12th International Kimberlite Conference Extended Abstract No. 12IKC-176, 2024

A New Approach to Sampling and Evaluating Large, Low-Grade Kimberlites at Fort à la Corne, Saskatchewan, Canada

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Introduction

The Fort à la Corne (FalC) Star and Orion South kimberlites form complexes that represent some of the largest diamond deposits in the world (Scott-Smith et al., 1998). These kimberlites are not mono-eruptive, carrot-shaped bodies but multi-eruptive volcaniclastic kimberlites with variably shaped volcanic edifices with shallow craters fed by narrow conduits. Historically, evaluation of these large tonnage, low grade kimberlites has required a methodic and multi-branched exploration strategy. During 2019-20, Rio Tinto Exploration Canada Inc. (RTEC) conducted an innovative bulk sampling exercise on the Star kimberlite using Bauer Maschinen's trench cutting equipment and a world-class bulk sample treatment plant. Newly recovered diamond parcels were used to calibrate the previous LDD sampling results while also augmenting the previous underground bulk sample (UGBS), enabling RTEC to produce updated resource block models for these large, shallow-bodied kimberlites.

Location and Geological Setting

The FalC kimberlite field is situated in east-central Saskatchewan, Canada 60km east of the city of Prince Albert (Figure 1). There are over 70 kimberlites in the FalC field comprising the main trend surrounded by several satellite clusters. Importantly, 75% of the kimberlites have proven to be diamond-bearing and close to 50% have been proven to be macrodiamond bearing (Harvey et al.,2008).

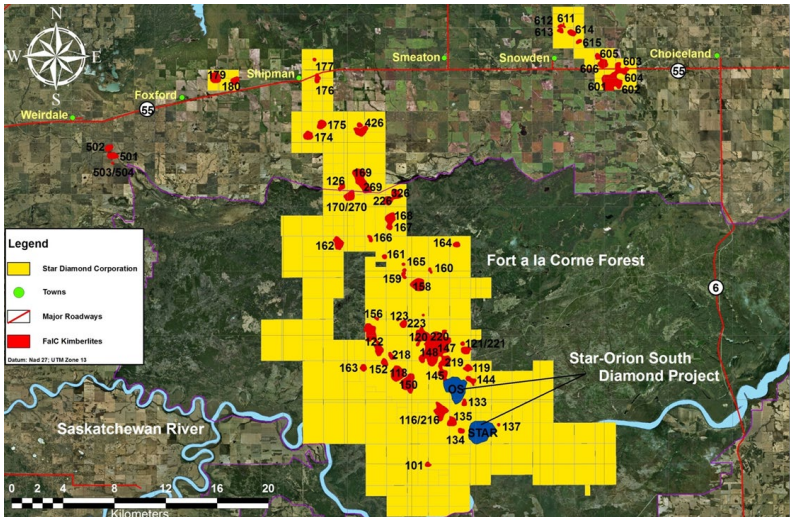

Figure 1: Location of FalC Kimberlite Field

To support the Star Bulk Sampling Program, a dedicated "pilot hole" diamond drill program, 2017 & 2019, of 13 HQ-sized core holes were drilled in close proximity to existing large diameter drill (LDD) holes. These core holes helped confirm and select the bulk sampling locations and provided fresh core for RTEC to log and compare with historical pilot holes. The ultimate product of this work were updates to a geological model of the Star Kimberlite, that was used to help interpret the bulk sampling results.

Star Bulk Sampling Program

In 2019, RTEC used Bauer Machinen's 'Trench Cutter' (Figure 2, left) to drill 10 x 250 metre vertical trenches measuring 3.2 x 1.5 metres, to 250 metres below surface. The Trench Cutter delivered 151 ~ 100 tonne spatially representative samples from the primary geological units in the Star kimberlite. The trench locations were twinned with previous 1.2 metre diameter LDD holes to enable RTEC to compare the concentrate yields and diamond results, and to complete a due diligence exercise.

The -80 mm trench cutter product was pumped to surface, screened at 1.0 mm on RTEC's bespoke and prototype Kimberlite Separation Unit (KSU) (Figure 2, centre) and collected in $1m^3$ bulk bags on Bauer's double-bag bagging unit. Over 6,400 bulk bags were collected during the Star sampling program.

Figure 2: Bauer Trench Cutter (left), KSU (centre), and BSP (right)

An on-site advanced bulk sample plant (BSP) (Figure 2, right) including a Tomra XRT sorting machine processing -25+6 mm kimberlite, a DMS circuit treating -6+0.85 mm kimberlite, a Krupp high pressure grinding rolls re-crushing -25+6 mm XRT rejects to -6 mm and a bespoke diamond recovery circuit (0.85 mm lower cut-off) at the Saskatchewan Research Council (SRC) delivered quantitative results.

Diamond Results and Analysis

On average, the 8-10 metre bulk samples of kimberlite weighed 84.80 dry tonnes, contained 9.98 carats of diamonds comprising 184 stones >1 DTC sieve size for a total of ~1,507 carats (~27,750 stones). The diamonds were sized, counted and weighed, and stones +9 DTC sieve size and larger were classified into Type I and II diamonds using Fourier Transform Infrared Spectroscopy (FTIR) at the SRC. The diamond parcel was sorted by Rio Tinto Diamonds (RTD) in Antwerp into shape, clarity and colour assortments for valuation purposes and was assessed for damage and comparison with historical sampling results.

The trench cutter sampling program achieved improved recoveries in the +1 to +5 DTC sieve sizes compared to the previous 1.2 m diameter LDD and the 235 m level Underground (UG) bulk sampling

programs. The proportion of 1st (top) white diamonds in the trench cutter parcel was higher in the +1 DTC to 4 Gr sizes than in the UG bulk sample parcel. Thirty-two percent of the +11 DTC sieve size and larger diamonds recovered from the trench cutter samples were Type IIs compared to 26.5% for the UG bulk sample (Read, 2022). The diamonds recovered from the Trench Cutter sampling program were assessed for damage (Davy, 2022). This assessment was focused primarily on the 4 Grainers and larger (146 stones weighing 0.9 Cts and heavier). These stones were examined under a binocular microscope for old and fresh damage and the severity of the damage was determined. Only 10% of the 4 Grs and larger (>0.9 Cts) exhibited fresh breakage surfaces, a top-quality result for a sampling program conducted from surface. The improvements listed above were attributed to the passive nature of the trench cutter sample extraction process and the exceptional performance of the modern sample processing plant, viz.:

- Excellent diamond liberation in the Krupp HPGR, recrushing -25+6 mm XRT rejects to -6 mm
- Processing the -6 mm material through a dedicated DMS circuit with a lower cut-off size of 0.85 mm
- Passing the + 2 mm primary XRT and DMS concentrates through an XRT sorting machine for final diamond recovery
- Passing the -2.0+0.85 mm DMS concentrate over a high intensity magnetic separator and treating the non-magnetic fraction in caustic fusion for final diamond recovery.

Summary

In this abstract we have attempted to highlight the benefits of modern sample extraction and processing equipment. To establish the true value (US$ per tonne) of an economic kimberlite, a bulk-sampling program must produce diamond parcels sufficient to define Size Frequency Distributions (SFDs) and Size Quality Distributions (SQDs) with high levels of confidence (i.e. recover 100s of stones in each size class). The price for a particular assortment of diamonds increases exponentially with increasing diamond size and hence the presence of larger stones (Caraters and Specials) in a population is beneficial. Predicting the exact frequency of occurrence and colour/quality of these large stones is a complex task since they are rare and seldom recovered in the exploration and evaluation stages of a project and hence the frequencies of occurrence of the large stones are often estimated as opposed to measured. The larger samples generated by the Bauer Trench Cutter (~100 tonnes per 10 vertical metres) improved the robustness of the historical LDD sample grades.

The 2019 Star Bulk Sampling Program provided access to a new, high-quality dataset enabling RTEC to calibrate the diamond results from previous LDD programs. Careful integration of the Trench Cutter data with the historical data from the LDD and UG bulk sampling programs allowed RTEC to produce updates to orebody models for the Star and Orion South kimberlites.

References

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