PLANNING A NEW ANALYTICAL LABORATORY FOR AN URANIUM MINE TAKING AUTOMATION INTO CONSIDERATION

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1.0 INTRODUCTION

Obviously all mining operations require much analytical work to be carried out. This starts with exploration, becomes more stringent with the evaluation of a mineralised area and finally becomes on-going when mining operations are under way. All these phases are carried out by geologists, metallurgists and mining engineers. They require analyses to carry out their functions but usually have no involvement in the analyses themselves. Analyses are carried out at commercial laboratories or in-house analytical laboratories. In the past in South Africa the tendency was for the larger mining houses to have their own centralised laboratories for exploration samples with each mine having it's own laboratory to meet only that mine's requirements. The centralised laboratory maintains QC functions at the subsidiary laboratories. In other mining areas of the world there has been a strong tendency for all geological analytical requirements, especially for exploration and mining, to be carried out at commercial analytical laboratories. In recent years there has been a tendency for mines in South Africa to move in the same direction.

This paper discusses the factors that need to be taken into consideration when a new laboratory is being planned and automation is an option. The planning of the laboratory at the new Langer Heinrich Uranium mine in Namibia is discussed considering these factors.

2.0 REQUIREMENTS OF A MINING ANALYTICAL LABORATORY

The purpose and requirements of a mining analytical laboratory are fairly obvious and can be summarised as follows :-

1. All mining operations must have access to analytical facilities, either in-house or commercial
2. The laboratory must be able to handle all the sample types submitted by the mining operation These can be mining, exploration and/or plant samples. They can comprise solids (rocks, bore-cores), slurries and/or liquids.

3. The laboratory must have the appropriate sample preparation equipment to handle the sample types submitted
4. The laboratory must have the appropriate analytical equipment to carry out the analyses required
5. Staff must be trained, experienced and competent
6. Turn-around time of analyses should be appropriate for those results to be used in process and/or mining control
7. If the mine is in a remote area the laboratory should have back-up sample preparation and analytical equipment in case of a break-down

3.0 CONVENTIONAL MANUAL ANALYTICAL LABORATORY

In a conventional manual mining analytical laboratory all samples will be logged in manually on arrival at the laboratory and will be processed manually through the comminution ie. crushing and milling, sample preparation steps. Splitting and weighing steps are carried out manually. All between-sample cleaning

stages of all sample preparation stages are carried out manually. Sample preparation stages for analysis eg. pressed powder pellet preparation for XRFS, are carried out manually. Samples are loaded into analytical instruments manually and results are collated manually.

Many of the analytical steps have been semi-automated or automated. These include the use of multiple sample magazines for analytical instruments such as XRFS, AAS and ICP.

Manual laboratories typically require large staff complements because sample preparation is very labour intensive and mining and process control samples typically require fast turn-around times which means running laboratories on a 24/7 basis which increases staff requirements even further.

4.0 MODERN AUTOMATED ANALYTICAL LABORATORY

An automated analytical laboratory differs from a manual one in that the bulk of the samples after logging into the computerised system are taken through the entire sample comminution and analytical processes including cleaning of equipment without operator assistance. However, some operators have to be present to replenish empty consumable hoppers and magazines and to be on hand to rectify any unforeseen problem which might occur. All automated systems are programmed to shut down immediately when a problem occurs eg. something jams, and the problem then needs operator attention to rectify the problem and restart the automated system. Such stoppages should be very rare.

Most automated laboratories use automated systems for the main analyses required to be carried out by the laboratory and those analyses which are required to be carried out very infrequently or on small sample numbers are carried out manually. It is obviously uneconomic to automate infrequently required analyses and it also keeps operators occupied who would otherwise have very little to do if they were only employed in the automated systems. It also keeps them in practice with manual analyses. Examples of these would be wet chemical titrations and UVVIS analyses of water for environmental monitoring.

5.0 ADVANTAGES OF AUTOMATION

The advantages of using automation in a mining analytical laboratory are as follows:-

1. As all samples are handled in exactly the same way biases, which can be introduced by operators doing things slightly differently, are removed. This improves the overall quality of data produced.
2. Common operator mistakes such as switching sample ID labels are avoided as samples are tracked by computer. The use of robotics eliminates the need for boring and repetitive jobs to be carried out manually which inevitably leads to some mistakes occurring and in some cases sabotage.
3. As samples are processed sequentially rather than in batches, as is usually the case in a manual laboratory, sample throughput is much quicker.
4. Only a few operators are required per shift. The number of staff required for an automated laboratory is far less than for a manual one. This has obvious cost benefits particularly for mines in first world countries, where labour costs are high, and mines situated in remote areas.
5. The unit cost of analysis per sample is far less in an automated compared to a manual laboratory provided the daily input of samples is high enough.

6.0 BASE METAL MINE LABORATORIES WHICH HAVE BEEN AUTOMATED

Base metal mine laboratories which have been completely automated (from sample preparation to analysis) are :-

1. Skorpion Zinc in Namibia (XRFS of mining and exploration samples)
2. Kumba Resources iron ore in the Northern Cape (XRFS of iron ores)
3. Phelps Dodge Central Laboratory (copper) in Arizona, USA (wet chemical analysis of mining and exploration samples)
4. Ti Mineral Sands (XRFS)

The EBRL laboratory of AngloPlats in Limpopo Province has fully automated XRFS for base metals as part of the fully automated fire assay facility.

Automated base metal analytical laboratories include a very large iron ore laboratory for BHPBilliton in Australia. Additional automated iron ore laboratories are in the final planning stages in the Northern Cape and also Australia.

7.0 BASE METAL MINE LABORATORIES SUITED TO AUTOMATION

Whether a planned base metal mine laboratory is suitable for automation depends on many factors. These can be summarised as follows:-

1. The sample types should be the same or very similar. Automation is best suited to the same comminution and analytical processes on the same types of samples. If different types of sample require differences in sample preparation procedures it can make the automation development very complicated which is likely to lead to break-downs of the automation system. Automation is not normally recommended in this situation.
2. Automation is best suited to those analytical procedures which have already been developed and are currently successfully in use. These include crushing and milling of mine and bore-core solid samples, filter-pressing and drying of plant slurries and the preparation of the comminuted samples for the analytical procedures. These include XRFS by pressed powder pellet and fusion disc, SG measurement by pycnometer and wet chemical base metal analysis. The same automated sample preparation procedures could be applied to AAS and ICP.

However, there is no reason why automated procedures cannot be developed where they do not currently exist if there is perceived to be a need for automation. For example, development is currently under way for the automated sample preparation and analysis by X-ray diffraction (XRD) which is the quantitative determination of mineral phases as opposed to XRFS which measures the concentration of elements.

8.0 FACTORS TO BE CONSIDERED IN MANUAL VERSUS AUTOMATED LABORATORIES

As automation is now available for so many procedures in a base metal mining laboratory (or any mining laboratory, for that matter), in the planning of a new laboratory or the refurbishment or enlargement of an existing laboratory, consideration should always be given to the utilisation of automated procedures.

The main factors to be considered when deciding between a manual or an automated laboratory are as follows :-

1. Cost effectiveness is always a major factor. The initial capital costs of automated laboratories are typically higher than for manual laboratories but the operational costs are lower so the expected life of the mine becomes important. An automated laboratory becomes more cost efficient for a mine with a 10 year life compared to one with a 3 year life. The break-even point can be calculated by taking the capital and estimated running costs of the manual versus automated laboratory for the expected life of the mine and for the expected sample numbers. Running costs would comprise predominantly staff salaries. Cost of consumables and maintenance of equipment will also be factors. Automated laboratories are usually easier to justify in a greenfield situation than a brownfield one. In a brownfield situation it can sometimes be difficult to justify the writing off of capital already spent

as much of the equipment in a manual laboratory cannot be used in an automated laboratory. However, such equipment can be useful as a back-up in case of a break-down in the automated circuits.

2. Number of samples to be analysed is a major factor. It would not be cost effective to have a fully automated analytical laboratory if the automated circuit was only in use for a short period per day. Automation becomes effective if the automated circuit is in operation 24/7 or close to it. In practice, an automated laboratory becomes cost effective if it is required to process at least 150 samples of a similar type per day. An automated sample comminution circuit equipped with one of each items of necessary equipment has a sample throughput time of approximately 10 minutes ie. 144 per day. It becomes difficult to justify for less than 100 samples per day.

However, other factors also come into the picture. Automated laboratories, in general, are more suited to first-world countries with high labour costs and well-developed infrastructures. Manual laboratories are typically more suited to third-world countries with poorly developed infrastructure, low labour costs and short life-span mines. Third-world countries also often demand high employment opportunities for local workers which also militates against automation. The maintenance of high tech automated laboratories would also become more difficult in remotely situated laboratories in third world countries.

Finally, there is no definitive formula for whether a laboratory should be manual or automated.. Each laboratory is unique and all the requirements for each laboratory have to be assessed before arriving at a final decision of whether a laboratory should be manual, automated or have aspects of both.

9.0 PLANNING THE LANGER-HEINRICH URANIUM MINE LABORATORY

The samples to be analysed at the Langer Heinrich Uranium mine are slurry samples, mine ore samples, and final product (yellowcake) samples. The routine slurry samples are pre-leach thickener underflow (leach feed), leach discharge and CCD tails. The slurries are shift composites made up of manually collected hourly aliquots. The ore samples will be infrequent and only taken when requested by the metallurgists. Final product (yellowcake) samples are taken from each drum and composited into batch samples which are delivered to the laboratory. There will only be two or three of these batch samples per day. All filtrates of the slurries are collected and also analysed.

Thus the daily sample throughput to the laboratory is 9 slurry plant composites which are filtered, dried and analysed by XRFS on pressed powder pellets and glass fusion discs. Ore and core samples are crushed, pulverised and also analysed by XRFS using the two methods. There will be about 30 liquor samples per shift and about 10 extra water samples taken on day shift only. At month end there will be an additional 18 slurry samples taken for the metallurgical inventory. All liquors will also be analysed by XRFS using disposable DeKat sample cells.

Clearly a completely manual laboratory is the best option for Langer Heinrich Uranium. The daily sample throughput is too small and there are too many different sample types, sample preparation methods required and analytical techniques for an automated laboratory to be viable.

10.0 CONCLUSIONS

It can be concluded that :-

1. Many factors have to be taken into account when making a decision on whether a new laboratory should be manual or automated.
2. The main factors are cost effectiveness (capital and operational cost of manual versus automated) and sample throughput numbers.
3. Other factors include the siting of the laboratory and whether proven automated technology exists for a particular laboratory's analytical requirements.
4. The Langer Heinrich Uranium laboratory is a manual one because the sample throughput numbers and large variety of sample types, sample preparation methods and required analyses do not make an automated laboratory a viable proposition.