Evaluation of coarse gold-bearing conglomerate mineralisation at Beatons Creek, Western Australia: Development of sampling and assaying procedures

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Many styles of gold mineralisation are challenging to sample because of the presence of coarse gold and a high spatial heterogeneity. The coarse gold-bearing conglomerates of the Beatons Creek deposit provide some challenges related to the presence of gold particles up to 8 mm in size and gold particle clusters (up to 500 mm^3) at low in situ grades (<2 g/t Au). Gold is present within a matrix of multiple, narrow-stacked oxide and fresh (sulphide) conglomeritic reef horizons, which are interbedded with unmineralised conglomerate, sandstones and grits. It is strongly associated with detrital pyrite and authigenic nodules.

Novo attempted to address these issues over the period 2018-2023, applying various methods (Dominy, van Roij and Graham, 2022; Dominy, Graham and Glacken, 2024). The Beatons Creek open pit operation was the first Pilbara conglomerate-hosted gold deposit to go into production. Between January 2021 and September 2022 it produced 2.51 Mt at 1.17 g/t Au for 87,313 oz Au recovered. The project was sold in December 2023.

Several sampling techniques have been applied across the project, including diamond core and reverse circulation (RC) drilling, trench channel sampling and bulk sampling. Assay methods applied include fire assay, screen fire assay, LeachWELL and more recently PhotonAssay. The dominant sampling protocol applied for resource development and grade control (2021-2023) utilised 0.5 m length RC samples; a 50% rig split (c. 8.5 kg) and laboratory crushing to 3 mm, followed by a 2.5 kg split and total assay via PhotonAssay. For part of the 2022 RC programme the detectORE technique was used to screen primary RC samples and reduce the feed to the laboratory. Novo operated a sampling and assay programme that aimed to reduce the impact of coarse gold on sample and assay preparation biases and to improve estimation.

Based on duplicate pair analysis using the mean relative standard deviation, sample precision values range from ±65% (channel, 3 kg LeachWELL), ±62% (RC, 3 kg LeachWELL), ±52% (RC, 2.5 kg PhotonAssay), ±38% (RC, 5 kg PhotonAssay) and ±22% (bulk, pilot plant). The best precision obtained was via bulk samples processed through a pilot plant. Channel sampling was prone to poor precision and high bias due to the over-collection of high-grade conglomerate matrix. The 2020–2021 protocol used the whole 0.5 m composite to form a 5 kg PhotonAssay sub-sample; however, this was reduced to a 50% rig split and 2.5 kg PhotonAssay sub-sample to provide cost and time savings. Sensitivity work in a 10 m by 10 m drilled area indicates that this change had a small impact on the block model (within 5% globally).

High deformable ground over time without any major stress field changes, often referred to as squeezing ground conditions, represents a significant obstacle in the construction and maintenance of underground excavations in rock ,Potvin and Hadjigeorgiou (2008). Mines with this condition have significant challenges to keep the excavations open and operational and often incur considerable expenses in rock reinforcement and support as well as time-consuming rehabilitation, Mercier-Langevin and Hadjigeorgiou (2011).

According to Mercier-Langevin and Hadjigeorgiou (2011), the majority of the currently documented case studies in high deformable ground are from the tunneling industry and not from mining, for example Steiner (1996), Aydan et al (1996) and Barla et al (2007). This process is normally associated with soft and/or weak rock types, but large deformations are also observed in hard rocks if both structure and high stress are present.

It is common not to recognize or to underestimate the conditions leading to squeezing ground during the feasibility stage of a project, which then causes significant difficulties in mining the deposit, higher costs and lost resources Varden et al.(2015). Field observations of the mechanism, associated with the geological-geotechnical characterization, monitoring, numerical modeling as well as support damage analysis can assist in understanding the problem as well as to define actions to solve it.

A 'best of breed' drilling, sampling and assaying programme to optimise grade and geological definition would be a costly exercise. The resource development programme would include RC drilling at <20 m by 20 m, likely 15 m by 15 m and whole 0.5 m composite assaying via either PhotonAssay or laboratory-scale gravity processing and tails assay. For grade control, the RC drill spacing would be c. 7.5 m by 7.5 m, with full PA PhotonAssay assay or laboratory-scale processing. Close-spaced drilling benefits both grade and geological continuity resolution. RC cuttings should be carefully logged for all programmes. The DetectORE method would be used to screen the samples prior to assay and reduce the load to the laboratory. Diamond core drilling would be integrated into the resource development stage, at a spacing of c. 45 m by 45 m, to provide geological information and material for bulk density determination. The drill spacings will only achieve Indicated Mineral Resources, with the resulting grade control model more local and better suited to selective mining. The inherent geological and grade variability in high-nugget coarse gold deposits precludes the definition of Measured Mineral Resources, even at a close drill spacing. On-going geological mapping and control during mining would be critical. The best of breed approach is impractical from cost, time and operational management perspectives and highlights the challenges of evaluating coarse gold-bearing mineralisation. This flags the importance of the Competent Person(s)/Qualified Person(s) in managing project expectations and risk at the resource development and operational stages.

Large mass assays (e.g., >1 kg, LeachWELL and PhotonAssay) are important for coarse gold grade determination. An alternative is to process samples in their entirety via a laboratory-scale unit, though this approach is time-consuming and costly, particularly when large numbers of samples are involved. Such an approach proves more rigorous in the presence of coarse gold, particularly that dominated by >1 mm particles, reducing sampling errors and potentially providing metallurgical data.

PhotonAssay is a significant development in the field of gold analysis (Dominy *et al*., 2024). It provides fast, automated and non-destructive measurements on large samples. The method is agnostic to material composition and granulometry. No chemicals are used and no waste produced. The sample material does not require pulverising and can be assayed in a crushed form. This provides distinct advantages in terms of time and cost and allows for multiple jars to be determined to achieve a large assay lot.

Practitioners should not accept so-called 'standard' or 'best practice' protocols and methodologies for the sampling, preparation and assay of coarse gold mineralisation. The optimisation of a sampling protocol comes from understanding the mineralisation and desired programme outputs. It is not a mathematical process, but a process taking advantage of orebody knowledge and an application of the Theory of Sampling (TOS). Conduct systematic quality control (QC) programmes to measure the reliability of each of the sampling, preparation and assaying steps and then optimise the process. QC cannot be divorced from the TOS and is a mandatory step in representative fit-for-purpose sampling.

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