PLACER DEPOSITS

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General

The criteria stated in the General Guidelines of the CIM Best Practice Code and the factors discussed in the Industrial Minerals Section form the background for the guidelines for the evaluation and reporting of MRMR for placer deposits. Placer deposits include several different types of commodities and a range of geological environments. The three deposit types discussed here; mineral sands, placer gold and alluvial diamonds, are considered to have specific technical issues that require specialized knowledge.

MINERAL SANDS

Mineral sands are deposits of ilmenite and other heavy minerals that are concentrated by weathering and beach processes. The minerals of value in mineral sands are predominantly ilmenite, rutile, zircon and their weathered equivalents. Titanium-bearing minerals of mineral sands deposits are one of the main sources of titanium feedstock used by white pigment producers for paints, paper and plastics. The titanium producers define the characteristics of the mineral products that are used to estimate MRMR of mineral sands deposits. Other criteria apply to co-products of titanium, which must satisfy physical and chemical requirements of end-users, provided that a viable market exists for those mineral products.

The QP must ensure that accurate and adequate sampling is completed. Recovery of unconsolidated sands can be achieved through a variety of drilling techniques, including hand auger, vibracore or sonic drill and double reverse circulation drilling. In clayey sand, mechanical flight augers have been used successfully, although care has to be taken to ensure that contamination of samples does not occur during sample retrieval.

During the evaluation phase, a geological model should be developed identifying boundaries of mineralization and features such as overburden, water table, clay beds, peat, gravel, cementation, induration or the presence of sulphides that adversely affect mining or mineral recoveries, and the likely quality of the mineral concentrate to be produced.

The estimation of MRMR must be based on reliable laboratory and metallurgical testing. Laboratory testing will comprise both heavy mineral determination analyses of individual drill samples supported by adequate mineralogical analyses of the heavy mineral suite. Although more information increases the degree of accuracy, it is generally accepted that mineralogical and chemical analyses are performed on composite samples, taking in to consideration the mineralogical variability of the mineralized body. Such variability will have been incorporated into the geological model used in the estimation of MRMR.

A variety of techniques that include microscope grain counting, microprobe or scanning electron microscope are available for mineralogical analyses. The merit of the testing used needs to be judged by the QP. Ultimately, verification of the mineral product quality and quantity should be determined through the application of physical techniques (grain size analysis, electrostatic/magnetic fractionation) and chemical analysis. Laboratory analyses will be complimented with metallurgical testing to determine the recoveries of saleable products and their physical and chemical characteristics. Beneficiation of the mineral products into saleable products can vary according to the presence of contamination minerals, grain coating, grain size and the response of the recoverable minerals to the various pieces of process equipment.

The reporting of MRMR for a mineral sand deposit must state the quantity of in-situ sand present above a given heavy mineral grade cut-off. The applied cut-off should be stated. It will have been determined by the QP on the basis of the economic criteria of the mineral sand deposit.

GOLD PLACERS

Preamble
Gold placers occur in a wide number of types located in a variety of geomorphological environments. Wells (1969) produced a simplified classification that included:

- Residual placers
- Eluvial placers
- Stream placers
- Bench placers
- Flood gold deposits
- Desert placers
- Tertiary gravels
- Miscellaneous types
  - Beach placers
  - Glacial deposits
  - Eolian deposits
  - Marine placers

No attempt is made to discuss these various types other than to point out the complexity of the issue. The pay section of a placer deposit may not be at surface and exploration and testing may need to be carried out through overburden. In some cases, this material may be wet. It is considered that representative placer samples are not easy to obtain and in almost all cases sample results need a large measure of interpretation.

Sampling
The sampling of gold placers typically has to deal with three problems. These are:

- The gold-bearing material, and/or the overlying material often have a wide variation in particle size. The range may vary from fine sand to boulders weighing hundreds of kilograms. It is difficult to get representative samples of these different materials.
- Gold has a high unit value, so that the amounts of gold in a cubic metre of gravel that is economic may be as low as 1 part per one hundred million.
- Gold distributions are often extremely erratic.

The combination of these problems results in a situation where the sampling of placer gold deposits is difficult. Typically, there is a requirement to take large samples and to reduce the sample size in the field. While panning for colours remains a useful tool in reconnaissance exploration, it is a semi-quantitative method at best and must not be used in Mineral Resource estimation.

There are many sampling techniques available to the QP for the testing of placer deposits. The technique selected will depend on the depth of overburden, the grain size of the host material, the presence or absence of water, whether the walls of an excavation slumps, among other factors. The interpretation of the results of any sampling campaign is a critical part of any placer deposit testing.

In all estimates of MRMR in placer gold deposits, the critical factors remain geology (with an emphasis on geomorphology, stratigraphy and sedimentology) and gold grain size. The QP must demonstrate that these factors are appropriately considered.

Environment
Placer mining has created severe environmental problems in many areas. Environmental considerations will require a significant amount of attention in any proposed mining operation.

Reporting
Gold placers should be reported in grams per unit volume (metres^3). The reported units refer to dry in situ metres^3. The gold grade should be reported to make a clear distinction between total gold and gold that may be recovered by the proposed recovery process.

Selected References

Clay, B.W., Shumaker, M.W., et al, 2004 Handbook for Mineral Examiners, United States Department of the Interior, Bureau of Land Management, H-3890-01, Mineral Examiners Certification Panel.

Macdonald, E.H., 1983, Alluvial Mining. The geology, technology and economics of placers. Chapman and Hall.

Wells, J.H., 1969, Placer Examination, Principles and Practice. United States Department of the Interior, Bureau of Land Management, Technical Bulletin 4.

McCulloch, R., et al, 2003, Applied Gold Placer Examination and Evaluation Techniques, in Montana Bureau of Mines and Geology, Special Report 115.

ALLUVIAL DIAMOND DEPOSITS

Preamble

Alluvial diamond deposits are derived from the weathering, erosion and transportation of diamonds from diamondiferous kimberlite pipes, dikes, fissures and lamproitic intrusions by fluvial processes. These processes can produce large alluvial diamond fields. Alluvial diamond deposits are presently known to occur in South Africa, Angola, Australia, Brazil, Democratic Republic of Congo ("DRC"), Central African Republic, Sierra Leone and Venezuela. The erosion, transport and deposition of diamond from the primary diamond deposit sources occur in five main types of deposit (Marshall and Baxter-Brown, 1995):

- **Fluvial;**
  - Plateau gravel deposits;
    - Eluvial deposits
    - Colluvial deposits
    - Slope deposits
    - Alluvial deposits
  - Coastal plain deposits;

- **Marine;**
  - Onshore (beach) and off shore (marine) deposits;

- **Lacustrine**;

- **Aeolian** (wind deflation); and,

- **Glacial**

No attempt is made to discuss in detail the various alluvial diamond deposit types or discuss the exploration and data collection methods other than to point out the regional, intermediate and small scale geological, geomorphological and sedimentological complexities that each deposit type may exhibit. It is widely accepted that the pay zone of an alluvial diamond deposit may not occur at surface. In all cases, the selected exploration and sampling methods to be used in determining the economic potential of alluvial diamond deposits require careful and rigorous geological control from the onset.

Sampling Techniques and Sample Treatment

Alluvial diamond deposits are usually lower in grade compared to their primary deposit counterparts. However, due to diamond's lack of size reduction from the effects of abrasion and because they can survive thousands of kilometres of fluvial transport, alluvial diamonds tend to be of higher quality to that found in primary sources. Since alluvial diamond deposit formation is dependant on numerous geological, geomorphological and sedimentological factors (e.g., paleotopography, fluvial geomorphology, fluvial architecture, bedrock geology, structural controls and/or traps, etc.) a thorough understanding of the geological controls is necessary in order to evaluate an alluvial diamond deposit.

In order to determine the presence of diamonds and the economic viability of an alluvial diamond deposit, the following objectives must be met:

- To determine the presence, size and grades of diamond in the alluvial deposit;

- If diamonds are present, the QP must select the sampling techniques to be used and data to be gathered to increase the confidence level in determining gravel resources on the property of a volume/tonnage that would support an acceptable minimum number of years of planned production. The data obtained will allow the QP to estimate a preliminary / potential resource base that, with additional in-fill sampling, may meet the criteria of Measured and Indicated Resource categories of the mineral by the CIM Standing Committee on Resource - Reserve Definitions to allow for an economic evaluation.

- To identify sites appropriate for bulk sampling/trial mining sites; and,

- To further delineate as required the different gravel types.

The following exploration sampling techniques for alluvial diamond deposits are generally carried out prior to advancing to a bulk sampling/trial mining phase. They are:

- Pitting (manual and/or mechanical);
- Trenching (manual and/or mechanical); and,
- Drilling;
  - Auger
  - Reverse circulation

As with placer gold deposits, the selected sampling technique will depend on various factors including; the overburden thickness; the granulometry of the gravels; the presence or absence of water; the pit wall stability, etc.

According to Rombouts (1995), sample sizes are dependent on gravel type and stone density (number of stones per unit volume), thus sample sizes should be large enough to obtain at least one diamond per sample. If no known systematic sampling has been completed on the alluvial deposit, it is suggested that orientation pitting be carried out to determine not only the presence of diamonds but also to obtain information on the stone size distribution and the stone densities (stones/cubic metre).

A representative systematic sampling grid pattern is dependent on the areal distribution and anisotropy of the gravels to be tested. The grid pattern and sampling density used should be regular in shape and sample size should be of in-situ unit volume (e.g. bank cubic metres) that facilitates any resource estimation. It is important that all large material contained in a sample (i.e.; large rocks and boulders) be included in the sampling process in order to avoid introducing a bias to that particular sample.

Sampling of Marine Deposits

The sampling techniques and treatment for marine deposits are generally carried out with specially equipped sampling/processing vessels prior to advancing to a bulk sampling/trial mining phase:

- Diver sampling;
- Drilling (vibrocore); and,
- Dredging.

Unlike alluvial diamond deposits, the gravel distribution (and ultimately the diamond distribution) of marine deposits can be affected by the following geological, geomorphological and marine parameters that the QP must take into consideration:

- Changes in the river course (i.e. paleo-fluvial conduits);
- Geomorphological bedrock features: gullies, potholes, riffles;
- Nature of the coastline;
- Sea floor characteristics;
- Water depth;
- Currents; etc.

Diamond Recovery Techniques:

When carrying out sampling programs – whether by pitting, trenching or dredging, it is extremely important that every stone that occurs in the volume of gravel being extracted be recovered, since it will improve the confidence limits in the grade estimations and also allow the QP to obtain quantitative data on diamond sizes and grade for geostatistical purposes.

The most appropriate sampling treatment techniques used for testing and processing diamondiferous alluvial gravel samples are:

Manual methods: hand jigging (for exploration sampling purposes); and,

Mechanical methods: Mechanical jigs, rotary pan plants or dense media separation plants ("DMS") (for bulk sampling / trial mining).

Although manual sample treatment methods are appropriate for determining the presence of diamond in gravel, results derived from mechanical recovery methods should be utilised for resource estimation purposes. The chosen sampling treatment plant and flow process should replicate as much as possible the process plant to be used in a future mining operation. As stated, the QP should be familiar with the various aspects of diamond exploration as listed in the Guidelines for the Estimation of Mineral Resources & Mineral Reserves Best Practices Guidelines for diamond deposits.

Bulk Sampling - Trial Mining

After a favourable sampling program and when sufficient gravel volume/tonnage resources have been identified to potentially support a minimum amount of projected production, the next phase of testing will consist of a bulk sampling/trial mining program to provide the technical data of suitable standards and confidence levels for an economic assessment of the property in question.

The objectives of a bulk sampling / trial mining program are:

- to confirm the results obtained from the exploration sampling and gravel resource estimates;
- to determine diamond sizes and grades for the different types of gravel deposits (if appropriate);
- to determine the mining parameters for the different types of gravel deposits (e.g. in-situ bulk density, clay content, etc.);
- to test and refine the proposed mining/processing methods for the different types of gravel present; and,
- to obtain a parcel of diamonds of sufficient size to allow for the determination of diamond size frequency distribution, valuation and modelled value analyses of the alluvial deposit.

Dependent on the number of gravel types and related sample grade estimates obtained from the initial exploration phase, the recommended minimum bulk sample size should be designed such that a minimum of 3,000 carats of diamonds are recovered for grade and valuation determinations. Testing should also be designed to obtain a representative sample from each of the main gravel types, if more than one type is present. Gravel samples should be processed in the same manner as to be used in the process plant that would be used in a full scale operation (refer to CIM Guidelines for the Reporting of Diamond Exploration Results). Types of 'closed' processing plants (as previously mentioned) are:

1) Mechanized jig plants;
2) Mobile or stationary pan plants, and,
3) Mobile or stationary dense / heavy media separation plants.

Diamond Valuation

Diamond valuation is covered under hard rock diamonds. Readers are referred to that Appendix.

Mineral Resource / Reserve Estimation

The CIM Guidelines for the Estimation of Mineral Resources and Mineral Reserves apply to alluvial diamond deposits. As for primary diamond deposits, the criteria utilized for the reporting of diamond MRMR are relevant in assessing the economic potential/viability of a deposit.

Environment

Alluvial diamond mining has created severe environmental problems in many areas. Environmental considerations will require a significant amount of attention in any proposed mining operation. It is strongly recommended that all future alluvial diamond mining projects adhere to current Canadian environmental regulations regarding mining land regulations as well as labour, health and safety regulations as a minimum standard, unless equivalent standards are available.

Reporting

Alluvial diamond placer results / grades have been reported in the following abbreviated manner:

1. Carats / area — ct/m^2 (planar grade)
2. Carats / cubic metre — ct/m^3 (in-situ dry volume or bank cubic metres)
3. Carats / tonne — ct/t
4. Carats / hundred tonnes — ct/100t

The recommended reporting of grades is a combination of 1 and 2. Reporting resources estimates as tonnages is only appropriate if in-situ bulk density measurements have been collected during the exploration and/or bulk sampling phases and if accompanied by a volume to weight calculation (CIM, 2003). However, since gravel generally consists of unconsolidated clastic material, the collection of in-situ bulk density measurements is difficult at best.

Selected References

Marshall, T.R. and Baxter-Brown, R. 1995. Basic principles of alluvial diamond exploration. In: W.L. Griffin (Editor). Diamond Exploration: Into the 21st Century. J. Geochem. Explor., 53, pp. 277-292.

Rombouts, L., 1995. Sampling and statistical evaluation of diamond deposits: Jour. Geochem. Expl., vol 53, pp. 351-367.