# COLLECTION & STORAGE OF ARSENIC BEARING DUST

AT

GIANT YELLOWKNIFE MINES LIMITED

YELLOWKNIFE, N.W.T.


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The Development of Dust and Arsenic Collection Systems

Initial gas cleaning commenced in October, 1951 with installation of a Cottrell electrostatic precipitator to collect the combined dust and arsenic from the exit gases of the Edwards-type, duplex, flat-hearth roaster. Collection efficiencies were in the order of 90 percent from a roaster feed of 40 tons per day.

Early in 1952, a two-stage Fluo-Solids roaster was added to the plant to handle expanded production. With the roaster expansion, a new 9-foot diameter by 150-foot high brick stack was added, together with a booster fan and an enlarged flue system. It was hoped that the new system would improve Cottrell performance with better control of draft and air tempering. However, with the added burden of increased production, the Cottrell efficiency dropped by approximately 10 percent. It appeared that the fluo-solids roasting of arsenopyrite under ideal conditions for gold extraction did not produce good conditions for Cottrell operation. This explained by examination of the chemical reactions occurring in the second stage of the roaster. Over-oxidation of the calcine was avoided, as this impaired extraction, and consequently the atmosphere was controlled to give approximately 0.5 percent oxygen in the exit gases. This was not favourable to sulphur trioxide formation, which aids Cottrell performance by condensing as acid on the dust particles and thereby improving their conductivity.

In 1955, a second Cottrell was installed to operate as a hot precipitator for the selective recovery of the gold-bearing dust prior to the collection of arsenic in the original unit. At this time, roaster tonnage was 100 tons per day and the dust and fume burden had increased to 15 tons per day. It was thought that the extra Cottrell capacity would aid collection and restore efficiency.

The tandem operation of the hot and cold Cottrells gave good dust collections, however through depletion of the meagre acid supply, an even poorer collection of arsenic resulted. Efforts were made to increase the acidity of the gases through the use of fumed sulphuric acid and water vapour, but the tests were only partly successful and the idea was abandoned. When the over-all collection dropped to 60 percent, it was found necessary to operate both precipitators at low temperatures for a more efficient combined dust and fume collection.

A further plant expansion in 1957 was to almost double the quantity of concentrates to be roasted. It was planned to install a new Dorrco Fluo-Solids roaster which would be capable of handling all concentrates. To collect the added burden of arsenic, it was decided to investigate the use of a cloth baghouse. A baghouse test unit was then placed in continuous operation for 1500 hours on a fraction of the roaster gases. Tests were conducted with and without electrostatic precipitators ahead of the test unit. Results were most encouraging and indicated an arsenic collection efficiency of 99 percent and a satisfactory bag life. Consequently, construction of a Dracco baghouse was started in mid-1958 and went into operation in November of that year - just prior to the new roaster start-up.

For a short period, the baghouse operated alone on bulk collection. However, as soon as the new roaster was operating satisfactorily, one Cottrell was again put on-stream as a hot precipitator. From that time, selective collection of dust and arsenic has been carried out without interruption. In the spring of 1962, the original cold Cottrell was converted and now operates in parallel with the other as a hot precipitator. Over-all collection is very satisfactory.

**Current Selective Dust - Collection Practice**

The two Cottrell units currently operate, in parallel, as hot precipitators, handling the gases and dust from the two-stage Dorrco Fluo-Solids roaster - which now treats 140 tons per day of auriferous sulphide concentrates. After passing through the hot Cottrells, the roaster gases are air cooled to 220° for arsenic fume condensation before entering the Dracco baghouse. Filtered gases from the baghouse continue on through a booster fan to a 150-foot brick stack. The dust in the hot Cottrell is processed for gold recovery, and the arsenic collected in the baghouse is either pumped to underground storage or to surface silo.

The two Cottrell precipitators are identical type K, rod-curtain units, each having two parts which operate in parallel. Each part has two sections in series, which have seventeen ducts formed by 8 foot by 12 foot collecting curtains. The power supply (550 volts) is rectified by two mechanical units which also transforms the voltage to 70,000 volts. Rapping hammers, used to dislodge the dust from the electrodes, are time-controlled on both wire and pipe-curtain frames. The dust is collected in V-shaped hoppers below the Cottrells and is removed by screw conveyor to a quench tank - from which it is pumped to a special treatment plant.

The Baghouse for collection of arsenic is an eight-compartment, No. 30 Dracco type. Each compartment contains 300, five-inch diameter by 10 foot Orlon bags. A pressure drop actuated shaking device is provided for dislodging the dust from the bags. Each two compartments are provided with a V-shaped hopper and screw conveyor for the collection and removal of the arsenic. A cross-collection conveyor and a Fuller-Kenyon pump is provided to transfer the arsenic to underground storage.

The gas volume leaving the roaster is approximately 20,500 c.f.m. at 840° F. These gases are air-tempered to a volume of approximately 25,500 c.f.m. at 685° F before entering the hot Cottrell. The temperature drop across the Cottrell is 130° F. The average of 14 tons of dust collected daily in the Cottrells contains 89 percent of the gold in the roaster exit gases. Further air tempering at the mixing fan gives a volume entering the baghouse of approximately 56,000 c.f.m. at 220° F. An average of 12 tons per day of material is collected in the baghouse. This product contains 99.8 percent of the arsenic content in the gases leaving the hot precipitator. The collection efficiency of the system is checked periodically by stack filtration tests.

## Underground Storage of Arsenic Dust

Arsenic dust is stored underground in specially prepared stopes with the following specifications:

1. The stopes are enclosed within an envelope of permafrost.

2. All openings from the arsenic stopes, to other mine workings are sealed to prevent any escape of arsenic bearing dust to them.

3. The storage stopes are excavated in competent ground, and the area is dry before arsenic dust storage is commenced.

Transportation of arsenic dust is achieved by means of Fuller-Kenyon pump, delivering the material through a 4-inch diameter standard weight pipe. The delivery pipe passes through air-tight bulkheads at entries to the storage stope, or is directly connected to 3-inch diameter drill holes to attain maximum distribution over the storage area. Displaced air is returned through a parallel 6-inch diameter pipe to the baghouse filter system. The system is therefore, completely enclosed and no dust loss occurs during transportation.

## Bulkhead Design for Underground Storage

Bulkheads in Arsenic Storage Stopes B2-30/33/34/35/36/08/12/13/14, C#9 and C#10 are of reinforced concrete construction with specifications as set out by the Ontario Department of Mines.

The bulkhead in C2-12 storage stope are of a massive plug design, using one part cement to two parts mine tailings, with no reinforcing material and no hitches. The design criteria is based on South African practice, and on the theory that load is transferred from the concrete to the rock in the form of punching shear around the periphery of the plug, and over its full length.

All bulkheads for retaining arsenic dust have been designed to withstand the full hydrostatic head up to surface. Approval from the Mining Inspector has been received for all bulkheads currently installed.

Detailed drawings of #10 Bulkhead and Inspection Seals are attached.

## Surface Storage of Arsenic Dust

Since March 1, 1981 a portion of arsenic production is stored in a surface silo prior to sale. The silo is located just outside the east end of Baghouse and Cottrell building.

The $As_2O_3$ surface storage and truck loading facility consists of a pneumatic conveying line, storage silo and a load-out building housing a scale (Figure 1.3.1).

The storage silo is a 15,000 cubic foot capacity Peabody pre-engineered, self-supporting bolted steel tank, 26 feet in diameter by 56 feet high. The interior tank surface is coated with an acid resistant epoxy paint while the exterior steel surface is painted with a baked on acrylic. The joints between the tank sections are rubber gasketed and caulked to ensure an air tight structure. The storage silo and foundation are designed to hold either: 780 tons of crystalline $As_2O_3$ at a bulk density of 105 lbs/cu.ft. or 300 tons of baghouse dust at a bulk density of 40 lbs/cu.ft. in a 100 m.p.h. wind, seismic zone 0. Initially the silo will only be used to store baghouse dust (unrefined $As_2O_3$).

A 4 inch diameter pneumatic conveying line and Fuller Kenyon compressed air pump are used to transport unrefined $As_2O_3$ dust from the mill baghouse hoppers to the storage silo. The silo itself will be maintained under negative pressure as air displaced while the silo is filled will be drawn through a fabric baghouse type filter and returned to the roaster gas handling system.

A manually operated DeZurik Knife gate valve is mounted on the bottom of the silo cone. This valve is physically locked in the closed position except for the period of time when a truck is being loaded. This precaution is taken to prevent any material leaving the silo and entering the loading equipment when a truck is not in position.

A Semco rotary valve (followed by a Ramsey sample cutter and splitter) is mounted directly beneath the Knife gate valve. The rotary valve controls the rate of withdrawal of product from the silo thus preventing flooding. The sample cutter and splitter automatically samples the product being loaded and divides this sample into four equal parts thereby minimizing employee exposure to $As_2O_3$.

A Sullivan Scott-Strong screw conveyor mounted beneath the sampler transports the product from the silo to the top of the trucks being loaded. An adjustable tight fitting loading spout mounted on the discharge end of the screw conveyor directs the product into the truck. Dust generated at this drop point is minimized by placing the truck tank and loading the truck tank and loading spout under negative pressure. Air and dust displaced during the loading cycle are drawn through the fabric baghouse type dust collector located on top of the silo and then returned to the roaster gas handling system (figure 1.3.1).

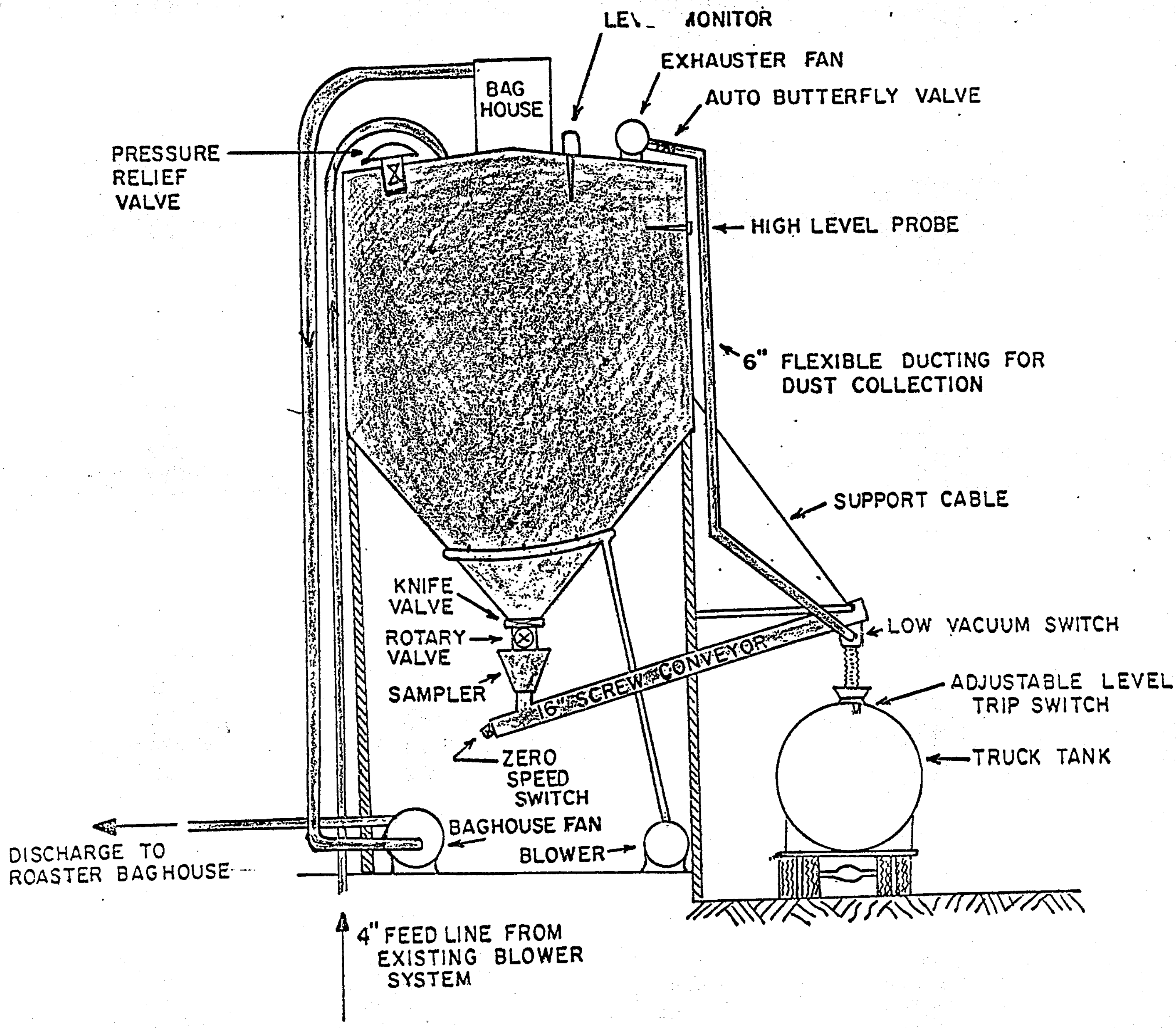


Figure 1.3.1.

ARSENIC RETURN HOPPER

The Silo and truck loading equipment design criteria were to eliminate the need for workmen to come in contact with the product at any time. To this end negative pressures have been induced at all potential dust generation points to prevent fugitive dust emissions.

A fully electronic low profile highway truck scale will be installed alongside the storage silo inside a 75 foot long by 20 foot wide self-supporting steel framed loadout building. Trucks will be loaded while standing on the scale to avoid any potential over-loading. The building will be equipped with overhead vacuum piping to allow immediate clean-up of any possible spillage occurring during loading cycle.

The storage silo is equipped with a high level alarm probe which shuts down the silo fill equipment when tripped to prevent over-filling.

Table I

**Summary of Arsenic Storage by Stopes**

| Stope | Volume Cu.Ft. | As Dust Tons Filled | Cumulative Tons | Date |
|---|---|---|---|---|
| B2-30 | 100,000 | 3,125 | 3,125 | Oct. 28/51 - Dec. 15/52 |
| B2-33 | 434,626 | 12,595 | 15,720 | Dec. 16/52 - Mar. 1/56 |
| B2-34 | 425,000 | 13,281 | 29,001 | Mar. 2/56 - Jul. 10/58 |
| B2-35/36 | 1,125,000 | 35,156 | 64,157 | Jul. 11/58 - Mar. 15/62 |
| B2-08 | 806,840 | 25,033 | | Mar. 16/62 - Dec. 31/64 |
| | | 4,704 | | Jan. 1/72 - Sep. 1/72 |
| | | 394 | | Jul. 1/75 - Jul. 31/75 |
| | | 355 | | Dec. 17/75 - Jan. 9/76 |
| | | 30,486 | 94,643 | |
| B2-12/13/14 | 1,920,000 | 60,410 | | Jan. 1/65 - Dec. 31/71 |
| | | 4,945 | | Sep. 1/72 - Jun. 14/73 |
| | | 65,355 | 159,998 | |
| C2-12 | 638,139 | 10,243 | | Jun. 14/73 - Jun. 30/75 |
| | | 1,794 | | Aug. 1/75 - Dec. 17/75 |
| | | 1,875 | | Jan. 9/76 - May 21/76 |
| | | 3,757 | | Jun. 1/80 - Jan. 9/82 |
| | | 17,668 | 177,666 | |
| C#9 | 471,000 | 20,276 | 197,942 | May 21/76 - May 31/80 |
| C#10 | 200,000 | 10,360 | 208,302 | Apr. /82 - Apr. 30/85 |

Note: 1. Records initiated January 1, 1961. Tons arsenic placed prior to this have been estimated using volume available divided by a tonnage factor of 32 cu.ft./ton for arsenic dust. (This factor appears to be high on the basis of recent data.)

2. The dust from the Jan. 9/82 to mid April/82 period was sold.

**Table II**

**Summary of Arsenic Storage By Years**

| Year | Tons | Cum. Tons | Stope | Remarks |
|---|---|---|---|---|
| 1951 | 467 | 467 | B2-30 (3,125) | 1. First Cottrell installed as Cold Precip. 2. Roaster Feed 40 t.p.d. |
| 1952 | 2,778 | 3,245 | | |
| 1953 | 2,778 | 6,023 | B2-33 | |
| 1954 | 2,778 | 8,801 | (12,595) | |
| 1955 | 5,935 | 14,736 | | 1. Second Cottrell installed as Hot Precip. 2. Roaster Feed 100 t.p.d. |
| 1956 | 5,678 | 20,414 | B2-34 | |
| 1957 | 5,592 | 26,006 | (13,281) | |
| 1958 | 7,979 | 33,985 | | 1. Baghouse installed November 1958. |
| 1959 | 9,500 | 43,485 | B2-35/36 | 2. Roaster Capacity Doubled 3. Roaster Feed 170 t.p.d. |
| 1960 | 9,500 | 52,985 | (35,156) | |
| 1961 | 9,377 | 62,362 | | 1. Records Started. |
| 1962 | 8,617 | 70,979 | | 1. Cold Cottrell converted to Hot Cottrell & operated in parallel with 2nd Hot Cottrell for Selective treatment of dust. |
| 1963 | 8,998 | 79,979 | | |
| 1964 | 8,552 | 88,529 | | |
| 1965 | 9,101 | 97,630 | | |
| 1966 | 8,385 | 106,015 | | |
| 1967 | 7,794 | 113,809 | | |
| 1968 | 8,792 | 122,591 | | |
| 1969 | 8,881 | 131,472 | | |
| 1970 | 8,782 | 140,254 | | |
| 1971 | 8,491 | 148,745 | | |
| 1972 | 6,689 | 155,434 | B2-12/13/14 | |
| 1973 | 6,195 | 161,629 | (65,355) | |
| 1974 | 4,614 | 166,243 | | |
| 1975 | 4,854 | 171,097 | B2-08 (30,486) | |
| 1976 | 5,069 | 176,166 | C #9 (3,100) | 1. To December 31, 1976 |

Summary of Arsenic Storage by Years - Table Continued

| Year | Tons | Cum. Tons | Stope | Remarks |
|---|---|---|---|---|
| 1977 | 5,728 | 181,894 | C #9 | |
| 1978 | 4,782 | 186,676 | C #9 | |
| 1979 | 4,461 | 191,137 | C #9 | |
| 1980 | 1,793 | 192,930 | C #9 (20,276) | To May 31, 1980 |
| 1980 | 716 | 193,646 | C2-12 (17,668) | Remainder of year |
| 1981 | 3,040 | 196,686 | C2-13 (16,915) | Tonnage to Jan. 9/82 when stope became filled. |
| 1982 | 2,501 | 199,187 | C #10 | Started April 1982 |
| 1983 | 3,419 | 202,606 | C #10 | |
| 1984 | 3,815 | 206,421 | C #10 (9,735) | To December 31/84 |
| 1985 | 625 | 207,046 | C #10 (10,360) | To Apr. 30/85 |

## Table III

**Giant Yellowknife Mines Limited - Daily Record Summary**

| Stope | Date Filled | Volume Ft$^3$ | Tonnage By Vol. Calc. | Tonnage Fr. Prod. REc. | Avg.Assay Au Oz/Ton | Record As % | Number of Samples | Geocon Samples Au Oz/Ton | Geocon Samples As % | Oz. Au |
|---|---|---|---|---|---|---|---|---|---|---|
| B2-30 | Oct. 28/51 - Dec. 15/52 | 100,000 | 3,125 | - | 0.724 | - | 5 | 0.766 | 45.32 | 2,262 |
| B2-33 | Dec. 16/52 - Mar. 1/56 | 434,626 | 12,595 | - | | | 8 | 1.325 | 36.93 | 16,688 |
| B2-34 | Mar. 2/56 - Jul. 10/58 | 425,000 | 13,281 | | | | 6 | 2.38 | 36.10 | 31,609 |
| B2-35 | Jul. 11/58 - Mar. 15/62 | | | | | | 6 | 0.776 | 55.20 | - |
| B2-36 | Jul. 11/58 - Mar. 15/62 | 1,125,000 | 35,156 | (Tonnage & Volume Records for these 2 stopes combined) | 0.79 | | 4 | 0.66 | 50.62 | 27,773 |
| | | | | | | | | | | 78,332 |

| Stope | Period | Tons of Dust | Avg % As | Tons of As (Prod.Records) | Avg. Au Oz/Ton | Total Ozs. Au | Stope | Geocon Samples Au Oz/Ton | Geocon Samples % As |
|---|---|---|---|---|---|---|---|---|---|
| B2-08 | Dec. 17/75 - Jan. 9/76 | 355.26 | 62.99 | 233.79 | 0.195 | 69.15 | B2-08 | 0.03 | 45.19 |
| 806,840 ft$^3$ | Jul. 1/75 - Jul. 31/75 | 393.95 | 63.72 | 251.03 | 0.12 | 47.95 | | 0.28 | 46.77 |
| | Jan. 1/72 - Sep. 1/72 | 4,703.82 | 65.07 | 3,051.09 | 0.33 | 1,600.07 | | 0.30 | 56.25 |
| | Jan. 1/64 - Dec. 31/64 | 9,414.07 | 67.51 | 6,355.42 | 0.292 | 2,748.05 | | 0.42 | 68.89 |
| | Jan. 1/63 - Dec. 31/63 | 8,997.66 | 64.89 | 5,838.95 | 0.377 | 3,392.17 | | 0.39 | 65.73 |
| | Mar. 16/62 - Dec. 31/62 | 6,621.65 | 64.38 | 4,263.31 | 0.511 | 3,385.30 | | 0.38 | 57.83 |
| | Total | 30,486.41 | 65.55 | 19,983.59 | 0.369 | 11,242.69 | | 0.19 | 51.51 |
| | | | | | | | Avg. | 0.293 | 57.24 |
| B2-12/13/14 | Jan. 1/65 - Dec. 31/65 | 9,098.28 | 65.47 | 5,939.17 | 0.384 | 3,509.53 | | | |
| 1,920,000 ft$^3$ | Jan. 1/66 - Dec. 31/66 | 8,598.62 | 64.73 | 5,592.14 | 0.315 | 2,731.62 | | | |
| | Jan. 1/67 - Dec. 31/67 | 7,794.21 | 62.50 | 4,882.88 | 0.44 | 3,268.33 | | | |
| | Jan. 1/68 - Dec. 31/68 | 8,774.37 | 62.74 | 5,507.82 | 0.443 | 3,985.35 | | | |
| | Jan. 1/69 - Dec. 31/69 | 8,880.90 | 60.67 | 5,377.21 | 0.492 | 4,437.06 | | | |
| | Jan. 1/70 - Dec. 31/70 | 8,781.83 | 58.51 | 5,144.6 | 0.551 | 4,835.28 | | | |
| | Jan. 1/71 - Dec. 31/71 | 8,481.72 | 55.92 | 4,697.41 | 0.628 | 5,505.91 | | | |
| | Sep. 1/72 - Dec. 31/72 | 1,975.20 | 67.57 | 1,334.44 | 0.215 | 427.25 | | | |
| | Jan. 1/73 - Jun. 14/73 | 2,969.77 | 63.52 | 1,879.44 | 0.285 | 866.71 | | | |
| | Total | 65,354.9 | 61.75 | 40,355.11 | 0.452 | 29,567.04 | | | |

| Stope | Period | Tons of Dust | Avg. % As | Tons of As (Prod.Records) | Avg. Au Oz/Ton | Total Ozs. Au | Stope | Geocon Samples Au Oz/Ton | Geocon Samples % As |
|---|---|---|---|---|---|---|---|---|---|
| C-12 | Jun. 14 - Dec. 31/73 | 3,229.46 | 66.39 | 2,151.99 | 0.214 | 672.18 | No Geocon sampling of C-12 | | |
| 638,139 ft³ | Jan. 1 - Dec. 31/74 | 4,576.08 | 63.90 | 2,926.75 | 0.235 | 1,088.12 | | | |
| | Jan. 1 - Jun. 30/75 | 2,437.29 | 61.37 | 1,500.05 | 0.192 | 463.47 | | | |
| | Aug. 1 - Dec. 17/75 | 1,793.5 | 65.01 | 1,174.02 | 0.13 | 233.88 | | | |
| | Jan. 10 - May 21/76 | 1,874.76 | 65.20 | 1,220.59 | 0.14 | 257.78 | | | |
| | Jun. 1 - Dec. 31/80 | 716.47 | 68.45 | 522.15 | 0.09 | 65.79 | | | |
| | Jan. 1/81 - Jan. 9/82 | 3,040.4 | 67.94 | 2,095.62 | 0.10 | 312.42 | | | |
| | Total | 17,667.96 | 65.61 | 11,591.17 | 0.175 | 3,093.64 | | | |
| C-9 | Jan. 1 - May 31/80 | 1,793.15 | 69.62 | 1,254.97 | 0.09 | 161.38 | C-9 | 0.20 | 40.76 |
| 471,000 ft³ | Jan. 1 - Dec. 31/79 | 4,460.71 | 70.44 | 3,139.41 | 0.08 | 325.98 | | 0.17 | 66.13 |
| | Jan. 1 - Dec. 31/78 | 4,782.28 | 67.16 | 3,237.21 | 0.11 | 521.68 | | 0.09 | 73.06 |
| | Jan. 1 - Dec. 31/77 | 5,727.66 | 64.76 | 3,702.31 | 0.19 | 1,088.26 | | 0.08 | 74.21 |
| | May 21 - Dec. 31/76 | 3,512.19 | 67.02 | 2,348.85 | 0.12 | 414.42 | | 0.06 | 50.56 |
| | Total | 20,276 | 67.48 | 13,682.75 | 0.124 | 2,511.72 | | 0.07 | 68.44 |
| | | | | | | | | 0.05 | 70.06 |
| | | | | | | | | 0.06 | 56.25 |
| | | | | | | | | 0.09 | 71.52 |
| | | | | | | | | 0.14 | 70.36 |
| | | | | | | | | 0.16 | 59.60 |
| | | | | | | | Avg. | 0.103 | 64.12 |
| C-10 200,000 ft³ | Apr. /82 - Apr. 31/85 | 10,360 | 66.94 | 6,935.4 | 0.133 | 1,376.0 | | | |
| Total: | Oct. 28/51 - Apr. 30/85 | 207,046 | 58.93 | 122,011 | 0.609 | 126,123 | | | |

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2. Lane, M.E., Mineral Dressing and Extraction Processes in Use at Giant Yellowknife Mines Limited, Internal Report, Giant Yellowknife Mines Limited, May, 1970.