfaces separate best using large pan rotations and long times of oscillation, but rounded or irregular grains of the same mineral separate best using smaller pan rotations and shorter times of oscillation. Notable exceptions are individual framboids of pyrite, only micrometers in diameter, which are trapped in the irregularities of the pan surface and readily removed. Aggregates of pyrite framboids cannot be separated by this method.

DISCUSSION AND APPLICATIONS

The efficiency of gold recovery using this technique has been tested both by studies of separates of the tailings prepared using heavy liquids and by fire assay analysis. Fire assay analyses for two of three samples of tailing from our panning technique yielded less than a microgram of gold (lower detection limit); the third sample contained only 3 micrograms of gold (the average weight of a piece of fine-grained gold has been determined by this study to be between 1 and 6 micrograms). In the examination of heavy liquid separates of tailings from two of our panned samples, three and five gold grains were found; the heavy mineral concentrates from these samples contained over 100 gold grains. A minimum recovery of 95 percent of gold particles is indicated using the mechanical panning technique.

Pure mineral separates of gold, native amalgam, mercury, pyrite, arsenopyrite, galena, sphalerite, brookite, and marcasite have been obtained using this technique. Mineral separates of zircon, zircon and pyrite, ilmenite, and magnetite have been obtained if this technique is used in conjunction with a Frantz magnetic separator. These separates have been used for grain mounts, polished sections, non-destructive X-ray fluorescence analysis, and scanning electron microscope and electron microprobe studies. The zircon separates would be suitable for fission-track dating studies but further work is necessary to determine whether they constitute a representative sample suitable for U-Pb isotopic studies.

We have used the Wilfley table mechanical panning method for the following applications on Snake River placer gold:

1. Individual gold grains were counted in concentrates prior to submitting those concentrates for fire assay gold and silver determinations. This provided a check on the fire assay data. For instance, we knew that if the placer gold grains we counted averaged about 0.005 mg (0.002 to 0.010 mg range) and there were 100 grains in the concentrate submitted for fire assay analysis, the assay should indicate 0.20 to 1.00 milligrams of gold in the concentrate. We used this procedure in about 300 analyses of 30-gram aliquots of table concentrates submitted for fire assay analysis of gold and silver by our most reliable fire assay analyst. Even though that analyst never over-estimated gold (and silver) values, about 1 in 20 (5 percent) of his fire assays were less than our gold grain-count estimates by a factor of ten or more.

2. For placer gold samples sent to private industry for gold and silver determinations, we required that all tailings were returned to determine efficiency of their gravity, flotation, or amalgamation methods. We then used a Gemeni table and the mechanical panning Wilfley table to do gold grain-counts for these tailings prior to submitting our concentrates (obtained from the contractors' tailings) for fire assay analysis. Thus we could evaluate the methods of each contractor for gold-recovery efficiency.
3. For the fine-grained placer gold of the Snake River drainage, we have compared the gold grain-count results of Wilfley table mechanical panning of five to ten 20-gram samples of minus 35-mesh (undersize) material, or comparable amounts from sand beds, to gold concentration estimates based on other methods of gold recovery (e.g. fire assay of Gemeni table concentrates) that have processed much larger samples (e.g. 25-30 kg) of the same material. For instance, if we recovered a total of five gold grains from five 20-gram aliquots of minus 35-mesh material that weighs 3,000 lb/yd^3 (average fineness of the gold is about 800), fire assay of the Gemeni concentrate from a larger sample should yield about 270 mg Au/yd^3. This approach provides a method of screening samples for Gemeni table processing.

Other applications we have investigated include recovery of native gold from hydrothermal gold ore from mine dumps and recovery of zircon from several igneous rocks.

This mechanical panning method offers several distict advantages over conventional techniques:

1. The technique utilizes very inexpensive laboratory equipment that is available in most mineral separation laboratories.
2. The technique uses no toxic or hazardous chemicals.
3. The sample remains free of residual processing chemicals.
4. The entire sample can be recovered for processing by other methods should this technique fail.
5. The entire sample remains below the surface of the water, eliminating problems of surface tension and oxidation.
6. Cleanup time between samples is minimal.

Disadvantages of this mechanical panning technique are:

1. Only a small quantity of sample can be processed at one time.
2. The technique does not work on grains larger than 500 micrometers in diameter.
3. The technique is not efficient if separating well-rounded grains larger than 100 micrometers.
4. If both gold and mercury are present in the sample, amalgamation may occur in the gold pan.

CONCLUSIONS

The mechanical panning technique described is a highly efficient method of recovering flour gold. The technique has further applications in the mineral separation process that can significantly reduce the amount of sample processed through heavy liquids.

REFERENCES CITED

Antweiler, J.C., and Love, J.D., 1967, Gold-bearing sedimentary rocks in northwest Wyoming--a preliminary report: U.S. Geological Survey Circular 541, 12 p.

Egleston, T., 1889 [1890], The treatment of fine gold in the sands of Snake River, Idaho: American Institute Mining Engineering Trans., v. 18, p. 597-609.

Hill, J.M., 1916, Notes on the fine gold of Snake River, Idaho: U.S. Geological Survey Bulletin 620, p. 271-294.

Taggart, A.F., 1956, Handbook of mineral dressing: ores and industrial minerals: New York, Columbia University, sixth printing, p. 11-12.