Modern analysis for gold: an overview of commercial techniques for exploration and mining.

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ABSTRACT

Modern exploration geologists and geochemists are often faced with a range of options for analysis of their samples for gold concentration. A discussion of the stages of analysis as found in modern minerals analysis laboratories is presented along with explanation of aspects of particular importance to the explorer.

Keywords: gold, analysis, laboratory, sample preparation, detection limits

INTRODUCTION

Analysis of mineral samples for gold content requires a collection or separation step, in which the precious metals are separated from the host matrix, possibly a concentration step and finally determination of elemental concentration by analytical instrument. Most advances in the field of minerals analysis over the past thirty years have been in the analytical instrument field, and extraction techniques have not varied greatly in that time.

Prior to the early 1980's geochemical exploration for gold largely relied on prospecting for pathfinder elements that were easier to detect, or occurred in large haloes around certain types of gold deposit. Analysis for elements such as arsenic, bismuth, tin and antimony was routinely used for this purpose. The advent of low-level detection techniques such as Graphite Furnace AAS for gold analysis in the late 1970's and early 1980's enabled explorers to use the target element itself as an indicator for potential deposits. The successes resulting from these techniques led to a subsequent requirement for even lower detection limits and more cost-effective analytical techniques.

The modern analytical laboratory must provide a service that yields trustworthy gold results in a reasonable timeframe and at a price that the exploration industry can bear. This has necessitated development of procedures that can handle large batches of samples simultaneously whilst maintaining adequate quality controls over all samples.

Analysis procedures consist of three stages: sample preparation, in which geological materials are generally pulverised for sub-sampling, an extraction or separation stage in which the analyte (in this case gold) is extracted and/or separated from the host matrix, and finally an instrumental determination of gold concentration, all of which must be subject to rigorous quality controls. These stages are discussed in the following sections, considering aspects that are of importance to the gold explorer.

SAMPLE PREPARATION

A primary limiting factor in commercially viable analysis of geological samples for gold content is the difficulty of obtaining a statistically valid sample for analysis. Sampling errors in the field or at the mine generally outweigh those in the laboratory[1], however are outside of this document's scope. In general, larger samples are better, however logistical constraints such as transport costs and manual handling constraints place limits on sample sizes, and for practical purposes exploration samples are limited to 2-3kg. Sampling issues in the laboratory are, however, relevant. "Sample preparation" is the term used by laboratories for the process of producing a pulverised sub-sample appropriate for analysis from the submitted bulk, and is a relatively low-technology process involving drying, crushing, splitting and pulverising the sample, however gold presents more challenges in this respect than most analytes.

Unlike most commercial metals, which are usually found as oxides or other compounds, gold often occurs in its metallic form in nature, whether in large nuggets, small veins or discrete, microscopic particles, due to its relative chemical inertness. When combined with the extreme malleability, ductility and density of the metal, this leads to significant problems in dispersing particles evenly through a portion of sample material, so that a representative sub-sample can be taken.

Ideally, any lot of material being sampled would undergo a testing program to determine its relevant properties such as particle shape and size distribution, liberation characteristics for gold particles, degree of heterogeneity, etc. before application of sampling statistical theory to determine optimum grind size and the minimum portions for representative analysis. In practice this is not feasible for exploration sampling, and is only performed on large mining operations where feed is relatively consistent and the cost of the sampling exercise can be justified. In the assay laboratory, sample preparation regimes are designed to be widely applicable, and able to reliably and cost effectively prepare all sample types likely to be received by the laboratory.

Modern laboratory milling machines can reduce most common mineral materials to less than 75μm particle size in a