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SUGGESTED COLLECTION METHODS FOR HEAVY MINERAL SAMPLES

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INTRODUCTION

During the past five years extensive exploration efforts for precious metal deposits, especially gold, in varied terrains has contributed many new insights regarding procedures for collecting and processing heavy mineral stream sediment samples. The collection, processing, and proper use of heavy mineral samples now constitute subjects of vigorous debate and research among exploration geologists and geochemists. From these discussions and field experince, some of the most serious problems inherent to heavy mineral samples have been defined, and tentative solutions have been proposed.

The methods outlined in this report deal primarily with sampling in areas of abundant to moderate rainfall where a ready supply of water is available in the drainages being sampled. The methods are not applicable, as written, for work in desert terrains. The concepts are, however, easily translated to processing 10 kg samples at a base camp where water is available.

Of the concepts presented, those based on Stoke's Law settling in the second class sampling procedure to derive a -200 mesh sample for use in exploration for ultra-fine grained disseminated gold deposits is the most tenuous and needs further research. In fact, true Stoke's Law conditions are not attained since the particles in the sample are not settling through a static column of water. This is significant because Fletcher (in preparation) has shown that at about 75 microns and less, heavy vs light partical enrichment begins to be negligible in moving water. As proposed, the -200 mesh (74 micron) size fraction would be removed from the coarser fractions in a still swirling column of water. One would also expect that much of the disseminated gold would still be locked in silt-sized quartz grains since gold particles in ultra-fine grained disseminated deposits range in size from 1 to 30 microns. These considerations suggest that the method proposed will be effective.

The first three methods outlined in this report preserve a wide range of options for the subsequent analysis of the sample. Professional prudence dictates that these options be thoroughly investigated by means of an orientation survey prior to settling on any sampling procedure. The results of an orientation survey can be expected to produce variations and additions to the suggested methods that perhaps will markedly enhance the signal to noise ratio as well as reduce site to site random variation.

Recent work by Kay Fletcher and his students at the University of British Columbia, (in press) and Ian Nichol at Queens University,(personal communication) has characterized some grave problems with conventional pan concentrate samples. Problems that Fletcher (1986) and Nichol (1986) describe have been encountered in the practical world of mineral exploration for years. Fipke (1986), Smith (1986), Mehrtens (1986), Dummett and Fipke (1986), provide several examples of mineral deposits that were found only after the quality of heavy mineral sampling was improved. The work reported by these geologists and others indicates that even if great care is taken in panning samples and in recording initial weights as well as those of analytical aliquots, the inherent variability of a conventional pan sample is such that it is of limited use, and results from some types of heavy mineral samples can be misleading.

A conventional pan concentrate sample incorporates several sources of significant variance.

Noise:
- Site-to-site hydraulic variance
- On site sample collection inconsistency
- Initial variation in sample size
- Variance in panning efficiency
- Variable loss of fine fractions
- Variance in laboratory preparation
- Analytical variance

Signal:
- Site-to-site mineralization variance

It is evident that the sought for signal is overlaid with multiple sources of noise that can effectively mask an anomaly from detection. Presently, a proper choice of analytical and sample preparation procedures in the laboratory can generally be counted on to limit laboratory sources of data variation to less than 15%-20% for routine geochemical data. Over the years many sampling variations and "normalizing" schemes have been tried to reduce the noise of the pan oriented field sample. None have been notably successful. Refinements in method that have produced some improvement include the following:

Definition of "high energy" and "low energy" sites to reduce variation in sample site selection between samplers.
1" to 4" gravel and cobbles (high energy)
-10 mesh to -18 mesh sand (low energy)

The use of backpack suction dredges.

Standardizing sample size to 10Kg of -10 mesh or 10kg of -18 mesh material.

The use of one person to pan all samples

A significant improvement was made in the reliability of heavy mineral concentrate geochemistry when the sampling procedure was changed to retrieving an undisturbed 10Kg, or a -10 mesh 10Kg sample from the field and then using a Deister table and heavy liquids to separate the heavy minerals back in camp or at a preparation laboratory. Even this method, however, does not allow one to remove the significant site-to-site variance in hydraulic regime and it results in a variable loss of the sample's fine (-200 mesh) fraction which is of fundamental importance in detecting ultra-fine grained disseminated deposits.

The exact nature of a heavy mineral oriented sample will vary somewhat with the target(s) being sought and the minerals of primary concern (Saxby and Fletcher, 1986), (Day and Fletcher, 1986). There is a growing consensus, however, that a scientifically sound heavy mineral stream sediment sample must initially consist of between 10-20kg of material that has been sized in the field to -10 mesh or -18 mesh. This material would then be returned to a preparation laboratory where it would be further screened in a closed system to previously determined size fractions for density and magnetic separations. If these separations are based on the results of a sound orientation survey, this type of sample will yield data that is effective in reducing all of the noise factors noted above. There seems little question that at present this is the most consistent and thorough way in which to collect and reduce a heavy mineral sample. Certainly it is the most conservative way to treat orientation samples since no potential signal enhancing or data normalizing fractions are lost.

A preferred history for a heavy mineral sample would, at present understanding, consist of the following:

Consistent selection of the same type of sample site, ie. high energy or low energy

Consistent collection of 10Kg or 20Kg of initial sample, this might consistently be -6,-10 or -18 mesh material depending on the type of sites chosen and the purpose of the survey

Approximate wet weight of the initial sample obtained in the field

Return the entire initial sample to the preparation laboratory

Determine the dry weight of the sample

Wet sieve the sample to the desired size fractions in a closed system so that no sample is lost

Separate the heavy minerals from the analytical size fractions with the use of heavy liquids so that no desired mineral grains are lost

Remove the magnetic and paramagnetic minerals if so desired and weigh the analytical fraction

Analyze the appropriate size, density, and magnetically separated fraction

Obtain the dry weight of the hydraulic equivalent normalizing mineral fraction so that the analytical data can be corrected for differences in the site-to-site hydraulic environment

If this or a similar sampling scheme were followed one could anticipate a higher signal to noise ratio in the analytical results and a higher probability of success in detecting subtle anomalies. One would also expect that the heavy mineral data would be more informative with regard to distance to source, Fletcher (in press). Both of these results should lead to more successful exploration. In addition, if modern nondestructive methods of analysis are employed, none of the sample need be lost. All fractions can be retained in storage ready for reanalysis should the development of new concepts or new techniques warrant.

In practice, one is not always able to implement the best solution. The question then becomes a matter of how far one can retreat from known superior methods without reaching the point of being ineffectual. If the procedure outlined above is rated as a first class or A-grade sample, there are four distinctly recognizable descending levels of sampling procedure that will yield heavy mineral samples of progressively inferior quality. With some care, and the willingness to adopt different methods it is possible to obtain very good heavy mineral samples with little degradation in quality from a first class sample.

The guiding concept for the methods outlined below is that, in the field, care must be taken to retain all the potential analytical size fractions while postponing any attempt at concentrating the heavy minerals until as late in the process as possible. All the methods outlined discard material. The better ones quantitatively remove known size fractions. Should those size fractions be of interest, they could easily be retained. Another common feature of the outlined procedures is that they reduce a 10Kg sample to approximately a 500 gram sample, or less, that is easily packed and is of a size that can be economically processed in commercial laboratories. If getting the initial 10Kg sample from the stream site to a central processing facility

is not a problem, then all samples could be reduced at a central base camp. The following methods assume that the samples will have to be backpacked and that reduction of the sample at stream side is desirable.

A suggested method for taking a second class heavy mineral sample requires the following field equipment for each sampler in addition to normal field gear:

A shovel

An 18 inch (45 cm) square of heavy gauge stainless steel 10 mesh screen

A 12 inch (30.5 cm) diameter stainless steel regular height framed 18 mesh sieve

An 8 inch (20.3 cm) diameter stainless steel regular height framed 35 mesh sieve and bottom pan

Two nesting 5 gallon (liter) polyethylene buckets with slightly smaller than, or slightly larger than 12 inch (30.5 cm) diameter tops

The raw sample material can be conveniently collected in one of the poly buckets and carried to an appropriate working location at stream side. The 10 mesh screen is laid across the mouth of the second poly bucket and successive portions of the raw sample are loaded onto the screen and the -10 mesh fraction is washed into the receiving bucket. The bottom pan of the -35 mesh sieve makes a good water vessel for this purpose. Sieving continues until a fixed volume mark on the receiving bucket is reached. This mark can be precalibrated to approximate the volume of a 10Kg sample. The poly buckets are translucent so the sediment level can be determined by inspection. Once the level mark is reached, the first transport bucket is cleaned of excess raw material and becomes the receiving bucket for the next screening operation. If a more exact weight of the wet sample is desired, this can be obtained by differential weighing of the -10 mesh fraction with a hand held spring scale.

For stage two of the process, all of the wash water from the first receiving bucket is carefully transferred to the second bucket. The 18 mesh framed sieve is then set on the second bucket. It should fit snugly over or into the top rim. Portions of the 10 mesh material from the first receiving bucket are loaded onto the 18 mesh sieve and the -18 mesh material is washed into the second receiving bucket. By this point the receiving bucket will be filled with water and much of the washing can be done by gently but rapidly rocking the bucket and capping sieve. Some water and intrained very fine grained and clay sized material will invariably be lost. With a modicum of care, however, this can be kept to a minimum for the silt sized material.

At the end of stage two, the sample has been reduced to 1/2 to 2/3 its original volume of -10 mesh material, and the wash water contains a high percentage of the original silt sized material from the original sample. If a 74 micron and smaller size fraction is needed from the sample it can now be collected using a procedure based on Stoke's law settling. The sampler should reach into the bucket and with smooth swirling strokes stir the entire mass of sediment and water in the bucket into a uniform slurry. The stirring is stopped and a period of (secs) is allowed to elapse. This allows all materials greater than 74 microns to settle out of the water column. At the end of the elapsed time the water is carefully poured from the sieve bucket into the now empty second bucket and set aside to stand until the final 35 mesh sieving of the remaining -18 mesh sediments is completed.

Portions of the -18 mesh material is loaded onto the 35 mesh sieve and washed into the nesting sieve pan until all the -18 mesh material has been processed. Usually the sieve pan will hold all of the -35 mesh fraction (about 500 grams). The -35 mesh material is washed from the sieve pan into a sample bag, and the wet weight of the sample is determined with a spring scale. This material will contain little material finer than 200-230 mesh (74-63 microns) unless a fairly long settling time was allowed prior to decanting the suspended material in the above Stoke's settling step.

By the time the -35 mesh sample has been bagged and weighed, water and clay sized fractions can be carefully decanted from the silt fractions that will have settled out in the bucket of slurried wash water saved from the 18 mesh sieving. The size range of the silt fractions retained, as well as sampling variance, can be controlled by adhering to consistent settling times. The size fractions desired may vary from project to project. Once dewatered the silt fractions are bagged and a wet weight recorded.

Although not as rapid as simply collecting 10-20 Kg of untreated sample, or 10-20 Kg of -10 mesh sample, the second class sampling procedure outlined above can be executed in a short time. The largest time interval is spent in collecting the initial sample material and will not exceed that taken for a first class sample. The subsequent sieving operations also are quickly accomplished. The positive features of this sampling method are that it incorporates most of the variance reduction, signal enhancing characteristics of the first class sample. Site selection is controlled; sample volume is standardized and can be quantified at least to the precision and accuracy of wet weight of the initial -10 mesh material; sample collection efficiency is controlled; panning variance is removed; the sample size fractions necessary to normalize sample site hydraulic variance is retained; and the -200 mesh fine fraction is retained. In addition, virtually all the -35 mesh to approximately 200 mesh

material is conveniently extracted and washed rendering it easily transportable and ready for any subsequent treatment in commercial laboratories. The fine fraction is essentially ready for analysis.

The second class sample is less controlled than first class sample in that some indeterminate amount of the -200 mesh material will be lost, all of the clay fraction will be lost, and the initial weight of the -10 mesh material will not be as accurately known. In addition, the separation of 200 mesh and finer material from the +200 mesh material will not be as absolute as in the first class sample. All of these shortcomings will act to increase the noise level (variance) of the analytical results obtained from the second class sample.

Objection may be made to carrying the poly buckets required for obtaining the second class samples. These can be omitted in the third class procedure and two gold pans substituted in their place. Necessary equipment for collecting a third class sample includes the following:

A shovel

A 16 inch (40.5 cm) diameter gold pan

A 14 inch (35.5 cm) diameter gold pan, black plastic riffled pan, or a second 16 inch pan

An 18 inch (45 cm) square 10 mesh heavy gauge stainless steel screen

A 12 inch (30.5 cm) diameter 18 mesh regular framed stainless steel sieve

An 8 inch (20.3 cm) diameter 35 mesh regular framed stainless steel sieve and bottom pan

The concept guiding the collection of the third class sample is the same as for the previous two collection methods. The emphasis is on controlling the on site variance and the loss of sample fractions to as great an extent as allowed by the equipment on hand.

The 10 mesh screen is placed directly across the top of the 16 inch gold pan. Raw sample material from the stream is loaded on the 10 mesh screen and wet sieved into the pan. This is continued until the gold pan is filled or until a pre-determined constant volume is reached. A standard 16 inch diameter gold pan holds approximately 16 pounds (7.25 Kg) when filled level to the rim with -10 or -20 mesh quartz and feldspar sand. Because of the gold pans sloping sides, the weight of the sample drops off rapidly with a decrease in fill level. For consistency, it is therefore important that the same sample volume is achieved from site to site, or that the wet sample weight is recorded, or both.

One full pan of -10 mesh material provides 25% less material than the recommended 10 Kg sample weight and may lead to insufficient non magnetic concentrates for some analyses, eg. Sn determined by XRF methods.

The 12 in diameter stainless steel 18 mesh sieve is now placed in the 14 inch gold pan. The 14 inch pan is modified if necessary so that the bottom rim fits flush with the pan around its entire circumference. The -10 mesh sample material is loaded onto the 18 mesh sieve and wet sieved into the second gold pan. The -10 mesh +18 mesh material can be saved or discarded. Following the 18 mesh screening the -18 mesh material loaded onto the 35 mesh sieve and bottom pan and wet sieved into the bottom pan. At the end of this process the sampler has three size fractions to retain or discard. The usual sample to be kept for analysis would be the -35 mesh material. Normally this will consist of 3/4 to one pound (340 to 450 grams) of material.

This sampling procedure preserves the integrity of the approximately 200 mesh sample material at about the level of the first and second class sample in that little or no -35 mesh +200 mesh material will be lost from the initial sample. Panning variance is eliminated; sample site selection is unaffected; and size fractions necessary to determine hydraulic equivalence are retained.

The shortcomings of this sample are the uncontrolled loss of the fine grained (-200-230 mesh and smaller) size fractions; the somewhat more uncertain lower size limit of the retained -35 mesh material; and the smaller initial sample size if only one pan of -10 mesh material is processed. All of these factors will act to increase the random variance of the third grade sample in comparison to sample grades one and two. In addition, because of the loss of virtually all of the -200 mesh fractions, the third grade sample is unsuitable for use in tracing ultra fine grained disseminated gold deposits, or any other type of ultra fine grained disseminated type of deposit.

A fourth grade sample marks the point at which a heavy mineral sample undergoes some density separation by panning in the field. There are many variations of procedures for collecting these samples but they all will involve some degree of panning to reduce sample volume. A common first step is to screen the material to be panned, Therefore a list of field equipment might include the following:

A shovel

An 18 inch (45 cm) square 10 mesh stainless steel screen

A 16 inch (40.5 cm) diameter gold pan

The sample would be treated the same as in the fourth grade sample example except that panning would be continued until all discernible lighter minerals had been removed. The remaining heavy material would be retained for analysis. This sample, like the fourth grade sample above, would be characterized by a wide range of grain sizes from -10 mesh to perhaps fine silt sizes. It is questionable whether this type of sample treatment would consistently yield enough heavy mineral concentrate to allow a restricted size range to be extracted for analysis. The sample, if analyzed in toto would be subject to extreme nugget effects. There would also be highly variable losses of the desired heavy mineral species. It is probable that the chance retention or rejection of the desired mineral grains would overshadow the natural distribution of the minerals in the survey region's streams. The end result of this would be a survey that would give only reliable positive information. That is if a sample showed the presence of the element or mineral sought, one could say that the element or mineral was present in some amount somewhere in the streams catchment area. If the sample was blank in the element or mineral sought, one could conclude nothing with regard to the area of influence attributed to that sample site. In a sense, the time spent taking a negative fifth class sample might be considered wasted.

It is easy to conceive of progressively worse sampling scenarios and it is difficult to categorically state at what point a sample is totally without redeeming qualities. At some point, however, the biased information derived from bad or inappropriate samples becomes worse than no data at all. For example a poor sample or series of samples may produce negative results when in fact there is mineralization in the drainage tested. If these results, based on substandard samples become part of the technical record for the area in question, they may well lead to inappropriate management decisions.

As a generalization, if one wishes to explore both for ore deposits that are characterized by relatively coarse grained heavy minerals, eg. vein or placer gold, scheelite, cassiterite, platinum group minerals, or sulfide minerals in reducing or high energy environments, as well as ultra fine grained disseminated deposits, eg. "Carlin" type gold deposits, then a second grade sample should be considered a minimum. If ultra fine grained ore deposits are not of interest in the program at hand, then a third grade sample is recommended as a minimum. The extra care needed to collect a third grade sample rather than grade 4 or 5 type samples is truly minimal, but the quality of the sample is markedly superior and preserves many important options.

Given this field equipment, or perhaps an additional 18 mesh screen, a full level pan, or a fixed volume of material that is less than a pan, is collected at each site. The sites are chosen to be a nearly hydraulically equivalent as can be discerned by using the energy definitions above. Once the desired screened material has been collected, it is panned down to a volume that is known to approximate one pound (450 grams) of material. No attempt is made to pan the material down to the point where the heavy minerals are obviously predominant. This sample is then sent to a laboratory where it can be screened to whatever mesh size fraction is desired for final density and magnetic separations of the analytical aliquot.

The advantage of this sample procedure lies predominantly in its simplicity and limited equipment requirements. Site selection criteria are maintained as in the previous methods, and the initial sample size can be controlled as closely as in a third grade sample.

A major shortcoming of this method is the large variance introduced when the sample is panned. Not even expert panners can pan consistently. Sampling crews comprised of inexperienced panners have virtually no hope of maintaining sample consistency between crew members. This factor alone can lead to a noise level that exceeds the level of the geochemical signal being sought. Panning only to a set volume may decrease this noise level to a point at which some confidence can be placed in negative results but it is dangerous to do so. Any survey using this method should be expected to miss a significantly higher number of positive indications of mineralization than those using any of the first three sampling alternatives. With this sampling procedure there is no control of sample losses either in terms of size or density. The fine silt fraction is completely lost, making the sample unsuitable for tracing ultra fine grained disseminated mineral deposits. There is no presently known way to extract a normalizing factor from this sample with which to neutralize site to site hydraulic effects. Because of uncontrolled heavy mineral losses, there is a greater possibility that insufficient heavy minerals will be retained for analysis of the desired size fraction.

As a final grade of sample method to review one may consider a one pan volume of raw sample material that has been systematically sized to -10 mesh. This procedure would require the same equipment as the fourth grade sample:

A shovel

An 18 inch (45 cm) square 10 mesh stainless steel screen

A 16 inch (40.5 cm) diameter gold pan

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