Sampling of high-nugget conglomerates from the Western Australian Pilbara: Bulk sampling at the Beatons Creek gold project, Nullagine

Simon C. Dominy [a,b,c], Alwin van Roij [d] and Janice C. Graham [e]

[a] **Novo Resources Corporation, West Perth, WA 6005, Australia. E-mail: simon.dominy@novoresources.com**

[b] **Camborne School of Mines, University of Exeter, Cornwall TR10 9FE, UK. E-mail: s.dominy@e3geomet.com**

[c] **Western Australian School of Mines, Curtin University, Perth, WA 6102, Australia.**

[d] **Novo Resources Corporation, West Perth, WA 6005, Australia. E-mail: alwin@novoresources.com**

[e] **Snowden-Optiro, Perth, WA 6000, Australia. E-mail: jan.graham@snowdenoptiro.com**

Many styles of gold mineralisation pose challenges during sampling because of the presence of coarse gold and high natural heterogeneity (“nugget effect”). The gold-bearing conglomerates of the Western Australian Pilbara provide some challenges. Novo Resources Corporation has addressed many of these over the last five years. Its Beatons Creek open pit operation is the first Pilbara conglomerate to go into production (January 2021) based on a total oxide Mineral Resource of 316,000 oz Au (5.2 Mt at 1.9 g/t Au at a 0.5 g/t Au cut-off). Mineralisation occurs within the Beatons Creek conglomerate member of the Hardey Sandstone formation, which constitutes part of the Fortescue Group. Gold is present within the matrix of multiple, narrow stacked and un-classified ferruginous-conglomeritic reef horizons, which are interbedded with un-mineralised conglomerate, sandstones and grits with minor intercalations of shale, mudstone, siltstone and tuffs. The gold occurs as free particles up to 5 mm across within the ferruginous matrix of the conglomerates. It is closely associated with detrital pyrite and authigenic nodules. Previous owners and Novo have employed several sampling techniques across the project including diamond and RC drilling, trench channel sampling and bulk sampling. Assay methods included fire assay, LeachWELL and more recently PhotonAssay. As part of its 2018 evaluation programme, fifty-eight c. 1-4 t bulk samples were collected from accessible oxide mineralisation and processed via a pilot plant. This paper presents some of the issues and solutions applied by Novo, which have wider implications and impact on the sampling of other heterogeneous orebodies.

Introduction

Background

Sampling is a critical component throughout the mine value chain, it includes the sampling of both in-situ and broken material. In all cases, the aim is to gain a representative sample to accurately describe the material in question. The data produced must be fit-for-purpose to contribute to a Mineral Resource (and/or Ore Reserve) reported in accordance with an accepted international reporting code (e.g. 2012 JORC Code, CIM Code 2004, etc).[1,2] Quality assurance/quality control (QAQC) is critical to maintain data integrity through documented procedures, sample security, and monitoring of precision, accuracy and contamination.

Coarse gold-bearing mineralisation is generally characterised by a high in-situ nugget effect and prone to high sampling nugget effect if sampling activities are not optimised.[3–7] Particles greater than 100 µm in size are generally considered to be coarse. The sampling nugget effect is directly related to the sampling process: that is, to the size of the field samples taken; the effectiveness of collection; sample preparation (crushing, pulverising and splitting); the size of sub-samples after splitting; and analysis. Many of these problems can be overcome using larger sample and assay charges, and procedures to minimize sampling errors. Bulk sampling is an accepted method to drive validation of grade and metallurgical parameters in high-nugget mineralisation.

Bulk sampling

The aim of a bulk sampling programmes is to de-risk a project by corroborating local grade estimates and metallurgical testwork (including ore sorter testwork) from drill holes and investigating scale-up and metallurgical responses.[3,8–16] In addition, they provide geological and geotechnical information on the underground or open pit extraction area. They are also used as part of focussed characterisation studies to investigate gold particle sizing in the context of grade and metallurgical properties.[7,10,14–16]

doi: https://doi.org/10.1255/tosf.155

It must be understood that any bulk sample, group of bulk samples or trial mine lot (100s to 1,000s t scale) are unlikely to represent the entire resource.[10,13] It is likely that a local comparison can be made between the resource model and the bulk samples (or trial mine lot). If it can be demonstrated that the local area is a reasonable physical representation of the entire resource (or domain area), then the local validation (if proved) may be inferred globally. It is up to the qualified person (QP)/competent person (CP) undertaking the study to define what a reasonable comparison is, and to declare its basis in all public reporting.

Bulk sampling generally provides the most effective way to assess local grades in complex often coarse-gold high-nugget gold deposits, producing samples at the scale of tonnes. It is also used extensively in the evaluation of hard rock diamond deposits, which display extremely heterogeneous distributions.[17,18] A well-planned bulk sampling programme aims to evaluate mineralisation variability, the resolution of which may require multiple samples from several locations in specific domains. In addition, a programme needs to account for grade variability and not focus solely on high-grade or run-of-mine mineralisation. It should also evaluate difficult to process, as well as easy to process domains if required.

The term “bulk sample” is not rigorously defined and needs to be understood within the context of trial mining. The following definitions can be applied:[10]

- A bulk sample can be taken as the collection of a series of large, often >0.5 t to 100 t samples within a mineralised zone; and
- Trial mining may comprise the extraction of a series of contiguous bulk samples, or underground stopes or open pit bench comprising 100s t or more of rock.

The processing of bulk samples requires careful consideration, options include:

1) Whole lot or batch processing in a process plant;
2) Whole lot or sub-sample split through pilot plant; or
3) Lot splitting via a sampling tower for laboratory or pilot plant processing.

The first (1) option provides the most defendable results given that, assuming rigorous design and operation, all material is processed, and actual gold grade and recovery determined. With appropriate calibration, options (2) and (3) may lead to option (1), but only provide an estimate of gold grade and recovery. Further, option (3) may be problematic on a round-by-round basis unless the sampling protocol is rigorously defined. The decision of whether to use a mill or sampling tower is related to several issues which includes programme aims, mill or tower availability, cost, minimisation of sampling errors, and nature of the mineralisation.

Bulk sampling programmes are typically undertaken during pre-feasibility or feasibility studies. Critical aspects for consideration include sample representativity (sample mass); number of samples; spatial distribution through a domain(s); representation of the grade distribution; and sample processing. These aspects are frequently forgotten or ill-considered during the planning process. During programme planning, the QP/CP must consider the nature of the test area(s) and what the results are likely to mean.[10]

The location and number of bulk samples applied should reflect the grade distribution of selective mining units (SMU). This may not be possible depending on the stage of the project. Geostatistical simulation may be required to simulate SMU blocks.

Theory of Sampling

Sampling remains a critical component throughout the mine value chain.[6,19,20] Without being able to analyse all material in advance, sampling of both in-situ and broken material serves to inform geological (resource and grade control), geoenvironmental and geometallurgical based mine planning and decision-making.[6,15,16,20] Sampling errors can generate both monetary and intangible losses.[6,19-22]

Representative samples are required to effectively evaluate the style of mineralisation in question.[5,6,16] This can be particularly challenging in deposits with coarse gold (>100 µm particles dominate), where large field samples and special preparation-assay protocols may be required.[3,4,7–14,16,23] Unrepresentative samples will not describe the true in-situ gold grade distribution and the overall result generally leads to a lower (undervalued) deposit mean grade.

The Theory of Sampling (TOS) aims to provide answers to two questions: how should a sample be selected and how much material should be taken? It defines a series of sampling errors which, if not minimised, lead to error and uncertainty in the final assay value.[6,21,24] TOS attempts to break down this error into a series of contributions from sample collection through to assaying. The sampling errors are defined in the TOS as promulgated by the works of Gy.[6,21,24]

Table 1 sets outs the definitions of the various TOS sampling errors. The Fundamental Sampling (FSE) and Grouping and Segregation (GSE) Errors are irreducible random errors related to the inherent heterogeneity and characteristics of the material being sampled. They lead to poor precision and can only be minimised through good sampling protocols. The other errors arise because of the physical interaction between the material being sampled and the technology employed to extract the sample. They result in bias, which can be reduced by the correct application of sampling methods and procedures. A sample can be described as representative when it results in acceptable levels of bias and precision.[6,21]

Table 1. Definition of TOS sampling errors. [6,21]

Sampling error	Acronym	Error type	Effect on sampling	Source of error	Error definition
Fundamental	FSE	Correct Sampling Error (CSE)	Random Errors - Precision Generator	Characteristics of the mineralisation. Relates to Constitution and Distribution Heterogeneity	Results from grade heterogeneity of the broken lot. FSE does not cancel out and remains even after a sampling operation is perfect. Experience shows that the total nugget effect can be artificially high because sample weights are not optimal.
Grouping and Segregation	GSE				Relates to the error due to the combination of grouping and segregation of rock fragments in the lot. Once rock is broken, there will be segregation of particles at any scale.
Delimitation	DE	Incorrect Sampling Error (ISE)	Systematic Errors - Bias Generator	Sampling equipment and materials handling	Results from an incorrect shape of the volume delimiting a sample.
Extraction	EE				Results from the incorrect extraction of a sample. Extraction is only correct when all fragments within the delimited volume are taken into the sample.
Weighting	WE				Relates to collecting samples that are of a comparable support. Samples should represent a consistent mass per unit.
Preparation	PE				Refers to issues during sample transport and storage (e.g., mix-up, damage), preparation (contamination and/or losses), and intentional (sabotage) and unintentional (careless actions and non-adherence of protocols) human error.
Analytical	AE	Analytical		Analytical process	Relates to all errors during the assay and analytical process, including issues related to rock matrix effects, human error, and analytical machine maintenance and calibration.

The heterogeneity of a given variable (e.g., grade) can be quantified through the nugget effect and has a direct link to TOS.[5–7,25] The nugget effect is a quantitative geostatistical term describing the inherent variability between samples at very small separation distances. The nugget effect has a wider remit than just differences between contiguous samples and its magnitude relates to the small-scale geological variation and sample measurement error.[5–7,25]

The geological component of the nugget effect expresses short-range data variability, which is particularly significant when samples are small, and protocols not optimised. The sampling component of the nugget effect expresses errors induced by inadequate sample mass, poor sample collection and preparation methods and poor analytical procedures. Throughout the mine value chain, sampling protocols should be optimised to reduce the sampling nugget effect which, in turn, reduces the total nugget effect, data skewness and the number of extreme data values.[3,4,6,7,25]

QAQC is critical to maintain data integrity through documented procedures, sample security and monitoring of precision, accuracy and contamination.[26–28] The ultimate test of any grade control programme comes through reconciliation of actual mine performance versus that predicted by grade control samples.

The Beatons Creek Gold Project

Introduction

The Beatons Creek gold project is in the East Pilbara Shire, between the major regional centres of Newman and Port Hedland, Western Australia. The project area is situated west of the town of Nullagine, which is 296 km southeast of Port Hedland and 170 km north of Newman.

Mineralisation consists of up to 2 m thick auriferous conglomerate reefs hosted by the Hamersley Basin of late Archaean-Paleoproterozoic age within the East Pilbara granite-greenstone terrain of the Early to Late Archaean Pilbara Craton on the north-western part of Western Australia.

There are no official records of gold production at Beatons Creek prior to 1897 and individual accounts of production post-1897 also vary. Most estimates suggest total production was <10,000 t for <4,000 oz Au at grades of between 15 g/t Au to 20 g/t Au. Localised high-grade pockets of mineralisation were mined underground in 1907-1912.

Modern evaluation did not commence until c. 1983, with various companies drilling up to 2007. Novo Resources Corporation (Novo: TSX.NVO) gained 100% control of the project in 2015 and continued drilling though to 2019, including a bulk sampling programme in 2018. The open pit mine went into production in January 2021.

Geology of Beatons Creek

Mapping and drilling have confirmed the Nullagine sub-basin subdivision of the Hardey Formation at Beatons Creek. Mineralisation is restricted to a c. 200 m sequence of poorly-stratified, poorly-sorted, polymictic, pebble-to-boulder ferruginous conglomerate sequence. The underlying sequence is of similar composition, but finer and including sandstone beds and minor tuffs. These beds are characterised by a more regular sediment input and range between sandstone to pebble-conglomerates with several extensive tuff horizons.

The Beatons Mineralised unit and Beatons Middle unit form the c. 200 m thick package comprised of a monotonous sequence of pebble-to-boulder conglomerate with occasional thin interbeds of sandstone. Conglomerate clasts comprise sandstone, siltstone, quartz and dromedary boulders-conglomerates and resembling the Dromedary Hills Mosquito Creek conglomerate unit towards the east.

Regular 0.5 m to 2 m thick horizons show cobble to boulder conglomerates with increased resistive clasts and increased pyrite and represent fluvial channels (proximal to the depositional fan) or zones of marine reworking.

Gold-bearing ferruginous conglomerates are restricted to these channels or marine lags and constrained to the 40 m thick Mineralised Unit at the top of the sequence. Fluvial type conglomerates and marine lags have a clearly defined top and base and represent a higher energy environment conducive to concentrating gold, as well as detrital pyrite and resistive clasts. Gold mineralisation within the Beatons Creek conglomerates occurs as fine grains, larger flakes, and rounded particles rarely exceeding 5 mm in size. Coarse and fine gold is spatially related to higher concentrations of pyrite, and there seems a broad correlation with gold and the 'buckshot pyrite' clast size.[30] Coarse gold particles are regularly visible (Figures 1 and 2).

Figure 1. Gold particles shown within blue circles amongst buckshot pyrite (black dots) from oxide channel conglomerate at South Hill.

Figure 2. Gold in drill core from fresh conglomerate, Grants Hill. Left: BCDD18-002, 0.5 m at 7.3 g/t Au. Right, BCDD18-001, 0.48 m at 4.3 g/t Au.

Mineralisation is restricted to fluvial type channel conglomerates or marine lag reworked conglomerates and readily recognizable from outcrop and drill core. The wider Beatons Mineralised unit and Beatons Middle unit contain minor disseminated pyrite, but the background mineralisation is no more than 0.1 g/t Au.

Channel Conglomerates

Fluvial type channel conglomerates are typically clast-supported, heterolithic, pebble-to-cobble conglomerate with occasional boulders (Figure 3). Imbrication of clasts is commonly evident indicating a general north to northwest flow direction in the project area, and trough cross bedding and channels are commonly evident, suggesting a braided river environment (Figure 4).

Individual channels are often c. 50 m across and can be traced over hundreds of meters. Thickness varies between 0.5 m to several meters. Clasts are dominantly sandstone, conglomerate, siltstone and shale locally derived from the nearby Mosquito Creek formation (+70%), and clasts of several types of metamorphic rocks and granite derived from the basement are less common (<10%), but ubiquitous. White and grey vein clasts are also ubiquitous making up around 10% to 20% of the clast population; sand and silt dominate the matrix and spotty clusters of detrital pyrite (up to 1 cm diameter); as well as fine (<1 mm) rounded and box-work pyrite are common in matrix material, up to 10% of the rock.

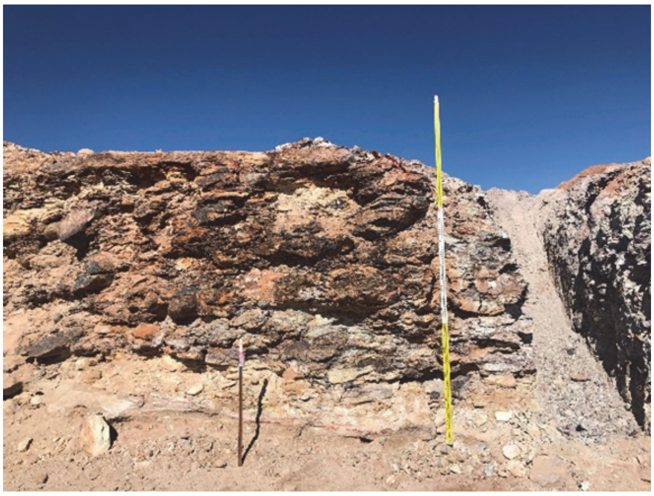

Figure 3. Fluvial type oxide conglomerate exposed in 2018 bulk sampling program (thickness c. 1.8 m).

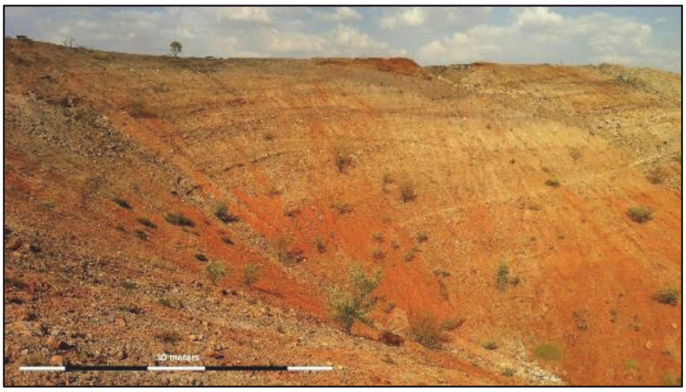

Figure 4. Channel trough cross-bedding in a sequence of fluvial type conglomerates on the southern margin of Golden Crown.

Marine Lags

Marine Lags are typically tightly packed, clast supported cobble-to-boulder conglomerate (Figures 5 and 6). Individual boulders can exceed 1 m diameter and comprise a heterolytic composition, but are dominated by hard, resistant, siliceous dromedary boulders, vein quartz and chert. Sandstone and locally derived shale clasts are less common in marine lags and commonly tucked between or under larger siliceous boulders. Imbrication is rare and individual beds are 0.3 m to 1.5 m thick and sheet-like, being continuous over hundreds of meters with the main two marine lags continuous over 2.5 km. Sand and silt flakes of yellow shale comprise the matrix, with ubiquitous and abundant detrital pyrite (up to 3 cm diameter) is common in matrix material and can comprise up to 20% of the rock (Figure 7).

Figure 5. Tightly packed armored lag-type oxide conglomerate with quartz boulders from the M1 reef, Edwards area.

Figure 6. Armored lag-type oxide conglomerate comprising elongated quartz boulders in the M1 reef, Golden Crown area.

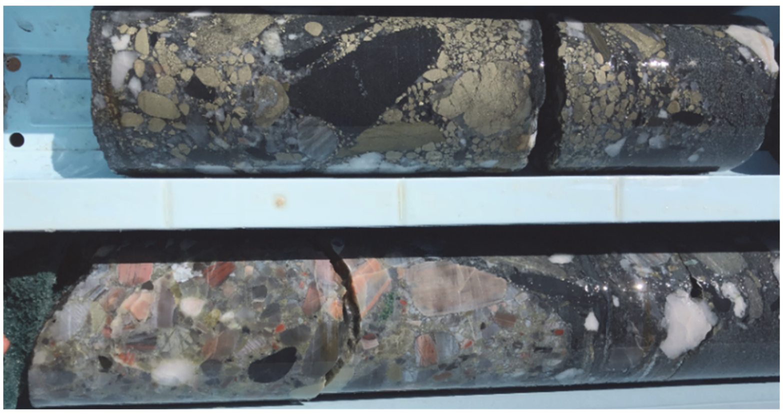

Figure 7. Detrital pyrite (upper) and dromedary boulder (bottom) in fresh mineralisation (PQ core) from Grants Hill.

All fault blocks apart from Golden Crown contain the M1 and M2 defined as the most dominant and consistent lodes. These represent the two most consistent marine lags and are always located in the same stratigraphic sequence (noticeably the M1 approximately 12 m below the lowest marker Tuff, and the M2 approximately 10 m below the M1). This initial framework provides support to the geological continuity of the system. The M1 and M2 lodes are consistent over 2.5 km of strike (Figure 8).

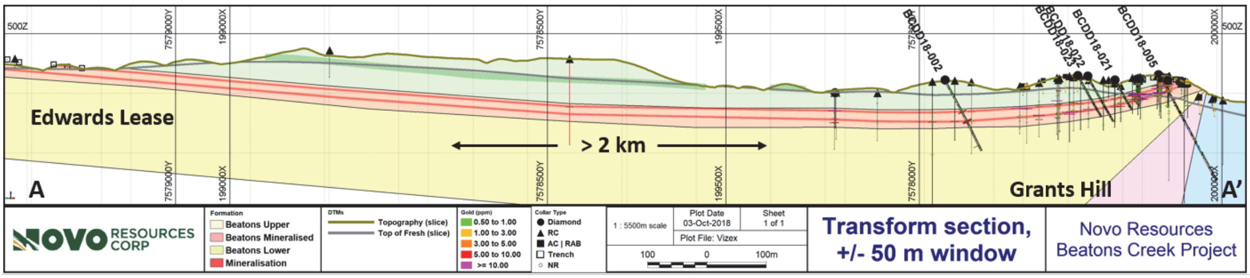

Figure 8. Cross section showing mine stratigraphy, marker tuff and M1 and M2 conglomerate reef continuity.

Conglomerate Formation

Both fluvial and marine lag-type conglomerates are interstratified, indicating the depositional facies in which they formed were laterally proximal. The depositional environment for these conglomerates is interpreted to have been a river fan delta along a coastline as shown in Figure 9. During periods of low-stand, a braided river delta prograde seaward, depositing channelised fluvial type conglomerates. As sea levels rose, wave action winnowed out fine, light sediment leaving behind a transgressive armored lag deposit of large siliceous boulders and heavy minerals including gold. It is in this environment that the conglomerates at Beatons Creek formed. This process repeated several times to create the interbedded conglomerates exposed currently (Figure 9).

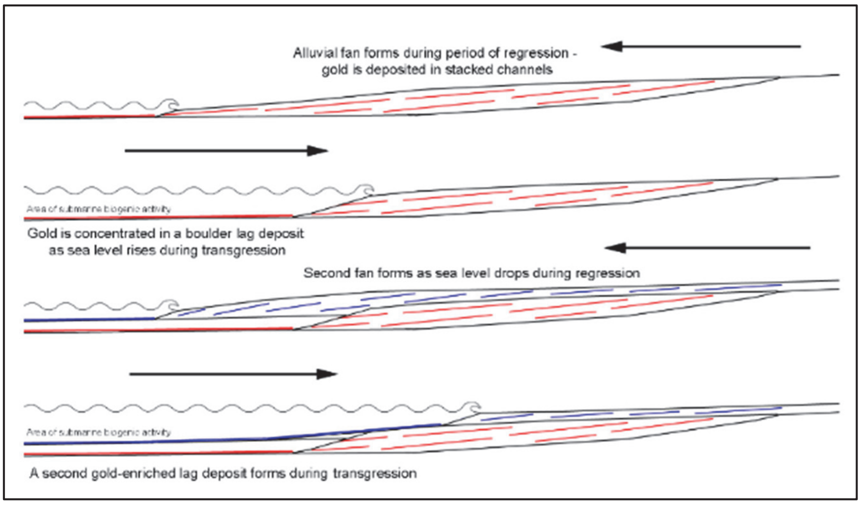

Figure 9. Sequence of two regressive and transgressive tracks from top to bottom.

The Palaeoplacer deposition model employed by Novo for the Beatons Creek project is based on detrital gold sourced from the nearby Mosquito Creek Formation and deposited locally. Mineralisation is further concentrated by reworking an already endowed sequence of conglomerates by marine processes as described above.

Bulk Sampling Programme

Introduction

Novo undertook a bulk samping programme at Beatons Creek during 2018.[29] The samples were part of the evaluation programme attempting to quantify the magnitude and distribution of gold grades within marine and channel lag conglomerate reefs. Forty-five primary and 13 duplicate approx. 2 t bulk samples across 1 m (actual widths vary from 0.3 m to 1.7 m) increments of conglomerate were collected. The bulk samples were collected to investigate:

(a) local grade at a large sample support;
(b) comparison to the block model; and
(c) metallurgical recovery.

The programme was key to support an updated Mineral Resource estimate that would be reported in accordance with Canadian National Instrument 43-101.[29] Samples were shipped to a commercial laboratory for pilot plant processing, and assaying of gravity concentrates, dust and tails samples.

Sample Mass Optimisation

A review of historical metallurgical testwork and trial mining permitted a gold particle size-grade relationship to be inferred across the breakeven cut-off (BCOG: 0.5 g/t Au), run-of-mine (ROM: nominally 2 g/t Au) and high (5 g/t Au) grades.[31,32] The coarsest gold fraction indicates particles up to 5 mm (Figure 10).

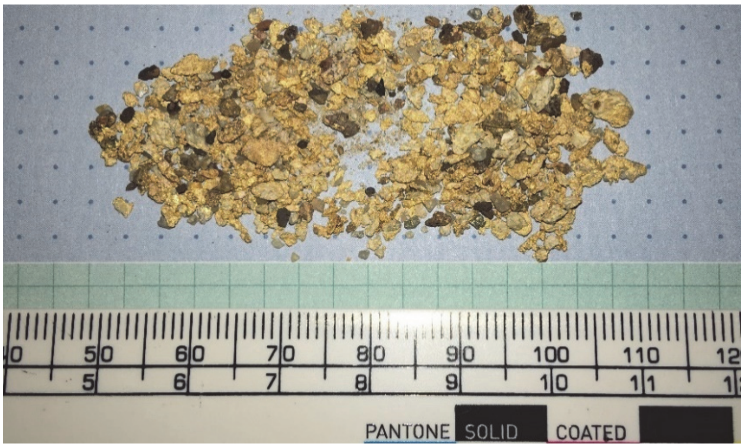

Figure 10. Very coarse gold fraction from a trial mining parcel collected/processed in 2017 yielding a head grade of 1.9 g/t Au.

These were used to apply Poisson statistics to define an optimal field sample mass to achieve a precision of ±15-20% at 90% reliability.[10,31,32] The masses indicated were based on interpretation of historical testwork results, which may or may not be representative of the oxide mineralisation. In addition, gold particle dimensions from testwork will always be less than the true in-situ particle size given comminution-liberation during testwork.

Table 2. Grade-liberation diameter parameters, sampling constant and optimum sample mass values.

Grade / parameter	0.5 g/t Au (BCOG)	2.0 g/t Au (ROM)	5 g/t Au (HG)
Liberation diameter [d_{Au95}] (μm)	250-1,000	500-2,000	1,500-3,000
Sampling Constant (K) (>1,000 is High)	2,300 – 37,000	1,800 – 16,500	8,300 – 23,000
Optimum sample mass [±15-20% at 90% reliability]	0.1 – [2 t] – 3 t	0.1 – [1 t] – 2 t	1 – 8 t

Approx. 1-8 t samples were indicated to achieve ±15-20% precision for high grade mineralisation (5 g/t Au), reducing to 1 t for ROM, and 2 t for BCOG mineralisation. Given a mean conglomerate thickness of 1 m, 2 t bulk sample were collected over 1 m of reef thickness. The sample area (2 m^2) was kept constant, with reef thickness controlling the final sample mass.

Data Quality Objectives

Given the programme was to be used to support a Mineral Resource estimate, data quality objectives (DQO) were targetted during the design phase.[31,32] An existing block model (2018) was used to investigate the distribution of grades. Block grades between the 5th and 95th percentiles were targetted. The presence of surface channel samples were also used to assit with the placing of the samples. Bulk sample location was controlled by uneven topography and acessibility (Figures 11 and 12).

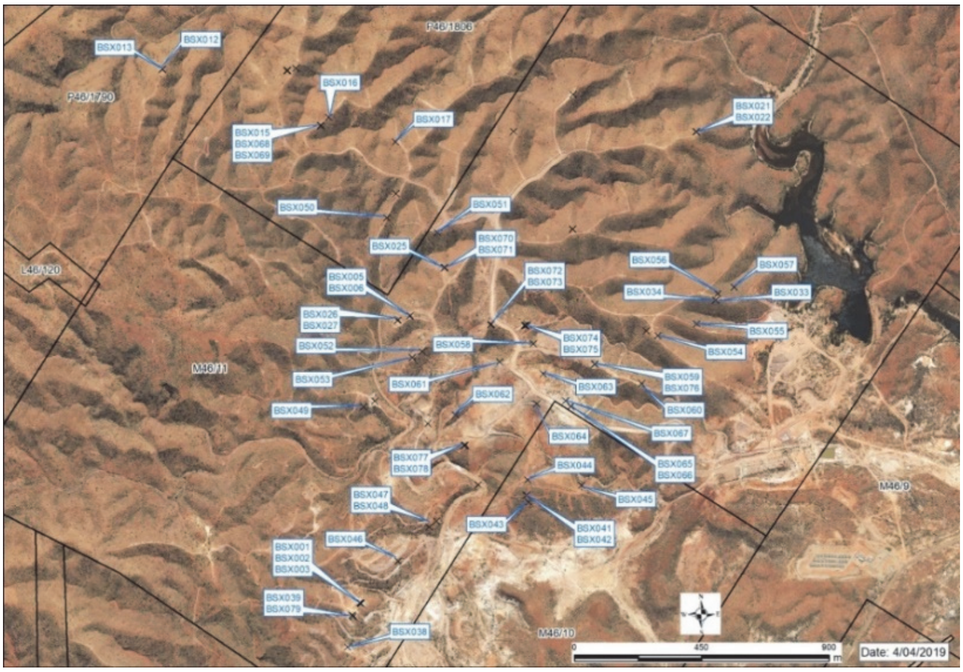

Figure 11. Bulk sample location map (refer to Figure 12).

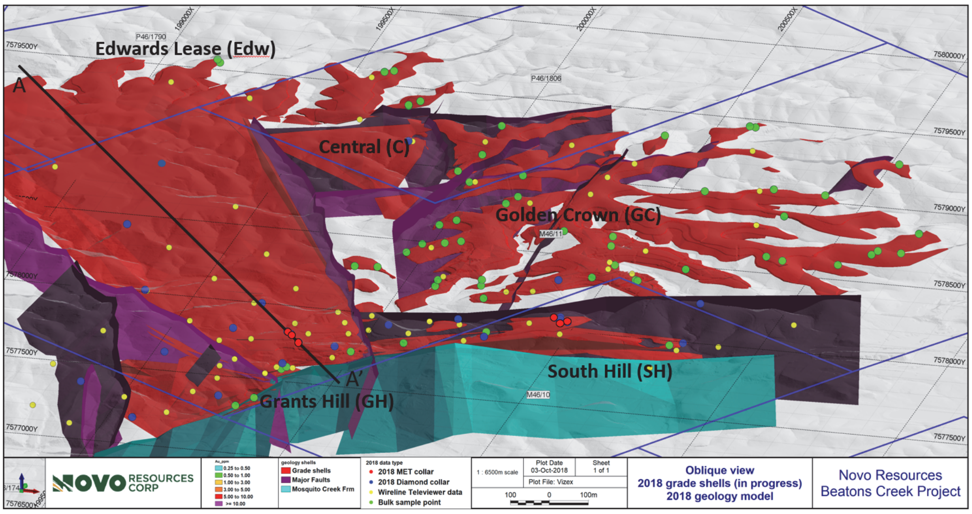

Figure 12. Bulk sample location (green dots) map in context of the resource wireframes.

Precision values (including the FSE) were optimised to be ±20% or better.[31,32] Sample collection and splitting throughout the bulk sample process aimed to minimise all sampling errors (Table 1).

Sample Collection

Sample collection was undertaken by Novo staff, comprising a geologist and field technicians. Once the surface had been cleared of vegetation, a trench was dug to expose a cross-section through the reef and ensure a sequence from the footwall through to the hangingwall was exposed (Figures 13 and 14).

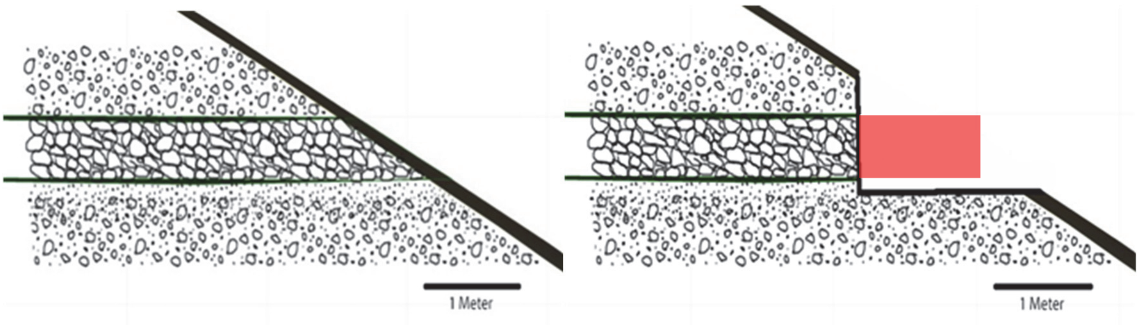

Figure 13. After clearing of surface material, the bulk sample (red box) was cut from the ground to ensure effective extraction.

The geologist guided removal of overburden to expose a 2 m by 2 m area to allow the excavation of a 1 m by 1 m area sample to minimise hangingwall contamination. The sample outline was marked out using spray paint and the surface of the sample was surveyed using differential global positioning (DGPS) system (Figure 14).

Figure 14. Marked out sample ready for collection, through to removal and collected.

The top and bottom (hanging and footwall) contacts of the reef; top and bottom surface of the bulk sample and collar of the sample (centre of the bulk sample) were surveyed by DGPS. Wooden one-cubic metre sample crates were placed within the dump reach of an excavator (Figure 15). A poly-weave bulka bag was placed inside each crate. A metal hopper and grizzly were placed on top of the box and bag to protect the bag and act as a funnel for loading (Figure 15). Any oversize caught in the grizzly (>20 cm) was removed, broken up and returned to the box. On filling, the crate lids were screwed into position ready for road transport. Once the bulk sample interval had been excavated and cleaned, the sample floor was surveyed. After collection, no sample processing was undertaken on site prior to dispatch to the pilot plant Perth.

Figure 15. Wooden shipping crates and metal hopper with grizzly.

All aspects of the sample collection process aimed to minimise DE and EE. The delimited area was kept as tight as possible and all material in that area was collected. Sidewalls of the bulk sample cuts were generally stable. Inevitably there was some fines loss, though this was minimised by sweeping the cut floor.

Bulk Sample Pilot Process

An analysis was undertaken as to the best way to process the bulk samples. Given the expected high level of coarse gold present, it was concluded that whole sample processing was the best option.[31,32] Any sample splitting prior to the extraction of coarse gold was likely to yield a high FSE, GSE, DE, EE and PE.

Fifty-eight samples were processed ranging in mass from 0.6 t to 4.9 t, with a mean of 2.3 t. At the pilot plant, samples passed through a staged crushing circuit that reduced the entire sample to P_{90} -2.5 mm and then pulverised by hammer mill to a P_{90} -0.75 mm (Figures 16 and 17C-D) and was fed to a gravity concentrator (Figures 16 and 17F). The key outputs were (1) gravity concentrate (generally 0.5-1 kg) and (2) 50 kg tails sample. The gravity concentrates were screen fire assayed to extinction. The gravity concentrate grade and tailings grades were combined to give the sample head grade. Key parts of the pilot plant process are shown in Figure 17.

The tails were passed through a slurry splitter to cut a 167 kg sub-sample for assay (Figure 17G), dried and then subsequently RSD split into a 50 kg sub-sample. This was pulverised to P_{80} -200 µm and further split into a series of duplicate samples for assay via 2x 2.5 kg LeachWELL (with duplicate residue 30 g fire assay); 1x screen fire assay (1 kg); and 10x 0.5 kg PhotonAssay.[33] In all, 11 kg of the pulverised 50 kg tails split were assayed.

All sample splits were optimised to keep the FSE to less than ±15% at 90% reliability. All physical splitting activities were undertaken via a rotary sample/sectoral splitter (RSD) to minimise DE and EE (Figures 16 and 17G; slurry and RSD splitters).

Moisture and dust samples were collected as part of the process. Moisture samples (c. 5 kg of –2.5 mm material) were cut from the feed belt prior to the final hammer mill stage (Figure 16). Moisture content was <2%. Material loss between the plant feed and prior to gravity concentration was between 1-4% by mass. This loss generally represented dust loss during the 5-stages of comminution. At selected times, vacuum units were used to collect dust for assay. These were assayed to extinction and contained <4% of the total sample gold.

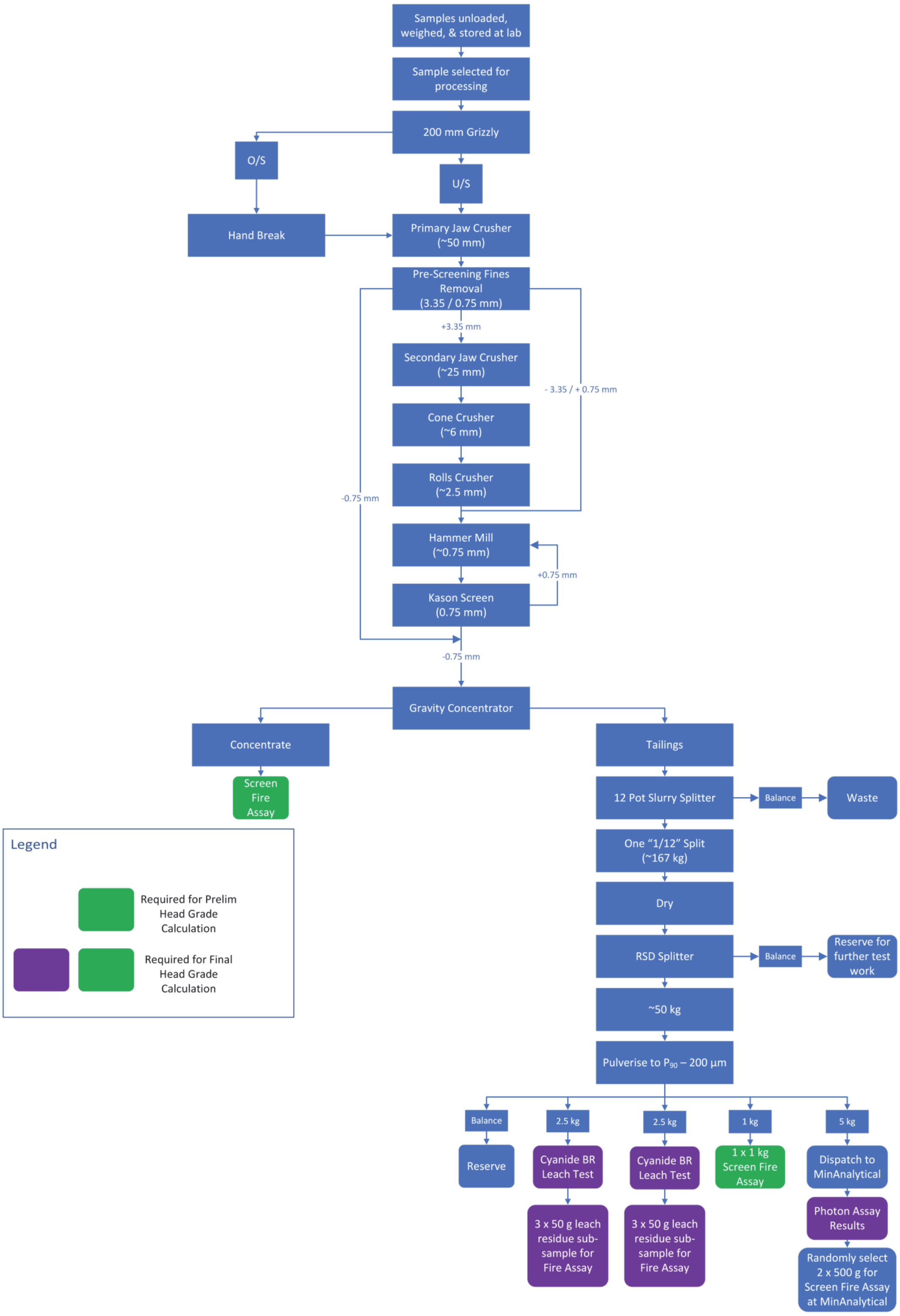

Figure 16. Beatons Creek bulk sample pilot plant process flow-sheet.

Figure 17. Bulk sample pilot plant: [A] Sealed samples boxes at the laboratory; [B] Tagged bulka bag within transport box; [C] Sample feed to primary crusher; [D] Rolls crusher; [E] Screen process; [F] Gravity concentrator; [G] Gravity tails splitter; [H] Tails samples ready for assay submission.

Pilot plant tails samples were assayed via the PhotonAssay method. Five kg of –200 µm material were split into 10x 0.5 kg charges for assay. The PhotonAssay method is a non-destructive and rapid gold assay technique capable of analysing coarse (crushed) 0.5 kg samples.[33] The PhotonAssay measurement precision varies from about 10% relative at a grade of 0.2 g/t Au to about 4% relative at a grade of 1 g/t Au. At grades of 10 g/t Au, the precision is 1.5% or better. The detection limit is approximately 0.03 g/t Au for typical samples.

Quality Assurance / Quality Control

A QAQC programme was designed to support all aspects of the bulk sampling programme. Performance of the QC programme is summarised in Table 3. The relative sampling variability (RSV) is applied (RSV = [standard deviation / mean] x 100) as a precision metric.

Table 3. Summary of bulk sampling programme QAQC outcomes.

Action	Stage	Action	Rate	Actual KPI
Sample collection and integrity	Sample collection, weighing, containment, dispatch and receipt	Novo / Lab	All collection, transport and receiving supervised/inspected	In compliance
Field duplicates	Sample collection	Novo	Approx. 1 in 3	RSV ±22%
Blank	200–250 kg (1 drum) entire pilot process	Lab	Only 1 undertaken due to focus on processing actual samples	<0.1 g/t Au
Barren quartz flush	200–250 kg (1 drum) crush/grind circuit	Lab	1 in 1 flush Assay 1 in 2; split-off 5 kg and assay via 2x LW2500 + 2x SFA500 tails	0.02-0.25 g/t Au; mean 0.1 g/t Au
Pilot plant cleaning	Circuit cleaning between each sample	Lab	All	In compliance
Visual inspection	Crushers, hammer mill and RSD	Lab	All	In compliance
Tails duplicates	35 kg gravity tails second split	Lab	1 in 2	RSV ±15%
Pulp duplicates	Duplicate tails pulps 1 kg 5 kg	Lab	All SFA1000 PA5000	 RSV ±30% RSV ±20%
Umpire	Tails 5 kg split	Lab	All (PA500 / 2x FA30)	RSV ±20%
CRM	Con. and tails assays	Lab	1 in 5	99% ±3δ Bias within ±5%
QAQC review	Throughout programme	Novo	Monthly	High compliance, minor issues only
Lab audit	Throughout programme	Novo	Monthly	All labs visited

RSV: Relative sampling variability; LW: LeachWELL; FA: fire assay; SFA: screen fire assay; PA: PhotonAssay.

Programme Results

Bulk sampling programme global results are summarised in Dominy, Hennigh and Graham[29] and Table 4.

Table 4. Global bulk sample results.

Metric	[1] All	[2] BS+Dup_1	[3] BS+Dup_2
Reported at 0 g/t Au cut-off			
Number of bulk samples	58	45	45
Total mass (t)	136	104	104
Mass weighted grade (g/t Au)	2.16	2.23	2.17
Min. and max. grade (g/t Au)	0.20–6.16	0.20–6.16	0.20–6.16
Min. and max. true reef width [mean true width] (m)		0.30–2.52 [0.81]	
Grade RSV (%)	±66	±65	±68
Reported above 0.5 g/t Au cut-off			
No of bulk samples	52	43	43
Total Mass (t)	119	93	92
Mass weighted grade (g/t Au)	2.42	2.44	2.39
Grade RSV (%)	±57	±60	±61

[1] "All" refers to all bulk samples, including the field duplicates.
[2] "BS+Dup_1" refers to the 45 primary bulk samples plus the primary samples of the field duplicates.
[3] "BS+Dup_2" refers to the 45 primary bulk samples plus the field duplicates.

The global weighted grade above 0.5 g/t Au of the bulk samples (excluding the duplicate pairs) is 2.39 g/t Au and 2.44 g/t Au (Table 5; BS+Dup_1 or Dup_2), and including the duplicate pairs is 2.42 g/t Au. The bulk sample results by resource area are provided in Table 5.

Table 5. Bulk sample results by resource area.

Area	Reefs	[1] No. BS	Total tonnes (t)	Weighted grade (g/t Au)
Central	M1; M2	8	12.1	2.02
Golden Crown channels	930; 931; 934	3	7.2	2.21
Golden Crown marine	921; 922; 923	16	36.6	2.39
Grants Hill	M0; M1	9	23.6	2.58
North	M1	2	2.0	0.79
South Hill channels	341; 342; 343	7	21.9	1.84
Total		45	104	2.23

[1] Note Table uses the single non-duplicated values, refer Table 4 "BS+Dup_1".

The bulk sample results by dominant reef are provided in Table 6.

Table 6. Bulk sample results by dominant reef.

Area	Reef	[1] No. BS	Total tonnes (t)	Weighted grade (g/t Au)
Central	M1	6	8.8	2.33
Grants Hill	M1	8	21.1	2.86
Golden Crown marine	922	10	25.6	2.65

[1] Note Table uses the single non-duplicated values, refer Table 4 "BS+Dup_1".

Bulk Sample Verification

On delivery to the pilot plant site in Perth, all sample boxes were checked for damage and to verify that the internal bulka bags and their seals were not broken. Novo staff visited the pilot plant on a weekly basis to inspect operations and sample progress. All assays (e.g. concentrates, and dust and tails samples) were provided as secured PDF certificates. The inputs to all bulk sample head grade calculations were checked by Novo against the original assay certificates.

Thirteen field duplicates were collected during the programme (Table 7). The duplicate sample was collected directly next to the original sample. The pairwise RSV value was 23%, which indicates that the bulk samples have an acceptable level of precision. The field duplicate precision value includes all variability from in-situ nugget effect; to sample collection and preparation error and analytical error.

Table 7. Beatons Creek duplicate bulk sample results.

Original BS	Duplicate BS	Original grade (g/t Au)	Duplicate grade (g/t Au)	Absolute difference (g/t Au)
BSX05	BSX06	2.26	1.93	0.33
BSX12	BSX13	1.47	0.97	0.50
BSX15	BSX68	4.38	4.46	0.08
BSX21	BSX22	0.77	0.70	0.07
BSX25	BSX70	1.74	0.94	0.80
BSX26	BSX27	1.13	1.23	0.10
BSX33	BSX34	0.44	0.38	0.06
BSX39	BSX79	0.20	0.39	0.19
BSX68	BSX69	4.46	4.29	0.17
BSX70	BSX71	0.94	1.25	0.31
BSX72	BSX73	2.63	2.89	0.26
BSX74	BSX75	1.29	1.33	0.04
BSX77	BSX78	2.81	1.85	0.96
Mass weighted mean grade (g/t Au)		2.07	1.87	-
Pairwise RSV		±23%		

Twenty-five tails duplicates (e.g. 50 kg at –750 µm; Figure 13) were collected during the programme. The pairwise RSV value was 16%, which indicates that the sample tails split has an acceptable level of precision. The tails duplicate precision value includes all error from the RSD split through to the preparation and analytical error.

Bulk Sample Programme and Reconciliation with Estimate

The global weighted bulk sample grade is 2.16 g/t Au (for 136 t) and 2.42 g/t Au (for 119 t) if only samples above the resource cut-off grade of 0.5 g/t Au are considered. Table 8 shows a resource area reconciliation of samples with the 2018 trench channel samples (used in the resource estimate) and the local estimation block grade closest to each bulk sample. Figure 18 shows the distribution of bulk samples and block model (2019) grade within the Golden Crown marine lag (922 domain).

Table 8. Bulk sample results by oxide resource area.

Area	Reefs	No. BS [1]	Weighted BS grade (g/t Au)	2018 trench channel sample grade at BS sites (g/t Au)	Local block model grade at BS site (g/t Au)
Central	M1; M2	8	2.02	4.34	3.27
Golden Crown channels	930; 931; 934	3	2.21	1.21	2.93
Golden Crown marine	921; 922; 923	16	2.39	4.32	2.93
Grants Hill	M0; M1	9	2.58	4.99	2.90
North	M1	2	0.79	3.22	2.33
South Hill channels	341; 342; 343	7	1.84	3.94	2.23
Total		45	2.23	3.97	3.16

[1] Note Table uses the single non-duplicated values, refer Table 4 “BS+Dup_1”.

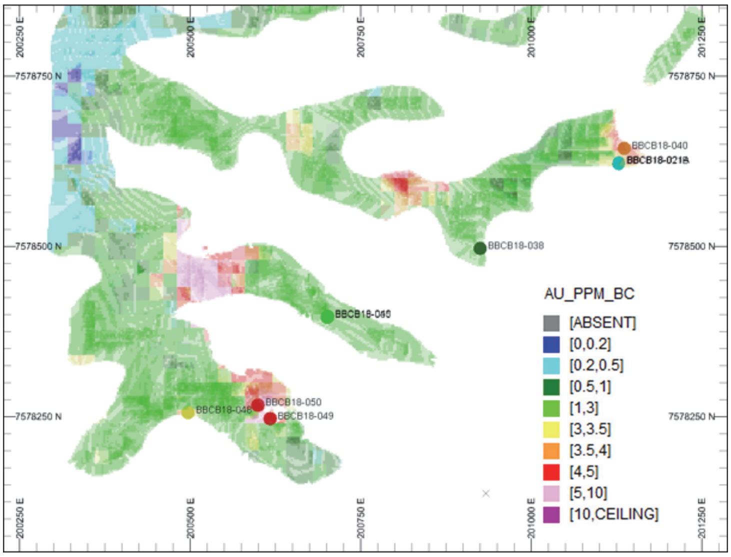

Figure 18. Golden Crown area reef domain 922 showing block model grades and bulk sample (N = 7) distribution and grade.

Figure 19 displays a log-probability plot comparing the bulk sample grades with the 2019 Indicated resource block model. The compared grade distribution is reasonable across the 5% to 95% probabilities.

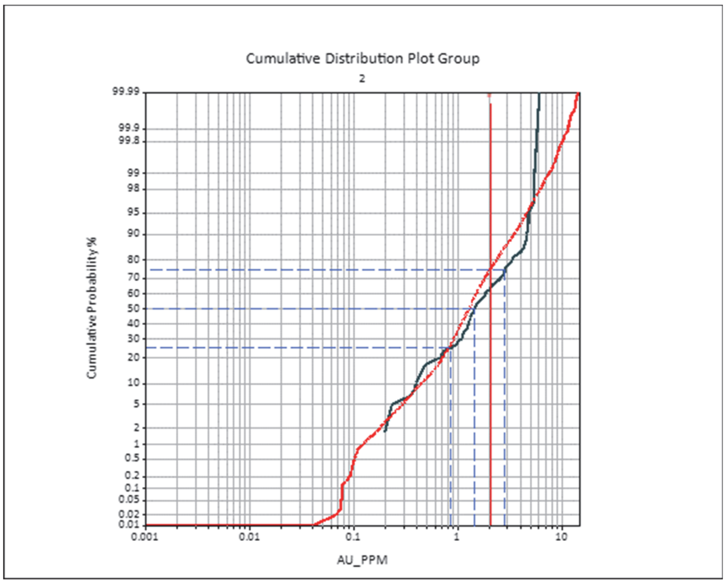

Figure 19. Log-probability plot of block model grade (red) versus bulk sample grade (black).

The local block model (i.e. the resource block that a bulk sample sits in) grades are generally higher than the bulk samples grades; globally 3.16 g/t Au versus 2.23 g/t Au. The trench channel grades are higher than the bulk sample grades; globally 3.97 g/t Au versus 2.23 g/t Au (Table 9).

Table 9. Comparison of mean grades across different sample supports in the oxide mineralisation Indicated Mineral Resource.

Support type	Trench channel sample mean grade at bulk sample sites (uncut grades)	Block model local (bulk sample sites) grades (cut grades in estimate)	Weighted bulk sample grades (uncut grades)	Block model global grade (cut grades in estimate)
Grade	3.97 g/t Au	3.16 g/t Au	2.23 g/t Au	1.88 g/t Au
Support mass	Multiple of c. 50 kg	960 t	2.3 t	960 t

Several issues are key:

- The comparison between a bulk sample (nominally 1 m by 1 m by 1 m; 2.3 t average mass) and an estimation block (nominally 20 m by 20 m by 1 m; 960 t) is not exact given the orders of magnitude difference in support.
- The trench channel samples were collected across the back of the extracted bulk sample void for comparison. It is known that the channel samples are biased high, due to the non-intentional selective sampling (e.g. EE) of the softer gold-bearing conglomerate matrix.
- In the block model-bulk sample comparison areas, trench channel samples dominate the input data and thus the block estimates are locally high.

The bulk sampling programme indicates that oxide mineralisation could locally yield grades of between 0.2 g/t Au and 6.2 g/t Au at a mean of around 2.23 g/t Au (undiluted). Individual or groups of bulk samples cannot be directly compared with resource blocks due to the two orders of magnitude difference in sample support, e.g. 2.3 t versus 960 t. A 960 t resource block could contain 417 bulk samples, which will show a range of grades, some of which will be below the cut-off grade.[13] The mining operation extracts on a selective mining unit (SMU) volume, which is less than the resource block and greater than the bulk sample volumes. At Beatons Creek the SMU block size is 5 m by 5 m by 0.5 m (c. 30 t of oxide mineralisation) based on 10 m by 10 m grade control drilling.[34]

The bulk sample results indicate that the resource grades are reasonable, given the high nugget nature of the mineralisation and sample support issues noted previously. The large estimation block size was applied to reduce conditional bias. There is no selectivity in the estimation blocks due to the smoothing nature of the high nugget effect.

Production/Grade Control Sampling

Beatons Creek went into production in January 2021. For the year 2021, the operation produced 49,365 oz Au from 1.32 Mt at a head grade of 1.25 g/t Au.[35] Mining is guided by 10 m by 10 m spaced RC grade control drilling utilising 0.5 m composite lengths to produce a 5 m by 5 m SMU model (Figure 20).[36] Samples are 50/50 split at the rig (c. 7–9 kg) and submitted to an on-site laboratory where they are crushed to P80 –3 mm and 2–3 kg split off for total PhotonAssay.[34,36] The grade control programme is supported by a full QAQC system including field duplicates, lab duplicates, assay replicates, CRMs, umpire assays and blanks.[37]

Figure 20. RC grade control drilling and sample bags awaiting laboratory submission (L) and grade control block model dig plan (R).

Resource development RC drilling utilises a 20 m by 20 m spacing.[34] Samples are prepared and assayed in the same way as the grade control samples.[36]

Conclusions

Bulk samples were collected following an initial review of historical metallurgical and mineralogical data to determine a grade-gold particle size relationship. The subsequent programme covered the broad grade distribution spatially across several conglomerates and wholly within oxide mineralisation. The bulk samples were collected from what were classified as Indicated Mineral Resources. The programme was deemed to be fit for purpose based on an acceptable total sampling error component of ±23%, and overall compliance with all QC requirements (Table 10).[29]

Table 10. Risk review for the Beatons Creek bulk sampling programme.

	Key Parameter	Comment	[1] Component Error	TOS Error	[2] Error Rating
1	Spatial distribution and number of samples	Samples collected across accessible surface areas of oxide conglomerate mineralisation 48 primary samples collected, with 10 field duplicate samples Reasonable representation of grade distribution (0.2 to 6.2 g/t Au)	20%	GNE	Low
2	Sample mass (representativity)	Indicated optimum mass approx. 1 t to achieve 68% ±15% 2 t samples collected across 1 m of conglomerate			Low-mod.
3	Collection and handling	Supervised collection of samples DGPS locations taken Samples placed into bulk bags		EE	Low
4	Transport and security	All bulka bag samples secured into wooden containers Chain of custody recorded between mine and off-site laboratory Independent transportation of samples to SGS Perth		-	Low
5	Preparation	Entire sample lot crushed and pulverised and passed through a gravity unit Tails sample split at -0.75 mm	16%	-	Low
6	Assay			-	Low
7	QAQC	Full inspection and cleaning of pilot plant; barren flushes run between samples CRMs and blanks inserted at 1 to 25 rate in assay stream Full written protocols for the sampling-assaying process QC results within acceptable limits	-	-	Low
8	Validation/variability indicators	Sample population RSV: 65%	Total 23%		Low-mod.
		Summary			
		Sample collection error rating (1)–(3)			Low
		Preparation and assay error rating (4)-(7)			Low
		Overall fit-for-purpose acceptance			Acceptable

[1] Component errors from limited duplicate pair analysis; [2] Indicative total error rating; red: high (>±50%); orange: moderate (±25–50%); low-moderate (±20–35%); green: low (<±25%). Percentages rounded to the nearest whole value.

From a grade perspective, the programme confirmed the tenor of the mineralisation, with the average grade across of the primary bulk samples (not duplicates) at 2.23 g/t Au (Table 9). It should be noted that the bulk samples were collected purposefully to minimise dilution, so that the grades achieved did not reflect those that may be achieved during mining. The global (Indicated) block model grade was 1.88 g/t Au compared to the bulk sample mean of 2.23 g/t Au. The local block model (immediately around the bulk samples) grade was higher at 3.16 g/t Au, reflecting the high-grade bias effect of the channel samples.

The programme indicated that even at a coarse grind size of 750 µm, good recoveries were possible via gravity (average of 62% recovery).

Recommendations

Bulk sampling programmes require effective planning based on ore characteristics, where protocols must fit the mineralisation type. Key areas for consideration include:

- Bulk sample site(s) requires representation of both grade spatial and population distribution within the ore zone.
- A programme requires definition of aims and DQOs, across grade and metallurgical parameters.
- Programme aims must consider the nature and quality of the estimate(s) being tested. Specific consideration is required of estimation block size and bulk sample size in context of data spacing.
- The application of a mill or sampling tower needs to carefully consider mill or tower availability, programme cost, DQOs (incl. achievable FSE) and sampling error minimisation, and nature of the mineralisation.

Acknowledgments

Current and previous Novo staff are thanked for their contribution to the bulk sampling programme including Dr Quinton Hennigh, Kas De Luca, Don Frost and Pete Gough. The pilot plant was owned and operated by SGS Minerals Pty Ltd. Assay services were provided by MinAnalytical Pty Ltd and SGS Minerals Pty Ltd. The programme was led by Chris O'Brien with Victoria Arrowsmith managing the pilot process, supported by Brendan Parker (Chemech Consulting Pty Ltd). At SGS, John Pizimolas, Matt Pupazzoni and Chris Casingena led the plant operations team. Grade and geological modelling were undertaken using Datamine RM software. Professor Kim Esbensen is thanked for comments on the manuscript, and Dr Anne Cole for assistance with formatting. Professor Hylke Glass and Saranchimeg Purevgerel are thanked for discussions on many sampling related topics.

Abbreviations

The following abbreviations are used in this manuscript:

AE	Analytical error
BCOG	Breakeven cut-off grade
CP	Competent Person (JORC, 2012)
CRM	Certified reference material
DE	Delimitation error
DGPS	Differential global positioning system
d_{95Au}	Liberation diameter for sampling purposes
DQO	Data quality objectives
EE	Extraction error
FA	Fire assay (assay charge size 30 g; FA30)
FSE	Fundamental sampling error
GSE	Grouping and Segregation error
LW	LeachWELL assay (assay charge size 500 g; LW500)
P_{80} or P_{90}	Percent passing (e.g., P_{90}; 90% passing a given screen size)
PA	PhotonAssay
PE	Preparation error
ROM	Run of mine grade
RSD	Rotary sample divider
RSV	Relative sampling variability
SFA	Screen fire assay (assay charge size 500 g; SFA500)
SMU	Selective mining unit
TOS	Theory of Sampling
QAQC	Quality assurance/quality control
QP	Qualified Person (National Instrument 43-101)

ORCID iDs
Simon C. Dominy: https://orcid.org/0000-0002-0638-3693

References

1. JORC Code, “*Joint Ore Reserves Committee (JORC), Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves—The JORC Code*”, Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia, p. 44 (2012).
2. CIM Code, “*CIM Definition Standards for Mineral Resources and Mineral Reserves*”, CIM Standing Committee on Reserve Definitions, p. 10 (2014).
3. S.C. Dominy and J.S. Petersen, “Sampling coarse gold-bearing mineralisation - developing effective protocols and a case study from the Nalunaq mine, southern Greenland”, in *Proceedings Second World Conference on Sampling and Blending*. AusIMM, pp. 151-165 (2005).
4. S.C. Dominy, “Sampling coarse gold-bearing mineralisation – developing effective protocols and a case study from Ballarat, Australia”, in Proceedings *Proceedings Eighth World Conference on Sampling and Blending*. AusIMM, pp. 71-84 (2017).
5. F.F. Pitard, “The in-situ nugget effect: a major component of the random term of a variogram”, in *Proceedings World Conference on Sampling and Blending*. Fundacao Luiz Englert, pp. 91-110 (2007).
6. F.F. Pitard, “*Theory of Sampling and Sampling Practice”*, CRC Press, pp. 694 (2019).
7. S.C. Dominy, “Predicting the unpredictable – evaluating high-nugget effect gold deposits”, in *Mineral Resource and Mineralisation Reserve Estimation – The AusIMM Guide to Good Practice, Monograph #23*. AusIMM, pp. 659-678 (2014).
8. E.C. Cintra, J.A. Scabora, E.P. Viegas, R. Barata and G.F. Maia, “Coarse gold sampling at Sao Francisco mine, Brazil”, in *Proceedings World Conference on Sampling and Blending*. Fundacao Luiz Englert, pp. 187-197 (2007).
9. S.C. Dominy, A.E. Annels, G.F. Johansen and B.W. Cuffley, “General considerations of sampling and assaying in a coarse gold environment”, *Applied Earth Sciences*. **109**, 145-167 (2000). doi.org/10.1179/aes.2000.109.3.145
10. S.C. Dominy, I.M. Platten and Y. Xie, “Bulk sampling of complex gold deposits: material characterisation and programme design and management”, in *Proceedings Sampling Conference*. AusIMM, pp. 41-57 (2008).
11. G.F. Johansen and S.C. Dominy, “Development of sampling protocols at the New Bendigo gold project, Australia”, in *Proceedings Second World Conference on Sampling and Blending*. AusIMM, pp. 175-183 (2005).
12. H. Thalenhorst and D. Dumka, “Bulk sampling of mineral projects using a sample tower: lessons from the field”, *CIM Journal*. **1**, 44-54 (2010).
13. I. Clark and S.C. Dominy, “Underground bulk sampling, uniform conditioning and conditional simulation - unrealistic expectations”, in *Proceedings of the Eighth World Conference on Sampling and Blending*. AusIMM, pp. 3-19 (2017).
14. S.C. Dominy, L. O’Connor, H.J. Glass and Y. Xie, “Geometallurgical study of a gravity recoverable gold orebody”, *Minerals*. **8** (2018). doi.org/10.3390/min8050186
15. S.C. Dominy, L. O’Connor, H.J. Glass, S. Purevgerel and Y. Xie, “Towards representative metallurgical sampling and recovery testwork programmes”, *Minerals*. ***8*** (2018). doi.org/10.3390/min8050193
16. S.C. Dominy, L. O’Connor and S. Purevgerel, “Importance of representative metallurgical sampling and testwork programmes to reduce project risk—a gold case study”, *Mining Technol.* **128**, 230-245 (2019) doi.org/10.1080/25726668.2019.1628462
17. L. Rombouts, “Assessing the diamond potential of kimberlites from discovery to evaluation bulk sampling”, *Mineralium Deposita*. **38**, 496-504 (2003). doi.org/10.1007/s00126-002-0313-4
18. J.J. Langenhoven, “The application of Gy’s formula and sampling best practice at the Snap Lake (Canada) Phase I diamond bulk sampling plant”, in *Proceedings Second World Conference on Sampling and Blending*. AusIMM, pp. 193-204 (2005).
19. P.C. Carrasco, P. Carrasco and E. Jara, “The economic impact of incorrect sampling and analysis practices in the copper mining industry”, *Chemom. Intell. Lab. Sys*. **74**, 209–214 (2004). doi.org/10.1016/j.chemolab.2004.04.013
20. S.C. Dominy, “Importance of good sampling practice throughout the gold mine value chain”, *Min. Technol.* **125**, 129–141 (2016). doi.org/10.1179/1743286315Y.0000000028
21. P.M. Gy, “*Sampling of Particulate Materials: Theory and Practice”*, Elsevier, p. 431 (1982).
22. R.C.A. Minnitt, “Sampling: The impact on costs and decision making”, *J. South. Afr. Inst. Min. Metall*. **107**, 451–462 (2007). doi.org/10.10520/AJA0038223X_3284

23. S.C. Dominy and I.M. Platten, "Clustering of gold particles and implications for sampling", *Appl. Earth Sci*. **116**, 130–142 (2007). doi.org/10.1179/174327507X207474
24. D.M. François-Bongarçon and P.M. Gy, "The most common error in applying Gy's formula in the theory of mineral sampling and the history of the Liberation factor", *J. South. Afr. Inst. Min. Metall.* **102**, 475–479 (2002).
25. D.M. François-Bongarçon, "Theory of sampling and geostatistics: an intimate link", *Chemom. Intell. Lab. Syst*. **74**, 143–148 (2004). doi.org/10.1016/j.chemolab.2004.03.015
26. C.R. Stanley and D. Lawrie, "Average relative error in geochemical determinations: Clarification, calculation and a plea for consistency", *Explor. Min. Geol*. **3–4**, 267–275 (2007). doi.org/10.2113/gsemg.16.3-4.267
27. C.R. Stanley and B.W. Smee, "Strategies for reducing sampling errors in exploration and resource definition drilling programmes for gold deposits", *Geochem. Explor. Environ. Anal*. **7**, 329–340 (2007). doi.org/10.1144/1467-7873/07-128
28. S.C. Dominy, S. Purevgerel and K.E. Esbensen, "Quality and sampling error quantification for gold mineral resource estimation", *Spec. Europe*. **32**, 21-27 (2020).
29. S.C. Dominy, Q.T. Hennigh and J.C. Graham, "Mineral Resource update, Beatons Creek conglomerate gold project, Pilbara Region, Western Australia", *NI 43-101 Technical Report by Novo Resources Corporation*, pp. 139 (2019).
30. P.C. Gough, "A petrographic study and genesis model of the auriferous conglomerates at Beatons Creek, Nullagine, WA", *Unpublished MSc Thesis, Camborne School of Mines,* pp 95 (2014).
31. S.C. Dominy, "Bulk sample representative mass study - Beatons Creek gold project, Nullagine, WA", *Unpublished report by Novo Resources Corporation*, pp. 31 (2018).
32. S.C. Dominy, "Resource development programme, including bulk sampling - Beatons Creek gold project, Nullagine, WA", *Unpublished report by Novo Resources Corporation*, pp. 95 (2018).
33. C.D. Tremblay, J. Tickner, D. Treasure, A. Oteri and G. Wheeler, "PhotonAssay - efficient and bulk gold analysis in the modern world", in *Proceedings of the International Mining Geology Conference*. AusIMM, pp. 88-98 (2019).
34. S.C. Dominy and J.C. Graham, "Grade control programme – Beatons Creek gold project, Nullagine, WA", *Unpublished report by Novo Resources Corporation*, pp. 183 (2020).
35. "Novo Reports 2021 Financial Results", News Release by Novo Resources Corporation dated 1st April 2022.
36. S.C. Dominy and J.C. Graham, "Beatons Creek gold project grade control programme – Stage 1: sensitivity and optimisation analysis and recommendations", *Unpublished report by Novo Resources Corporation*, pp. 120 (2021).
37. S.C. Dominy, "Beatons Creek gold project: Protocols and KPIs for resource development and grade control drilling, sampling and QC", *Unpublished report by Novo Resources Corporation (January 2022 revision)*, pp. 11. (2022).