SUPPORTING DOCUMENT D Arsenic Trioxide Dust Chambers & Stopes

Supporting Document D1 Arsenic Trioxide Chamber Drilling and Testing Program (2004) (SRK, 2004)



## Giant Mine Arsenic Trioxide Management Project

## Arsenic Trioxide Chamber Drilling and Testing Program (2004)

Prepared for:

Giant Mine Project Team Department of Indian Affairs and Northern Development

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# Giant Mine Arsenic Trioxide Management Project

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## **Executive Summary**

This report summarizes the work carried out by SRK Consulting (Canada) Inc. during January to April, 2004 designed to:

- Investigate the geotechnical properties of the *in situ* dust;
- Collect *in situ* samples for laboratory testing, and
- Install long-term monitoring equipment in select, representative arsenic trioxide dust chambers and stopes at the Giant Mine.

The program objectives were to collect data to assess the:

- Loading and bearing capacity of the dust for design of backfilling procedures if required (as based on associated crown pillar stability evaluation);
- Variability of different dust vintages (ie: from different periods of dust production and storage) with respect to chemical, geotechnical, and thermal properties, both in the original dust and due to possible weathering influence; and
- Thermal and piezometric conditions in the selected chambers and stopes to allow for a better understanding of the heat transfer and water saturation/movement within the dust mass.

This report includes the planning and the methodology used in the program, as well as the test results. The analysis and interpretation of the data will be presented in later reports dealing with the actual design of backfilling, freezing, and water infiltration studies that will make up supporting documents to the site Remediation Plan.

Details of the primary drilling (Phase 1) are included in the complimentary report "*Crown Pillar* Stability Evaluation – Arsenic Trioxide Dust Storage Chambers and Stopes, Giant Mine, NT" (SRK, 2004).

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# 1 Introduction

## 1.1 Background

Collection of *in situ* data within the arsenic trioxide chambers and dust stopes was recognized as an important requirement in the overall planning and decision making process for the remediation at the arsenic trioxide stored underground. A two-phase program was carried out in January to April 2004 to study the properties of the crown pillars above the chambers and stopes (Phase 1) and to investigate and instrument the dust stored within (Phase 2).

The physical and chemical properties of the arsenic trioxide dust have been assessed in several studies conducted over the past twenty years. The most important of these studies are:

- Routine gold and arsenic assays by the mine staff;
- Geocon Inc. (1981) Sampling of underground dust and testing of geotechnical properties;
- Giant Yellowknife Mines Ltd. (1981) Analysis of arsenic and gold content of Geocon (1981) samples;
- Jenike & Johanson (1982) Testing of flow properties on Geocon (1981) samples;
- New Brunswick RPC (1988) Chemical and particle size analysis of current dust production;
- Royal Oak Mines Inc. (1998) Chemical analysis of current dust production;
- CANMET (2000) Chemical properties and mineralogy of recent dust production and underground dust samples; and,
- Lakefield Research (2002) Physical and chemical properties of later dust production.

Programs to further investigate the *in situ* condition of the arsenic trioxide dust have been discussed since at least 2001. With the publication of a final report on the arsenic trioxide management alternatives in December 2002, and the subsequent decision by DIAND to select ground freezing as the preferred alternative, it was possible to more precisely define the investigation objectives. That process occurred in mid-2003 and involved the DIAND Giant Mine Remediation Project Team (GMRPT), the Independent Peer Review Panel, and SRK Consulting. Details of the program were then developed by SRK and the GMRPT.

Additional specialists were brought onto the team to prepare health and safety plans and to assist with the *in situ* geotechnical testing of the dust. Miramar Giant Mines Limited (MGML) was contracted to prepare access to the drill sites and construct a personnel decontamination facility. The drilling contract was put out to tender by DIAND, and the successful bidder was Connors Drilling Limited (Connors Drilling), based out of Yellowknife, NT.

## 1.2 Phase 1 Crown Pillar Drilling

Geotechnical drilling was carried out in Phase 1 in order to collect rock mechanics data for the crown pillars. The Phase 1 program is described in a separate report; "*Crown Pillar Stability Evaluation – Arsenic Trioxide Dust Storage Chambers and Stopes, Giant Mine, NT*", SRK, 2004.

Preferred targets for the Phase 1 drill program were selected based on a desktop assessment of the stability of each crown pillar. Where possible, the Phase 1 drillholes were located to provide access points for the Phase 2 work. Siting of the Phase 2 investigation points also took into account the age of the dust in each chamber so that samples representing the early years of production could be obtained.

The Phase 1 drilling took place between January 8, 2004 and February 16, 2004. Drilling operations were carried out by Connors Drilling, and were supervised by SRK, except for some initial drill supervision carried out by T. Canam (former mine geologist at Giant) under subcontract to SRK. As existing underground mine data (tunnel mapping, stope models, etc.) are currently in imperial units, the drilling was conducted using imperial units. To remain consistent with current mine drawings and maps, this report will use imperial units, with metric equivalents listed for comparison.

## **1.3 Phase 2 Dust Investigation**

Phase 2 of the program was carried out from February 19 through March 31, 2004 to measure *in situ* physical properties of the dust, collect and analyse samples of dust produced prior to 1963, and install monitoring instruments in selected chambers and stopes. Phase 2 consisted of re-entering to a number of the boreholes drilled in Phase 1 and completing geotechnical sampling and testing, geochemical sampling, and instrument installation inside selected boreholes. Figure 1.1 shows the drillhole locations.

Progress was delayed on several occasions due to winter conditions (water lines freezing, ice buildup on equipment, cold operating conditions for drill), mechanical downtime, drill staffing problems, required decontamination of staff and equipment, and safety concerns. Phase 2 drilling and sampling were undertaken on a single 12-hour shift (0700 to 1900) basis only. It was considered that sampling operations would be simpler and safer under daylight conditions, and that emergency response (mine first responders and outside emergency response) would be better during normal work hours in the event of an emergency.

The Phase 2 field work was also supervised by SRK staff, with the exception of initial testing and training in the operation of Cone Penetrometer Testing (CPT) equipment. This work was carried out by J. Hughes of Hughes *In situ* Engineering (subcontracted directly to DIAND). Connors Drilling continued to provide and operate all drill equipment for Phase 2. Samples taken in the Phase 2 program were forwarded to several specialist laboratories for testing.

# 2 Methods and Materials

## 2.1 Occupational Health and Safety

#### 2.1.1 General Procedures

In addition to the hazards common to all drill programs on active mine sites, both the Phase 1 and the Phase 2 programs were expected to encounter the arsenic trioxide dust. Therefore, prior to the start of work, BC Research was contracted to develop an Occupational Health and Safety Plan specifically for the program (BCRI, 2003). The following outlines the major activities undertaken to carry out and to monitor the performance of the plan.

All workers were given both a Miramar Giant Mine Ltd. site orientation and a GMRPT Arsenic Chamber Drilling Program orientation prior to starting work on the project. These orientations included general emergency responses, first aid, and safety information, as well as an introduction to hazards and avoidance procedures specific to the chamber drilling program. At the same time, all workers that would potentially be exposed to arsenic dust were trained in the use of non-powered, air-purifying half-face respirators. Each worker was then assigned a respirator and fit-tested to ensure the respirators performed acceptably for each individual.

Daily safety meetings were conducted at the beginning of each shift between, at a minimum, the SRK supervisor and the drilling staff. These meetings were used to discuss the activities of the upcoming shift, to discuss any issues from previous shifts, and to review various aspects of the health and safety plan. Records of these meetings were kept by SRK and staff in attendance signed the records at the conclusion of each meeting.

#### 2.1.2 Urine Arsenic Levels

Staff exposure to arsenic was monitored through the collection and lab analysis of urine samples, provided by each team member. Workers were expected to submit a baseline sample prior to working on the project, and to submit a minimum of one sample a week for the duration of their involvement in the project. Samples were submitted to MGML, and analysed at Miramar's laboratory at Con Mine.

MGML's urine arsenic threshold values were adopted for the Arsenic Chamber Drilling program. These thresholds include a warning level of 100 ppb of total urine arsenic, and a maximum allowable level of 150 ppb urine arsenic. Employees would be removed from working at the drill site if the warning level was exceeded, and not return until urine arsenic levels were shown to be below the warning level. Any worker that exceeded the maximum allowable level would be removed from the contaminated area and sent for medical evaluation.

#### 2.1.3 Airborne Particulate Arsenic Levels

Air-borne arsenic levels within the drill shack were also monitored over the course of the program. An air-borne particulate sampling device consisting of a precisely calibrated pump, timer, and singleuse filter canisters were used to collect samples. Samples were collected during different drilling and sampling to determine the potential exposure of workers to arsenic trioxide dust. For example, background samples were collected from the inside of the drill shack when no activity was occurring, as well as additional samples being collected during general rock coring, during rock coring within 5m of the expected break through to the chamber, during sampling, and during decontamination activities. Activity, duration of sampling, and flow rate were recorded, and the sample canisters were shipped to Envirotest Laboratories in Edmonton for particulate and total arsenic analysis.

A series of samples were collected over the duration of the program to test levels of airborne particulate arsenic in the working environment. At the outset of the program, a maximum acceptable exposure limit of 0.2 mg total As/m<sup>3</sup> was established (BCRI, 2003). This limit represents the maximum concentration of airborne arsenic that was deemed safe for workers with no respiratory protection. Because actual concentrations were unknown ahead of time, the decision was made to require respiratory protection, in the form of air-purifying non-powered half-face respirators, for work in all situations where exposure to elevated concentrations of airborne arsenic might reasonably be expected. Standard occupational hygiene practice dictates that such respirators provide a level of protection such that exposure limits are increased ten-fold, in this case to 2 mg/m<sup>3</sup>.

## 2.2 Phase 1 Drilling

Phase 1 is discussed in detail in "*Crown Pillar Stability Evaluation – Arsenic Trioxide Dust Storage Chambers and Stopes, Giant Mine, NT*" (SRK, June 2004). Drilling was conducted by Connors Drilling, using a 30 HH diamond drill running two 12-hour shifts daily. The drill cut HQ3 core (61 mm) using the triple tube coring technique to minimize mechanical breakage and ensure the highest possible quality core.

Following core drilling and breakthrough into the chambers or stopes, the cavities between the dust surface and the roof of the chambers were investigated using a laser-based Cavity Monitoring System (CMS) operated by Thomas Engineering Ltd. (TEC). The cavity monitoring equipment required that a 150 mm diameter hole be drilled into the stope and a multiple-step process was required to achieve this. First, the overburden was penetrated with a tricone bit driven using HW (114 mm) casing. Tricone advance was halted approximately 0.3 to 0.6 m after bedrock was initially encountered. The overburden hole was then enlarged using large diameter UW (198 mm) casing with a custom cutting surface coated with tungsten abrasive. The UW casing was to remain in place following completion of drilling, monitoring, testing, sampling and instrumentation, and was anchored 0.3 to 1 m into bedrock.

Following setting of UW casing, bedrock coring commenced using diamond drill bits cutting HQ3 (61 mm) diameter core. Coring proceeded from top of bedrock to breakthrough into the respective arsenic stopes. Clay bomb testing was done at multiple positions in each hole to provide information regarding original orientation of the recovered core. The actual path of the borehole was recorded via downhole survey using the Sperry Sun technique. Sperry Sun tests were conducted at two points immediately below the overburden/ bedrock interface, and just above breakthrough into the arsenic trioxide cavity for each hole, and were used in conjunction with the borehole collar survey to position the drillhole in 3-D space.

Following coring and surveying, those drillholes targeted for cavity monitoring were reamed out to 150 mm diameter to accommodate the CMS using a down-the-hole hammer driven by compressed air. During reaming, cuttings and compressed air were conveyed down the diamond drill hole into the open stope below. No cuttings were brought to surface. Following reaming of each hole to 150 mm, the hammer apparatus was withdrawn from the hole, and the rig proceeded to the next hole. Holes were capped with a steel plate following completion of drilling to await cavity monitoring.

The cavity monitoring included an initial video reconnaissance of the drillhole, prior to the laser cavity survey, also performed by TEC. Video reconnaissance was necessary to ensure that the drillhole did not contain any jagged or rough sections that could damage the CMS or cause it to become stuck down the hole. Details of the laser cavity survey methodology are provided in the Phase 1 report, along with the survey results.

## 2.3 Cone Penetration Testing

#### 2.3.1 Method Applicability

The cone penetrometer is essentially an instrumented rod, which can measure the stress on the point of this rod as it is pushed into the ground. In this manner, the resistance of the arsenic dust to the penetration can be determined. As well as the tip stress, the cone records the friction on the side of the cone, and the pressure of any excess pore pressure generated during penetration as shown in Figure 2.1. Figure 2.2 shows the computer data acquisition system in the drill shack.

In natural materials, the side friction, together with the tip stress, can be used to determine the material type that is being penetrated. For example, higher friction stress relative to tip stress indicates higher clay content. The ratio of the pore pressure to the tip stress can also be used to gain some understanding of the material type.

The literature contains many references to the use of the cone data to determine the material properties of natural soils (Robinson and Campanella, 1984; Lunne et al. 1997). However, as the arsenic dust is not a natural material, the correlations presented in the standard texts on cone testing may not be appropriate. A limited investigation undertaken in 1981 by Geocon raised questions regarding the geotechnical behaviour of the arsenic trioxide dust. During that investigation, undisturbed samples could not be obtained, and only limited SPT (standard penetrometer testing)

was conducted. As a result, there was no clear picture as to the likely behaviour of this material. At best, it was postulated that it would be very weak.

In light of the uncertainty about the dust properties, and several practical complications discussed in the next section, SRK and the GMPT decided to contract a specialist for that portion of the work. Mr. John Hughes, P.Eng., of Hughes In situ Engineering, was contracted to ascertain if useable data could be collected from the arsenic trioxide dust using the cone penetrometer. Following initial testing, it was decided that the equipment and methodology provided useful data and so all subsequent drillholes were tested. All CPT equipment was supplied by Hughes In situ Engineering for the duration of the project. From Feb 17 to March 12, six tests were conducted as the drill moved progressively between holes. The cone testing for the first two holes was done by Mr. John Hughes. For the remainder of the holes, testing was completed by Mr. Dylan MacGregor, of SRK Consulting, following training by Mr. Hughes.

#### 2.3.2 CPT Equipment

Conventionally, cones are deployed on specially manufactured rods of 1 m in length and 2.5 cm in diameter. The communication cable, which transmits the signal from the cone tip to the computer at the surface, goes inside the cone rods and is thus protected from damage as the cone is pushed into the ground. Most cone testing is conducted from the surface or within a few feet of the surface. The ground then provides lateral support, so the rods can be pushed into the ground with considerable force. However, at the Giant Mine, the start of testing was over 30 m below the surface. Hence, at least 30 m of rods would have to be assembled and carefully lowered into the hole before the arsenic dust would be encountered. For drillers who are inexperienced in handling rods of this size, this is not an easy task, and the chance of dropping the rods and damaging the communication cord is ever present.

A more serious problem is the unfilled void, of up to 10 m, which was presumed to exist beneath the ceiling of the chambers and the surface of the dust. The small diameter rods would have no lateral support in this void and could easily buckle under axial loads. Additionally, some of the holes were inclined up to 55 degrees to the vertical, and there was the possibility that the surface of the dust could be cemented. These concerns are outlined in Figure 2.3.

In view of these mechanical concerns, the cone was deployed using standard drill rods (see Figure 2.4). BQ (56 mm) drill steel was selected as the advancing rod. Using these standard drill rods meant that the drillers were experienced with the procedures for handling the steel rods, that the drill was properly set up for lowering and holding them, and that the larger steel would be more robust than the smaller cone rods.

To avoid having to thread the communication cable through the drill steel when adding sections, it was necessary to bring the communication cable up the outside of the rods as shown in Figure 2.4. This required protection from dragging against the rough wall of the borehole and the lip of the hole through the cap rock, particularly for inclined holes. As a measure of protection, the cable was fixed

to the drill rods using electrical tape, and a combination of cable ties and custom PVC protective shields. The cone penetrometer itself was attached to a single length of cone rod, in which the cable was housed internally. An adaptor enabled the attachment of the cone rod to the drillers' BQ (56 mm) rods and allowed internal to external transition of the communication cable. This critical joint was protected by a custom housing approximately 100 mm in diameter to protect the communication cable in the event that an exceptionally hard layer or object was encountered.

The communication cable was connected to a notebook computer on surface running proprietary HIE software for recording and displaying real-time CPT data.

#### 2.3.3 CPT Data Collection

Data collection involved progression through a series of steps as directed by the CPT software. Real-time display of data allowed decisions regarding test progress to be made based on conditions experienced at the cone tip and on the response of related hydraulic gauges on the drill rig. In particular, hydraulic head pressure applied by the drill rig was monitored and the decision to end a given test was made largely on the basis of the downward pressures being required to advance the cone that would not trigger buckling of the rods.

Upon "refusal", the CPT was extracted from the hole and fully decontaminated.

#### 2.3.4 Further Data Acquisition

CPT data collection was halted when the applied downward advance pressure was considered to threaten the integrity of the testing apparatus. Dust sampling was then carried out after completion of the CPT test as previously described. During sampling operations, records were kept of downward pressure applied by the drill head, and this data was used to correlate an equivalent cone tip stress. Although this method is not accurate, the information is nonetheless valuable for establishing a rough estimate of the bearing strength of the material encountered, in particular the variability of the resistance.

The sampling procedure varied depending on sampling conditions encountered. The general case was a 0.6m advance of the drill string with a terminal 0.6m split sampling tube without rod rotation. Downward pressure to advance the sampling apparatus was obtained from the pressure gauge for the drill's head, and a value representing a rough average for the 0.6m run was recorded. Where excessive resistance to advance was encountered, advance was facilitated by rotation of the drill string, and the head pressure was also monitored.

In holes B235-P13 and B233-P9, the HQ drill stem was initially advanced through the dust by pushing (+/- rotating) the sampling unit into the dust. When sampling was terminated, the sampling unit was replaced with a tricone. Down-hole advance was then achieved through standard rod rotation/ applied head pressure/ water flushing. All return water remained in the chamber.

During advance, the gauge pressure from the drill head hydraulic cylinder was recorded. This applied pressure, in combination with the weight of the drill head + rod string, gave a very approximate indication of the force at the drill bit. The equilibrium pressure at the bit (drill head + rod string weight, no applied hydraulic load) usually increased uniformly as a function of depth.

To gain some indication of material strength during tricone/ sampler advance, a simple calibration was carried out using the cone at surface. The piezometric cone was pushed into a block of wood at the surface using the drill, and the resulting hydraulic gauge pressure and the cone tip stress were recorded concurrently. The result of this crude calibration indicated that an increase of 100 psi on the drill's hydraulic pressure gauge corresponded to 1000 lb load at the cone tip. Using this rough calibration, the gauge hydraulic pressure was correlated with an equivalent cone tip stress under conditions of bit advance without rotation. If advance by applied downward pressure was halted, it was necessary to rotate the drill string to facilitate further advance. In this case, the relationship between hydraulic gauge pressure and equivalent cone tip stress was used to estimate a lower limit of equivalent cone tip stress. Because rotation of the drill string (+/- washing with water) made it easier to advance down the hole, the recorded applied hydraulic pressure represents a minimum stress necessary for advance.

The sampling process was slightly different in the remainder of the holes. The drill stem was always advanced with the sampling unit in place rather than the tricone. Refusal was not encountered when the rods were advanced by an applied downward hydraulic pressure with rotation. The applied hydraulic pressures were recorded during sampling unit advance. In this situation, resistance to dust penetration is more complex than when a solid drill bit is pushed into the dust. The resistance to penetration will be the result of both end area resistance and friction along the inside and outside of the sampling tube. Based on the geometry of the sampling tube and the drill stem, it was estimated that approximately 50% of the tip force would be resisted by end area alone. Using this approximation, the recorded applied hydraulic pressure could again be used to give some indication of the equivalent cone tip stress. If the rod string and sampling unit required rotation to advance, the estimate of equivalent cone tip stress would yield a lower limit of material strength characteristics.

In the weaker zones, the drill rod would penetrate under its own weight with no applied downward pressure. Where advance by rod weight alone was halted, the additional weight of the drill head was often sufficient to allow further penetration. Where water was used during triconing operations (B235-P13 and B233-P9), the drill rods remained full of water for the lower portion of the hole. This additional weight was often sufficient to advance the rods without any downward hydraulic force.

## 2.4 Arsenic Trioxide Dust Sampling

#### 2.4.1 Sample Selection

Following collection of CPT data, samples of the arsenic trioxide dust were retrieved for laboratory testing of geotechnical, geochemical and thermal properties. Bulk samples of arsenic trioxide dust produced during the late stages of ore processing at Giant are stored on surface and are readily

accessible for sampling and testing purposes. Therefore, the 2004 sampling focused on the collection of arsenic trioxide dust produced during the early stages of ore processing.

As shown in Table 2.1, the drillholes provided good access to dust deposited over the entire history of the mine. Any variability in chemistry and degree of weathering over time was expected to be captured through sampling from these holes. In particular, the older dust, for which there was previously very little available geotechnical and geochemical information available, was well targeted.

Stope or Chamber	Date(s) Filled	Volume (m³)	Weight Dust (Tonnes)	Arsenic Content (%)	Weight Arsenic (Tonnes)	Equiv. As₂0₃ (Tonnes)	Gold g/t	Gold Content (gram)
B230	Oct. 28/51-Dec. 15/52	2,832	2,835	45.31	1,285	1,696	24.8	70,372
B233	Dec. 16/52-Mar.1/56	12,307	11,426	36.93	4,219	5,569	57.3	654,611
B234	Mar.2/56-July 10/58	12,035	12,048	36.10	4,349	5,741	80.0	963,315
B235/336	July 11/58-Mar. 15/62	31,856	31,893	53.37	17,022	23,453	27.1	863,844
B235	Aug. 22/88		1,052	60.78	640		4.9	5,123
B236	Dec. 12/88-Dec.30/88		167	63.59	106		7.8	1,305
B208	Mar.16/62-Dec.31/64	22,847	22,710	65.75	14,930	25,451	13.1	296,652
	Jan.1/72-Sept.1/72		4,267	64.86	2,768		11.3	48,283
	July1/75-July31/75		357	63.71	228		4.1	1,471
	Dec.17/75-Jan.9/76		322	65.92	212		66.9	21,531
	Mar.11/86-Sept.26/86		1,707	66.95	1,143		4.1	7,024
B212/213/ 214	Jan.1/65-Dec.31/71	54,368	54,803	61.48	33,694	48,325	16.0	879,354
	Sept.1/72-June14/73		4,486	64.99	2,916		9.0	40,297
C212	June.14/73-June30/75	18,070	9,292	64.23	5,968	14,674	7.4	69,135
	Aug.1/75-Dec.17/75		1,627	65.44	1,065		4.5	7,254
	Jan.10/76-May21.76		1,701	65.12	1,108		4.8	8,165
	June 1/80-Jan9/82		3,408	69.68	2,375		3.5	11,802
	May 22/85-Mar.1/86		917	65.48	601		4.1	3,773
#9	May 21/76-May 31/80	13,337	18,394	67.48	12,413	16,386	4.3	78,201
#10	Apr.1/82-May 22/85	5,663	9,569	66.83	6,395	8,441	4.6	43,963
#11	Sept.26/86-Aug.22/88	9,833	5,743	67.52	3,878	5,214	4.7	26,978
	Nov.30/88-Dec.12/88		116	61.27	72		7.8	904
#12	Dec.30/88-Dec.31/94	25,485	24,872	69.78	16,373	21,612	6.0	148,381
	Nov.15/97-Dec.31/97		320	68.72	220	291	4.6	1,460
	Added after 1997		1,051	na	na	na	na	na
#14	Jan.1/95-Nov.14/97	12,013	9,105	65.48	5,962	7,870	5.5	49,633
	Added from Jan. 98 $\rightarrow$		3,152	na	na	na	na	na
#15	Not used (empty)							
Total:	Oct.28/51-1998	220,640	237,343	60.02	139,941	184,721	18.4	4,361,689
	•	Equivale	ent As <sub>2</sub> 0 <sub>3</sub> (%)	79.20		•		

Table 2.1: Arsenic Trioxide Dust Filling History

Note: Highlighted cells denote chambers investigated during the Phase 2 program and the related date of dust production/filling. Many of the chambers were filled at an early date in the mine life, and later "topped up". Imperial units used in original tables

Original gold values assumed to be reported in oz/t = troy oz/short tons

g/t = grams/metric tonne

#### 2.4.2 Initial Sampling Methodology

Samples were collected using a 0.6 m split sampling tube, also referred to as a split spoon. The sampling was carried out through the drill rods, using a wireline sampling system, as shown in Figure 2.5. The split tube is held together by a threaded lifter case at the terminal (bottom) end. The terminal end of this lifter case is what penetrates the dust during advance, and the lifter case is bevelled to facilitate penetration. The top end of the split tube is secured by a threaded sub which connects the split tube to a casing advancer. The casing advancer has a shoulder at the bottom that prevents the casing advancer from passing a landing ring fixed at the end of the rods, and a spearhead at the top that allows the entire sampling unit to be retrieved with the wireline. When the sampling unit is seated, the casing advancer rests on the landing ring at the end of the rods and is locked in place, and the split tube extends out the end of the rods.

Sampling was generally conducted as follows. The drill rods would be raised at least 0.6 m to provide room for the split tube to extend beyond the end of the rods. The sampling unit (casing advancer and attached split tube) was lowered down the rods using the wireline and locked in place. The sampling unit could not simply be dropped down the rods because there was no water inside the rods to slow the sampling unit on the way down. When the sampling unit was seated, the rods were advanced 0.6m ahead of the previous end of hole using downward head pressure with +/- slow rotation. Hydraulic pressure required to advance the sampling unit was monitored on the drill gauge, and was averaged each run. On completion of the 0.6m run, the rods were lifted at least 0.6 m and the sampling unit was brought to surface with the wireline.

The collected dust samples were shipped in standard "UN 1A2" 20L open-head plastic pails that met the requirements of the Canadian Transportation of Dangerous Goods regulations. When the sampling unit exited the drill rods, the end of the split tube was placed in a 20L sampling pail to minimise dispersion of free product. The sampling unit and pail were lowered down to the floor of the drill shack using the wireline, which was then disconnected. The split tube was emptied into the sample pail, either by tapping the tube with a rubber mallet or by removing the lifter case and opening the split tube to remove product by hand. Removal of the dust from the sampling unit was dependent on moisture content of the dust. When very dry, the dust would fall from the split tube with minor tapping. When the dust was slightly moist, the split tube had to be disassembled and product scraped out. Wet dust was very sticky, and required tedious scraping of the split tube to remove product of sample to minimise dispersion of product and to minimise problems related to seating sampler at the landing ring. Under optimum conditions, the greatest rate of sampling achieved was 3 m per hour, based on a 0.6 m sample run.

#### 2.4.3 Modifications to Sampling Method

A number of deviations from the general case described above were necessary, depending on sampling conditions. The most common problem was a build-up of arsenic trioxide product inside the drill rod at the landing ring. This accumulation was suspected to result from a combination of

product being forced inside during advance, and from residue exterior to the split tube being scraped off at the landing ring during retrieval of the sampling unit.

The accumulation of product inside the base of the rods made it difficult to properly seat the sampling unit, which prevented the locking mechanism from engaging. To achieve a proper seating, it was necessary to allow the sampling unit to 'freefall' for a short distance by releasing the brake on the wireline. In order to minimise the drop distance and the potential for damage to the sampling unit, the wireline was initially allowed to drop only a short distance (~ 0.3 m). This distance was incrementally increased by 0.3 m until the sampling unit seated properly. This repeated freefall process lead to the wireline becoming unspooled, and frequent delays were required to fix the wireline.

Initially, two split tubes were available, and the plan was to swap split tubes off the sampling unit to allowed continued collection of samples while product was extracted from the tube on surface. During initial sampling on the first hole, the entire sampling unit became disengaged from the wireline and fell unrestricted to the bottom of the rods. This damaged the split tube portion of the sampling unit, as well as the landing ring, beyond repair, and subsequent sampling was carried out with a single split tube following the replacement of the landing ring. This necessitated product removal from sampling unit prior to continuation of sample collection, which further delayed the sampling.

Where advance of sampling unit became difficult, it was facilitated by slow rotation (25-45 rpm) of rods along with applied downward pressure. On occasion, pulsed rotation of rods allowed the sampling unit to be advanced more easily.

#### 2.4.4 Decontamination Following Sampling

Following sampling, drill rods were cleaned of gross contamination by pressure washing the rods as they were slowly removed from the drill hole. Washing was undertaken at the top of the surface casing, underneath the drill rig, and wash water was directed back down the surface casing. Rods were slowly rotating during the removal process, and a scrub brush wedged inside the surface casing was effective in scouring loose any arsenic trioxide that hadn't been dislodged by water pressure alone. This product was then also washed back down the hole. The pressure washing was carried out by the SRK inspector, with close visual monitoring of the effectiveness of the decontamination. Close communication with the drill staff ensured that, where required, rods could be advanced back into the surface casing for removal of any remaining free product, and that the decontamination proceeded in a safe and effective manner.

Challenges to decontamination of drill rods were largely related to cold temperatures, including ice build-up on rods, and freeze-up of water lines and the pressure washer nozzle. On occasion, the degree of scrubbing required to clean the drill rods also hindered progress of the decontamination.

The sealed sample containers were cleaned of gross product with a brush, then a final cleaning was done by washing the sealed pails by hand with sponge, brush, soap and water. The washing was followed by a clean water rinse. The wash-rinse process was carried out a total of three times for each sample container, using clean water each time. Contaminated water was stored in dedicated plastic garbage cans for final disposal within the South Pond.

### 2.5 Instrumentation

#### 2.5.1 Instrument Selection

An array of vibrating wire transducers, to measure water pressure, and resistance thermistors, to measure temperature, was installed in each drillhole sampled. Each array was equipped with multiple thermistor beads and either one or two transducer units, with all sensors attached to a single, sealed cable for better protection during installation. The instrument arrays and readout unit were manufactured by RST Instruments Inc of Coquitlam, BC.

The pressure transducers used have an overall rated accuracy of +/-0.1% of their full range, 700kPA (0.70kPa), which translates to approximately 0.07 m (0.23 ft) of water pressure. The low range instrument error (for all readings near zero pressure, or unsaturated conditions) is specific to each instrument and was determined by the manufacturer through laboratory calibration. The individual low-range errors are listed on the figures showing in-situ data for the instrumented drillholes as discussed in section 3. The maximum low range error of all instruments was 0.16 % of full range (1.14kPa, or 0.14m head). The transducers also measure temperature (used in temperature corrections when measuring pressure) and have a rated accuracy of +/ 0.1°C. Thermistors have a rated accuracy of +/-0.2°C. Temperature data from both types of instruments are shown on the figures. Calibration sheets for all instruments are attached in Appendix A.

Due to the time required to manufacture the instrument strings, the positions were predetermined based on chamber dimensions used in the drillhole planning. Because of this, some cable design lengths did not match the final drillhole depth. Therefore, some "extra" beads are located above the drillhole collar in holes that did not reach their planned depth. The final position of each sensor bead was recalculated based on final drill measurements and amount of cable remaining at surface.

#### 2.5.2 Casing Installation

#### 2.5.2.1 PVC Installation (external instrument cable attachment)

The initial installation of an instrument string in B235-P13 was unsuccessful due to breakage of the PVC pipe during retrieval of the HQ drill rods that the PVC were installed through. It appeared that the PVC pipe was broken when the drill string was at, or near, the surface of the arsenic trioxide dust in the chamber, indicating that the steel rods may have "kicked out", or moved laterally, causing the PVC to break. The PVC pipe and attached instrument string above the dust surface collapsed into the chamber. Attempts were made to retrieve the cable by fishing with a rebar hook on the end of the wireline. This was unsuccessful, and further the string was abandoned in the chamber. An

attempt will be made to retrieve the cable end via the underground inspection hatch when this chamber is next inspected.

#### 2.5.2.2 Alternative Installation: AQ/BQ Drill Rods (internal cable installation)

Following the loss of the B235 string, it was decided even if heavier walled PVC or more flexible HDPE were used, the same problem could occur, especially in the inclined drillholes. Therefore, after discussion with DIAND, a decision was made to install the instrument strings inside used AQ or BQ drill rods. The proposed installation method was evaluated using both thermal modelling to determine if thermal conditions would be compromised by the steel rods, or by possible movement within the rods. The steel was shown not to be an issue, except possibly very near surface, and as the rods are sealed at the top, vertical air movement would not occur.

Because the instrument cables were installed inside the steel rods, the upper vibrating wire piezometers in drillholes B233-P9, C212-2, B208-1, B212-4, and B214-1 will not be hydraulically connected to the dust immediately outside the steel casing. Therefore, water pressure data measured will be due to either drill water inside the steel pipe, or water pressure from the tip of the steel rods if the dust inside the rod is saturated. The upper transducer data for the nodes listed above is may be misleading with respect to dust saturation levels at the depth illustrated, and so has not been included in the data plots at this time.

However, the upper piezometers in drill holes C212-4 and B208-3 do measure actual piezometric levels outside the steel casing as slots were cut in the AQ/BQ rods at the appropriate depth prior to installation. To prevent a hydraulic connection between the upper and lower transducer through the rods, cement grout was added to the inside of the rods. This will restrict conductivity connecting pathway through the rods, but still allow for direct measurements of hydraulic pressure immediately outside the steel through the porous cement. Fully cemented transducer installations have been successfully installed and monitored at other sites in a similar manner, so the resulting data are expected to be representative of adjacent dust saturation conditions.

#### 2.5.3 Instrumentation Installation

Instrument cables were installed to the bottom of the internal drill rods placed in each drillhole. Foam insulation was wrapped around top 3m of cable below the collar to prevent surface air from descending the drill rod. This foam insulation was not installed in C212-4 or in B208-3; these holes were grouted to surface shortly after cable installation as described above to hydraulically separate the two transducers.

Vibrating wire piezometers were not pre-saturated at the surface because of the risk of freezing (-30°C air temperatures at time of installation). Consequently, installed vibrating wire piezometers will require time to equilibrate with the saturation levels in the surrounding dust.

#### 2.5.4 Grouting

All of the drillholes were grouted at the end of the program to prevent entry of surface and shallow ground water into the arsenic storage chambers. Temporary plugs were placed in instrumented and non-instrumented holes as described below, at approximately 10 to 20ft (3 to 6.1m) above the top of each chamber. The final grouted length was to extend from the temporary plug above the chamber to well above the bottom of the surface casing. In practice, holes were grouted from the plug location up to, or very near, the ground surface (within 2m). Grouting was conducted by Capital Transit Mix for all cavity monitoring holes except B214-1 and B208-2, which were filled by Connors Drilling.

#### 2.5.4.1 Cement Baskets

As all cavity monitoring drillholes penetrated underground openings, it was necessary to form an initial plug in each drillhole that would prevent the grout from flowing freely down the hole and into the void. Matters were complicated in instrumentation holes by the presence of the instrument conduit, which required some form of radial plug surrounding the conduit. To achieve this, a series of 'cement baskets' were placed on each conduit at a distance of 3 to 6 meters above the void. These cement baskets were constructed of pieces of rubber inner tube cut to size, and wired to the conduit to form an inverted cone. It was critical that the size of the rubber cone be large enough to collapse outwards and block the entire drillhole, yet be small enough to allow the HQ rods to be pulled over the rubber and to fit through the opening in the shoe at the end of the rods. The down-hole end of the cement basket system was secured with duct tape to minimise the possibility of the shoe catching on the cement basket during rod extraction, and the rubber was sprayed with lubricant to minimise friction.

Three to five of these inverted cones were nested together to provide a composite system designed to catch an initial ~15L batch of cement and allow the formation of a blockage that would hold the final grout column during curing. In some cases, bentonite pellets were added, followed by 20L of water, prior to the mixing and addition of the initial batch of cement. A minimum of ~15L of additional cement was added on top of the initial cement basket plug and allowed to set at least 48hrs before final grouting to surface.

Table 2.2 shows the position of cement baskets and the initial radial cement plugs in the instrumentation drillholes.

Hole ID	Breakthrough Length m (ft)	Position of Cement Basket (down- hole length)*
B233-P9	41.1 m (135 ft)	35.6 m (117 ft)
C212-2	36.6 m (120 ft)	32.0 m (105 ft)
C212-4	69.8 m (229 ft)	53.9 m (177 ft)
B208-1	29.0 m (95 ft)	Foam plug used: 23 m(75 ft)
B208-3	77.7 m (255 ft)	73.1 m (240 ft)
B212-4	27.7 m (91 ft)	Foam plug used: 24.5 m (78 ft)
B214-1	31.1 m (102 ft)	27.4 m (90 ft)

Table 2.2: Location of Starter Plugs in Instrumented Drillholes

\* Distance along alignment of hole

Note: All lengths are feet below top of surface casing. Positions have not been corrected for dip.

#### 2.5.4.2 Expanding Foam Plugs

Drill holes B208-1 and B212-4 were not successfully sealed using the cement baskets. Therefore, these drill holes were successfully sealed using expanding urethane foam injected through 15 mm ID tubing. Foam plugs were set at approximately 23 m(75 ft) and 24.5 m (78 ft) respectively in each hole. Following plugging with the foam, 30 L of cement was added to each hole to strengthen the initial plug. Each hole was grouted to surface after allowing the cement plugs to set for at least 1 week.

#### 2.5.4.3 Non-Instrumented Holes: Starter Plugs

To grout each cavity monitoring hole that did not contain instrumentation, a 178mm Nisku rubber plug was placed approximately three meters above the cavity to form the initial plug. Following cavity monitoring, the drill was moved back onto the hole and the rubber plug was pushed down to the target depth using the drill rods.

At drillhole B208-2, initial installation of the starter plug failed due to an accumulation of ice in the hole. Seepage and ice development in the hole was observed as part of the cavity monitoring investigation, and appeared to result from water seeping from fractures cut by the drillhole. The initial attempt advanced a rubber plug approximately 20ft (6.1m) down the hole before refusal. An ice-cutting drill bit with jagged teeth was used in an attempt to turn the rubber plug and advance further. No further advance was achieved, with the bit cutting through the rubber plug and coring approximately 1.5m of ice beneath the plug before removal of rods. Attempts to plug B208-2 were put on hold pending development of a plan to deal with the unexpected situation, and the drill proceeded to plug the remaining holes without difficulty.

Following plug installation in remaining holes, the drill was moved back onto B208-2. It was decided to clean out the hole with a 6" tricone using hot  $CaCl_2$  brine as the drilling fluid. Immediately following breakthrough, a second rubber plug was installed to the appropriate depth, and B208-2 was immediately grouted to surface by drilling staff.

#### 2.5.5 Surface Completions

Steel lock-boxes were placed over instrumented drillhole collars to protect instrument cables and boxes from weather and tampering. Boxes are painted black to protect the steel against corrosion. The boxes were set into concrete pads to provide a solid work platform and long term protection as shown in (Figure 2.6).

## 2.6 Laboratory Testing Program

#### 2.6.1 Sample Handling

Laboratory geotechnical, geochemical and thermal testing of arsenic trioxide dust from samples collected during the Phase 2 program, and from product in surface storage ("stored barrel" sample) was carried out at three separate laboratories.

The laboratories, the specific samples tested, and the tests carried out are listed in Table 2.3.

- Discrete depth samples tested are delineated using an "X" in the table;
- Composite samples tested are delineated using "C" for "composite in a combined box.
- Several samples were submitted for testing, but not tested by the laboratory. These are delineated using "nt" for "not tested

The sample depth intervals listed in Table 2.5 do not always match the sample intervals listed in Table 7.3. This discrepancy relates to the poor recovery of dust in some of the sample intervals. The sample depth in Table 2.5 sample is a best estimate only.

All samples were originally shipped to Lakefield SGS Labs. Sub-samples were subsequently allocated to CanMet and EBA for their portion of the work. Copies of all available shipping and chain of custody documents are attached in Appendix B.

The "Stored Barrel" sample(s) tested consists of the remnants of material shipped to Lakefield laboratory in 2002 for use in cement and bitumen stabilization testing. The arsenic trioxide dust in the barrel was reported to have been collected directly from the Giant Mine bag house in 1998 and 1999.

		Lake	field						CANMET			EBA	
Sample ID	Submitted Sample Interval (feet)	Chemical analysis	Specific Gravity	Particle Size	Atterberg Limits	Standard Proctor	Wettability - column	Wettability- capillary	Heat capacity	Mineralogy	Microscopy	Thermal Conductivity	Unfrozen water content
B233-P9	175-181	Х	Х	х	х				Х	х	Х		
C212-2	140-168	Х	Х	х	х								
C212-2	168-189	Х	Х	х	х				Х	х	Х	х	Х
B235-P13	130-137	х	Х	х	nt								
B212-4	96-132	С	С	С	С								
B212-4	132-166	С	С	С	С								
B212-4	216-224	С	С	с	С								
B212-4	224-231	С	С	С	С								
B208-1	97-122	С	С	С	С					С	С		
B208-1	122-162	С	С	С	С	nt	nt		nt	С	С	х	Х
B214-1	98-117	С	С	С	С								
B214-1	117-147	С	С	С	С								
B214-1	147-148	С	С	С	С								
Stored Barrel	n/a	х	nt	х	х	x	х	х		х	х	х	

 Table 2.3: Arsenic Trioxide Sample Submission

Sample Submission Codes:

X = sample tested as depth discrete sample

C = sample tested as part of composite

nt = sample requested for testing in original submission, but not tested

<u>Note:</u> All sample depths have been corrected for drillhole dip. (ie: sample depth = true vertical position

#### 2.6.2 Testing Procedures

Specific laboratory test methods are listed in Table 2.4 below.

Laboratory Test	Laboratory	Laboratory Procedure					
Chemical analysis	Lakefield	strong acid digest. ICP analysis					
Specific Gravity	Lakefield	Micromeritics Multi-Volume Pycnometer 1305					
Particle Size	Lakefield	Malvern Model 2600 laser meter					
Atterberg Limits	Lakefield	ASTM D 4318					
Standard Proctor	Lakefield	ASTM D 698-91					
Wettability - column	Lakefield	Custom: see App 4 (SGS – Lakefield, 2004)					
Capillary rise	Lakefield	Custom: see App 4 (SGS – Lakefield, 2004					
Compaction	Lakefield	Custom: see App 4 (SGS – Lakefield, 2004					
Heat capacity	Canmet	ASTM E1269-01					
Mineralogy	Canmet	Rigaku D/MAX B Rotaflex powder diffractometer. JADE v6.0 software					
Microscopy	Canmet	JEOL 820 SEM					
Thermal Conductivity	EBA	ASTM D 5334					
Unfrozen water content	EBA	see Topp et al (1980) and Smith and Tice (1988).					

Table 2.4: Laboratory Test Details

# 3 Field Results

## 3.1 Occupational Health and Safety Monitoring

#### 3.1.1 Urine Arsenic Levels

Figure 3.1 is a compilation of all urine arsenic results for all staff involved in on-site work as part of the Arsenic Chamber Drilling program. As shown in Figure 3.1, there was only a single instance in which an individual's urine tested above both the 100 ppb warning level and the maximum allowable level of 150 ppb for arsenic (Feb. 6, 2004). Immediately on receipt of this result, the individual was barred from entering the high exposure risk zone (the drill shack under breakthrough/ sampling conditions) until additional testing showed acceptable arsenic levels in urine. A sample was given the same day, and analysis was expedited. This resulted in an acceptable urine arsenic reading for this individual (Feb. 13, 2004), and he was cleared for work in all zones. This single high value could have been the result of dietary influence (fish and rice are known to increase urine arsenic levels) or of analytical error. Alternatively, the individual may have had an acute exposure due to a breach of the PPE/ decontamination system.

The remaining results all show generally low urine arsenic levels, with all values below the warning level. This indicates that, throughout the program in general, the measures taken to protect workers against arsenic exposure were effective.

#### 3.1.2 Airborne particulate arsenic levels

Table 3.1 shows the results of airborne particulate arsenic monitoring over the duration of the program. All airborne arsenic concentrations are more than an order of magnitude lower than the exposure limits for unprotected workers of 0.2 mg of total arsenic per  $m^3$ . As samples were commonly collected during times when high exposures were considered possible, workers were equipped with respirators during the sample collection periods. In effect, workers' exposure to airborne particulate arsenic was more than two orders of magnitude lower than the exposure limit where respirators are in use.

## 3.2 Drillholes Tested and Instrumented

Final as-drilled characteristics of each drillhole are summarized in Table 3.2. Coordinates provided are in the Giant Mine Engineering Grid system, and all lengths are listed in imperial units. Lengths have not been corrected for drillhole angle, and so do not represent true vertical 'depths'.

Sample No.	Client No.	Start Date	End Date	Туре	Location	Time (min)	Flow (L/min)	Vol (M3)	Total Dust Mass (mg)	Total Dust concentration (mg/m3)	Arsenic Mass (ug)	Arsenic Concentration (mg/m3)
1	Jan11-S1	11/1/2004	11/1/2004	Area	Drill Rig	651	1.95	1.27	0.18	0.14	ND	ND
2	Jan12-S1	12/1/2004	12/1/2004	Personal	Geologist	750	1.95	1.46	0.23	0.16	0.350	0.00024
3	Jan14-S1	14/1/2004	14/1/2004	Area	Drill Shack	392	1.94	0.76	0.02	0.03	0.160	0.00021
4	Jan14-S2	14/1/2004	14/1/2004	Personal	Geologist	447	1.93	0.86	Nav	Nav	0.220	0.00026
5	Jan15-S1	15/1/2004	15/1/2004	Personal	Driller	185	2.93	0.54	0.14	0.26	0.350	0.00065
6	Jan15-S2	15/1/2004	15/1/2004	Area	Drill Shack	321	2.95	0.95	0.13	0.14	0.070	0.00007
7	B1	22/1/2004	22/1/2004	Blank	Blank	0	0.00	0.00	0.00	n/a	ND	ND
8	Feb8-S1	8/2/2004	9/2/2004	Area	Drill Shack	562	2.07	1.16	0.08	<0.09	0.16	0.00014
9	Feb9-S1	9/2/2004	9/2/2004	Area	Drill Shack	399	2.80	1.12	0.12	0.11	15.00	0.01343
10	Feb10-S1	10/2/2004	11/2/2004	Area	Drill Shack	341	2.80	0.95	0.12	0.13	0.34	0.00036
11	Feb11-S1	12/2/2004	12/2/2004	Area	Drill Shack	176	2.80	0.49	0.28	0.57	1.71	0.00347
12	Feb14-S1	14/2/2004	14/2/2004	Area	Drill Shack	37	2.80	0.10	ND	n/a	<0.05	ND
13	Feb14-S2	14/2/2004	14/2/2004	Area	Drill Shack	72	2.80	0.20	ND	n/a	0.45	0.00223
14	Feb18-S1	18/2/2004	18/2/2004	Area	Drill Shack	Nav	Nav	0.23	0.21	0.91	<0.0002	ND
15	Mar13-S1	13/3/2004	13/3/2004	Area	Drill Shack	207	2.80	0.58	0.06	0.10	0.06	0.00010
16	Mar14-S1	14/3/2004	14/3/2004	Area	Drill Shack	114	2.80	0.32	0.17	0.53	1.30	0.00407
17	Mar23-S1	23/3/2004	23/3/2004	Area	Drill Shack	Nav	Nav	0.91	0.06	0.07	0.06	0.00007
18	Mar30-S1	30/3/2004	30/3/2004	Area	Drill Shack	98	2.80	0.27	0.00	0.00	<0.05	ND
							Max	timum ar	senic expos	ure limit for unprotect	ed workers:	0.20000

## Table 3.1: Airborne particulate arsenic sampling results

				Colla	ar Posit	ion	Break Through Point		Overburden	Overburden	Breakthrough	Stope Bottom			
	Hole No.	Instrument	СРТ	North	East	Elev	North	East	Elev	Contact	Length	Length	Length	Dip	Azimuth
		Installation		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	elev. (ft)	(ft)	(ft)	(ft)	(degrees)	(degrees)
Stope C212	C212-2	yes	yes	10470	6605	6003	10474	6603	5886	5956	50	120	189	-88	333
	C212-3	no	no	10522	6711	6003	10564	6645	5890	5943	50	no breakthrough	hole missed stope	-56	302
	C212-4	yes	no	10513	6690	6005	10523	6667	5781	5955	50	229	237	-84	294
Stope B208	B208-1	yes	yes	11930	7445	6005	11951	7415	5921	5969	37	95	176	-67	306
	B208-2	no	no	11959	7489	6010	12000	7428	5920	5974	53	127	stope not drilled	-51	305
	B208-3	yes	no	12199	7566	6019	12097	7440	5819	5976	55	255	296	-51	231
Stope B212	B212-1	no	no	12510	7455	6017	12510	7455	5937	5960	59	84	stope not drilled	-90	na
	B212-3	no	no	12561	7500	6017	12588	7469	5928	5953	71	98	stope not drilled	-65	312
	B212-4	yes	yes	12529	7492	6020	12546	7457	5933	5960	59	91	230	-66	296
Stope B213	B213-1	no	no	12445	7440	6015	12445	7440	5934	5964	49	86	stope not drilled	-90	na
Stope B214	B214-1	yes	yes	12425	7438	6017	12411	7387	5934	5961	71	102	180	-55	254
	B214-3	no	no	12440	7310	5986	12415	7335	5935	5981	33	64	stope not drilled	-55	135
	B214-5	no	no	12450	7426	6018	12410	7350	5935	5969	76	135	stope not drilled	-45	242
Chamber B233	B233-P9	yes	yes	11655	7432	6020	11655	7432	5893	5979	6	135	257	-90	na
Chamber B235	B235-P12	no	no	11577	7547	6020	11565	7543	5945	5996	24	no breakthrough	stope not targeted	-81	198
	B235-P13	yes	yes	11540	7570	6024	11540	7570	5923	6002	25	104	252	-90	na

#### Table 3.2: Summary of as-drilled details for chamber investigation drillholes

Note: drill lengths listed represent distance from collar along hole axis, and have not been corrected for dip. As such, these lengths are not true depths.

## 3.3 CPT and Related Test Results

#### 3.3.1 CPT Test Results

Data was successfully obtained in all six holes where cone penetration tests were attempted. The results are shown in Figures 3.2 to 3.6. In most holes, the rod string + cone advanced under self-weight for about 10 ft ( $\sim$ 3 m). It was then pushed until it was considered unsafe to continue due to the risk of buckling of the rods. Up to 31 ft ( $\sim$ 10 m) of cone penetration were obtained in each of the six test holes. Table 3.3 summarizes the CPT intervals at each drillhole. It should be noted that the position of breakthrough into the chamber, top of dust, and refusal on the CPT push refer to the length along the vertical or angled drillhole. Positions have <u>not</u> been corrected for dip of drillhole.

Hole	Date	Distance to breakthrough		Dista top o	nce to f dust	Distar bottom pu	nce to of cone sh	Dip from horizontal
		(ft) (m)		(ft)	(m)	(ft)	(m)	(degrees)
B235-P13	February 19	104	31.7	128	39.0	168	51.2	90
B233-P9	February 24	135	41.1	160	48.8	180	54.9	90
C212-2	February 28	120	36.6	140	42.7	167	50.9	88
B208-1	March 3	95	29.0	105	32.0	133	40.5	67
B212-4	March 7	91	27.7	96	29.3	132	40.2	66
B214-1	March 12	102	31.2	106	32.3	142	43.3	55

Table 3.3: Down-hole lengths for CPT boreholes

### 3.3.2 Tricone/Sampler Testing

Results and observations for the drillholes tested using the tricone bit and/or sampler are discussed below. Details of the additional push testing intervals and final test depths are listed in Table 3.4. Figures 3.7 through 3.12 summarize the results of the correlated penetration resistance.

 Table 3.4: Down-hole lengths for additional dust strength testing

Hole	Date	Distance of con	to bottom e push	Test Se (top/botto	Dip from horizontal		
		(ft)	(m)	m) (ft) (m)		(degrees)	
B235-P13	February 19	168	51.2	168 – 252	51.2 - 76.8	-90	
B233-P9	February 24	180	54.9	180 – 257	54.9 - 78.35	-90	
C212-2	February 28	167	50.9	167 – 187	50.9 - 57	-88	
B208-1	March 3	133	40.5	133 – 176	40.5 - 53.6	-67	
B212-4	March 7	132	40.2	132 – 233	40.2 - 71.0	-66	
B214-1	March 12	142	43.3	142 - 180	43.3 - 54.9	-55	

Note: all test intervals refer to length along drill trace, and have not been corrected for dip.

In B235-P13, the water did not freely drain from the rods below 190 ft (~58 m) depth. At 220 ft (~67 m), a falling head test was undertaken. This test showed a drop in water level from surface to about 102 ft (31 m) over five minutes, followed by 25 minutes of constant water level. A subsequent test at 226 ft (~69 m) resulted in a drop in water level from surface to about 118 ft (~36 m), followed by 15 minutes of constant water level. In contrast, water level following completion of drilling stabilised at about 240 ft (~73 m), which is near the base of the hole. At this point, it is unclear whether this water level and the previously recorded constant water levels represent perched water tables within the chamber or indicate the generally low vertical hydraulic conductivity within the dust.

#### Hole B233-P9

In B233-P9, a hard layer was encountered within the dust at approximately 174 ft (53 m). Penetration was not possible using downward hydraulic pressure alone, and conventional tricone drilling (rotation + pressure + flushing with water) was required to advance. Below this layer, zones of loose material were again encountered as advance proceeded intermittently through application of hydraulic pressure and through acceleration due to self-weight only.

#### Hole B208-1

Sampling in B208-1 extended from the dust surface to the base of the hole. At no time was the applied load from the drill insufficient to advance the sampling unit down hole. Therefore, tricone drilling was necessary.

#### Hole B212-4

Sampling in B212-4 extended from the dust surface to 169 ft ( $\sim$ 52 m), with advance over this interval requiring self-weight of rods + head only; no hydraulic pressure was applied. From 169 ft ( $\sim$ 52 m) through 217 ft (66 m), rods were advanced by rotating and applying pressure, with the end of rods plugged by the casing advancer. At 217 ft (66 m), the casing advancer was retrieved and the sampling unit was reattached. Sampling proceeded from 217 ft (66 m) to 232 ft (71 m) (EOH) through advance by rod + head weight only (no applied pressure).

#### Hole B214-1

Sampling in B14-1 extended from the dust surface to the base of the hole. At no time was the applied load from the drill insufficient to advance the sampling unit down hole, and no tricone drilling was necessary.

#### Hole C212-2

Sampling in C212-2 extended from surface to the base of the hole. The applied load from the drill was sufficient to advance the sampling unit and rods without developing unacceptably high pressures that would require replacing the sampling unit with a tricone bit.

#### 3.3.3 In Situ Geotechnical Properties

A commonly used chart to describe the material type of natural soils that relate tip stress to friction ratio is shown in Figure 3.20. In this chart the arsenic dust in the top 10 m has a maximum tip stress of 500 kPa and a friction ration of 1%. Natural materials in this range are likely to be fine-grained cohesive/non-cohesive soils to sensitive clays. However, visually, the dry dust does not have the consistency of clay. It seems more like a loose non-cohesive frictional material. If it is considered as a frictional material, then for natural materials the friction angle can be determined from the tip stress and the associated vertical stress as shown in Figure 3.21. Unfortunately the results from the dust intervals fall well below the published data from chamber tests on natural frictional materials as shown in Figure 3.22. Hence the cone data cannot be used directly to determine a friction angle from existing charts. However, the data suggest a friction angle of 30° or less. That value is slightly lower than what was measured in laboratory tests (see Section 4).

The cone data for most of the tests in the dry upper dust are relatively consistent. In general, cone tip stress increases with depth in a linear fashion. Hence the increase in strength is probably dominated by gravitational forces rather than inter-particle electric charges (cohesive forces). However, in some holes, there are zones at depth that are particularly strong. These zones are probably cohesive in nature, which may be a result of wetting and subsequent drying, or some cementing process.

The dust is in a loose state, such that under shock loading, such as seismic loading, the dust particles could rearrange themselves to a denser, more stable configuration thus inducing some settlement of the surface. Any surface fill load would consequently settle and it would not provide support to the rock crown. This problem would be eliminated once the dust had been frozen in place.

## 3.4 Observations during Dust Sampling

Sampled material was generally dry, with varying levels of humidity yielding a range of powdery to clumping dust. Dust was generally a homogenous, light tan powder, with visible layering and colour darkening to a dark chocolate brown on rare occasions. Sample recovery was generally poor near the surface of the dust and increased with sample depth.

Wet sample material was encountered at the dust surface in vertical holes B233-P9 and B235-P13. Sampling in both vertical holes was terminated above the bottom of the respective chamber. This moisture is thought to have been introduced by drilling and is not considered indicative of *in situ* conditions.

Saturated material was encountered over a depth of approximately 0.25 m (1 ft) at the base of B214-1. Arsenic trioxide dust was sampled over the entire dust interval encountered in this hole, as well in holes C212-2 and B208-1. The arsenic trioxide encountered in B212-4 was sampled over the top 21 m (70ft) as well as over the bottom 4.5 m (15ft). A 15 m (50ft) interval was skipped to reduce the amount of time required for sampling. Table 3.5 summarizes the details of sample interval and volume recovered for each drillhole.

It should be noted that sample ID "positions" are related to the length along the vertical, or inclined, drillhole. These position "depths" are listed in Table 3.5 to correspond with the sample ID labels recorded in the filed on the sample containers, and therefore subsequently used in all sample shipping and laboratory documentation. True depth locations (corrected for dip of drillhole) of each sample interval is also listed in Table 3.5. The actual sample intervals in each drill hole (except B235-P13) are shown in the accompanying diagrams (Figures 3.13 - 3.19).

		Total S	Sampled Inte	ted for dip		
Hole ID	Sample ID (Downhole Position)	From (ft)	To (ft)	From (m)	To (m)	Sample Volume (L) <sup>*</sup>
B208-1	106-133'	97	122	29.6	37.2	3
B208-1	133-176'	122	162	37.2	49.4	12
B212-4	97-133'	96	132	29.3	40.2	3
B212-4	133-167'	132	166	40.2	50.6	10
B212-4	217-225'	216	224	65.8	68.3	2
B212-4	225-232'	224	231	68.3	70.4	1
B214-1	119-143'	98	117	29.9	35.7	10
B214-1	143-179'	117	147	35.7	44.8	10
B214-1	179-180'	147	148	44.8	45.1	<1
B233-P9	157-181'	157	181	47.9	55.2	3
B235-P13	128-144'	128	144	39	43.9	2
C212-2	140-168'	140	168	42.7	51.2	5
C212-2	168-189	168	187	51.2	57.6	5

#### Table 3.5: Summary of arsenic trioxide sample intervals

Note: \* Sample volumes estimated

Sample ID: Not corrected for dip

Sample Interval: corrected for dip in inclined holes

## 3.5 Instrument Cables

Tables 3.6 and 3.7 show installed thermistor and transducer positions at the corrected true depths for all instrument cables. All data presented are in the true position with respect to the drillhole collar.

Hole ID	Bead #1 (m)	Bead #2 (m)	Bead #3 (m)	Bead #4 (m)	Bead #5 (m)	Bead #6 (m)	Bead #7 (m)	Bead #8 (m)
C212-2	16.2	26.2	36.2	46.2	56.0			
B208-1	9.8	19.0	28.2	37.3	46.5			
B212-4	3.9	8.4	17.6	26.7	35.8	45.0	54.1	63.2
B214-1	4.7	12.9	21.1	29.3	41.5			
B233-P9	3.5	8.5	18.5	28.5	38.5	48.5	58.5	68.5
B208-3	-0.2	4.6	9.3	21.2	33.0	52.9	56.7	69.7
C212-4	-3.7	0.3	7.9	23.0	45.7	59.6	66.9	72.1

 Table 3.6a:
 Thermistor Locations (True Depth - metric)

Note: All depths are metres below top of surface casing

Positions have been corrected for dip.

#### Table 3.6b: Thermistor Locations (True Depth - Imperial)

Hole ID	Bead #1 (ft)	Bead #2 (ft)	Bead #3 (ft)	Bead #4 (ft)	Bead #5 (ft)	Bead #6 (ft)	Bead #7 (ft)	Bead #8 (ft)
C212-2	53.2	86.0	118.8	151.6	183.8			
B208-1	32.2	62.3	92.4	122.5	152.6			
B212-4	12.7	27.7	57.7	87.6	117.6	147.5	177.5	207.4
B214-1	15.4	42.3	69.2	96.0	136.3			
B233-P9	11.4	27.8	60.6	93.4	126.2	159.0	191.8	224.6
B208-3	-0.5	15.0	30.6	69.4	108.3	173.6	186.0	228.8
C212-4	-12.0	0.9	25.8	75.5	150.0	195.7	219.5	236.4
Note: All depths are feet below top of surface casing								

e: All depths are feet below top of surface casing Positions have been corrected for dip.

Table 3.7: Vibrating wire transe	ducer locations (True Depth)
----------------------------------	------------------------------

Hole ID	Transducer #1 (m)	Transducer #1 (ft)	Transducer #2 (m)	Transducer #2 (ft)
C212-2	36.2	118.8	57.2	187.6
B208-1	46.5	152.6	Na	na
B212-4	26.7	87.6	64.1	210.4
B214-1	25.2	82.6	44.0	144.4
B233-P9	58.5	191.8	77.4	254.1
B208-3	52.8	173.3	69.9	229.5
C212-4	57.7	189.4	72.1	236.4

Note: All depths are feet below top of surface casing.

Positions have been corrected for dip.
Figures 3.13 through 3.18 show temperature and pressure head results for the instrumented drillholes. Temperature fluctuations illustrated in some graphs (as noted in the figures) are thought to have been caused by warm drill fluids used during the installation, or hot brine used to clear accumulated frost in the drillholes during installation and grouting procedures. The anomalous temperatures observed on April 7th, 2004 were likely caused by heat from hot water poured down the drillhole when checking initial plug seals. Elevated temperatures are also noted in the thermistor beads that are located inside the steel box at surface due to radiant heating of the air inside the box during the day.

# 4 Laboratory Testing Results

# 4.1 Data Sources

Laboratory reports are included in Appendix D and include the following:

- SGS Lakefield Research (2004) The Characterization of Various Arsenic Trioxide Dust Samples from Giant Mine Yellowknife Mine
- CANMET (2004) A Mineralogical Investigation of Arsenic Trioxide (As2O3) Rich Tailings from the Giant Mine, Yellowknife, NWT
- CANMET (2004) Heat Capacity Study of Dust Samples containing Arsenic Trioxide (CERL Report 2004-31 (CF))
- EBA (2004) Results of Laboratory Measurements of the Thermal Properties of Arsenic Trioxide (File: 1100052)

# 4.2 Physical Properties

Table 4.1 provides a summary of physical properties measured in the studies to date. None of the investigations have recovered intact samples, although direct and indirect *in situ* testing has been performed. The recovered dust samples were tested for a wide range of parameters for physical, chemical and thermal characterisations. The *in situ* testing provided some indication of the in-place density and strength, through standard penetration tests (SPT - split spoon) and cone penetration testing (CPT).

Parameter	Range (1998 and 2002)	2004 Data	Total Range/ Avg
Grain Size	92 - 97% <0.0045mm	72 - 98 % <0.0045mm	72 - 98% / 88.5% (<0.0045mm)
Dry Density (kg/m <sup>3</sup> )			Range =
Maximum	1106.7 - 1459.3 kg/m <sup>3</sup>	1414.0 - 1726.0 kg/m <sup>3</sup>	1106.7 - 1726.0 kg/m <sup>3</sup>
Minimum	653.9 - 890.6 kg/m <sup>3</sup>	1333.0 - 1369.0 kg/m <sup>3</sup>	653.9 - 1369.0 kg/m <sup>3</sup>
In-situ	1340.7 - 1622.7 kg/m <sup>3</sup>		Avg. = 1402.3 kg/m <sup>3</sup>
Specific Gravity	2.59 – 3.79 (avg. 3.17)	3.29 – 3.77 (avg. 3.48)	2.59 - 3.79 / 3.38
Atterberg Limits			
Liquid limit	inconclusive	25.0 - 41.7%	25.0 - 41.7% / 31.9 %
Plastic limit	19% - 24%	Nonplastic & 28.5% – 35.3%	19.0 - 35.3% / 28.6%
Angle of Repose	46° - 58°	NT	46° - 58°
Angle of Internal Friction	33° - 35°	NT	33° - 35°
Hydraulic Conductivity (at 1150.1 kg/m <sup>3</sup> )	7 x 10 <sup>-7</sup> m/s	NT	7 x 10 <sup>-7</sup> m/s
Thermal Conductivity		0.47 - 2.02 W/m-k	0.47 - 2.02 W/m-k
at 0% H2O	0.093 W/m-k		0.093 W/m-k
at 1% H2O	0.100 W/m-k		0.100 W/m-k
Freezing point of saturated solution	-0.7°C	NT	-0.7°C

Table 4.1: Physical Properties of Arsenic Trioxide Dust.

Notes:

NT - not tested

## 4.3 Geochemical

### 4.3.1 Arsenic and Gold Content

The arsenic trioxide dust product from the plant was assayed for arsenic and gold on a routine basis, generally daily, throughout the dust production period, from 1951 through 1999. The weighted averages of these assays for the entire inventory of each chamber and stope are shown in Table 3.9.

The roasting and gas cleaning circuits of the plant saw a number of changes during the early production period, the most significant of which were changes to the electrostatic precipitator circuits (Cottrells) and the installation of a baghouse. The major changes affecting the quality of the arsenic trioxide dust were made in the period from 1958 through 1963, while the B235 and B236 chambers were being filled.. The production assays in Table 3.9 show significantly lower arsenic concentrations and higher gold concentrations in the dust produced before these changes were completed. The estimated total inventory of gold in the dust is approximately 4.3 million grams, and about 60% of the gold is contained in the five oldest chambers, which hold just 25% of the total dust inventory.

Results of arsenic and gold analyses completed on the samples collected in 2004 are also provided in Table 4.2. The 2004 results for arsenic are generally within a reasonable range of the averages estimated from production assays. The gold concentrations in the 2004 samples are generally significantly lower than the average concentrations estimated from the production assays. Since the production data are based on the assays of hundreds of samples, while the 2004 data are based on only a few samples, differences probably reflect variability in the 2004 samples. The 2004 data still show the general trend that the arsenic content is lower and the gold content is much higher in the older dust, as represented by the sample from Chamber B233.

Chamber / Stone	Production Assays 1951-1999		2004 – Laboratory Data		
Champer / Stope	Arsenic (%)	Gold (g/t)	Arsenic (%)	Gold (g/t)	Number of Samples
B 230	45.3	24.8			
B 233	36.9	57.3	39.5	38	1
B 234	36.1	80.0			
B 235 / 236	53.7	26.3	66.0 (B235)	9 (B235)	1
B 208	65.7	12.1	66.5	4	2 (comp)
B 212 / 213 / 214	61.7	15.5	60.2 (B212) 57.8 (B214)	6 (B212) 9 (B214)	7 (comp)
C 212	65.6	5.9	62.7 to 66.3	<2 to 6	2
#9	67.5	4.3			
#10	66.8	4.6			
#11	67.4	4.8			
#12	65.9	5.9			
#14	65.5	5.5			
Inventory Averages	60.1	18.1			

#### Table 4.2: Arsenic and Gold Content of Arsenic Trioxide Dust

Note: g/t = grams/tonne

Range of values for C212 given as two depth discrete samples tested. All other stopes are represented by either single depth discrete samples or composite samples.

### 4.3.2 Other Chemical Components

The analytical results for other components of the dust sampled in 2004 are shown in Table 3.10, along with the range of measured concentrations. The data indicate that the material collected from Chamber B233, the oldest dust, is distinctly different from the other materials. The oldest material has significantly higher concentrations of all the elements measured above the method detection limits, with the exception of arsenic and antimony. In particular, the silver, copper, iron, lead and zinc contents of the oldest dust are much higher than found in the dust produced later. These differences reflect the inefficiency of the plant, during the 1950's, in separating arsenic trioxide from other components of the dust produced by the roaster.

The sample collected from Chamber B235 has chemical characteristics that are similar to the material collected from the chambers and stopes that were filled later. This chamber was filled while major modifications were being made in the plant and the dust properties were changing, from 1958 through 1962. The chamber was also "topped up" with new dust in 1988. The analytical results suggest that the sample collected from B235 probably represents later production.

Parameter	Unit	"Old" Dust	"New" Dust	"Old" Dust 2004	"New" Dust 2004	Range
As	%	46.4	65.3	51.0	59.9	46.4 - 65.3
Au	g/t	36.7	3.2	na	na	3.2 - 36.7
Sb	ppm	12200	11078	8200	10200	8200 - 12200
Fe	ppm	21400	22889	55000	23400	21400 - 55000
AI	ppm	9900	7180	20000	9500	7180 - 20000
Ca	ppm	6100	4718	9200	32300	4178 - 32300
Mg	ppm	3600	2078	6800	22200	2078 - 22200
Si	ppm	19400	6806	-	-	6806 - 19400
Ва	ppm	-	8.5	47	26	8.5 - 47
Be	ppm	-	<0.5	<0.2	<0.5	<0.2 - <0.5
Cd	ppm	-	1.1	<25	<25	1.1 - <25
Cr	ppm	-	12.6	48	31	12.6 - 48
Со	ppm	-	18.6	57	41	18.6 - 57
Cu	ppm	-	246	340	270	246 - 340
Pb	ppm	-	472	1300	1140	472 - 1300
Mn	ppm	-	87	250	135	87 - 250
Hg	ppm	-	14	-	-	1.4
Мо	ppm	-	1.9	<20	<20	1.9 - <20
Ni	ppm	-	43	100	78	43 - 100
Р	ppm	-	52	<100	<100	52 - <100
К	ppm	-	889	5000	2670	889 - 5000
Se	ppm	-	<1	<60	<60	<1 - <60
Ag	ppm	-	3.1	20	11	3.1 - 20
Na	ppm	-	288	970	460	288 - 970
Sn	ppm	-	<20	<40	<40	<20 - <40
Zn	ppm	-	154	510	600	154 - 600

 Table 4.3: Chemical Composition of "Old" and "New" Arsenic Trioxide Dust

Note: g/t = grams/tonne

"New dust" data based on 2004 laboratory analysis of seven (7) discrete or composite samples of dust collected during drill program (Lakefield, 2004)

### 4.3.3 Mineralogy

Four samples of the arsenic trioxide dust collected in 2004 were examined using X-ray diffraction, scanning electron microscopy and electron microprobe methods, in order to characterize the mineralogy of the materials. The samples were taken from Chamber B233, and the stopes B208 and C212 underground. The fourth sample came from material collected directly from the baghouse in 1999.

Apart from differences in the amount of arsenic trioxide and the proportions of accessory phases, the samples were found to be broadly similar in mineralogy, and consistent with samples examined in previous mineralogical studies. The largest variation between samples is the amount of arsenic trioxide grains they contain, with oldest material containing less of this phase. The amount of hematite also varies greatly between samples, being classified as a minor phase in the oldest material, but only a trace phase in the later material. Explanations for the variations in arsenic trioxide and hematite phases between samples can be drawn from the history of changes in the plant technology and operation. The content of antimony minerals in the dust samples varied irregularly with respect to the time of production, and is seemingly not related to changes in the plant, suggesting that these variations are due to changes in the mineralogy of the ore being processed.

# 5 Summary

## 5.1 Physical Properties

The cone penetration testing showed that the arsenic dust behaves like a loose granular material when dry, with its strength increasing linearly with the confining pressure of the material. These findings can be used as a basis for designing a system to fill the voids above the dust. Moist zones were encountered in some of the holes, but the majority was dry. The *in situ* testing, sampling and instrumentation of the dust inside the chambers and stopes did not detect any significant zone of saturated dust, other than a thin layer at the bottom of the stope. Laboratory testing of samples taken in 2004 generally has provided estimates of other physical and thermal properties needed for the design of the freezing system.

## 5.2 Geochemical Properties

Laboratory test work on the arsenic trioxide dust samples collected from the chambers and stopes in 2004 indicates geochemical characteristics that are consistent with the results of earlier studies. The new data supports older data that has been used in various engineering assessments for the arsenic trioxide management project. The key findings are that the dust produced early in the mine history, in the 1950's, contains significantly less arsenic and more gold than found in the dust produced later. The reasons for these differences can be drawn from the history of changes in the technology and operation of the roaster and gas cleaning circuits of the plant.

This report, 1CI001.12.B66 Giant Mine - Arsenic Trioxide Chamber Drilling and Testing **Program (2004)** has been prepared by:

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Figures









2.2

FIGURE:







Giant Mine Remediation Project Chamber Drilling and Testing Program

# Components Of CPT System which Connect to Drill Stem

DATE: APPROVED: FIGURE: Nov. 2004

2.4































#### **B208-1 Instrument Cable Thermistor Data**

Indian and Northern Affairs Canada

SRK Consulting	GIANT MINE REMEDIATION PLAN			
Engineers and Scientists				
Indian and Northern		Drillhole	9 BZUO-I	
Affairs Canada	PROJECT NO.	DATE	APPROVED	FIGURE
	1Cl001.12.B66	DEC 2004		5.15

#### **B208-3 Instrument Cable Thermistor Data**

Refi







GIAN	NT MINE RE	MEDIATION P	LAN		
Drillhole B208–3					
PROJECT NO.	DATE	APPROVED	FIGURE		
1Cl001.12.B66	DEC 2004		3.14		



**B214-1 Instrument Cable Thermistor Data** 



#### B233-P9 Instrument Cable Thermistor Data

Affairs Canada

PROJECT NO.	DATE	APPROVED	FIGURE
1Cl001.12.B66	DEC 2004		3.16



#### C212-2 Instrument Cable Thermistor Data

PROJECT NO.	DATE	APPROVED	FIGURE
1CI001.12.B66	DEC 2004		3.17



C212-4 Instrument Cable Thermistor Data








Appendix A Instrument String Calibration Documentation

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	30	525.4	70	153.2	110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107,9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116,8	120
94.48K	-39	9310	1	1535	41	364.9	81	113.8	121
88,46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	3422	83	107.9	123
77.99K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-35	7252	6	1260	46	311.3	86	99.9	126
64,09K	-33	6905	7	1212	47	301.7	87	97.3	127
60,17K	-32	6576	8	1167	48	282.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	29	56.92	11	1040	51	266.6	91	87.9	131
46,94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965	53	250.9	93	83.6	134
39,13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229,3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23,16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
L								55.6	150

## Resistance versus Temperature Relationship 3000 Ohm NTC Thermistors

Temperature calculated using:

**Steinhart-Hart Linearization** 

$$T_{C} = \frac{1}{C_{0} + C_{1}(\ln R) + C_{3}(\ln R)^{3}} - 273.15$$

.....

3000 Ohm @ 25C NTC Thermistor

 $\begin{array}{rrrr} C_0 = & 0.0014050 \\ C_1 = & 0.0002369 \\ C_3 = & 0.0000001013 \end{array}$ 

InR= Natural Log of Resistance

T<sub>c</sub>= Temperature in °C



200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



### **Vibrating Wire Pressure Transducer Calibration**

Customer: Model: Serial Number Mfg Number String Serial Range: Date of Calib Temperature Barometric P W.O. Number Cable Length Cable Colour Cable Insulat Thermistor ty	er: Number: ration: : ressure: r: r: r Code: tion ype:	STEFFE red / black (cc PE Polyethyle	N, ROBERTS bil) ane	SON & KIRSTEN VW2100-0.7 VW0693 03-29258 TS1569 700.0 21-Nov-03 21.9 990.3 Q01815 52 green / white 3	kPa °C millibars meters (thermistor) Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(%)	(% FS)
0.0	9011	0.0	9012	0.00	9012	1.14	0.16	0.00
140.0	8050	140.0	8050	140	8050	139.69	-0.04	-0.01
280.0	7082	280.0	7081	280	7082	279.25	-0.11	0.02
420.0	6112	420.0	6111	420	6112	419.03	-0.14	-0.01
560.0	5136	560.0	5135	560	5136	559,67	-0.05	-0.01
700.0	4153	700.0	4154	700	4154	701.18	0.17	0.01
L					Max.	Error (%):	0.17	0.02
	Linear Calibrat Regression Zel Temperature C	ion Factor: ro: orrection Fact	At tor:	C.F.= Calibration Bi = Tk =	0.1441 9019.4 -0.01163	kPa/B unit B unit kPa/⁰C rise		
Polynomial (	Gage Factors (k	Pa)	Α:	<u>-3.6122E-07</u>	В:	<u>-0.1393</u>	C:	<u>1285.0</u>
	Pressure is calo Linear, P(kPa) = Polynomial:	culated with the = C.F. X ( Li - L P(kPa)=A(Lc)	following equ c ) - [ Tk ( Ti - <sup>2</sup> +BLc+C+Tk(	uations: Tc)] + [ 0.10(E (Tc-Ti)-[0.10(Bc-!	3i - Bc ) ] Bi)]			
	FACTORY ZER SHIPPED ZERG	O READINGS D READINGS:		DATE (mm/dd/yr) 12/10/2003 1/30/2004	VW2104 Pos. B (Li) <u>9001</u> <u>9001</u>	TEMP <sup>°</sup> C (Ti) <u>24.2</u> <u>21.3</u>	BARO (Bi) <u>1001.9</u> <u>1001.0</u>	
	Li, Lc = initial ( Ti, Tc = initial ( Bi, Bc = initial ( B units = B scal B units = Hz <sup>2</sup> /	at installation) ; at installation) at installation) le output of VM 1000 ie: 1	and current re and current te and current b 2102, VW 21 700Hz = 2890	adings emperature, in °C arometric pressu 104 readouts ) B units	re readings, in n	nillibars		
Technician: <u>C. Christen</u>						Date: <u>30-JA</u> I	<u>N-04</u>	

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

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Recv



200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



## Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Number Mfg Number String Serial I Range: Date of Calibb Temperature: Barometric P W.O. Number Cable Length Cable Colour Cable Insulat Thermistor ty	r: Number: ration: : ressure: : : Code: ion ype:	STEFFE red / black (cc PE Polyethyle	N, ROBERTS pil) ene	ON & KIRSTEN VW2100-0.7 VW0694 03-29259 TS1570 700.0 21-Nov-03 21.9 990.3 Q01815 60 green / white	kPa °C millibars meters (thermistor) Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomia
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	(Bunits)	(kPa)	( B units )	(kPa)	( B units )	(kPa)	(%)	(% FS)
0.0	8990	0.0	8990	0.00	8990	1.36	0.19	0.01
140.0	8044	140.0	8044	140	8044	139.55	-0.06	-0.03
280.0	7089	280.0	7089	280	7089	279.05	-0.14	0.01
420.0	6131	420.0	6131	420	6131	418.99	-0.14	0.00
560.0	5167	560.0	5167	560	5167	559.81	-0.03	0.01
700.0	4199	700.0	4199	700	4199	701.21	0.17	-0.01
					iviax.	Error (%):	0.19	0.03
	Linear Calibrat Regression Ze Temperature C	ion Factor: ro: correction Fact	At tor:	C.F.= Calibration Bi = Tk =	0.1461 8999.3 -0.12076	kPa/B unit B unit kPa/°C rise		
Polynomial (	Gage Factors (k	Pa)	Α:	<u>-4.1458E-07</u>	B	- <u>0.1406</u>	C:	1297.7
	Pressure is calo Linear, P(kPa) <sup>:</sup> Polynomial:	culated with the = C.F. X ( Li - L P(kPa)=A(Lc	e following equ c)- [ Tk(Ti - ) <sup>2</sup> +BLc+C+Tk	uations: - Tc)] + [ 0_10(I (Tc-Ti)-[0.10(Bc-	Bi - Bc ) ] Bi)]			
	FACTORY ZEF SHIPPED ZER	RO READINGS O READINGS:	:	DATE (mm/dd/yr) 12/10/2003 1/30/2004	VW2104 Pos. B (Li) <u>8981</u> <u>8983</u>	TEMP °C (Ti) <u>24.3</u> <u>20.4</u>	BARO (Bi) <u>1001.9</u> <u>1001.0</u>	
	Li, Lc = initial ( Ti, Tc = initial ( Bi, Bc = initial ( B units = B sca B units = Hz <sup>2</sup> /	at installation) ( at installation) ( at installation) le output of VV 1000 ie: ⁄	and current re and current to and current b V 2102, VW 2 1700Hz = 2890	eadings emperature, in °C earometric pressu 104 readouts 0 B units	; ire readings, in i	millibars		
	Technician: <u>C. Christen</u>					Date: <u>30-JA</u>	<u>N-04</u>	

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



## Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Number Mfg Number String Serial Range: Date of Calib Temperature: Barometric P W.O. Number Cable Length Cable Colour Cable Insulat Thermistor ty	er: Number: ration: : ressure: r: .: Code: tion ype:	STEFFE red / black (cc PE Polyethyle	N, ROBERTS pil) ane	ON & KIRSTEN VW2100-0.7 VW0695 03-29260 TS1570 700.0 21-Nov-03 21.9 990.3 Q01815 37 green / white	kPa °C millibars meters (thermistor) Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	( B units )	(kPa)	( B units )	(kPa)	(Bunits)	(kPa)	(%)	(% FS)
0.0	9042	Ó.O	9042	0.00	9042	1.01	0.14	0.00
140.0	8215	140.0	8215	140	8215	139.73	-0.04	-0.01
280.0	7383	280.0	7382	280	7383	279.38	-0.09	0.03
420.0	6550	420.0	6549	420	6550	419.11	-0.13	-0.01
560.0	5712	560.0	5711	560	5712	559.68	-0.05	-0.02
700.0	4869	700.0	4868	700	4869	701.08	0.15	0.01
					Max.	Error (%):	0.15	0.03
	Linear Calibrati Regression Zer Temperature Co	on Factor: o: orrection Fact	At or:	C.F.= Calibration Bi = Tk =	0.1677 9048.0 -0.19065	kPa/B unit B unit kPa/⁰C rise		
Polynomial (	Gage Factors (kF	Pa)	A:	<u>-4.3863E-07</u>	В:	<u>-0.1616</u>	C:	<u>1497.4</u>
	Pressure is calc Linear, P(kPa) = Polynomial:	ulated with the C.F. X ( Li - Li P(kPa)=A(Lc)	following equ c)-[Tk(Ti- <sup>2</sup> +BLc+C+Tk(	ations: Tc)] + [ 0.10(B Tc-Ti)-[0.10(Bc-E	ii - Bc)] Bi)]			
	FACTORY ZER SHIPPED ZERC	O READINGS: D READINGS:		DATE (mm/dd/yr) 12/10/2003 1/30/2004	VW2104 Pos. B (Li) <u>9031</u> <u>9044</u>	TEMP <sup>°</sup> C (Ti) <u>23.5</u> <u>20.5</u>	BARO (Bi) <u>1001.9</u> <u>1001.0</u>	
	Li, Lc = initial (a Ti, Tc = initial ( Bi, Bc = initial ( B units = B scal B units = Hz <sup>2</sup> / 1	at installation) a at installation) at installation) e output of VW 1000 ie: 1	and current re and current te and current ba 2102, VW 21 700Hz = 2890	adings mperature, in °C arometric pressur 04 readouts ) B units	re readings, in r	nillibars		
Technician: <u>C. Christen</u> CC Date: <u>30-JAN-04</u>								

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1







# Vibrating Wire Pressure Transducer Calibration

Customer:		STEFFE	N, ROBERTS	ON & KIRSTEN					
Model:				VW2100-0.7					
Serial Numbe	r:			VW0701					
Mfa Number				03-30779					
String Serial	Number:			TS1571					
Range:				700.0	kPa				
Date of Calib	ration:			5-Jan-04					
Temperature				24.3	°C				
Parometric P	ressure			990.5	millibars				
				Q01815					
Cable Length	•			61	meters				
Cable Colour	Code:	red / black (co	il)	green / white	(thermistor)				
Cable loculat	tion	PE Polvethvie	ne	•					
Thermister to	upe'	,, .		3	Kohms 0.1C				
mermistor q	ype.								
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial	
Bressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit	
(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	( B units )	(kPa)	(%)	(% FS)	
	8901		8901	0.00	8901	0.86	0.12	0.00	
140.0	8096	140.0	8096	140	8096	139.88	-0.02	0.01	
140.0	7289	280.0	7289	280	7289	279.26	-0.11	-0.01	
280.0	6479	420.0	6478	420	6479	419.24	-0.11	-0.01	
420.0	5664	560.0	5664	560	5664	559.91	-0.01	0.01	
560.0	4848	700.0	4848	700	4848	700.84	0.12	0.00	
700.0	4040	100.0			Max.	Error (%):	0.12	0.01	
	Linear Calibra Regression Ze Temperature C	tion Factor: ro: Correction Fac	At tor:	C.F.= Calibration Bi = Tk =	0.1727 8906.0 -0.18650	kPa/B unit B unit kPa/⁰C rise			
Polynomial	Gage Factors (F	(Pa)	A	: <u>-3.9895E-07</u>	у В	: <u>-0.1672</u>	с	: <u>1520.0</u>	
	Pressure is cal Linear, P(kPa) Polynomial:	culated with the = C.F. X ( Li - L P(kPa)=A(Lc	e following eq .c)-[Tk(Ti :) <sup>2</sup> +BLc+C+Tk	uations: - Tc)] + [ 0.10( ‹(Tc-Ti)-[0.10(Bc·	Bi - Bc)] -Bi)]				
	FACTORY ZE SHIPPED ZEF	RO READINGS RO READINGS:	5: :	DATE (mm/dd/yr) 1/12/2004 1/30/2004	VW2104 Pos. B (Li) <u>8900</u> <u>8900</u>	TEMP °C (Ti) <u>25.2</u> <u>19.1</u>	BARO (Bi) <u>989.6</u> 1001.0		
	Li, Lc = initial Ti, Tc = initial Bi, Bc = initial B units = B sc B units = Hz <sup>2</sup>	( at installation) ( at installation) ( at installation) ale output of VV ( 1000 ie:	and current r ) and current f ) and current f N 2102, VW 2 1700Hz = 289	eadings temperature, in °( barometric press 2104 readouts 30 B units	C ure readings, in	millibars			
	Technician: C. Christen								

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Document Number : ELLO

200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



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## **Vibrating Wire Pressure Transducer Calibration**

Customer:		STEFFE	N, ROBERTS	SON & KIRSTEN				
Model:				VW2100-0.7				
Serial Numbe	er:			VW0696				
Mfg Number				03-30630				
String Serial	Number:			TS1571				
Range:				700.0	kPa			
Date of Calib	oration:			24-Nov-03				
Temperature	:			21.8	°C			
Barometric P	ressure:			995.9	millibars			
W.O. Numbe	r:			Q01815				
Cable Lengt	h:			40	meters			
Cable Colou	r Code:	red / black (co	oil)	areen / white	(thermistor)			
Cable Insulat	tion	PE Polvethyle	ne	3	,			
Thermistor t	ype:	,,.		Э	Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(%)	(% FS)
	8802		8803	0.00	8803	0.93	0.13	0.00
140.0	7998	140.0	7998	140	7998	139.84	-0.02	0.00
280.0	7190	280.0	7191	280	7191	279.26	-0.11	0.00
420.0	6380	420.0	6380	420	6380	419.21	-0.11	0.00
420.0	5566	560.0	5566	560	5566	559 75	-0.04	-0.01
700.0	4748	700.0	4748	700	4748	700.99	0.14	0.00
700.0		1 100.0	4140	1	Max.	Error (%):	0.14	0.01
								1
	Linear Calibrati	on Factor		C F =	0.1727	kPa/B unit		
	Pegression 7et	011 actor.	At	Calibration Bi =	8807 9	R unit		
	Temperature C	orrection Eact		Tk =	-0 17760	kPa/ <sup>o</sup> C rise		
	remperature of		.01.	TK -	0.11100	N 4, 0 1150		
Polynomial (	Gage Factors (ki	Pa)	A	-4.3849E-07	, В:	-0.1667	C:	1501.5
		,		<u></u>	•			
	Pressure is calc	ulated with the	following equ	ations:				
	l inear. P(kPa) =	C.F. X (Li - Li	c) - [Tk (Ti -	Tc)]+[0.10(]	Bi-Bc)]			
	Polynomial:	P(kPa)=A(Lc)	<sup>2</sup> +BLc+C+Tk	(Tc-Ti)-[0,10(Bc-	Bi)]			
	engine (men	, (, , , , , , , , , , , , , , , , ,			<i>,,</i>			
				DATE	VW2104	TEMP °C	BARO	
				(mm/dd/vr)	Pos. B (Li)	(Ti)	(Bi)	
	FACTORY ZER			12/10/2003	8796	23.4	1001.9	
	SHIPPED ZERC	READINGS		1/30/2004	8805	17.9	1001.0	
				100/2001		1.1.10	100110	
	Li Ic=initial (a	t installation) a	and current re	adings				
	Ti To = initial (	at installation)	and current te	emnerature in °C	:			
	Bi Bc = initial (	at installation)	and current h	arometric pressu	re readings, in n	nillihars		
	B units = B scale	e output of \/M	2102 \AM 21	104 readouts	a counys, in			
		o output of VVV	- 10 <i>-</i> , VVV 2					
	B units = $H_7^2 / 1$	000 in 1	$700H_7 = 2800$	B units				
	B units = Hz <sup>2</sup> / 1	000 ie: 1	700Hz = 2890	) B units				
	B units = $Hz^2 / 1$	000 ie: 1 Christen C-4	700Hz = 2890	) B units		Date: 30-JAN	N-04	

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1







## Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Number String Serial Range: Date of Calib Temperature Barometric P W.O. Number Cable Length Cable Colour Cable Insulat Thermistor ty	r: Number: ration: : ressure: : : : Code: don /pe:	STEFFE red / black (cc PE Polyethyle	N, ROBERTS pil) ane	CON & KIRSTEN VW2100-0.7 VW0691 03-25898 TS1572 700.0 4-Aug-03 23.4 995 Q01815 81 green / white 3	kPa °C millibars meters (thermistor) Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	( B units )	(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(%)	(% FS)
0.0	8833	0.0	8836	0.00	8835	0.83	0.12	0.01
140.0	8022	140.0	8022	140	8022	139.69	-0.04	-0.02
280.0	7205	280.0	7204	280	7205	279.40	-0.09	00.0
420.0	6385	420.0	6385	420	6385	419.45	-0.08	0.01
560.0	5563	560.0	5563	560	5563	559.94	-0.01	0.01
700.0	4740	700.0	4739	///////////////////////////////////////	4740	700.67	0.10	-0.01
					Max.	EITOI (%).	0.12	0.02
Linear Calibration Factor: Regression Zero: Temperature Correction Factor:				C.F.= Calibration Bi = Tk =	0.1709 8839.4 0.05691	kPa/B unit B unit kPa/⁰C rise		
Polynomial (	Gage Factors (kF	Pa)	А:	<u>-3.3196E-07</u>	В:	B: <u>-0.1664</u> C: <u>1496.0</u>		
	Pressure is calc Linear, P(kPa) = Polynomial:	ulated with the C.F. X ( Li - L P(kPa)=A(Lc)	following equ c)-[Tk(Ti- <sup>2</sup> +BLc+C+Tki	lations: · Tc)] + [ 0.10(E (Tc-Ti)-[0.10(Bc-E	ii - Bc ) ] Bi)]			
				DATE	VW2104	TEMP °C	BARO	
				(mm/dd/yr)	Pos. B (Li)	(Ti)	(Bi)	
	FACTORY ZER	O READINGS:	:	9/11/2003	8825	<u>22.6</u>	<u>1005.4</u>	
	SHIPPED ZERC	READINGS:		1/30/2004	8826	<u>20.4</u>	<u>1001.0</u>	
	Li, Lc = initial (a Ti, Tc = initial ( Bi, Bc = initial ( B units = B scal B units = $Hz^2 / 1$ Technician: <u>C</u> .	at installation) a at installation) at installation) e output of VW 000 ie: 1 Christen	and current re and current te and current b / 2102, VW 2- 700Hz = 2890	re readings, in r	nillibars Date: <u>30-JAI</u>	<u>N-04_</u>		

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

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## Vibrating Wire Pressure Transducer Calibration

Customer:		STEFFE	N, ROBERTS	ON & KIRSTEN				
Model:				VVV2100-0.7				
Serial Numbe	r:			000052				
Mfg Number				03-29254				
String Serial	Number:			151572	-D.			
Range:				700.01	кРа			
Date of Calib	ration:			21-Nov-03				
Temperature	:			21.9	-C			
Barometric P	ressure:			990.3	millibars			
W.O. Number	•			Q01815				
Cable Length	1:			62	meters			
Cable Colour	Code:	red / black (co	ii)	green / white	(thermistor)			
Cable insulat	ion	PE Polyethyle	ene					
Thermistor ty	/pe:			3	Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	( B units )	(kPa)	(%)	(% FS)
0.0	8793	0.0	8793	0.00	8793	1.00	0.14	0.00
140.0	7976	140.0	7977	140	7977	139.85	-0.02	0.01
280.0	7158	280.0	7158	280	7158	279.04	-0.14	-0.02
420.0	6333	420.0	6333	420	6333	419.34	-0.09	0.02
560.0	5507	560.0	5507	560	5507	559.81	-0.03	0.00
700.0	4677	700.0	4677	700	4677	700.95	0.14	0.00
					Max.	Error (%):	0.14	0.02
		_		0.5-	0 4704	kPa/R unit		
	Linear Calibrati	ion Factor:		U.F.=	0.1701	Rra/D unit		
	Regression Zer	·0:	At	Calibration BI =	0/30.3	kBa/°C rice		
	Temperature C	orrection Fact	or:	1K =	-0.04755	KFal Glise		
Polynomial	Gage Factors (kl	Pa)	A:	-4.3687E-07	В:	-0.1642	C:	<u>1477.4</u>
		,						
	Pressure is calc	ulated with the	following equ	ations:				
	Linear, P(kPa) =	= C.F. X ( Li - L	c) - [Tk (Ti -	Tc)]+[0.10(E	Bi-Bc)]			
	Polynomial:	P(kPa)=A(Lc)	) <sup>2</sup> +BLc+C+Tki	(Tc-Ti)-[0.10(Bc-I	3i)]			
				DATE	VW2104	TEMP °C	BARO	
				(mm/dd/yr)	Pos B (Li)	(T)	(Bi)	
	EACTORY 7EP			12/10/2003	8780	23.8	1001.9	
	SUIDDED 7ER		•	1/30/2004	8790	20.0	1001.0	
	Shiffed Zerk	J READINGS.		(130/2004	0130	20.0	100.10	
	Li. Lc = initial (	at installation)	and current re	adings				
	Ti. Tc = initial (	at installation)	and current te	emperature, in °C				
	Bi, Bc = initial (	at installation)	and current b	arometric pressu	re readings, in r	nillibars		
	B units = B scal	le output of VM	/ 2102. VW 2	104 readouts	0.			
	B units = $Hz^2$ /	1000 ie: 1	700Hz = 2890	) B units				
			rr.			_		
	Technician: <u>C</u>	. Christen (	يىلە			Date: <u>30-JA</u>	<u>N-04</u>	

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

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200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



## Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Number String Serial Range: Date of Calif: Temperature Barometric F W.O. Numbe Cable Lengtl Cable Colour Cable Insula Thermistor t	er: Number: pration: :: Pressure: r: h: r Code: tion ype:	STEFFE red / black (cc PE Polyethyle	EN, ROBERTS pil) ene	SON & KIRSTEN VW2100-0.7 VW0697 03-30775 TS1573 700.0 5-Jan-04 24.3 990.5 Q01815 62 green / white 3	kPa °C millibars meters (thermistor) Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(%)	(% FS)
0.0	9007	0.0	9006	0.00	9007	0.75	0.11	0.00
140.0	8201	140.0	8202	140	8202	139.85	-0.02	0.00
280.0	7394	280.0	7394	280	7394	279.37	-0.09	-0.01
420.0	6584	420.0	6583	420	6584	419.42	-0.08	0.00
560.0	5771	560.0	5770	560	5771	559.89	-0.02	0.01
700.0	4955	700.0	4956	700	4956	700.71	0.10	0.00
l					Max.	Error (%):	0.11	0.01
	Linear Calibrati Regression Zer Temperature Co	on Factor: o: orrection Fact	At or:	C.F.= Calibration Bi = Tk =	0.1728 9010.9 -0.2217	kPa/B unit B unit kPa/°C rise		
Polynomial C	Gage Factors (kF	Pa)	A:	<u>-3.3840E-07</u>	В:	<u>-0.1681</u>	C:	<u>1541.1</u>
	Pressure is calc Linear, P(kPa) = Polynomial:	ulated with the C.F. X ( Li - Lo P(kPa)=A(Lc)	following equ c)-[Tk(Ti- <sup>2</sup> +BLc+C+Tk(	ations: Tc ) ] + [ 0.10 ( B Tc-Ti)-[0.10(Bc-E	i - Bc)] 3i)]			
	FACTORY ZER	O READINGS: READINGS:		DATE (mm/dd/yr) 1/12/2004 1/30/2004	VW2104 Pos. B (Li) <u>9004</u> <u>9009</u>	TEMP °C (Ti) <u>25.2</u> <u>17.8</u>	BARO (Bi) <u>989.6</u> 1001.0	
	Li, Lc = initial ( a Ti, Tc = initial ( a Bi, Bc = initial ( a B units = B scale B units = $Hz^2 / 1$	t installation) a at installation) a at installation) a output of VW 000 ie: 17	nd current rea and current ter and current ba 2102, VW 210 700Hz = 2890	adings mperature, in °C irometric pressur 04 readouts B units	e readings, in m	illibars		
	Technician: <u>C.</u>	Christen 📿	2			Date: <u>30-JAN</u>	I-04	
This instrume	ent has been calib	rated using sta	Indards tracea	able to the NIST i	n compliance w	ith ANSI Z540-	1	

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200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



## Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Numbe String Seria Range: Date of Cali Temperatur Barometric W.O. Numbe Cable Lengt Cable Colou Cable Insula Thermistor	per: r I Number: bration: e: Pressure: er: th: ur Code: ation type:	STEFF red / black (cr PE Polyethyl	EN, ROBERT Dil) ene	SON & KIRSTEN VW2100-0. VW0699 03-3077 TS157 700.0 5-Jan-04 24.3 990.5 Q01815 81 green / white	N 7 7 3 0 kPa 4 3 °C 5 5 7 8 millibars 5 7 1 meters (thermistor) 8 Kohms 0.1C				
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial	
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	ES Error	Polynomiai	
(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	F.S. EIIO		
0.0	9161	0.0	9161	0.00	9161		(70)	(%FS)	
140.0	8296	140.0	8296	140	8296	139.97	0.11	0.00	
280.0	7431	280.0	7431	280	7431	279.13	-0.12	-0.02	
420.0	6559	420.0	6559	420	6559	419.42	-0.08	0.01	
560.0	5686	560.0	5686	560	5686	559.87	-0.02	0.01	
700.0	4810	700.0	4810	700	4810	700.80	0.11	0.00	
					Max.	Error (%):	0.12	0.03	
	Linear Calibrati Regression Zer Temperature Co	on Factor: o: prrection Fact	At or:	C.F.= Calibration Bi = Tk =	0.1609 9166.0 -0.1895	kPa/B unit B unit kPa/°C rise			
Polynomial (	Gage Factors (kP	a)	A:	<u>-3.3004E-07</u>	В:	<u>-0.1563</u>	C:	<u>1459.3</u>	
	Pressure is calcu Linear, P(kPa) = Polynomial:	ulated with the C.F. X ( Li - Lc P(kPa)=A(Lc) <sup>2</sup>	following equa ) - [ Tk ( Ti - +BLc+C+Tk(	ations: Tc)] + [ 0.10(B Fc-Ti)-[0.10(Bc-E	ii - Bc)] 3i)]				
	FACTORY ZERC SHIPPED ZERO	) READINGS: READINGS:		DATE (mm/dd/yr) 1/12/2004 1/30/2004	VW2104 Pos. B (Li) <u>9157</u> <u>9158</u>	TEMP °C (Ti) <u>24.8</u> <u>18.7</u>	BARO (Bi) <u>989.6</u> 1001.0		
	Li, Lc = initial ( at installation) and current readings Ti, Tc = initial ( at installation) and current temperature, in °C Bi, Bc = initial ( at installation) and current barometric pressure readings, in millibars B units = B scale output of VW 2102, VW 2104 readouts B units = Hz <sup>2</sup> / 1000 ie: 1700Hz = 2890 B units								
	Technician: <u>C.C</u>	Christen (C	,		ļ	Date: <u>30-JAN-</u>	04		
This instrume	nt has been calibr	ated using star	idards tracea	ble to the NIST ir	n compliance wit	h ANSI Z540-1			

Document Number.: ELL0130E



200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



### **Vibrating Wire Pressure Transducer Calibration**

Customer: Model: Serial Number String Serial Range: Date of Calib Temperature Barometric F	er: Number: pration: :: Pressure:	STEFFE	N, ROBERTS	SON & KIRSTEN VW2100-0.7 VW0698 03-30776 TS1574 700.0 5-Jan-04 24.3 990 5	kPa °C millibars			
W.O. Numbe	r:			Q01815				
Cable Lengti	n:			42	meters			
Cable Colou	r Code:	red / black (co	oil)	areen / white	(thermistor)			
Cable Insula	tion	PE Polyethyle	ene	5	(			
Thermistor t	ype:			3	Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	E.S. Error	Fit
(kPa)	( B units )	(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(%)	(% ES)
0.0	9097	0.0	9098	0.00	9098	0.88	0.13	0.00
140.0	8272	140.0	8272	140	8272	139.85	-0.02	0.00
280.0	7444	280.0	7444	280	7444	279.25	-0.11	-0.01
420.0	6612	420.0	6612	420	6612	419.32	-0.10	0.00
560.0	5778	560.0	5777	560	5778	559.81	-0.03	0.00
700.0	4939	700.0	4940	700	4940	700.88	0.13	0.00
					Max.	Error (%):	0.13	0.01
	Linear Calibrati Regression Zero Temperature Co	on Factor: o: prrection Fact	At s	C.F.= Calibration Bi = Tk =	0.1684 9102.7 -0.23310	kPa/B unit B unit kPa/⁰C rise		
Polynomial G	age Factors (kP	a)	A:	<u>-3.8473E-07</u>	В:	<u>-0.1630</u>	C:	<u>1514.3</u>
	Pressure is calcu Linear, P(kPa) = Polynomial:	ulated with the C.F. X ( Li - Lc P(kPa)=A(Lc) <sup>2</sup>	following equa ) - [ Tk ( Ti - +BLc+C+Tk(	ations: Tc ) ] + [ 0.10 ( B Tc-Ti)-[0.10(Bc-B	i - Bc)] 8i)]			
	FACTORY ZERO READINGS: SHIPPED ZERO READINGS:				VW2104 Pos. B (Li) <u>9097</u> <u>9101</u>	TEMP °C (Ti) <u>25.2</u> <u>20.0</u>	BARO (Bi) <u>989.6</u> <u>1001.0</u>	
	Li, Lc = initial (at Ti, Tc = initial (a Bi, Bc = initial (a B units = B scale B units = Hz <sup>2</sup> / 10	installation) at t installation) a t installation) a output of VW 3 000 ie: 17	nd current rea nd current ter nd current ba 2102, VW 210 00Hz = 2890	dings nperature, in °C rometric pressure 04 readouts B units	e readings, in m	illibars		
	Technician: <u>C. (</u>	Christen 📿	•			Date: <u>30-JAN</u>	-04	

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Document Number.: ELL0130E

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200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



## Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Number String Serial Range: Date of Calib Temperature Barometric P W.O. Number Cable Length Cable Colour Cable Insulat Thermistor ty	er: Number: ration: : ressure: r: : Code: tion ype:	STEFFE red / black (cc PE Polyethyle	N, ROBERTS bil) ane	ON & KIRSTEN VW2100-0.7 VW0700 03-30778 TS1574 700.0 5-Jan-04 24.3 990.5 Q01815 83 green / white	kPa °C millibars meters (thermistor) Kohms 0.1C			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	(Bunits)	(kPa)	( B units )	(kPa)	(Bunits)	(kPa)	(%)	(% FS)
0.0	8980	0.0	8981	0.00	8981	0.94	0.13	0.00
140.0	8176	140.0	8177	.140	8177	139.92	-0.01	0.02
280.0	7371	280.0	7372	280	7372	279.08	-0.13	-0.02
420.0	6561	420.0	6560	420	6561	419.27	-0.10	0.01
560.0	5747	560.0	5748	560	5748	559.81	-0.03	0.00
700.0	4931	700.0	4931	700	4931	700.96	0.14	0.00
					Max.	Error (%):	0.14	0.02
	Linear Calibrati Regression Zer Temperature C	ion Factor: o: orrection Fact	At tor:	C.F.= Calibration Bi = Tk =	0.1729 8985.9 -0.18670	kPa/B unit B unit kPa/⁰C rise		
Polynomial (	Gage Factors (kl	⊃a)	A:	<u>-4.4473E-07</u>	B:	<u>-0.1667</u>	C:	<u>1532.7</u>
	Pressure is calc Linear, P(kPa) = Polynomial:	ulated with the C.F. X ( Li - Li P(kPa)=A(Lc)	following equ c)-[Tk(Ti- <sup>2</sup> +BLc+C+Tk(	ations: Tc ) ] + [ 0.10 ( B Tc-Ti)-[0.10(Bc-E	ii - Bc)] 3i)]			
	FACTORY ZER SHIPPED ZERC	O READINGS: D READINGS:		DATE (mm/dd/yr) 1/12/2004 1/30/2004	VW2104 Pos. B (Li) <u>8977</u> <u>8980</u>	TEMP °C (Ti) <u>24.6</u> <u>19.1</u>	BARO (Bi) <u>989.6</u> 1001.0	
	Li, Lc = initial ( ; Ti, Tc = initial ( Bi, Bc = initial ( B units = B scal B units = Hz <sup>2</sup> / 1	at installation) a at installation) at installation) e output of VW 1000 ie: 1	and current rea and current te and current ba 2102, VW 21 700Hz = 2890	adings mperature, in °C arometric pressur 04 readouts I B units	e readings, in n	nillibars		
	Technician: <u>C</u>	Christen C	<u>[</u> [.			Date: <u>30-JAN</u>	1-04	i

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1



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200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



### 3000 ohm THERMISTOR STRING FUNCTION CHECK

Customer: Date: Work Order: Serial number: STEFFEN, ROBERTSON & KIRSTEN 25-Mar-04 Q02189 TS1589

Point	Cable	Measured	Calculated
	Length	Resistance	Temperature
	feet	ohms	°C
1	20	4143	17.8
2	33	4164	17.7
3	58	4188	17.6
4	108	4153	17.8
5	183	4170	17.7
7	228	4176	17.7
8	253	4178	17.6
10	270	4195	17.6

#### Temperature calculated using:

#### **Steinhart-Hart Linearization**

$$T_{C} = \frac{1}{C_{0} + C_{1}(\ln R) + C_{3}(\ln R)^{3}} -273.15$$

3000 Ohm @ 25C NTC Thermistor

 $C_0$ = 0.0014050  $C_1$ = 0.0002369  $C_3$ = 0.0000001013 InR= Natural Log of Resistance  $T_c$ = Temperature in °C

Checked By: C Christen 7

Document Number · THM0004A

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## Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Number Mfg Number Range: Date of Calibh Temperature: Barometric P W.O. Number Cable Length Cable Colour Cable Insulat Thermistor ty	r: ration: ressure: : Code: ion rpe:	STEFFE	N, ROBERTS bil) ene	CON & KIRSTEN VW2100-0.7 VW0724 03-30784 700.0 5-Jan-04 24.3 990.5 Q02189 223 green / white 3	kPa °C millibars feet (thermistor) Kohms			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	( B units )	(kPa)	( B units )	(kPa)	( B units )	(kPa)	(%)	(% FS)
0.0	9096	0.0	9097	0.00	9097	0.44	0.06	0.01
140.0	8307	140.0	8307	140	8307	139.77	-0.03	-0.02
280.0	7514	280.0	7514	280	7514	279.72	-0.04	0.00
420.0	6721	420.0	6720	420	6721	419.75	-0.04	0.00
560.0	5925	560.0	5926	560	5926	560.05	0.01	0.02
700.0	5131	700.0	5131	700	5131	700.26	0.04	-0.01
					Max. I	Error (%):	0.06	0.02
Polynomial G	Linear Calibrati Regression Zer Temperature Co Gage Factors (kF	ion Factor: :o: orrection Fact Pa)	At or: A:	C.F.= Calibration Bi = Tk = <u>-1.6524E-07</u>	0.176478 9099.0 -0.19050 B:	kPa/B unit B unit kPa/°C rise -0.17413	C:	<u>1597.7</u>
	Pressure is calc Linear, P(kPa) = Polynomial:	culated with the = C.F. X ( Li - L P(kPa)=A(Lc)	following eq c ) - [ Tk ( Ti - <sup>2</sup> +BLc+C+Tk	uations: · Tc ) ] + [ 0.10 ( E (Tc-Ti)-[0.10(Bc-l	3i - Bc ) ] Bi)]			
	FACTORY ZER SHIPPED ZERC	O READINGS: D READINGS:		DATE (dd/mm/yr) 12-Jan-04 25-Mar-04	VW2104 Pos. B (Li) <u>9096</u> <u>9106</u>	TEMP <sup>°</sup> C (Ti) <u>24.8</u>	BARO (Bi) <u>989.6</u> 1007.1	
	Li, Lc = initial ( a Ti, Tc = initial ( a Bi, Bc = initial ( a B units = B scal B units = $Hz^2 / 1$	at installation) a at installation) a at installation) a e output of VW 1000 ie: 1	and current re and current te and current b 2102, VW 2 700Hz = 289	eadings emperature, in °C arometric pressu 104 readouts 0 B units	re readings, in n	nillibars		
This is -town	Technician:	C Christen	<u>(</u> G	-	Date:	25-Mar-04		

Document Number.: ELL0130E





# Vibrating Wire Pressure Transducer Calibration

Customer: Model: Serial Number Mfg Number Range: Date of Calibh Temperature: Barometric P W.O. Number Cable Length Cable Colour Cable Insulat Thermistor ty	r: ressure: : Code: ion rpe:	STEFFEN red / black (cc PE Polyethyle	N, ROBERTS bil) ene	ON & KIRSTEN VW2100-0.7 VW0725 03-30785 700.0 5-Jan-04 24.3 990.5 Q02189 268 green / white 3	kPa ⁰C millibars feet (thermistor) Kohms			
Annlied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Proceuro	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
riessure (kDa)	( B unite )	(kPa)	(Bunits)	(kPa)	(Bunits)	(kPa)	(%)	(%FS)
	9150		9150	0.00	9150	0.63	0.09	-0.01
140.0	8326	140.0	8324	140	8325	139.95	-0.01	0.01
280.0	7499	280.0	7499	280	7499	279.44	-0.08	0.00
420.0	6670	420.0	6670	420	6670	419.43	-0.08	0.00
560.0	5838	560.0	5839	560	5839	559,85	-0.02	0.00
700.0	5005	700.0	5004	700	5005	700.69	0.10	0.00
100.0					Max. I	Error (%):	0.10	0.01
	Linear Calibra Regression Ze Temperature C	tion Factor: ro: Correction Fact	At	C.F.= Calibration Bl = Tk =	0.168872 9153.7 -0.07870 B.	kPa/B unit B unit kPa/°C rise -0 16471	C	1531.7
Polynomial	Pressure is cal Linear, P(kPa) Polynomial:	culated with the = C.F. X ( Li - L P(kPa)=A(Lc	e following eq .c ) - [ Tk ( Ti ) <sup>2</sup> +BLc+C+Tk	uations: - Tc)] + [ 0.10(i ‹(Tc-Ti)-[0.10(Bc-	Bi - Bc)] Bi)]			
	FACTORY ZEI SHIPPED ZER	RO READINGS O READINGS:	:	DATE (dd/mm/yr) 12-Jan-04 25-Mar-04	VW2104 Pos. B (Li) <u>9136</u> <u>9132</u>	TEMP °C (Ti) <u>25.2</u>	BARO (Bi) <u>989.6</u> <u>1007.1</u>	
	Li, Lc = initial ( Ti, Tc = initial Bi, Bc = initial B units = B sc B units = Hz <sup>2</sup> /	at installation) ( at installation) ( at installation) ale output of VV 7 1000 ie:	and current r and current t and current t V 2102, VW 2 1700Hz = 289	eadings emperature, in °C parometric press 2104 readouts 20 B units	; ure readings, in i	millibars		
	Technicia	n: <u>C Christen</u>	<u>(4</u>		Date	25-Mar-04		

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1



200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



#### 3000 ohm THERMISTOR STRING FUNCTION CHECK

Customer:	STEFFEN, ROBERTSON & KIRSTEN
Date:	25-Mar-04
Work Order:	Q02219
Serial number:	TS1590

90 Calculated Cable Measured Point Resistance Length Temperature °C ohms feet 4187 17.6 1 18 4188 17.6 2 38 3 58 4222 17.4 4167 17.7 4 108 5 4208 17.5 158 6 242 4191 17.6 4221 17.4 8 258 4216 17.4 9 313 10 314 4210 17.5

Temperature calculated using:

#### **Steinhart-Hart Linearization**

$$T_{c} = \frac{1}{C_{0} + C_{1}(\ln R) + C_{3}(\ln R)^{3}} -273.15$$

3000 Ohm @ 25C NTC Thermistor

 $\begin{array}{l} C_{0}{=} \ 0.0014050 \\ C_{1}{=} \ 0.0002369 \\ C_{3}{=} \ 0.0000001013 \\ \text{InR= Natural Log of Resistance} \\ T_{c}{=} \ \text{Temperature in } ^{\circ}\text{C} \end{array}$ 

Checked By: C Christen

Document Number.: THM0004A

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200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



### **Vibrating Wire Pressure Transducer Calibration**

Customer:		STEFFE	N, ROBERTS	ON & KIRSTEN				
Model:				VW2100-0.7				
Serial Numb	er:			VW0726				
Mfg Number				03-30786				
Range:				700.0	kPa			
Date of Calib	ration:			5-Jan-04				
Temperature	:			24,3	°C			
Barometric F	Pressure:			990,5	millibars			
W.O. Numbe	r:			Q02219				
Cable Lengtl	า:			243	feet			
Cable Colou	r Code:	red / black (co	oil)	green / white	(thermistor)			
Cable Insula	tion	PE Polyethyl	ene					
Thermistor t	vpe:			3	Kohms			
Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	( B units )	(kPa)	( B units )	(kPa)	( B units )	(kPa)	(%)	<u>(% FS)</u>
0.0	8806	0.0	8808	0.00	8807	-0.06	-0.01	0.01
140.0	8013	140.0	8014	140	8014	139.91	-0.01	-0.02
280.0	7219	280.0	7219	280	7219	280.05	0.01	-0.01
420.0	6424	420.0	6425	420	6425	420.19	0.03	0.01
560_0	5630	560.0	5632	560	5631	560.15	0.02	0.02
700.0	4839	700.0	4840	700	4840	699.76	-0.03	-0.01
					Max.	Error (%):	0.03	0.02
	Linear Calibrat	ion Factor:		C.F.=	0.176389	kPa/B unit		
	Regression Ze	ro:	At	Calibration Bi =	8806.7	B unit		
	Temperature C	orrection Fact	or:	Tk =	-0.04640	kPa/⁰C rise		
Polynomial (	Gage Factors (kl	Pa)	A:	7.0000E-08	B:	<u>-0.17734</u>	C:	<u>1556.5</u>
	Pressure is cal	culated with the	e tollowing equ	uations:				
	Linear, P(kPa)	= U.F. X (LI - L	.C)-[IK(  -	· IC)]+[0.10(E	51 ~ BC )]			

Polynomial: P(kPa)=A(Lc)<sup>2</sup>+BLc+C+Tk(Tc-Ti)-[0.10(Bc-Bi)]

	DATE	VW2104	TEMP °C	BARO
	(dd/mm/yr)	Pos. B (Li)	(Ti)	(Bi)
FACTORY ZERO READINGS:	12-Jan-04	<u>8805</u>	<u>24.9</u>	<u>989.6</u>
SHIPPED ZERO READINGS:	25-Mar-04	8806		<u>1007.1</u>

Li, Lc = initial ( at installation) and current readings

Ti, Tc = initial ( at installation) and current temperature, in  $^{\circ}$ C

Bi, Bc = initial ( at installation) and current barometric pressure readings, in millibars

B units = B scale output of VW 2102, VW 2104 readouts

B units =  $Hz^2 / 1000$  ie: 1700Hz = 2890 B units

Technician: C Christen C-(-

Date: 25-Mar-04

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5



### Vibrating Wire Pressure Transducer Calibration

Customer:	STEFFEN, ROBE	RTSON & KIRSTEN	
Vodel:		VW2100-0.7	
Serial Number:		VW0785	
Vifg Number		03-30795	
Range:		700.0 kPa	
Date of Calibration:		5-Jan-04	
Temperature:		24.3 °C	
Barometric Pressure:		990.5 millibars	
W.O. Number:		Q02219	
Cable Length:		314 feet	
Cable Colour Code:	red / black (coil)	green / white (thermist	(10
Cable Insulation	PE Polyethylene		
Thermistor type:		3 Kohms	

Applied	First	Applied	Second	Average	Average	Calculated	Linearity	Polynomial
Pressure	Reading	Pressure	Reading	Pressure	Readings	Pressure	F.S. Error	Fit
(kPa)	( B units )	(kPa)	( B units )	(kPa)	( B units )	(kPa)	(%)	(% FS)
0.0	8971	0.0	8971	0.00	8971	0.96	0.14	0.00
140.0	8163	140.0	8164	140	8164	139.75	-0.04	-0.01
280.0	7352	280.0	7351	280	7352	279.31	-0,10	0.01
420.0	6537	420.0	6538	420	6538	419.22	-0.11	0.00
560.0	5719	560.0	5720	560	5720	559.82	-0.03	0.00
700.0	4898	700.0	4899	700	4899	700.93	0.13	0.00
					Max.	Error (%):	0.14	0.01

Linear Calibration Factor:	C.F.=	0.171877 kPa/B unit
Regression Zero:	At Calibration Bi =	8976.6 B unit
Temperature Correction Factor:	Tk =	-0.13290 kPa/°C rise

A:

```
Polynomial Gage Factors (kPa)
```

<u>-4.2328E-07</u> B: <u>-0.16601</u>

C: <u>1523.3</u>

	DATE	VW2104	TEMP °C	BARO
	(dd/mm/yr)	Pos. B (Li)	(Ti)	(Bi)
FACTORY ZERO READINGS:	12-Jan-04	<u>8970</u>	24.8	<u>989.6</u>
SHIPPED ZERO READINGS:	25-Mar-04	8969	<u>19.6</u>	<u>1007.1</u>

Li, Lc = initial ( at installation) and current readings

Ti, Tc = initial ( at installation) and current temperature, in  $^{\rm o}{\rm C}$ 

Bi, Bc = initial ( at installation) and current barometric pressure readings, in millibars

B units = B scale output of VW 2102, VW 2104 readouts

B units =  $Hz^2 / 1000$  ie: 1700Hz = 2890 B units

Technician: <u>C Christen</u>

Date: 25-Mar-04

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

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Appendix B Arsenic Trioxide Dust Shipping and Chain of Custody Documentation

WEBSITE: http://www.nwtl.com	)
Please Print Pro Bill # Here 3568572	
Date March 2, 2004	
Shipper <u>Roscenna Massimi</u> , Indian & Northern Affairs (anada Shipper No	
Address 5th Floor Precambrian Bldg, PO Box 1500 yellowknife, NT X1A ZR3	
POINT OF ORIGIN Received at the point of origin on the date specified, from the consignor mentioned herein, the property herein described, in apparent good order, except as noted (contents and condit of package unknown) marked, consigned and destined as indicated below, which the carrier agrees to carry and to deliver to the consignee at the said destination, if on its own authorized ro to cause to be carried by another carrier on the route to said destination, subject to the rates and classification in effect on the date of shipment. It is mutually agreed, as to each carrier of all or any of the goods overall or any portion of the route to destination, and as to each party of any time interested in all or any of the goods, that be performed hereunder shall be subject to all the conditions not prohibited by law, whether printed or written, including conditions set aside by the standard Bill of Lading, which are he the consignor and accepted for himself and his assigns. The Contract for the carriage of the goods listed in the bill of lading is governed by regulation in force in the jurisdiction at the time and place of shipment and is subject to the cond such regulations.	ons of contents ute or otherwise every service to reby agreed by ttions set out in
Consignee Dr C. Joe Ferron, Sc.5 - hakefield (Name and Address)	
Destination 183 (mession St, Lakefield, Ontavio Route	
PIECES DG VES / NO DANGEROUS GOODS PAPERWORK WILL BE ATTACHED Ibs. L W H	HARGES
4 Yes Arsenical Dust/6.1/UN 1562/II 32.5 kg 20 L pails Freight charges will be	collect unless
C.O.D. SHI	MENTS
Amount	\$
Collection charge	\$
Collect	. s
If at consignor's risk, write or stamp here SPECIAL INSTRUCTIONS	
24 hour phone no. 867-444-2115	· · ·
DECLARED VALUATION	
\$	
<ul> <li>(a) No carrier is liable for loss, damage or delay to any goods under the Bill of Lading unless notice thereof setting out particulars of the origin, destination and date of sh goods and the estimated amount claimed in respect of such loss, damage or delay is given in writing to the originating carrier or the delivering carrier within sixty (60) or delivery of the goods, or, in the case of failure to make delivery, within nine (9) months from the date of shipment.</li> <li>(b) The final statement of the claim must be filed within nine (9) months from the date of shipment together with a copy of the paid freight bill.</li> </ul>	pment of the ays after the
Consignor <u>flexanna Massinii</u> Uhit # Trl #1 2/04 Receiver	
Per         # of pieces         Per         Per	)

		<b>NO</b>		<b>EST</b> 15811 • Edmont (780) 44 Fax: (78 WEBSI	112 Aven on, Alberta 52-9601 30) 454-30 FE: http://v	ue a T5M 2V 41 vww.nwtl.	′9 com		N.W.I.L. 3568566
12		, , ,			Please I	Print Pro B	ill # Here		
							Date _	March	15,2004
Ship	per <u>Bos</u>	<u>anna Ma</u>	Ssimi, Ind. (Or A	and Northern Aff gent)	airs can	ada	Shippe	r No	
Addi	ress <u>5<sup>+h</sup> F</u>	bor Prece	umbrian Bldg	<u>, PO Box 1500</u>	, Yella	sknife, r	NT X	1A 28	3
of pacito cause It is be per the con The such re	kage unknown ise to be carrie mutually agree formed hereur nsignor and ac Contract for t egulations.	in to dright of high of high d by another carrier ad, as to each carrie inder shall be subje- coepted for himself a he carriage of the	e dand destined, inform the on the route to said dest on the route to said dest on the route to said dest of the all or any of the good ct to all the conditions no and his assigns. goods listed in the bill of <u>e Ferron</u>	Consigner mentioned herein, the ad below, which the carrier agrees nation, subject to the rates and c is overall or any portion of the rou of prohibited by law, whether prin- lading is governed by regulation	property herein s to carry and to d lassification in effi te to destination, ited or written, in i in force in the j	described, in ag deliver to the co act on the date and as to each cluding condition urisdiction at th	parent good a nsignee at the of shipment. party of any tii ns set aside t e time and pl	order, except a said destinati me interested i by the standar ace of shipme	as noted (contents and conditions of contents on, if on its own authorized route or otherwise n all or any of the goods, that every service to d Bill of Lading, which are hereby agreed by nt and is subject to the conditions set out in
Dest	ination 🖄	5 Conces	sion St. La	(Name Kefield, Ontar	and Address) KOL	2HO Bout	Δ		
ECES	DG YES / NO	PARTICULARS	S OF THE GOODS, N GOODS PAPERWO	ARKS AND EXCEPTIONS	WEIGHT			IONS	FREIGHT CHARGES
	YES	ArsenicalD	ust /6.1/un	1562/IL	82.3kg	9-2	OL po		Collect     Preparent     Freight charges will be collect unless     marked prepaid
									C.O.D. SHIPMENTS
									\$
									Collection charge\$
									Prepaid TOTAL \$
at consig	jnor's risk, wri	te or stamp here	SPECIAL INSTRU	CTIONS			<u>x</u>		4
			DONOT	FREEZE	-				
DECL	ARED VA	LUATION			L//	14	$\neg$		
			24 hour f	shone number	1 867-4	<b>\$-211</b>	5		
ximum ind unl es oth	liability of less declar ierwise.	\$2.00 per ed valuation							
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				Cartier Northwes	t Transpo	ort Ltd.			
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Appendix C Laboratory Reports

### UNOFFICIAL COPY / COPIE NON OFFICIELLE

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Protected Business Information

A Mineralogical Investigation of Arsenic Trioxide (As<sub>2</sub>O<sub>3</sub>) Rich Dust from the Giant Mine, Yellowknife, NWT

by Glenn Poirier

Work performed for: SRK Consulting Inc.

Project: 602758 Report CANMET-MMSL 04-028(CR)

Version: October 2004

## CONFIDENTIAL

DECLASSIFICATION: February 5, 2007

### EXECUTIVE SUMMARY

Four samples of arsenic trioxide dust from the underground storage chambers of the Giant mine were examined using X-ray diffraction, SEM-EDS and electron microprobe as part of a study of their mineralogy. The results of this study will be used to characterize the 237,000 tonnes of arsenic trioxide dust stored in stopes and chambers within the mine.

Apart from changes in the amount of arsenic trioxide and the proportions of accessory phases, all the samples are broadly similar and are consistent with the samples described by Dutrizac *et al.* (2000). One of the biggest changes is the amount of hematite. In Old Feed and B233-p9 As-bearing hematite is a minor phase, whereas in C212-2 and B208-1 it is a trace phase. The root cause of the variation in mineral proportions may be the result of two factors. The first being less efficient collection of arsenic trioxide in the 1950's leading to increased proportions of secondary phases and the second factor being variability in composition of the ore being processed. Variability in the amount of antimony in the ore is also probably responsible for variation in the Sb content in the arsenic trioxide grains. The higher hematite content in the mill shutdown.

The arsenic trioxide grains have an apparent bimodal size distribution. The most likely cause of this distribution is the growth of  $As_2O_3$  crystals on surfaces in the baghouse and their subsequent release and collection.

There is some evidence that arsenic trioxide content of the dust varies within the storage chambers. One sample has a significantly different arsenic trioxide content than a sample from the same chamber examined in another study. With the exception of the Old Feed sample, the bulk arsenic trioxide contents are consistent with the samples date of production (*i.e.* more recent samples are richer in arsenic trioxide).
#### DISCLAIMER

**CANMET-MMSL** makes no representation or warranty respecting the results arising from the Work, either expressly or implied by law or otherwise, including but not limited to implied warranties or conditions of merchantability or fitness for a particular purpose.

**CANMET-MMSL** shall keep confidential and not disclose to third parties the information contained in or regarding this report for a period of three years from the coming into force of this Agreement, i.e. until February 5, 2007, except with the written consent of the **CLIENT**.

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### INTRODUCTION

Since its initial opening in 1948 the Giant mine has produced over 6.8 million ounces of gold. As a by-product of this gold production, large amounts of As<sub>2</sub>O<sub>3</sub> dust (owing to the arsenopyrite-rich nature of the ore) were produced (Dutrizac *et al.*, 2000). Initially this dust was released to the environment, but from 1951 onward it has been captured and stored underground in mined-out stopes and specially built chambers. When the mine's owner (Royal Oak Mines) went out of business in 1999, responsibility for the mine and its wastes fell to the Department of Indian and Northern Affairs. Presently, approximately 237,000 tonnes of dust containing from 50 to 88 weight percent arsenic trioxide are stored underground (SRK final report to DIAND, 2002, Giant Mine Arsenic Trioxide Management Technical Meeting Proceedings, 1997)). As part of a study dealing with long term storage options for this dust CANMET-MMSL was approached by SRK Consulting to carry out a mineralogical investigation of this dust. Four samples of the dust were received on May 24<sup>th</sup> 2004. They were labelled "Old Feed", C212-2, B208-1 and B233-p9.

Samples B208-1 and B233-p9 and C212-2 were collected from the underground stopes and chambers using split spoon samplers. C212-2 and B208-1 samples are composites of several discrete depth samples collected from the drill holes. The sample labelled "Old Feed" (also referred to as "Barrel") is dust that was packed into barrels directly from the baghouse in 1998/99. Sample B233-p9 represents material that was collected and deposited underground in the early-to-mid 1950's. The material represented by sample B208-1 was collected and deposited in the mid-1960's. The sample C212-2 material was produced and deposited underground in the 1970's. The Old Feed sample (also known as "Barrel") was collected in the baghouse and packed directly into barrels in 1998/1999. At this time the mine had ceased operations and operating conditions in the mill were atypical. As a result the Old Feed sample may not be representative of samples produced in the 1990's (Steven Schultz, SRK Consulting, pers. comm.).

### EXPERIMENTAL

The samples consisted of an extremely fine-grained light grey powder. For each of the powders a polished block was prepared by embedding the dust in a cold-set epoxy and polished using diamond compound on a lead lap. Powder samples were prepared by dispersing the dust on double-sided carbon tape mounted on an aluminium SEM stub.

The polished sample was coated with a thin layer of carbon for conductivity and the powder sample was coated with a thin layer of gold for the same purpose.

### X-ray Diffraction

All samples were submitted for X-ray diffraction (XRD) to determine the bulk mineralogy of the samples. Samples were prepared for X-ray diffraction by grinding to -37  $\mu$ m grain size in an agate mortar and pestle. The powder samples were packed in a Teflon-coated sample holder in preparation for analysis. XRD powder patterns for each sample were obtained by means of a Rigaku D/MAX B Rotaflex powder diffractometer scanning from 5 to 90° (20) with CuK $\alpha$  radiation produced at an accelerating voltage of 55 kV and a beam current of 180 mA. The scan rate was 10°/minute at a step of 0.04°. Phase identification was done using the JADE v6.0 search/match software.

#### **Electron Microscopy**

The polished samples were examined using a JEOL 820 scanning electron microscope with an LINK digital EDS detector. Digital images were captured using Quartz PCI software. Operating conditions were 15 kV and 2 to 0.002 nA. Semi-quantitative EDS analyses were corrected using a standard ZAF matrix correction.

Powder samples were examined using a Hitachi 3200N variable pressure scanning electron microscope in high-vacuum mode. Digital images were captured using Quartz PCI software. The electron gun was operated at 15 kV.

#### **Microprobe Analysis**

 $As_2O_3$  and hematite in the polished blocks were quantitatively analysed using a JEOL 8900 electron microprobe. Matrix corrections were performed using the CiTZAF correction (Armstrong, 1995). Operating conditions are provided below in Table 1.

### Table 1 – Microprobe Analytical Conditions

### **Analytical Conditions**

Accelerating Voltage	15 kV
Beam Current	20 nA
Spot Size	1 µm

Element	Standard	Counting Times	Precision	Detection
			(70)	
As	FeAs <sub>2</sub>	20s peak, 10 s bg*	1	3000
Sb	$Sb_2S_3$	20s peak, 10 s bg	2-15	900
Fe	Fe <sub>2</sub> O <sub>3</sub>	20s peak, 10 s bg	2-20**	1000
S	FeS <sub>2</sub>	20s peak, 10 s bg		700
Si	CaSiO₃	20s peak, 10 s bg		700
Ca	CaSiO₃	20s peak, 10 s bg		400
Pb	PbS	20s peak, 10 s bg		900
Bi	Bi <sub>2</sub> S <sub>3</sub>	20s peak, 10 s bg		1500
Cr	Chromite (GS2)	20s peak, 10 s bg		1100

\* background \*\* 2% in hematite, 20% in As<sub>2</sub>O<sub>3</sub>

### RESULTS AND DISCUSSION

### X-ray Diffraction Results

A summary of X-ray diffraction results is presented as Table 2. Identification of phases as major or accessory is based on a qualitative assessment of the strength of X-ray lines and examination with SEM. The actual diffraction patterns are presented in Appendix A.

Sample	Identified Minerals								
	(major)	(accessory)							
Old Feed	As <sub>2</sub> O <sub>3</sub> , muscovite	Gypsum, clinochlore, hematite, tennantite							
B208-1	As <sub>2</sub> O <sub>3</sub>	Muscovite, gypsum, dolomite (?)							
B233-p9	As <sub>2</sub> O <sub>3</sub> , hematite	Muscovite, clinochlore, pyrite, gypsum							
C212-2	As <sub>2</sub> O <sub>3</sub>	Clinochlore, muscovite, gypsum							

Table 2 – X-ray Diffraction results

#### SEM-EDS

Examination of the samples using SEM-EDS reveals that all samples are grossly similar, consisting primarily of mainly euhedral arsenic trioxide with a grain size of less than 10  $\mu$ m (Figures 1, 8, 15 and 22). Sample B233-p9 (Figure 19) is notable in that it contains significantly less arsenic trioxide than the other samples. This agrees well with the bulk chemical assay for the sample and is consistent with the sample being produced in the mid-1950's when collection efficiency was lower. The B208-1 sample material, produced in the mid-1960's (Figure 8) contains as much arsenic trioxide as the more recent sample, C212-2, (Figure 22) dating from the 1970's. This is also consistent with its bulk chemistry. All of the samples contain varying amounts of a second coarser-grained population of arsenic trioxide. These grains are generally euhedral and range in size from 30  $\mu$ m to 100  $\mu$ m (Figures 3, 9,10, 13,18 and 28).

Another significant difference between the samples is the amount of hematite. Old Feed and B233-p9 both contain significant amounts of hematite (Figures 2, 15, 17 and 20). In both samples most of the hematite appears porous or spongy and occurs as small (10-20  $\mu$ m) grains. Larger grains (30-50  $\mu$ m) are also observed (Figure 4) and

typically exhibit a banded structure probably indicative of cyclic oxidation of pyrite during roasting. In the remaining samples B208-1 and C212-2 hematite is a very minor phase (Figures 14 and 22).

Chlorite (clinochlore) and muscovite, gypsum and quartz are common accessory phases in all samples although the proportions vary. Chlorite and muscovite occur as lathlike grains, which are often larger than the arsenic trioxide grains (Figures 12, 16, 19 and 24). Gypsum and quartz occur as small equant grains, typically less than 10  $\mu$ m in diameter (Figures 2, 15, 16, 22 and 27).

Some trace minerals found using SEM but not reported by X-ray diffraction include chalcopyrite (Figure 16) and an Fe-Ca arsenate tentatively identified as yukonite  $(Ca_2Fe_3(AsO_4)_4(OH)\bullet12H_2O)$  (Figures 22 and 26).

### **Electron Microprobe Analyses**

Electron microprobe analyses were performed on As-bearing phases in all samples. In all samples, small and large grains of  $As_2O_3$  were analysed. Additionally in the Old Feed sample and in B233-p9, hematite was sufficiently abundant to analyse. Although the large arsenic trioxide grains were easily analysed the 1-2 µm grain size of the small  $As_2O_3$  and hematite presented some difficulty. In general the small  $As_2O_3$  grains gave good totals and stoichiometry, but occasional poor results were probably due to the presence of other minerals within the analytical volume. Hematite analyses were uniformly at least ten weight percent too low. These poor results are attributable to the spongy nature of these grains. Summaries of the results are presented as Tables 3 - 5and complete data sets are supplied in Appendix B.

For all of the samples between ten and twenty randomly selected small grains of  $As_2O_3$  and between 10 and 15 large grains of  $As_2O_3$  were selected for analysis. Although the sample is small it can be seen from Tables 3-4 and Figure 30 that the majority of grains are relatively pure, with less than one percent impurities, the most common being antimony and iron.

	Old Feed	n=17			B233-p9	n=14			B208-1	n=15			C212-2	n=15		
	Average	Max	Min	St. Dev.	Average	Max	Min	St. Dev.	Average	Max	Min	St. Dev.	Average	Max	Min	St. Dev.
As <sub>2</sub> O <sub>3</sub>	92.92	100.24	77.35	6.56	98.02	100.16	95.19	1.42	88.38	98.08	58.40	12.34	97.30	100.98	93.04	2.68
Sb <sub>2</sub> O <sub>3</sub>	2.36	13.63	0.11	3.56	0.31	0.86	0.00	0.29	6.00	30.78	0.26	10.67	0.82	5.81	0.08	1.54
Fe <sub>2</sub> O <sub>3</sub>	0.43	1.33	0.20	0.32	1.12	1.54	0.63	0.29	0.36	2.85	0.07	0.70	0.18	0.36	0.08	0.07
SO₃	0.03	0.16	0.00	0.04	0.04	0.21	0.00	0.05	0.07	0.24	0.00	0.08	0.02	0.08	0.00	0.03
CaO	0.00	0.04	0.00	0.01	0.05	0.37	0.00	0.09	0.06	0.80	0.00	0.21	0.02	0.09	0.00	0.03
SiO <sub>2</sub>	0.51	6.83	0.00	1.64	0.13	1.02	0.00	0.27	0.37	3.11	0.00	0.81	0.15	0.87	0.00	0.22
Bi <sub>2</sub> O <sub>3</sub>	0.03	0.20	0.00	0.06	0.03	0.13	0.00	0.04	0.05	0.20	0.00	0.06	0.04	0.14	0.00	0.05
Cr <sub>2</sub> O <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01
PbO	0.02	0.06	0.00	0.02	0.03	0.10	0.00	0.03	0.10	1.04	0.00	0.26	0.04	0.21	0.00	0.06
Total	96.30	105.35	86.26	4.71	99.72	101.66	97.36	1.24	95.39	100.96	86.97	4.24	98.58	101.51	94.25	2.53

## Table 3 – Small As<sub>2</sub>O<sub>3</sub> Grains (< 10 $\mu$ m). Weight percent Oxide

### Table 4 – Large $As_2O_3$ Grains (> 30 µm). Weight percent Oxide

	Old Feed	n=10			B233-p9	n=23			B208-1 n=10	)			C212-2 r	n=15		
	Average	Max	Min	St. Dev.	Average	Max	Min S	St. Dev.	Average Max	Min	St. D	ev.	Average	/lax	Min	St. Dev.
As <sub>2</sub> O <sub>3</sub>	96.74	103.18	92.72	3.15	97.94	102.80	70.48	6.66	99.03 101	.48 94	.99 1	.82	97.55	100.05	93.21	2.57
Sb <sub>2</sub> O <sub>3</sub>	0.27	0.75	0.00	0.25	0.24	1.41	0.00	0.36	0.47 0	.80 0	.20 0	.18	0.77	5.11	0.08	1.63
Fe <sub>2</sub> O <sub>3</sub>	0.37	0.96	0.18	0.23	0.54	3.40	0.16	0.64	0.13 0	.24 0	.04 0	.08	0.17	0.37	0.05	0.11
SO₃	0.08	0.48	0.00	0.15	0.03	0.32	0.00	0.07	0.02 0	.06 0	.00 0	.02	0.02	0.06	0.00	0.02
CaO	0.05	0.11	0.00	0.04	0.01	0.05	0.00	0.01	0.05 0	.11 0	.00 0	.04	0.06	0.37	0.00	0.12
SiO <sub>2</sub>	0.28	0.74	0.00	0.25	0.05	0.35	0.00	0.08	0.14 0	.58 0	.00 0	.19	0.21	1.26	0.00	0.40
Bi <sub>2</sub> O <sub>3</sub>	0.04	0.10	0.00	0.04	0.06	0.22	0.00	0.06	0.07 0	.23 0	.00 0	.08	0.04	0.11	0.00	0.04
Cr <sub>2</sub> O <sub>3</sub>	0.01	0.08	0.00	0.03	0.00	0.00	0.00	0.00	0.02 0	.10 0	.00 0	.03	0.00	0.00	0.00	0.00
PbO	0.01	0.06	0.00	0.02	0.01	0.05	0.00	0.02	0.02 0	.07 0	.00 0	.02	0.02	0.05	0.00	0.02
Total	97.85	104.21	94.39	2.98	98.88	103.40	72.60	6.14	99.95 102	.78 96	.03 1	.87	98.83	100.74	93.77	2.16

# Table 5 – Hematite. Weight percent Oxide

#### Hematite

Old Feed n=9

		B2

233-p9 n=9

	Average	Max	Min S	St. Dev.	Average	Max I	Min	St. Dev.
$As_2O_3$	5.97	7 12.96	3.34	3.12	8.50	13.14	5.90	2.43
Sb <sub>2</sub> O <sub>3</sub>	1.03	3 2.00	0.45	0.57	0.54	0.65	0.38	0.10
Fe <sub>2</sub> O <sub>3</sub>	80.73	3 89.14	68.12	7.01	76.31	80.95	62.30	5.76
SO₃	1.37	7 3.82	0.24	1.14	0.28	0.66	0.11	0.17
CaO	0.03	3 0.10	0.00	0.03	0.38	0.49	0.25	0.08
SiO <sub>2</sub>	0.15	5 0.24	0.08	0.06	0.14	0.20	0.07	0.04
Bi <sub>2</sub> O <sub>3</sub>	0.03	3 0.10	0.00	0.04	0.04	0.10	0.00	0.04
Cr <sub>2</sub> O <sub>3</sub>	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00
PbO	0.1	1 0.30	0.00	0.11	0.39	0.58	0.21	0.13
Total	89.42	94.21	79.57	4.63	86.57	90.05	77.52	3.79

Typically antimony occurs in concentrations of less than one weight percent oxide. In some grains, especially the smaller ones antimony can become a major component of the arsenic trioxide. In the Old Feed sample and in B208-1, in particular Sb concentrations can reach up to 30 weight percent Sb<sub>2</sub>O<sub>3</sub>. (Semi-quantitative EDS data suggest values as high as 35 weight percent). Elevated concentrations of Sb occur in the larger grains as well, but not to the extent observed in the smaller grains. The elevated antimony contents of the arsenic trioxide grains in the Old Feed and B-208-1 are consistent with their high bulk antimony assay (Appendix C). B233-p9 which has the highest bulk antimony content of all the samples, appears to have a lower average antimony content in the arsenic trioxide grains. Rare, coarser-grained Sb-rich arsenic trioxide grains were observed in this sample during SEM-EDS observation, but none were found during grain selection for electron microprobe analyses.

The only other minor components of the arsenic trioxide grains are iron and silicon. Iron occurs in similar concentrations in the small and large grains, with small grain averages ranging from 0.18 to 1.12 weight percent  $Fe_2O_3$ . The large grains average between 0.13 to 0.54 weight percent  $Fe_2O_3$ . Maximum iron values are typically in the one to two percent range in the small grains. These values may be somewhat inaccurate due to the possibility of fluorescence of hematite particles around the arsenic trioxide grains. Similar values in larger arsenic trioxide grains, however, suggest that the values for the smaller grains are reasonable. The two samples with the highest bulk iron content (B233-p9 and Old Feed) have the highest iron content in both large and small arsenic trioxide grains.

Silicon values range from 0.15 to 0.50 weight percent SiO<sub>2</sub>. It is possible that silicate minerals adjacent to the small arsenic trioxide grains could elevate these concentrations, but again, similar values in the larger grains suggest that the values for the small grains are reasonable.

Hematite analyses in samples Old Feed and B233-p9 show that the iron oxides incorporate significant amounts of arsenic and antimony. Average  $As_2O_3$  contents of the iron oxide phases are 5.97 and 8.50 weight percent for Old Feed and B233-p9 respectively. Maximum  $As_2O_3$  contents reach approximately 13 weight percent  $As_2O_3$  for both samples. Average  $Sb_2O_3$  contents are 1.03 and 0.54 weight percent for Old Feed and B233-p9 respectively. Maximum  $Sb_2O_3$  contents reach approximately 2 weight percent  $Sb_2O_3$  in Old Feed and 0.65 weight percent in B233-p9. Although microprobe analyses cannot confirm that these grains are hematite, the compositions

and the presence of a strong hematite line in the X-ray pattern indicates that the iron oxide is probably hematite. Dutrizac *et al.* (2000) surmise that the incorporation of As and Sb into the hematite is an intermediate step in the formation of an arsenate mineral.

Other impurities in the hematite include sulphur and lead. Sulphur in the Old Feed hematites reaches up to 3.8 weight percent  $SO_3$  and averages 1.3 weight percent  $SO_3$ . Sulphur content in B233-p9 hematites is considerably lower, reaching 0.66 weight percent and averaging 0.28 weight percent  $SO_3$ .

Hematite in sample B233-p9 contains up to 0.5 weight % PbO with average concentrations approximately 0.4 weight % PbO. This is consistent with bulk assays of this sample, which indicate elevated lead concentrations, compared to the other samples. In the Old Feed sample average PbO contents hover around the limit of detection (900 ppm).

#### Discussion

In general, as determined by XRD and SEM examination, the four samples are similar in the mineral phases they contain. Where they differ is in the proportions of these minerals. The largest variation is in the amount of arsenic trioxide grains they contain. In order of increasing arsenic trioxide, the ranking is B233-p9, Old Feed, C212-2 and B208-1. This order is surprising given the origin of the samples. B208-1 which was produced in the mid-1960's has more arsenic trioxide than the samples produced in the 1990's (Old Feed) and the 1970's (C212-2) when collection efficiency was supposedly better. Dutrizac *et al.* (2000) in their investigation of another sample from the C212 chamber found that it contained the least amount of  $As_2O_3$  of all their samples (56% As as compared to 63% in C212-2 in the current study). The high arsenic content of B208-1 and the variability in different samples from the C212 chamber suggest that there may be significant inhomogeneity within individual chambers. The low arsenic trioxide content of Old Feed is likely the result of the unusual plant operating conditions at the time of its production.

The apparent bimodal grain size distribution of the arsenic trioxide appears to be a function of residence time in the roaster. The larger grains may have nucleated on a surface in the roaster during the process and had time to reach larger sizes before being detached and collected. The presence of other minerals inside large arsenic trioxide supports this assertion (Figures 9 and 16).

The seemingly irregular variability in the antimony content of arsenic trioxide grains may be a function of the antimony content of the ore being processed at the time of crystal formation. The presence of an antimony rich core in a large grain of arsenic trioxide (Figure 9) suggests that the crystal nucleated during a period in which Sb-rich ore was being processed and continued growing as the antimony content fell.

### CONCLUSIONS

Four samples of arsenic trioxide dust from the underground storage chambers of the Giant mine were examined using X-ray diffraction, SEM-EDS and electron microprobe as part of a study of their mineralogy. The results of this study will be used to assess long term storage options for the 237,000 tonnes of arsenic trioxide dust stored in stopes and chambers within the mine.

Apart from changes in the amount of arsenic trioxide and the proportions of accessory phases, all the samples are broadly similar and are consistent with the samples described by Dutrizac *et al.* (2000). One of the biggest changes is the amount of hematite. In Old Feed and B233-p9 As-bearing hematite is a minor phase, whereas in C212-2 and B208-1 it is a trace phase. The higher hematite content in sample B233-p9 may be the result of two factors. The first being less efficient collection of arsenic trioxide in the 1950's leading to increased proportions of secondary phases and the second factor being variability in composition of the ore being processed. Variation in the amount of antimony in the ore is probably responsible for variation in the Sb content in the arsenic trioxide grains. The higher hematite content of the Old Feed sample is probably a result of the atypical plant operating conditions at the time of its production.

The arsenic trioxide grains have an apparent bimodal size distribution. The most likely cause of this distribution is the growth of  $As_2O_3$  crystals on surfaces in the baghouse and their subsequent release and collection.

There is some evidence that arsenic trioxide content of the dust varies within the storage chambers. One sample has a significantly different arsenic trioxide content than a sample from the same chamber examined in another study. With the exception of the Old Feed sample the bulk arsenic trioxide contents are consistent with the sample's date of production (*i.e.* more recent samples are richer in arsenic trioxide).

If additional studies of the arsenic trioxide dust stored in the Giant mine are being considered they would benefit from a larger sample size in order to understand the variability in arsenic trioxide content within individual chambers. This could be done by bulk chemistry or, if grain size information is required, by high-speed image processing methods. This approach would also provide concrete data on the mineral proportions in each sample.

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Figure 1. General view of Old Feed sample. All bright grains are As<sub>2</sub>O<sub>3</sub>. Darker grains are mainly silicates (*e.g.* chlorite and mica).



Figure 2. A second general view of the Old Feed sample 1) hematite, 2), 3), 6) As<sub>2</sub>O<sub>3</sub>, 4) chlorite, 5) quartz, and 7) calcite.



Figure 3. Large As<sub>2</sub>O<sub>3</sub> grain in Old Feed 1) As<sub>2</sub>O<sub>3</sub>, 2) chlorite, 3) As<sub>2</sub>O<sub>3</sub> – silicate mix, 4) hematite, 5) muscovite, and 6) chlorite.



Figure 4. Large hematite grain in Old Feed 1) hematite, rest of numbered grains are As<sub>2</sub>O<sub>3.</sub>



Figure 5. General view of Old Feed powder mount. Equant prisms are As<sub>2</sub>O<sub>3</sub>, platy material is mainly silicate.



Figure 6. Close-up view of muscovite flake from Old Feed. Note well-developed crystal faces on arsenic trioxide crystals.



Figure 7. General view of B208-1. 1) As<sub>2</sub>O<sub>3</sub>, 2) clinochlore, and 3) dolomite.



Figure 8. General view of sample B208-1. Tennantite (1) and Sb-bearing  $As_2O_3$  (2).  $As_2O_3$  grain has approximately 20 wt%  $Sb_2O_3$ .



Figure 9. Sample B208-1. Large crystal of As<sub>2</sub>O<sub>3</sub> exhibiting zonation in Sb. Point 1 has 2.5 wt % Sb. Point 2 has 28 wt% Sb.



Figure 10. Sample B028-1. Large crystal of As<sub>2</sub>O<sub>3</sub>. No Sb was detectable by EDS.



Figure 11. Sample B208-1. All crystals are As<sub>2</sub>O<sub>3</sub> except for marked quartz fibre.



Figure 12. Sample B208-1. Flake of muscovite (centre) and crystals of As<sub>2</sub>O<sub>3</sub>.



Figure 13. Sample B208-1. Large bipyramidal crystal of As<sub>2</sub>O<sub>3</sub> coated with smaller arsenic trioxide crystals.



Figure 14. Sample B208-1. Arsenic trioxide crystals and grains of hematite, quartz and alkali feldspar.



Figure 15. General view of B233-p9. Note quantity and spongy appearance of hematite.



Figure 16. Close-up of mineral clump in B233-p9. Bright mass is all arsenic trioxide. Area marked as (As,Sb)<sub>2</sub>O<sub>3</sub> is 66 weight % Sb<sub>2</sub>O<sub>3</sub>.



Figure 17. Sample B233-p9, spongy grain of hematite.



Figure 18. Sample B233-p9, large crystals of arsenic trioxide.



Figure 19. Sample B233-p9, large grain of muscovite.



Figure 20. General view of B233-p9 powder. Note relative scarcity of arsenic trioxide crystals.



Figure 21. Sample B233-p9. General view of powder sample.



Figure 22. General mineralogy of sample C212-2. 1) hematite, 2) As<sub>2</sub>O<sub>3</sub>, 3) Fe-Ca arsenate (yukonite?), 4) silicate, 5) As<sub>2</sub>O<sub>3</sub>, 6) quartz, 7) Fe-Ca arsenate (yukonite?), and 8) mica.



Figure 23. X-ray map of same area pictured in Figure 22. Intensity is proportional to the concentration of the element of interest for a given pixel.



Figure 24. Sample C212-2. Large pyrite crystal. Darker oblong grains are muscovite.



Figure 25. High contrast image of the same area as Figure 24. Bright area in pyrite grain is As-rich.



Figure 26. Sample C212-2. Very rare grain of yukonite (Ca<sub>2</sub>Fe<sub>3</sub>(AsO<sub>4</sub>)<sub>4</sub>(OH)•12H<sub>2</sub>O).



Figure 27. Sample C212-2. Rock fragment containing dolomite (1), muscovite (2), and quartz (3).



Figure 28. Sample C212-2. Large bipyramidal crystal of As<sub>2</sub>O<sub>3</sub>.



Figure 29. Sample C212-2. High magnification image of average sized crystal of As<sub>2</sub>O<sub>3.</sub>

Sb<sub>2</sub>O<sub>3</sub> vs As<sub>2</sub>O<sub>3</sub>



Figure 30. Average arsenic and antimony values for all analysed arsenic trioxide grains.

# **APPENDIX A**

**X-ray Diffraction Patterns** 



Figure 31. X-ray pattern and mineral Identification from Old Feed sample.



Figure 32. X-ray pattern and mineral Identification from B208-1.



Figure 33. X-ray pattern and mineral identification from B233-p9 sample.



Figure 34. X-ray pattern and mineral identification from C212-2 sample.

## **APPENDIX B**

Electron Microprobe Data
B233-p9 Small As<sub>2</sub>O<sub>3</sub> grains Weight Percent Oxide

No.	As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO₃	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO	Total	Comment
3	<b>5</b> 97.04	0.70	1.33	0.02	0.00	0.00	0.00	0.00	0.00	99.08	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 1
30	<b>6</b> 95.19	0.41	1.47	0.03	0.04	0.14	0.04	0.00	0.03	97.36	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 2
3	<b>7</b> 99.27	0.50	0.91	0.01	0.00	0.00	0.00	0.00	0.00	100.68	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 3
3	<b>8</b> 97.24	0.41	1.54	0.21	0.37	1.02	0.13	0.00	0.03	100.94	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 4
3	<b>9</b> 95.85	0.65	1.34	0.00	0.05	0.30	0.00	0.00	0.00	98.19	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 5
40	<b>0</b> 97.72	0.01	0.80	0.04	0.02	0.00	0.06	0.00	0.03	98.67	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 6
4	<b>1</b> 99.18	0.00	1.29	0.02	0.03	0.07	0.00	0.00	0.00	100.58	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 7
4:	<b>3</b> 96.83	0.86	0.64	0.04	0.00	0.01	0.00	0.00	0.01	98.39	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 9
4	4 100.16	0.08	1.36	0.06	0.02	0.00	0.00	0.00	0.00	101.66	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 10
4	<b>5</b> 98.88	0.22	1.21	0.03	0.04	0.21	0.05	0.00	0.10	100.74	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 11
40	<b>6</b> 98.60	0.04	0.63	0.00	0.00	0.05	0.00	0.00	0.08	99.39	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 12
4	<b>7</b> 98.91	0.00	0.98	0.02	0.05	0.00	0.05	0.00	0.05	100.06	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 13
4	<b>8</b> 98.51	0.41	1.05	0.05	0.00	0.00	0.01	0.00	0.04	100.07	B233-p9 Small As <sub>2</sub> O <sub>3</sub> a 14
49	<b>9</b> 98.91	0.03	1.13	0.07	0.04	0.04	0.05	0.00	0.04	100.29	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 15
Average	98.02	0.31	1.12	0.04	0.05	0.13	0.03	0.00	0.03	99.72	
Max	100.16	0.86	1.54	0.21	0.37	1.02	0.13	0.00	0.10	101.66	
Min	95.19	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	97.36	
St. Dev.	1.42	0.29	0.29	0.05	0.09	0.27	0.04	0.00	0.03	1.24	

B233-p9 Small As<sub>2</sub>O<sub>3</sub> grains Cations on the Basis of Three Oxygen

			00				,0					
No.		As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
	35	1.972	0.010	0.043	0.001	0.000	0.000	0.000	0.000	0.000	2.026	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 1
	36	1.968	0.006	0.049	0.001	0.002	0.005	0.000	0.000	0.000	2.032	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 2
	37	1.981	0.007	0.029	0.000	0.000	0.000	0.000	0.000	0.000	2.017	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 3
	38	1.930	0.006	0.049	0.006	0.015	0.039	0.001	0.000	0.000	2.046	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 4
	39	1.963	0.010	0.044	0.000	0.002	0.012	0.000	0.000	0.000	2.030	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 5
	40	1.988	0.000	0.026	0.001	0.001	0.000	0.001	0.000	0.000	2.016	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 6
	41	1.980	0.000	0.041	0.001	0.001	0.003	0.000	0.000	0.000	2.026	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 7
	43	1.977	0.012	0.021	0.001	0.000	0.001	0.000	0.000	0.000	2.013	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 9
	44	1.980	0.001	0.043	0.002	0.001	0.000	0.000	0.000	0.000	2.026	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 10
	45	1.973	0.003	0.038	0.001	0.002	0.008	0.001	0.000	0.001	2.026	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 11
	46	1.990	0.001	0.020	0.000	0.000	0.002	0.000	0.000	0.001	2.013	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 12
	47	1.985	0.000	0.032	0.001	0.002	0.000	0.001	0.000	0.001	2.021	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 13
	48	1.979	0.006	0.034	0.001	0.000	0.000	0.000	0.000	0.000	2.020	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 14
	49	1.981	0.000	0.036	0.002	0.002	0.002	0.001	0.000	0.000	2.023	B233-p9 Small As <sub>2</sub> O <sub>3</sub> 15
Average		1.975	0.004	0.036	0.001	0.002	0.005	0.000	0.000	0.000	2.024	
Max		1.990	0.012	0.049	0.006	0.015	0.039	0.001	0.000	0.001	2.046	
Min		1.930	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	2.013	
St. Dev.		0.015	0.004	0.009	0.002	0.004	0.010	0.000	0.000	0.000	0.009	

B233-P9 Large As<sub>2</sub>O<sub>3</sub> Weight Percent Oxide

	0 =	~ 0									
No.	As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO <sub>3</sub>	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO	Total	Comment
110	97.27	0.01	0.64	0.08	0.02	0.35	0.06	0.00	0.03	98.47	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 30 um 1 1
111	98.47	0.00	0.68	0.02	0.02	0.00	0.04	0.00	0.00	99.23	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 30 um 1 2
112	99.90	0.05	0.49	0.02	0.02	0.10	0.05	0.00	0.02	100.63	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 1
113	<b>9</b> 8.26	0.12	0.40	0.00	0.01	0.01	0.10	0.00	0.02	98.92	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 2
114	101.08	0.00	0.46	0.01	0.01	0.00	0.00	0.00	0.00	101.56	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 3
115	<b>5</b> 101.46	0.00	0.61	0.06	0.02	0.09	0.00	0.00	0.03	102.27	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 4
116	<b>5</b> 70.48	1.41	0.60	0.01	0.04	0.00	0.00	0.00	0.05	72.60	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 5
117	100.13	0.09	0.40	0.00	0.01	0.05	0.08	0.00	0.02	100.77	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 1
118	<b>3</b> 98.96	0.36	0.53	0.01	0.01	0.00	0.04	0.00	0.00	99.90	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 2
119	97.77	0.86	0.41	0.05	0.01	0.04	0.08	0.00	0.00	99.21	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 3
120	87.56	0.76	3.40	0.32	0.00	0.12	0.00	0.00	0.00	92.15	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 4
121	100.74	0.30	0.53	0.04	0.01	0.00	0.11	0.00	0.00	101.73	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 5
122	2 100.28	0.13	0.52	0.00	0.05	0.00	0.15	0.00	0.00	101.12	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 6
123	<b>3</b> 98.11	0.72	0.19	0.00	0.00	0.00	0.05	0.00	0.04	99.11	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 1
124	99.12	0.20	0.16	0.00	0.00	0.05	0.03	0.00	0.00	99.56	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 2
125	100.20	0.09	0.26	0.04	0.03	0.00	0.00	0.00	0.01	100.63	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 3
126	<b>i</b> 100.59	0.12	0.25	0.00	0.00	0.08	0.02	0.00	0.00	101.06	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 4
127	99.96	0.16	0.22	0.02	0.00	0.00	0.05	0.00	0.00	100.42	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 5
128	<b>9</b> 7.32	0.04	0.32	0.00	0.02	0.00	0.22	0.00	0.00	97.92	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 1
129	102.80	0.00	0.42	0.05	0.00	0.00	0.11	0.00	0.02	103.40	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 2
130	102.29	0.01	0.25	0.00	0.04	0.18	0.00	0.00	0.00	102.77	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 3
131	99.88	0.01	0.22	0.01	0.01	0.05	0.11	0.00	0.03	100.31	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 4
132	2 100.09	0.04	0.37	0.06	0.01	0.05	0.00	0.00	0.00	100.61	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 5
Average	97.94	0.24	0.54	0.03	0.01	0.05	0.06	0.00	0.01	98.88	
Max	102.80	1.41	3.40	0.32	0.05	0.35	0.22	0.00	0.05	103.40	
Min	70.48	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	72.60	
St. Dev.	6.66	0.36	0.64	0.07	0.01	0.08	0.06	0.00	0.02	6.14	

B233-P9 Large As<sub>2</sub>O<sub>3</sub> Cations on the Basis of Three Oxygen

	<u> </u>	-				<b>U</b>					
No.	As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
110	1.977	0.000	0.021	0.002	0.001	0.014	0.001	0.000	0.000	2.016	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 30 um 1 1
111	1.990	0.000	0.022	0.001	0.001	0.000	0.000	0.000	0.000	2.014	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 30 um 1 2
112	1.989	0.001	0.016	0.001	0.001	0.004	0.000	0.000	0.000	2.011	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 1
113	1.992	0.002	0.013	0.000	0.000	0.001	0.001	0.000	0.000	2.009	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 2
114	1.994	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	2.009	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 3
115	1.987	0.000	0.019	0.002	0.001	0.003	0.000	0.000	0.000	2.013	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 4
116	1.960	0.028	0.027	0.000	0.002	0.000	0.000	0.000	0.001	2.018	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 100 um 2 5
117	1.992	0.001	0.013	0.000	0.001	0.002	0.001	0.000	0.000	2.009	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 1
118	1.987	0.005	0.017	0.000	0.000	0.000	0.000	0.000	0.000	2.010	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 2
119	1.979	0.012	0.013	0.001	0.000	0.002	0.001	0.000	0.000	2.009	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 3
120	1.924	0.012	0.120	0.010	0.000	0.005	0.000	0.000	0.000	2.071	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 4
121	1.987	0.004	0.017	0.001	0.000	0.000	0.001	0.000	0.000	2.010	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 5
122	1.990	0.002	0.016	0.000	0.002	0.000	0.001	0.000	0.000	2.012	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 120 um 3 6
123	1.987	0.010	0.006	0.000	0.000	0.000	0.001	0.000	0.000	2.004	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 1
124	1.993	0.003	0.005	0.000	0.000	0.002	0.000	0.000	0.000	2.004	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 2
125	1.994	0.001	0.008	0.001	0.001	0.000	0.000	0.000	0.000	2.006	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 3
126	1.993	0.002	0.008	0.000	0.000	0.003	0.000	0.000	0.000	2.006	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 4
127	1.994	0.002	0.007	0.001	0.000	0.000	0.001	0.000	0.000	2.004	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 4 5
128	1.994	0.001	0.010	0.000	0.001	0.000	0.002	0.000	0.000	2.008	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 1
129	1.992	0.000	0.013	0.002	0.000	0.000	0.001	0.000	0.000	2.008	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 2
130	1.991	0.000	0.008	0.000	0.002	0.007	0.000	0.000	0.000	2.007	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 3
131	1.994	0.000	0.007	0.000	0.000	0.002	0.001	0.000	0.000	2.005	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 4
132	1.991	0.001	0.012	0.002	0.000	0.002	0.000	0.000	0.000	2.007	B233-p9 Large As <sub>2</sub> O <sub>3</sub> 200x100 um 5 5
Average	1.986	0.004	0.018	0.001	0.001	0.002	0.001	0.000	0.000	2.012	
Max	1.994	0.028	0.120	0.010	0.002	0.014	0.002	0.000	0.001	2.071	
Min	1 924	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	2 004	
St Dov	0.015	0.006	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.012	
	0.015	0.000	0.020	0.007	0.001	0.005	0.001	0.000	0.000	0.013	

No.		As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO₃	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO	Total	Comment
	50	5.90	0.45	79.47	0.25	0.25	0.07	0.08	0.00	0.58	87.06	B233-p9 Small Hematite 1
	51	11.55	0.62	74.77	0.11	0.34	0.16	0.00	0.00	0.44	88.00	B233-p9 Small Hematite 2
	53	7.40	0.53	80.95	0.18	0.34	0.13	0.02	0.00	0.49	90.05	B233-p9 Small Hematite 4
	54	8.53	0.55	77.82	0.16	0.35	0.20	0.00	0.00	0.23	87.85	B233-p9 Small Hematite 5
	55	7.55	0.61	79.30	0.31	0.43	0.19	0.05	0.00	0.54	88.99	B233-p9 Small Hematite 6
	56	6.79	0.38	80.86	0.32	0.49	0.13	0.00	0.00	0.21	89.19	B233-p9 Small Hematite 7
	57	6.47	0.45	76.67	0.14	0.33	0.14	0.07	0.00	0.28	84.53	B233-p9 Small Hematite 8
	58	9.14	0.65	74.63	0.66	0.46	0.11	0.00	0.00	0.36	86.00	B233-p9 Small Hematite 9
	59	13.14	0.62	62.30	0.39	0.43	0.17	0.10	0.00	0.37	77.52	B233-p9 Small Hematite 10
Average		8.50	0.54	76.31	0.28	0.38	0.14	0.04	0.00	0.39	86.57	
Max		13.14	0.65	80.95	0.66	0.49	0.20	0.10	0.00	0.58	90.05	
Min		5.90	0.38	62.30	0.11	0.25	0.07	0.00	0.00	0.21	77.52	
St. Dev.		2.43	0.10	5.76	0.17	0.08	0.04	0.04	0.00	0.13	3.79	

### B233-P9 Hematite Weight Percent Oxide

### B233-P9 Hematite Cations on the Basis of Three Oxygen

No.		As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
5	50	0.103	0.003	1.867	0.010	0.008	0.003	0.001	0.000	0.004	2.000	B233-p9 Small Hematite 1
5	51	0.203	0.005	1.766	0.005	0.011	0.008	0.000	0.000	0.003	2.000	B233-p9 Small Hematite 2
5	53	0.126	0.004	1.843	0.007	0.011	0.006	0.000	0.000	0.003	2.000	B233-p9 Small Hematite 4
5	54	0.149	0.004	1.819	0.007	0.011	0.009	0.000	0.000	0.001	2.000	B233-p9 Small Hematite 5
5	55	0.130	0.005	1.827	0.013	0.014	0.009	0.000	0.000	0.003	2.000	B233-p9 Small Hematite 6
5	56	0.116	0.003	1.846	0.013	0.016	0.006	0.000	0.000	0.001	2.000	B233-p9 Small Hematite 7
5	57	0.117	0.003	1.854	0.006	0.011	0.007	0.000	0.000	0.002	2.000	B233-p9 Small Hematite 8
5	58	0.163	0.005	1.782	0.027	0.015	0.005	0.000	0.000	0.002	2.000	B233-p9 Small Hematite 9
5	59	0.265	0.005	1.683	0.018	0.016	0.009	0.001	0.000	0.003	2.000	B233-p9 Small Hematite 10
Average		0.15	0.00	1.81	0.01	0.01	0.01	0.00	0.00	0.00	2.00	
Max		0.26	0.01	1.87	0.03	0.02	0.01	0.00	0.00	0.00	2.00	
Min		0.10	0.00	1.68	0.00	0.01	0.00	0.00	0.00	0.00	2.00	
St. Dev.		0.05	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	

B208-1 Small As<sub>2</sub>O<sub>3</sub> grains Weight Percent Oxide

No		<u> </u>	<u> </u>	5.0	80	<u> </u>	6:0	Pi O	Cr 0	PhO	Total	Commont
INO.		AS2U3	5D2U3	re <sub>2</sub> U <sub>3</sub>	503	CaU	5102	BI2U3		P00	TOLAI	Comment
6	50	95.06	2.18	0.16	0.03	0.00	0.61	0.20	0.00	0.09	98.33	B208-1 Small As <sub>2</sub> O <sub>3</sub> 1
6	61	98.08	0.57	0.12	0.03	0.01	0.00	0.10	0.00	0.04	98.94	B208-1 Small As <sub>2</sub> O <sub>3</sub> 2
e	62	97.92	2.86	0.09	0.06	0.00	0.00	0.00	0.00	0.03	100.96	B208-1 Small As <sub>2</sub> O <sub>3</sub> 3
e	63	97.04	0.62	0.14	0.10	0.01	0.15	0.13	0.00	0.00	98.19	B208-1 Small As <sub>2</sub> O <sub>3</sub> 4
e	64	95.36	0.66	0.27	0.00	0.00	0.01	0.00	0.00	0.00	96.30	B208-1 Small As <sub>2</sub> O <sub>3</sub> 5
6	65	81.02	0.89	2.85	0.23	0.80	1.05	0.04	0.00	0.09	86.97	B208-1 Small As <sub>2</sub> O <sub>3</sub> 6
6	66	94.44	1.49	0.15	0.11	0.00	0.02	0.09	0.00	0.03	96.32	B208-1 Small As <sub>2</sub> O <sub>3</sub> 7
6	67	65.97	29.31	0.55	0.10	0.00	3.11	0.00	0.00	0.08	99.12	B208-1 Small As <sub>2</sub> O <sub>3</sub> 8
6	68	86.77	0.81	0.07	0.00	0.00	0.20	0.00	0.00	0.00	87.84	B208-1 Small As <sub>2</sub> O <sub>3</sub> 9
6	69	91.15	0.33	0.18	0.24	0.00	0.22	0.00	0.00	1.04	93.17	B208-1 Small As <sub>2</sub> O <sub>3</sub> 10
7	70	95.07	1.01	0.07	0.03	0.00	0.05	0.03	0.00	0.02	96.28	B208-1 Small As <sub>2</sub> O <sub>3</sub> 11
7	71	77.64	17.53	0.34	0.00	0.00	0.01	0.00	0.00	0.00	95.52	B208-1 Small As <sub>2</sub> O <sub>3</sub> 12
7	72	96.89	0.67	0.15	0.05	0.01	0.07	0.10	0.00	0.12	98.06	B208-1 Small As <sub>2</sub> O <sub>3</sub> 13
7	73	58.40	30.78	0.13	0.04	0.00	0.12	0.00	0.00	0.00	89.46	B208-1 Small As <sub>2</sub> O <sub>3</sub> 14
7	74	94.90	0.26	0.20	0.00	0.01	0.00	0.00	0.00	0.00	95.38	B208-1 Small As <sub>2</sub> O <sub>3</sub> 15
Average		88.38	6.00	0.36	0.07	0.06	0.37	0.05	0.00	0.10	95.39	
Max		98.08	30.78	2.85	0.24	0.80	3.11	0.20	0.00	1.04	100.96	
Min		58.40	0.26	0.07	0.00	0.00	0.00	0.00	0.00	0.00	86.97	
St. Dev.		12.34	10.67	0.70	0.08	0.21	0.81	0.06	0.00	0.26	4.24	

### B208-1 Small As<sub>2</sub>O<sub>3</sub> grains Cations on the Basis of Three Oxygen

	-	<u> </u>									
No.	As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
60	1.945	0.032	0.005	0.001	0.000	0.024	0.002	0.000	0.001	2.009	B208-1 Small As <sub>2</sub> O <sub>3</sub> 1
61	1.988	0.008	0.004	0.001	0.000	0.000	0.001	0.000	0.000	2.003	B208-1 Small As <sub>2</sub> O <sub>3</sub> 2
62	1.956	0.041	0.003	0.002	0.000	0.000	0.000	0.000	0.000	2.002	B208-1 Small As <sub>2</sub> O <sub>3</sub> 3
63	1.980	0.009	0.004	0.003	0.001	0.006	0.001	0.000	0.000	2.004	B208-1 Small As <sub>2</sub> O <sub>3</sub> 4
64	1.986	0.010	0.009	0.000	0.000	0.000	0.000	0.000	0.000	2.005	B208-1 Small As <sub>2</sub> O <sub>3</sub> 5
65	1.881	0.015	0.106	0.008	0.038	0.047	0.001	0.000	0.001	2.095	B208-1 Small As <sub>2</sub> O <sub>3</sub> 6
66	1.971	0.022	0.005	0.003	0.000	0.001	0.001	0.000	0.000	2.003	B208-1 Small As <sub>2</sub> O <sub>3</sub> 7
67	1.433	0.452	0.019	0.003	0.000	0.129	0.000	0.000	0.001	2.037	B208-1 Small As <sub>2</sub> O <sub>3</sub> 8
68	1.979	0.013	0.003	0.000	0.000	0.009	0.000	0.000	0.000	2.003	B208-1 Small As <sub>2</sub> O <sub>3</sub> 9
69	1.972	0.005	0.006	0.008	0.000	0.009	0.000	0.000	0.012	2.011	B208-1 Small As <sub>2</sub> O <sub>3</sub> 10
70	1.981	0.015	0.003	0.001	0.000	0.002	0.000	0.000	0.000	2.002	B208-1 Small As <sub>2</sub> O <sub>3</sub> 11
71	1.719	0.276	0.012	0.000	0.000	0.000	0.000	0.000	0.000	2.007	B208-1 Small As <sub>2</sub> O <sub>3</sub> 12
72	1.983	0.010	0.005	0.002	0.000	0.003	0.001	0.000	0.001	2.005	B208-1 Small As <sub>2</sub> O <sub>3</sub> 13
73	1.449	0.543	0.005	0.001	0.000	0.006	0.000	0.000	0.000	2.004	B208-1 Small As <sub>2</sub> O <sub>3</sub> 14
74	1.993	0.004	0.007	0.000	0.001	0.000	0.000	0.000	0.000	2.005	B208-1 Small As <sub>2</sub> O <sub>3</sub> 15
Average	1.881	0.097	0.013	0.002	0.003	0.016	0.000	0.000	0.001	2.013	
Max	1.993	0.543	0.106	0.008	0.038	0.129	0.002	0.000	0.012	2.095	
Min	1.433	0.004	0.003	0.000	0.000	0.000	0.000	0.000	0.000	2.002	
St. Dev.	0.192	0.177	0.026	0.002	0.010	0.034	0.001	0.000	0.003	0.024	

As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>2</sub>	60	0-0	0:0	D: 0	~ ~			
		10203	303	CaU	SIO <sub>2</sub>	$BI_2O_3$	$Cr_2O_3$	PbO	Total	Comment
101.48	0.44	0.24	0.05	0.00	0.58	0.00	0.00	0.01	102.78	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 1 1
97.18	0.42	0.21	0.06	0.02	0.14	0.02	0.00	0.01	98.05	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 1 2
98.80	0.42	0.19	0.00	0.01	0.00	0.07	0.00	0.02	99.51	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 1 3
100.37	0.44	0.21	0.01	0.09	0.02	0.18	0.00	0.00	101.31	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 1 4
98.75	0.30	0.04	0.02	0.07	0.40	0.04	0.05	0.07	99.74	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 2 1
62.62	0.21	0.07	0.00	0.05	0.00	0.11	0.00	0.02	63.08	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 2 2
99.77	0.37	0.06	0.03	0.09	0.10	0.23	0.10	0.00	100.74	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 2 3
88.44	1.31	0.68	0.09	0.15	0.12	0.11	0.00	0.00	90.89	B208-1 Large As <sub>2</sub> O <sub>3</sub> 80 um 3 1
86.13	1.59	0.43	0.09	0.00	4.01	0.00	0.00	0.00	92.25	B208-1 Large As <sub>2</sub> O <sub>3</sub> 80 um 3 2
94.99	0.80	0.15	0.01	0.02	0.07	0.00	0.00	0.00	96.03	B208-1 Large As <sub>2</sub> O <sub>3</sub> 80 um 3 3
99.47	0.20	0.07	0.00	0.06	0.00	0.04	0.00	0.05	99.88	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 1
99.29	0.61	0.12	0.00	0.07	0.00	0.02	0.00	0.00	100.11	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 2
100.20	0.69	0.05	0.03	0.11	0.12	0.08	0.03	0.01	101.30	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 3
94.42	0.60	0.19	0.03	0.06	0.43	0.07	0.01	0.01	95.82	
101.48	1.59	0.68	0.09	0.15	4.01	0.23	0.10	0.07	102.78	
62.62	0.20	0.04	0.00	0.00	0.00	0.00	0.00	0.00	63.08	
10.64	0.42	0.18	0.03	0.05	1.09	0.07	0.03	0.02	10.45	
	101.48 97.18 98.80 100.37 98.75 62.62 99.77 88.44 86.13 94.99 99.47 99.29 100.20 94.42 101.48 62.62 10.64	101.48 0.44   97.18 0.42   98.80 0.42   100.37 0.44   98.75 0.30   62.62 0.21   99.77 0.37   88.44 1.31   86.13 1.59   99.499 0.80   99.29 0.61   100.20 0.69   94.42 0.60   101.48 1.59   62.62 0.20	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	101.48 0.44 0.24 0.05 0.00 0.58 0.00 0.00   97.18 0.42 0.21 0.06 0.02 0.14 0.02 0.00   98.80 0.42 0.19 0.00 0.01 0.00 0.07 0.00   98.80 0.42 0.19 0.00 0.01 0.00 0.07 0.00   98.75 0.30 0.04 0.02 0.07 0.40 0.04 0.05   62.62 0.21 0.07 0.00 0.05 0.00 0.11 0.00   99.77 0.37 0.06 0.03 0.09 0.10 0.23 0.10   88.44 1.31 0.68 0.09 0.15 0.12 0.11 0.00   86.13 1.59 0.43 0.09 0.02 0.07 0.00 0.00   94.99 0.80 0.15 0.01 0.02 0.07 0.00 0.02 0.00   99.29 0.61	101.48 0.44 0.24 0.05 0.00 0.58 0.00 0.00 0.01   97.18 0.42 0.21 0.06 0.02 0.14 0.02 0.00 0.01   98.80 0.42 0.19 0.00 0.01 0.00 0.07 0.00 0.02   100.37 0.44 0.21 0.01 0.09 0.02 0.18 0.00 0.00   98.75 0.30 0.04 0.02 0.07 0.40 0.04 0.05 0.07   62.62 0.21 0.07 0.00 0.05 0.00 0.11 0.00 0.02   99.77 0.37 0.06 0.03 0.09 0.10 0.23 0.10 0.02   99.77 0.37 0.06 0.03 0.09 0.10 0.23 0.10 0.00   86.13 1.59 0.43 0.09 0.15 0.12 0.11 0.00 0.00   94.499 0.80 0.15	101.48 0.44 0.24 0.05 0.00 0.58 0.00 0.00 0.01 102.78   97.18 0.42 0.21 0.06 0.02 0.14 0.02 0.00 0.01 98.05   98.80 0.42 0.19 0.00 0.01 0.00 0.07 0.00 0.02 99.51   100.37 0.44 0.21 0.01 0.09 0.02 0.18 0.00 0.00 101.31   98.75 0.30 0.04 0.02 0.07 0.40 0.04 0.05 0.07 99.74   62.62 0.21 0.07 0.00 0.05 0.00 0.11 0.00 0.02 63.08   99.77 0.37 0.06 0.03 0.09 0.10 0.23 0.10 0.00 100.74   88.44 1.31 0.68 0.09 0.15 0.12 0.11 0.00 0.00 92.25   94.99 0.80 0.15 0.01 0				

B208-1 Large As<sub>2</sub>O<sub>3</sub> grains Weight Percent Oxide

B208-1 Large As<sub>2</sub>O<sub>3</sub> grains Cations on the Basis of Three Oxygen

No		Ch Ch	Fo	6	Ca	<u> </u>	Di	Cr	Dh	Total	Commont
INU.	AS	30	ге	5	Ca	51	DI	Ur	P0	TOTAL	Comment
133	1.972	0.006	0.007	0.001	0.000	0.021	0.000	0.000	0.000	2.009	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 11
134	1.984	0.006	0.007	0.002	0.001	0.005	0.000	0.000	0.000	2.006	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 1 2
135	1.991	0.006	0.006	0.000	0.001	0.000	0.001	0.000	0.000	2.004	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 1 3
136	1.988	0.006	0.007	0.000	0.004	0.001	0.002	0.000	0.000	2.007	B208-1 Large As <sub>2</sub> O <sub>3</sub> 100 um 1 4
137	1.980	0.004	0.001	0.001	0.003	0.016	0.000	0.002	0.001	2.007	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 2 1
138	1.991	0.005	0.004	0.000	0.003	0.000	0.002	0.000	0.000	2.005	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 2 2
139	1.986	0.005	0.002	0.001	0.004	0.004	0.002	0.003	0.000	2.006	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 2 3
140	1.959	0.021	0.024	0.003	0.007	0.005	0.001	0.000	0.000	2.019	B208-1 Large As <sub>2</sub> O <sub>3</sub> 80 um 3 1
141	1.836	0.024	0.015	0.003	0.000	0.164	0.000	0.000	0.000	2.041	B208-1 Large As <sub>2</sub> O <sub>3</sub> 80 um 3 2
142	1.984	0.012	0.005	0.000	0.001	0.003	0.000	0.000	0.000	2.004	B208-1 Large As <sub>2</sub> O <sub>3</sub> 80 um 3 3
143	1.995	0.003	0.002	0.000	0.003	0.000	0.000	0.000	0.001	2.003	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 1
144	1.989	0.009	0.004	0.000	0.003	0.000	0.000	0.000	0.000	2.004	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 2
145	1.983	0.010	0.002	0.001	0.004	0.005	0.001	0.001	0.000	2.005	B208-1 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 3
Average	1.972	0.009	0.007	0.001	0.002	0.017	0.001	0.000	0.000	2.009	
Max	1.995	0.024	0.024	0.003	0.007	0.164	0.002	0.003	0.001	2.041	
Min	1.836	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	2.003	
St. Dev.	0.042	0.006	0.006	0.001	0.002	0.044	0.001	0.001	0.000	0.010	

C212-2 Small As<sub>2</sub>O<sub>3</sub> grains Weight Percent Oxide

		C	<u> </u>									
No.		As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO₃	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO	Total	Comment
	75	93.93	0.09	0.11	0.00	0.00	0.02	0.09	0.00	0.00	94.25	C212-2 Small As <sub>2</sub> O <sub>3</sub> 1
	76	99.51	0.08	0.11	0.00	0.04	0.10	0.07	0.00	0.00	99.91	C212-2 Small As <sub>2</sub> O <sub>3</sub> 2
	77	99.09	0.27	0.25	0.00	0.00	0.07	0.14	0.00	0.05	99.86	C212-2 Small As <sub>2</sub> O <sub>3</sub> 3
	78	93.04	0.39	0.14	0.01	0.00	0.87	0.00	0.00	0.09	94.54	C212-2 Small As <sub>2</sub> O <sub>3</sub> 4
	79	99.77	0.57	0.19	0.00	0.00	0.00	0.04	0.00	0.03	100.60	C212-2 Small As <sub>2</sub> O <sub>3</sub> 5
	80	98.05	0.35	0.36	0.03	0.00	0.20	0.00	0.00	0.07	99.05	C212-2 Small As <sub>2</sub> O <sub>3</sub> 6
	81	99.98	0.11	0.16	0.00	0.09	0.00	0.00	0.00	0.00	100.34	C212-2 Small As <sub>2</sub> O <sub>3</sub> 7
	82	94.50	0.51	0.17	0.03	0.00	0.14	0.01	0.00	0.21	95.56	C212-2 Small As <sub>2</sub> O <sub>3</sub> 8
	83	93.73	5.81	0.26	0.08	0.00	0.25	0.00	0.00	0.05	100.18	C212-2 Small As <sub>2</sub> O <sub>3</sub> 9
	84	100.98	0.12	0.08	0.05	0.00	0.18	0.11	0.00	0.00	101.51	C212-2 Small As <sub>2</sub> O <sub>3</sub> 10
	85	96.68	0.17	0.13	0.05	0.06	0.11	0.00	0.00	0.05	97.24	C212-2 Small As <sub>2</sub> O <sub>3</sub> 11
	86	94.45	0.39	0.14	0.00	0.00	0.00	0.00	0.00	0.00	94.98	C212-2 Small As <sub>2</sub> O <sub>3</sub> 12
	87	99.12	0.10	0.20	0.00	0.08	0.14	0.14	0.03	0.04	99.84	C212-2 Small As <sub>2</sub> O <sub>3</sub> 13
	88	99.10	0.50	0.24	0.00	0.01	0.20	0.06	0.00	0.08	100.20	C212-2 Small As <sub>2</sub> O <sub>3</sub> 14
	89	97.58	2.88	0.16	0.01	0.00	0.00	0.00	0.00	0.00	100.63	C212-2 Small As <sub>2</sub> O <sub>3</sub> 15
Average		97.30	0.82	0.18	0.02	0.02	0.15	0.04	0.00	0.04	98.58	
Max		100.98	5.81	0.36	0.08	0.09	0.87	0.14	0.03	0.21	101.51	
Min		93.04	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	94.25	
St. Dev.		2.68	1.54	0.07	0.03	0.03	0.22	0.05	0.01	0.06	2.53	

C212-2 Small As<sub>2</sub>O<sub>3</sub> grains Cations on the Basis of Three Oxygen

			0									
No.		As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
	75	1.996	0.001	0.004	0.000	0.000	0.001	0.001	0.000	0.000	2.003	C212-2 Small As <sub>2</sub> O <sub>3</sub> 1
	76	1.993	0.001	0.004	0.000	0.002	0.004	0.001	0.000	0.000	2.004	C212-2 Small As <sub>2</sub> O <sub>3</sub> 2
	77	1.990	0.004	0.008	0.000	0.000	0.003	0.001	0.000	0.001	2.006	C212-2 Small As <sub>2</sub> O <sub>3</sub> 3
	78	1.963	0.006	0.005	0.000	0.000	0.035	0.000	0.000	0.001	2.011	C212-2 Small As <sub>2</sub> O <sub>3</sub> 4
	79	1.989	0.008	0.006	0.000	0.000	0.000	0.000	0.000	0.000	2.004	C212-2 Small As <sub>2</sub> O <sub>3</sub> 5
	80	1.983	0.005	0.012	0.001	0.000	0.008	0.000	0.000	0.001	2.009	C212-2 Small As <sub>2</sub> O <sub>3</sub> 6
	81	1.995	0.002	0.005	0.000	0.004	0.000	0.000	0.000	0.000	2.005	C212-2 Small As <sub>2</sub> O <sub>3</sub> 7
	82	1.984	0.008	0.006	0.001	0.000	0.006	0.000	0.000	0.002	2.006	C212-2 Small As <sub>2</sub> O <sub>3</sub> 8
	83	1.902	0.084	0.009	0.002	0.000	0.010	0.000	0.000	0.001	2.007	C212-2 Small As <sub>2</sub> O <sub>3</sub> 9
	84	1.990	0.002	0.002	0.002	0.000	0.007	0.001	0.000	0.000	2.003	C212-2 Small As <sub>2</sub> O <sub>3</sub> 10
	85	1.990	0.003	0.004	0.001	0.002	0.004	0.000	0.000	0.001	2.005	C212-2 Small As <sub>2</sub> O <sub>3</sub> 11
	86	1.992	0.006	0.005	0.000	0.000	0.000	0.000	0.000	0.000	2.003	C212-2 Small As <sub>2</sub> O <sub>3</sub> 12
	87	1.989	0.001	0.006	0.000	0.003	0.005	0.001	0.001	0.000	2.008	C212-2 Small As <sub>2</sub> O <sub>3</sub> 13
	88	1.983	0.007	0.008	0.000	0.001	0.008	0.001	0.000	0.001	2.007	C212-2 Small As <sub>2</sub> O <sub>3</sub> 14
	89	1.957	0.041	0.005	0.000	0.000	0.000	0.000	0.000	0.000	2.003	C212-2 Small As <sub>2</sub> O <sub>3</sub> 15
Average	•	1.980	0.012	0.006	0.001	0.001	0.006	0.000	0.000	0.000	2.006	
Max		1.996	0.084	0.012	0.002	0.004	0.035	0.001	0.001	0.002	2.011	
Min		1.902	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	2.003	
St. Dev.		0.024	0.022	0.002	0.001	0.001	0.009	0.001	0.000	0.001	0.002	

No.		As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO₃	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO	Total	Comment
	90	99.16	0.08	0.28	0.03	0.37	0.10	0.00	0.00	0.01	100.03	C212-2 Large As <sub>2</sub> O <sub>3</sub> 1 1
	91	93.21	0.21	0.07	0.00	0.00	0.11	0.11	0.00	0.04	93.77	C212-2 Large As <sub>2</sub> O <sub>3</sub> 1 2
	92	93.60	5.11	0.09	0.00	0.00	0.08	0.06	0.00	0.00	98.94	C212-2 Large As <sub>2</sub> O <sub>3</sub> 20 um 2 1
	93	96.99	0.17	0.07	0.00	0.02	0.00	0.07	0.00	0.00	97.32	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 3 1
	94	100.05	0.25	0.15	0.03	0.05	0.15	0.07	0.00	0.00	100.74	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 3 2
	95	98.86	0.52	0.14	0.03	0.00	0.00	0.06	0.00	0.05	99.65	C212-2 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 1
	96	75.14	0.43	2.01	0.09	0.08	0.61	0.00	0.00	0.06	78.43	C212-2 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 2
	97	99.82	0.18	0.37	0.06	0.00	0.15	0.03	0.00	0.04	100.64	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 5 1
	98	97.19	0.25	0.27	0.01	0.05	1.26	0.00	0.00	0.01	99.04	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 5 2
	99	99.03	0.14	0.05	0.00	0.03	0.05	0.00	0.00	0.00	99.30	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 6 1
Average		95.31	0.73	0.35	0.02	0.06	0.25	0.04	0.00	0.02	96.79	
Max		100.05	5.11	2.01	0.09	0.37	1.26	0.11	0.00	0.06	100.74	
Min		75.14	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	78.43	
St. Dev.		7.49	1.54	0.59	0.03	0.11	0.39	0.04	0.00	0.03	6.76	

C212-2 Large As<sub>2</sub>O<sub>3</sub> grains Weight Percent Oxide

C212-2 Large As<sub>2</sub>O<sub>3</sub> grains Cations on the Basis of Three Oxygen

		•	0									
No.		As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
	90	1.985	0.001	0.009	0.001	0.015	0.004	0.000	0.000	0.000	2.015	C212-2 Large As <sub>2</sub> O <sub>3</sub> 1 1
	91	1.991	0.003	0.003	0.000	0.000	0.005	0.001	0.000	0.001	2.003	C212-2 Large As <sub>2</sub> O <sub>3</sub> 1 2
	92	1.921	0.075	0.003	0.000	0.000	0.003	0.001	0.000	0.000	2.003	C212-2 Large As <sub>2</sub> O <sub>3</sub> 20 um 2 1
	93	1.996	0.002	0.002	0.000	0.001	0.000	0.001	0.000	0.000	2.002	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 3 1
	94	1.988	0.004	0.005	0.001	0.002	0.006	0.001	0.000	0.000	2.005	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 3 2
	95	1.989	0.007	0.004	0.001	0.000	0.000	0.001	0.000	0.001	2.003	C212-2 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 1
	96	1.929	0.008	0.083	0.003	0.004	0.030	0.000	0.000	0.001	2.058	C212-2 Large As <sub>2</sub> O <sub>3</sub> 40 um 4 2
	97	1.986	0.003	0.012	0.002	0.000	0.006	0.000	0.000	0.000	2.008	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 5 1
	98	1.953	0.004	0.009	0.000	0.002	0.048	0.000	0.000	0.000	2.016	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 5 2
	99	1.995	0.002	0.002	0.000	0.001	0.002	0.000	0.000	0.000	2.002	C212-2 Large As <sub>2</sub> O <sub>3</sub> 30 um 6 1
Average		1.973	0.011	0.013	0.001	0.003	0.010	0.000	0.000	0.000	2.012	
Max		1.996	0.075	0.083	0.003	0.015	0.048	0.001	0.000	0.001	2.058	
Min		1.921	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	2.002	
St. Dev.		0.028	0.022	0.025	0.001	0.005	0.016	0.000	0.000	0.000	0.017	

Old Feed Small As<sub>2</sub>O<sub>3</sub> grains Weight Percent Oxide

No.	As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO <sub>3</sub>	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO	Total	Comment
8	96.10	0.32	0.29	0.03	0.00	0.23	0.00	0.00	0.00	96.97	Old Feed Small As <sub>2</sub> O <sub>3</sub> 1
9	97.09	0.98	0.33	0.03	0.00	0.05	0.00	0.00	0.03	98.52	Old Feed Small As <sub>2</sub> O <sub>3</sub> 2
10	88.98	0.36	1.33	0.09	0.00	0.00	0.00	0.00	0.01	90.77	Old Feed Small As <sub>2</sub> O <sub>3</sub> 3
11	100.24	4.63	0.37	0.00	0.00	0.11	0.00	0.00	0.00	105.35	Old Feed Small As <sub>2</sub> O <sub>3</sub> 4
12	93.92	5.27	0.48	0.00	0.00	0.09	0.00	0.00	0.00	99.76	Old Feed Small As <sub>2</sub> O <sub>3</sub> 5
13	96.42	0.95	0.28	0.06	0.00	0.08	0.00	0.00	0.00	97.78	Old Feed Small As <sub>2</sub> O <sub>3</sub> 6
14	96.82	1.43	0.25	0.00	0.00	0.00	0.00	0.00	0.06	98.56	Old Feed Small As <sub>2</sub> O <sub>3</sub> 7
15	97.43	0.28	0.27	0.00	0.00	0.00	0.02	0.00	0.03	98.03	Old Feed Small As <sub>2</sub> O <sub>3</sub> 8
16	82.10	13.63	0.32	0.00	0.00	0.07	0.00	0.00	0.00	96.12	Old Feed Small As <sub>2</sub> O <sub>3</sub> 9
17	83.73	1.08	0.62	0.06	0.00	0.63	0.14	0.00	0.00	86.26	Old Feed Small As <sub>2</sub> O <sub>3</sub> 10
18	93.04	0.12	0.30	0.02	0.01	0.00	0.00	0.00	0.00	93.50	Old Feed Small As <sub>2</sub> O <sub>3</sub> 11
19	98.32	0.31	0.20	0.00	0.00	0.00	0.04	0.00	0.00	98.87	Old Feed Small As <sub>2</sub> O <sub>3</sub> 12
20	97.56	3.35	0.22	0.01	0.00	0.25	0.00	0.00	0.01	101.40	Old Feed Small As <sub>2</sub> O <sub>3</sub> 13
21	77.35	6.76	1.11	0.16	0.00	6.83	0.07	0.00	0.06	92.33	Old Feed Small As <sub>2</sub> O <sub>3</sub> 14
22	88.01	0.11	0.28	0.01	0.04	0.18	0.20	0.00	0.00	88.83	Old Feed Small As <sub>2</sub> O <sub>3</sub> 15
23	97.14	0.37	0.28	0.00	0.00	0.00	0.03	0.00	0.06	97.88	Old Feed Small As <sub>2</sub> O <sub>3</sub> 16
24	95.40	0.20	0.36	0.00	0.00	0.12	0.03	0.00	0.02	96.12	Old Feed Small As <sub>2</sub> O <sub>3</sub> 16
Average	92.92	2.36	0.43	0.03	0.00	0.51	0.03	0.00	0.02	96.30	
Max	100.24	13.63	1.33	0.16	0.04	6.83	0.20	0.00	0.06	105.35	
Min	77.35	0.11	0.20	0.00	0.00	0.00	0.00	0.00	0.00	86.26	
St. Dev.	6.56	3.56	0.32	0.04	0.01	1.64	0.06	0.00	0.02	4.71	

Old Feed Small As<sub>2</sub>O<sub>3</sub> grains Cations on the Basis of Three Oxygen

No.		As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
1	8	1.983	0.005	0.010	0.001	0.000	0.009	0.000	0.000	0.000	2.007	Old Feed Small As <sub>2</sub> O <sub>3</sub> 1
	9	1.979	0.014	0.011	0.001	0.000	0.002	0.000	0.000	0.000	2.007	Old Feed Small As <sub>2</sub> O <sub>3</sub> 2
	10	1.972	0.006	0.047	0.003	0.000	0.000	0.000	0.000	0.000	2.028	Old Feed Small As <sub>2</sub> O <sub>3</sub> 3
	11	1.929	0.063	0.011	0.000	0.000	0.004	0.000	0.000	0.000	2.008	Old Feed Small As <sub>2</sub> O <sub>3</sub> 4
	12	1.915	0.076	0.016	0.000	0.000	0.004	0.000	0.000	0.000	2.010	Old Feed Small As <sub>2</sub> O <sub>3</sub> 5
	13	1.978	0.014	0.009	0.002	0.000	0.003	0.000	0.000	0.000	2.006	Old Feed Small As <sub>2</sub> O <sub>3</sub> 6
	14	1.976	0.021	0.008	0.000	0.000	0.000	0.000	0.000	0.001	2.005	Old Feed Small As <sub>2</sub> O <sub>3</sub> 7
	15	1.992	0.004	0.009	0.000	0.000	0.000	0.000	0.000	0.000	2.006	Old Feed Small As <sub>2</sub> O <sub>3</sub> 8
	16	1.783	0.210	0.011	0.000	0.000	0.003	0.000	0.000	0.000	2.007	Old Feed Small As <sub>2</sub> O <sub>3</sub> 9
	17	1.947	0.018	0.023	0.002	0.000	0.028	0.002	0.000	0.000	2.020	Old Feed Small As <sub>2</sub> O <sub>3</sub> 10
	18	1.993	0.002	0.010	0.001	0.000	0.000	0.000	0.000	0.000	2.006	Old Feed Small As <sub>2</sub> O <sub>3</sub> 11
	19	1.993	0.005	0.007	0.000	0.000	0.000	0.000	0.000	0.000	2.004	Old Feed Small As <sub>2</sub> O <sub>3</sub> 12
	20	1.942	0.047	0.007	0.000	0.000	0.010	0.000	0.000	0.000	2.006	Old Feed Small As <sub>2</sub> O <sub>3</sub> 13
	21	1.652	0.103	0.038	0.005	0.000	0.279	0.001	0.000	0.001	2.078	Old Feed Small As <sub>2</sub> O <sub>3</sub> 14
	22	1.986	0.002	0.010	0.000	0.002	0.008	0.002	0.000	0.000	2.010	Old Feed Small As <sub>2</sub> O <sub>3</sub> 15
	23	1.991	0.005	0.009	0.000	0.000	0.000	0.000	0.000	0.001	2.006	Old Feed Small As <sub>2</sub> O <sub>3</sub> 16
	24	1.988	0.003	0.012	0.000	0.000	0.005	0.000	0.000	0.000	2.008	Old Feed Small As <sub>2</sub> O <sub>3</sub> 16
Average		1.941	0.035	0.015	0.001	0.000	0.021	0.000	0.000	0.000	2.013	
Max		1.993	0.210	0.047	0.005	0.002	0.279	0.002	0.000	0.001	2.078	
Min		1.652	0.002	0.007	0.000	0.000	0.000	0.000	0.000	0.000	2.004	
St. Dev.		0.090	0.054	0.011	0.001	0.000	0.067	0.001	0.000	0.000	0.018	

Old Feed Large As<sub>2</sub>O<sub>3</sub> grains Weight Percent Oxide

No.	As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO₃	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO T	otal Comment
100	103.18	0.44	0.33	0.07	0.00	0.10	0.09	0.00	0.00	104.21 Old Feed Large As <sub>2</sub> O <sub>3</sub> 40 um 1 1
101	98.71	0.54	0.35	0.00	0.10	0.17	0.00	0.00	0.01	99.88 Old Feed Large As <sub>2</sub> O <sub>3</sub> 40 um 1 2
102	97.94	0.00	0.18	0.00	0.08	0.21	0.00	0.00	0.03	98.44 Old Feed Large As <sub>2</sub> O <sub>3</sub> 50 um 2 1
103	94.08	0.02	0.22	0.00	0.11	0.74	0.03	0.08	0.00	95.27 Old Feed Large As <sub>2</sub> O <sub>3</sub> 50 um 2 2
104	99.18	0.03	0.24	0.00	0.10	0.49	0.10	0.05	0.01	100.20 Old Feed Large As <sub>2</sub> O <sub>3</sub> 50 um 2 3
105	93.86	0.75	0.37	0.04	0.00	0.63	0.00	0.00	0.00	95.66 Old Feed Large As <sub>2</sub> O <sub>3</sub> 60 um 3 1
106	95.16	0.24	0.55	0.10	0.01	0.00	0.00	0.00	0.01	96.08 Old Feed Large As <sub>2</sub> O <sub>3</sub> 60 um 3 2
107	92.72	0.13	0.96	0.48	0.00	0.04	0.06	0.00	0.00	94.39 Old Feed Large As <sub>2</sub> O <sub>3</sub> 60 um 3 3
108	97.33	0.35	0.22	0.05	0.05	0.14	0.00	0.00	0.06	98.19 Old Feed Large As <sub>2</sub> O <sub>3</sub> 30 um 4 1
109	95.25	0.19	0.23	0.10	0.07	0.27	0.08	0.00	0.01	96.19 Old Feed Large $As_2O_3$ 30 um 4 2
Average	96.74	0.27	0.37	0.08	0.05	0.28	0.04	0.01	0.01	97.85
Max	103.18	0.75	0.96	0.48	0.11	0.74	0.10	0.08	0.06	104.21
Min	92.72	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	94.39
St. Dev.	3.15	0.25	0.23	0.15	0.04	0.25	0.04	0.03	0.02	2.98

### Old Feed Large As<sub>2</sub>O<sub>3</sub> grains Cations on the Basis of Three Oxygen

No.	As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total	Comment
100	1.984	0.006	0.010	0.002	0.000	0.004	0.001	0.000	0.000	2.007	Old Feed Large As <sub>2</sub> O <sub>3</sub> 40 um 1 1
101	1.981	0.008	0.011	0.000	0.004	0.007	0.000	0.000	0.000	2.011	Old Feed Large As <sub>2</sub> O <sub>3</sub> 40 um 1 2
102	1.990	0.000	0.006	0.000	0.003	0.008	0.000	0.000	0.000	2.007	Old Feed Large As <sub>2</sub> O <sub>3</sub> 50 um 2 1
103	1.970	0.000	0.007	0.000	0.005	0.030	0.000	0.003	0.000	2.014	Old Feed Large As <sub>2</sub> O <sub>3</sub> 50 um 2 2
104	1.979	0.000	0.008	0.000	0.004	0.019	0.001	0.001	0.000	2.012	Old Feed Large As <sub>2</sub> O <sub>3</sub> 50 um 2 3
105	1.962	0.011	0.012	0.001	0.000	0.025	0.000	0.000	0.000	2.012	Old Feed Large As <sub>2</sub> O <sub>3</sub> 60 um 3 1
106	1.985	0.004	0.018	0.003	0.001	0.000	0.000	0.000	0.000	2.011	Old Feed Large As <sub>2</sub> O <sub>3</sub> 60 um 3 2
107	1.966	0.002	0.032	0.015	0.000	0.002	0.001	0.000	0.000	2.017	Old Feed Large As <sub>2</sub> O <sub>3</sub> 60 um 3 3
108	1.985	0.005	0.007	0.001	0.002	0.005	0.000	0.000	0.001	2.007	Old Feed Large As <sub>2</sub> O <sub>3</sub> 30 um 4 1
109	1.981	0.003	0.008	0.003	0.003	0.011	0.001	0.000	0.000	2.008	Old Feed Large As <sub>2</sub> O <sub>3</sub> 30 um 4 2
Average	1.978	0.004	0.012	0.003	0.002	0.011	0.000	0.000	0.000	2.011	
Max	1.990	0.011	0.032	0.015	0.005	0.030	0.001	0.003	0.001	2.017	
Min	1.962	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	2.007	
St. Dev.	0.009	0.004	0.008	0.004	0.002	0.010	0.000	0.001	0.000	0.003	

No.	As <sub>2</sub> O <sub>3</sub>	Sb <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	SO <sub>3</sub>	CaO	SiO <sub>2</sub>	Bi <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	PbO	Total Comment
25	<b>5</b> 3.34	0.45	89.14	1.00	0.04	0.11	0.00	0.00	0.14	94.21 Old Feed Small Hematite
27	7 12.96	1.31	68.12	3.82	0.00	0.21	0.00	0.00	0.00	86.42 Old Feed Small Hematite
28	<b>3</b> 3.60	0.46	75.06	0.24	0.06	0.14	0.01	0.00	0.00	79.57 Old Feed Small Hematite
29	9 5.42	1.32	85.22	0.88	0.03	0.24	0.09	0.02	0.16	93.38 Old Feed Small Hematite
30	<b>)</b> 3.48	0.53	87.58	0.70	0.02	0.17	0.00	0.00	0.23	92.70 Old Feed Small Hematite
31	l 4.07	0.74	87.09	0.40	0.02	0.21	0.03	0.00	0.30	92.85 Old Feed Small Hematite
32	2 5.49	0.80	79.50	1.43	0.01	0.11	0.05	0.00	0.12	87.51 Old Feed Small Hematite 8
33	<b>3</b> 8.04	2.00	77.49	1.34	0.00	0.08	0.10	0.00	0.03	89.08 Old Feed Small Hematite
34	<b>1</b> 7.34	1.67	77.34	2.54	0.10	0.09	0.00	0.00	0.00	89.08 Old Feed Small Hematite 1
Average	5.97	1.03	80.73	1.37	0.03	0.15	0.03	0.00	0.11	89.42
Max	12.96	2.00	89.14	3.82	0.10	0.24	0.10	0.02	0.30	94.21
Min	3.34	0.45	68.12	0.24	0.00	0.08	0.00	0.00	0.00	79.57
St. Dev.	3.12	0.57	7.01	1.14	0.03	0.06	0.04	0.01	0.11	4.63

### Old Feed Hematite Weight Percent Oxide

#### Old Feed Hematite Cations on the Basis of Three Oxygen

No.	As	Sb	Fe	S	Ca	Si	Bi	Cr	Pb	Total Comment
25	0.053	0.003	1.900	0.037	0.001	0.005	0.000	0.000	0.001	2.000 Old Feed Small Hematite 1
27	0.227	0.010	1.598	0.156	0.000	0.010	0.000	0.000	0.000	2.000 Old Feed Small Hematite 3
28	0.068	0.004	1.908	0.011	0.002	0.007	0.000	0.000	0.000	2.000 Old Feed Small Hematite 4
29	0.088	0.009	1.856	0.033	0.001	0.010	0.001	0.000	0.001	2.000 Old Feed Small Hematite 5
30	0.056	0.004	1.904	0.026	0.001	0.007	0.000	0.000	0.001	2.000 Old Feed Small Hematite 6
31	0.066	0.005	1.902	0.015	0.001	0.009	0.000	0.000	0.002	2.000 Old Feed Small Hematite 7
32	0.094	0.006	1.836	0.058	0.000	0.005	0.000	0.000	0.001	2.000 Old Feed Small Hematite 8
33	0.138	0.015	1.788	0.054	0.000	0.003	0.001	0.000	0.000	2.000 Old Feed Small Hematite 9
34	0.124	0.012	1.756	0.100	0.003	0.004	0.000	0.000	0.000	2.000 Old Feed Small Hematite 10
Average	0.10	0.01	1.83	0.05	0.00	0.01	0.00	0.00	0.00	2.00
Max	0.23	0.02	1.91	0.16	0.00	0.01	0.00	0.00	0.00	2.00
Min	0.05	0.00	1.60	0.01	0.00	0.00	0.00	0.00	0.00	2.00
St. Dev.	0.06	0.00	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00

### **APPENDIX C**

**Bulk Chemical Assay** 

Sample ID	Unit	C-212-2 (168-189)	B-233-P9	Old Feed	B208 1 Comp
Ag	g/t	6	38	20	4
AI	g/t	6700	19000	20000	4300
As	g/t	10000	61000	7200	
Ва	g/t	16	44	47	16
Ве	g/t	< 0.2	< 0.2	< 0.2	< 0.05
Bi	g/t	< 20	< 20	< 20	< 20
Ca	g/t	2300	9300	9200	2300
Cd	g/t	< 25	< 25	< 25	< 8
Со	g/t	28	110	57	< 25
Cr	g/t	23	71	48	16
Cu	g/t	230	810	340	100
Fe	g/t	21000	150000	55000	18000
к	g/t	1900	5200	5000	1200
Li	g/t	< 40	< 40	< 40	< 40
Mg	g/t	2200	5900	6800	1600
Mn	g/t	88	300	250	74
Мо	g/t	< 20	< 20	< 20	< 20
Na	g/t	230	960	970	230
Ni	g/t	53	230	100	40
Р	g/t	< 100	< 100	< 100	< 100
Pb	g/t	550	4300	1300	470
Sb	g/t	3600	18000	8200	11000
Se	g/t	< 60	< 60	< 60	< 60
Sn	g/t	< 40	< 40	< 40	< 40
Sr	g/t	5.7	14	16	3.2
Ti	g/t	510	2000	1400	160
ті	g/t	< 60	< 60	< 60	< 60
V	g/t	26	73	67	18
Y	g/t	0.9	2.1	1.8	0.7
Zn	g/t	250	2100	510	300
As	%	66.3	39.5	51	66.5

### Bulk Chemical Assays of Dust Samples

\* Data provided by Diana Sollner, SRK Consulting Inc.

Protected Business Information



# **CANMET Canadian Explosives Research Laboratory**



### HEAT CAPACITY STUDY OF DUST SAMPLES CONTAINING **ARSENIC TRIOXIDE**

T. Parekunnel, Q. S. M. Kwok and D. E. G. Jones

August 2004

CERL Report 2004-31 (CF)

Work performed for: Indian and Northern Affairs Canada Giant Mine Remediation Project Team





### HEAT CAPACITY STUDY OF DUST SAMPLES CONTAINING ARSENIC TRIOXIDE

### Abstract

Dust samples containing arsenic trioxide (As<sub>2</sub>O<sub>3</sub>) were analyzed using Differential Scanning Calorimetry (DSC) to determine their heat capacity. Measurements were conducted in accordance with ASTM Standard Method E1269-01.

### Introduction

Differential scanning calorimetry can be used to provide a fast, simple method for determining the specific heat capacity of materials. The specific heat capacity of dust samples containing  $As_2O_3$  can be determined using a standard test method consisting of heating the dust sample at a controlled rate in a controlled atmosphere through the temperature region of interest. The difference in heat flow between the sample and a reference material due to energy changes in the sample is continuously monitored and recorded.

### Experimental

Three different dust samples were provided by SRK Consulting and used without purification.

A TA 5200 Thermal Analysis System with a 2910 DSC module and a Du Pont Instruments Mechanical Cooling Accessory was used to determine the specific heat capacity of the dust samples following ASTM standard test method E 1269-01 [1]. Hermetic Al pans containing samples of the dust were held isothermally at -10 °C for 5 minutes, then heated from -10 to 10 °C at a heating rate of 5 °C min<sup>-1</sup>. At the end of each run, the sample was held isothermally for an additional 5 minutes before the run was terminated. Sample size varied from 9 mg to 20 mg between samples due to the varying densities of the different samples. For the sample supplied with the label "Mar 0348 2/5 C-212-2(168-189) March 25/04 T38.4" (henceforth referred to as Sample A), 20.0  $\pm$  0.3 mg was used in each run. For the sample labelled "Mar 0348 3/5 old feed T38.4" (Sample B), 8.94  $\pm$  0.02 mg was used in each run. Somple size was determined such that the sample container held the maximum amount of sample. Each sample was run in duplicate. The DSC was calibrated for heat flow [2] and temperature [3]. Synthetic sapphire was used as a reference material.

### **Results and Discussion**

Originally, attempts were made to determine the specific heat capacity of the samples for the temperature region of -10 to 50 °C. However, in the initial run on Sample C, a large exothermic peak was observed between 40 and 50 °C and a small endothermic peak in the 20 to 25 °C region. It was therefore decided to determine the specific heat capacity only for the temperature region -10 to 10 °C. The DSC thermal curves for the samples are shown in Appendix A.

The thermal curves of the samples were compared with that of the sapphire reference to determine the specific heat capacities of the dust samples. The calculations used for the determination of specific heat capacity can be found in the ASTM method E 1269-01 [1]. The plots of the specific heat capacities obtained for the samples are shown in Figure 1. Error analysis for each sample can be found in Appendix B. Variation between duplicate runs can be attributed to the inhomogeneity of the samples. Variation between samples may be due to the different composition of the samples. The specific heat capacity for Sample A was significantly lower than the heat capacities for Samples B and C. Taking into account the error, there is no significant difference in the specific heat capacity values of Samples B and C.

### References

- ASTM E 1269-01, Standard Test Method for Determining Specific Heat Capacity by Differential Scanning Calorimetry, American Society for Testing and Materials, Philadelphia, PA, U.S.A.
- 2. ASTM E 968, Standard Practice for Heat Flow Calibration of Differential Scanning Calorimeters, American Society for Testing and Materials, Philadelphia, PA, U.S.A.
- ASTM E 967, Standard Practice for Temperature Calibration of Differential Scanning Calorimeters and Differential Thermal Analyzers, American Society for Testing and Materials, Philadelphia, PA, U.S.A.





### **APPENDIX A**

Below are the thermal curves for the dust samples containing  $As_2O_3$ . Each graph shows the duplicate curves of the sample, as well as the curves for the standard sapphire and the empty sample holders, used to calculate specific heat capacity.







### **APPENDIX B**

Below are the individual plots of specific heat capacity for the different samples. The dotted lines indicate 95% prediction limits for the linear regression, represented by the solid line.



Heat Capacity of Dust Sample A





### SGS Lakefield Research Limited

An Investigation into

#### THE CHARACTERIZATION OF VARIOUS ARSENIC TRIOXIDE DUST SAMPLES FROM GIANT YELLOWKNIFE MINE

prepared for

### SRK CONSULTING LTD.

LR10750-001 – Final Report

NOTE:

This report refers to the samples as received.

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Lakefield Research

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#### 2

### Abstract

The size distribution, chemical analyses and specific gravity of various arsenic trioxide dust samples from the Giant Yellowknife mine have been measured. The arsenic content ranged from 40 to 66%; the P<sub>80</sub> of the various dust samples also varied widely from 10  $\mu$ m to 55  $\mu$ m, while the specific gravity ranged from 3.29 to 3.77.

Other geotechnical parameters such as Atterberg limits, Standard Proctor, wettability, capillary rise and compaction were also measured.

### Introduction

An in-situ freezing process is being developed for the arsenic trioxide dust presently stored in various stopes of the underground Giant Yellowknife Mine. SGS Lakefield Research was contracted to determine various chemical, physical and geotechnical parameters of arsenic trioxide dust samples.

This report describes the procedures and results of the various measurements conducted at Lakefield.

#### SGS LAKEFIELD RESEARCH LIMITED

C.J. Ferron, Ph. D., Vice President / Metallurgical Technologies

Report Preparation By: Experimental Work By: S. McKenzie J. Dirycz, S. Jurchison 3

### **Discussion of Results**

#### 1. Feed Samples

The arsenic trioxide dust samples were received in March, 2004 at Lakefield in two shipments, and were given Lakefield identification numbers LR2400713 and LR2400797. For some measurements requiring large quantities of sample, a dust sample used previously at Lakefield for cement and bitumen stabilization testwork (LR10394-001, 2002) was used. This material is reported to have been collected directly from the Giant Mine mill bag house and stored on site in barrels. The sample was received by Lakefield in 2002 in a dry condition. This sample will be referred to as "Bag House Dust" in this report.

The dust samples were received at Lakefield in 2 separate shipments: the first shipment (4 pails, about 35 kg gross weight) was received at Lakefield on March 16<sup>th</sup>, 2004, and was given Lakefield identification number LR2400713. The second shipment (9 pails) about 72 kg gross weight) was received at Lakefield on March 23<sup>rd</sup>, 2004, and was given Lakefield identification number LR 2400797. Table 0 lists the various samples received at Lakefield.

Sample ID #	Sample Depth (feet)	LR#
B233-P9	175-181	LR 2400713
C212-2	140-168	LR 2400713
C212-2	168-189	LR 2400713
B235-P13	130-137	LR 2400713
B212-4	96.5-133	LR2400797
B212-4	133-167	LR2400797
B212-4	217-225	LR2400797
B212-4	225-232	LR2400797
B208-1	106-133	LR2400797
B208-1	133-176	LR2400797
B214-1	119-143	LR2400797
B214-1	143-179	LR2400797
B214-1	179-180	LR2400797
Bag House Dust	Not applicable	Received in 2002

Table 0: List of dust samples received at Lakefield

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Samples B212-4, B208-1, B214-1 were composited prior to testing. The other samples (B233-P9, C212-2, B235-P13, Bag House dust) were tested as discrete samples.

#### 2. Chemical and Size Analyses of the Various Dust Samples

Selected samples were submitted for chemical and size analyses (Table 1).

Two chemical analyses were conducted; a 26-element ICP scan (after strong acid digest), and a direct arsenic analysis. Size analyses were conducted using a Malvern Model 2600 laser meter. Because of the high solubility of arsenic dust in water, the dust samples were prepared in an arsenic saturated solution prior to measurement of their size.

All detailed results are included in Appendix 1 of this report.

Results indicate a wide variability of dust samples, with arsenic assays ranging from 40 to 66% As, and size analysis ranging from  $P_{80} = 10 \ \mu m$  to 55  $\ \mu m$ . Lower grade dust samples (B-233-P9, Bag House Dust) indicated the presence of large quantities of iron, from 5.5 to 15% Fe.

	C212-2	C212-2	B233-	B235-	Bag House	B208-1	B214-1	B212-4
Element g/t	(140-168)	(168-189)	P9	P13	Dust	Comp	Comp	Comp
Ag	<2	6	38	9	20	4	9	6
Al	9300	6700	19000	7700	20000	4300	12000	7300
Ba	25	16	44	24	47	16	30	25
Be	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5
Bi	<20	<20	<20	<20	<20	<20	<20	<20
Ca	6800	2300	9300	2900	9200	2300	5300	3400
Cd	<25	<25	<25	<25	<25	<8	<8	<8
Co	22	28	110	28	57	<25	43	26
Cr	30	23	71	20	48	16	36	22
Cu	130	230	810	240	340	100	230	160
			15000					
Fe	23000	21000	0	20000	55000	18000	42000	25000
K	2600	1900	5200	2000	5000	1200	3600	2200
Li	<40	<40	<40	<40	<40	<40	<40	<40
Mg	5500	500	5900	2900	6800	1600	3600	2200
Mn	170	88	300	100	250	74	130	85
Mo	<20	<20	<20	<20	<20	<20	<20	<20
Na	270	230	960	600	970	230	560	370
Ni	42	53	230	48	100	40	83	50
P	<100	<100	<100	<100	<100	<100	<100	<100
Pb	240	550	4300	440	1300	470	1200	810
Sb	2100	3600	18000	3700	8200	11000	16000	17000
Se	<60	<60	<60	<60	<60	<60	<60	<60
Sn	<40	<40	<40	<40	<40	<40	<40	<40
Sr	8.1	5.7	14	5.8	16	3.2	9.4	6
Ti	840	510	2000	610	1400	160	330	310
TI	<60	<60	<60	<60	<60	<60	<60	<60
l v	39	26	73	30	67	18	44	28
Y	0.9	0.9	2.1	1	1.8	0.7	1.6	1
Zn	220	250	2100	290	510	300	640	420
As (%)*	62.7	66.3	39.5	66	51	66.5	57.8	60.2
Size								
Analysis	55	51	45	10.4	34.2	36.8	15.2	18.4
$P_{80} \blacktriangle (\mu m)$								

Table 1. Chemical Analyses

\*Direct arsenic analysis

 $\blacktriangle$  Using a Malvern Laser meter, with a saturated arsenic solution as a medium.

### 3. Specific Gravity

Selected dust samples were also submitted for measurement of their specific gravity. Specific gravity was measured using a Micromeritics Multi-Volume Pycnometer 1305. Results are presented in Table 2.

**Table 2. Pycnometer Specific Gravity of Selected Dust Samples** 

Sample #	C212-2 (140-168)	C212-2 (168-189)	B233-P9	B235-P13	B212-4 Comp	B214-1 Comp	B208-1 Comp
SG	3.47	3.47	3.59	3.37	3.38	3.29	3.77

### 4. Atterberg Limits

Atterberg limits (liquid LL and plastic PL) were measured for selected dust samples using the procedure described in Appendix 2 (ASTM D 4318). All detailed results are also presented in Appendix 2. Results are summarized in Table 3.

	Atterberg Limit (% moisture)			
Sample No.	LL	PL		
Bag House Dust	29.6	33.8		
B208-1 Comp	36.3	30.9		
B212-4 Comp	31.1	28.5		
B214-1 Comp	31.8	28.9		
B233-P9	41.7	35.3		
C212-2 (168-189)	27.7	non plastic		
C212-2 (140-168)	25.0	non plastic		

**Table 3. Atterberg Limits of Selected Dust Samples** 

### **5. Standard Proctor**

A standard Proctor compaction test was conducted on the Bag House dust sample, since it was the only dust sample available in large quantities. The procedure is presented in Appendix 2 (ASTM D 698-91), together with some results.

The results obtained were not deemed satisfactory, very likely due to the difficulty of measuring and modifying the moisture content of the dust sample that proved vary difficult to mix with water.

#### 6. Column Wettability Test

A test was designed to examine qualitatively the behaviour of a dust sample, packed to a given compaction, when water is poured onto it. The procedure was developed after discussions with SRK. It can simply be described as follows:

- A dust sample was packed into a transparent plastic column (actual in-situ density: 820 kg/m<sup>3</sup>; target in-situ density : 1100 kg/m<sup>3</sup>).
- $\clubsuit$  A certain volume of water was placed on top of the dust sample at time = 0
- The penetration of the liquid front through the dust was followed through the tube as a function of time.

The set up is illustrated in Figure 1. The sample used for the test was the Bag House dust sample. Of notice is the fact that the hydrostatic pressure was not maintained constant during the test. Test details are included in Appendix 4. Results are illustrated in Figure 2.





Figure 2. Column Wettability Test – Results Bag House Dust

### 7. Capillary Rise

Another test was designed to assess qualitatively the capillary rise of water through a bed of arsenic trioxide dust compacted to a given value. The same Bag House dust sample was used for this test. The procedure can be described as follows:

- A dust sample was packed into a transparent plastic column fitted with a screen at the bottom (1012 kg/m<sup>3</sup>).
- ✤ The packed column was placed in a container filled with water.
- The rise of water through the bed of packed dust was observed and recovered as a function of time.

The set up is illustrated in Figure 3. Test details are included in Appendix 4, with results illustrated in Figure 4.







Photographs of the set up are presented in Appendix 5.

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#### 8. Compaction Tests

A test was designed to qualitatively assess the resistance to compaction of dust samples. The same Bag House dust sample (dry) was used for the testing. The procedure can be described as follows:

- ♣ A certain amount of dust (5.8kg) was placed in a glass container. The bulk density of the dust at the start of the test was 562 kg/m<sup>3</sup>.
- Increasing weights were placed on top of the dust, and the penetration of the weights in the dust was measured.
- After dry compaction test, the dust was placed in a freezer at  $\sim 28^{\circ}$ C for 5 days.
- Four liters of water were poured on the frozen dust. The water completely penetrated the dust in a few minutes.
- The water-saturated dust was thawed.
- The compaction test was repeated on the thawed water-saturated dust sample.

The set up for the compaction test is shown in Figure 5, while the results of the compaction tests are presented in Figure 6.







### 9. Testwork by Outside Laboratories

At the request of SRK Consulting, small samples (±50 grams) of dusts were shipped to Canmet, Ottawa.

Samples shipped were: B233-P9 C212-2 (168-189) B208-1 Comp Bag House Dust.

In July, EBA Engineering was present at Lakefield to conduct testwork on samples C212-2 (168-189) and B208-1 (133-176). They also conducted work on the Bag House dust.

At the completion of Lakefield and EBA test programs, samples used were sent for

disposal to a licensed facility in Ontario (Detox Environmental).

**10. Inventory of Dust Samples Remaining at Lakefield** 

**Inventory of samples still at Lakefield** Sample ID Depth (ft) Pulp remaining weight B212-4 96.5-133 5,586 B212-4 133-167 11,920 B212-4 217-225 5,485 B212-4 225-232 750 B208-1 106-133 3,286 C212-2 4,446 140-168 B214-1 119-143 9,389 B214-1 143-179 11,802 B214-1 179-180 1,264 B233-P9 175-181 7,317

Remaining samples and approximate weights are:

Appendix 1: Chemical and Size Analyses
REP No. Customer Attention Reference Project Chargeld Batch	CA0348-M LR Interna Jacek D/C SRK Cons 10750001 OTHER Feed	AR04 al Dept <sup>-</sup> JF sulting	14									
Title												
Date	25-Ma	r-04 15:	:41									
Sample ID	Ag	AI	As	Ba	Be	Bi	Ca	Cd	Со	Cr	Cu	
	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	
C212-2 (140-168)	< 2	9300	20000	25	< 0.2	< 20	6800	< 25	22	30	130	
C212-2 (168-189)	6	6700	10000	16	< 0.2	< 20	2300	< 25	28	23	230	
B233-P9	38	19000	61000	44	< 0.2	< 20	9300	< 25	110	71	810	
B235-P13	9	7700	26000	24	< 0.2	< 20	2900	< 25	28	20	240	
Bag House Dust	20	20000	7200	47	< 0.2	< 20	9200	< 25	57	48	340	
	Fe	к	Li	Mg	Mn	Мо	Na	Ni	Ρ	Pb	Sb	
	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	
C212-2 (140-168)	23000	2600	< 40	5500	170	< 20	270	42	< 100	240	2100	
C212-2 (168-189)	21000	1900	< 40	2200	88	< 20	230	53	< 100	550	3600	
B233-P9	150000	5200	< 40	5900	300	< 20	960	230	< 100	4300	18000	
B235-P13	20000	2000	< 40	2900	100	< 20	600	48	< 100	440	3700	
Bag House Dust	55000	5000	< 40	6800	250	< 20	970	100	< 100	1300	8200	
	Se	Sn	Sr	Ti	ті	V	Y	Zn	As			
	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	%			
C212-2 (140-168)	< 60	< 40	8.1	840	< 60	39	0.9	220	62.7			
C212-2 (168-189)	< 60	< 40	5.7	510	< 60	26	0.9	250	66.3			
B233-P9	< 60	< 40	14	2000	< 60	73	2.1	2100	39.5			
B235-P13	< 60	< 40	5.8	610	< 60	30	1	290	66			
Bag House Dust	< 60	< 40	16	1400	< 60	67	1.8	510	51			

CA0392 LR Inte Jacek I SRK Co 1075000 OTHER Feed	2-MAR04 rnal Dep Dirycz onsulting 01	t 14 J								
30-Mar-	04 11:40									
Ag	Al	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe
g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t
4	4300	16	< 0.05	< 20	2300	< 8	< 25	16	100	18000
9	12000	30	< 0.05	< 20	5300	< 8	43	36	230	42000
6	7300	25	< 0.05	< 20	3400	< 8	26	22	160	25000
к	Li	Mg	Mn	Мо	Na	Ni	Р	Pb	Sb	Se
g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t
1200	< 40	1600	74	< 20	230	40	< 100	470	11000	< 60
3600	< 40	3600	130	< 20	560	83	< 100	1200	16000	< 60
2200	< 40	2200	85	< 20	370	50	< 100	810	17000	< 60
Sn	Sr	Ті	TI	v	Y	Zn	As			
g/t	g/t	g/t	g/t	g/t	g/t	g/t	%			
< 40	3.2	160	< 60	18	0.7	300	66.5			
< 40	9.4	330	< 60	44	1.6	640	57.8			
< 40	6	310	< 60	28	1	420	60.2			
-	CA0392 LR Inte Jacek I SRK Co 107500 OTHER Feed  30-Mar- Ag g/t 4 9 6 K g/t 1200 3600 2200 Sn g/t < 40 < 40 < 40 < 40	CA0392-MAR04 LR Internal Dep Jacek Dirycz SRK Consulting 10750001 OTHER Feed  30-Mar-04 11:40 Ag Al g/t g/t 4 4300 9 12000 6 7300 K Li g/t g/t 1200 < 40 3600 < 40 2200 < 40 3600 < 40 2200 < 40 3600 < 40 2200 < 40 3600 < 40 3600 < 40 2200 < 40 3600 < 40	CA0392-MAR04 LR Internal Dept 14 Jacek Dirycz SRK Consulting 10750001 OTHER Feed  30-Mar-04 11:40 Ag Al Ba g/t g/t g/t 4 4300 16 9 12000 30 6 7300 25 K Li Mg g/t g/t g/t 1200 < 40 1600 3600 < 40 3600 2200 < 40 3600 2200 < 40 2200 Sn Sr Ti g/t g/t g/t Sn Sr Ti g/t g/t g/t   Sn Sr Ti g/t g/t g/t   9,40 3.2   160   3600 < 40 3600	CA0392-MAR04 LR Internal Dept 14 Jacek Dirycz SRK Consulting 10750001 OTHER Feed  30-Mar-04 11:40 Ag Al Ba Be g/t g/t g/t g/t 4 4300 16 < 0.05 9 12000 30 < 0.05 6 7300 25 < 0.05 6 7300 25 < 0.05 K Li Mg Mn g/t g/t g/t g/t 1200 < 40 1600 74 3600 < 40 3600 130 2200 < 40 3600 130 2200 < 40 2200 85 Sn Sr Ti Tl g/t g/t g/t g/t < 40 3.2 160 < 60 < 40 9.4 330 < 60 < 40 6 310 < 60	CA0392-MAR04         LR Internal Dept 14         Jacek Dirycz         SRK Consulting         10750001         OTHER         Feed            30-Mar-04 11:40            30         4       4300       16       < 0.05	CA0392-MAR04         LR Internal Dept 14         Jacek Dirycz         SRK Consulting         10750001         OTHER         Feed	CA0392-MAR04         LR Internal Dept 14         Jacek Dirycz         SRK Consulting         10750001         OTHER         Feed	CA0392-MAR04         LR Internal Dept 14         Jacek Dirycz         SRK Consulting         10750001         OTHER         Feed            30-Mar-04 11:40         Ag       Al       Ba       Be       Bi       Ca       Cd       Co       g/t       g/t	CA0392-MAR04         LR Internal Dept 14         Jacek Dirycz         SRK Consulting         10750001         OTHER         Feed       Sign Ca       Cd       Co       Cr         g/t       <th colspan="6</td> <td>CA0392-MAR04 LR Internal Dept 14 Jacek Dirycz SRK Consulting 10750001 OTHER Feed         SRK Consulting 10750001 OTHER Feed         Ag       Al       Ba       Be       Bi       Ca       Cd       Co       Cr       Cu         g/t       g/t</td>	CA0392-MAR04 LR Internal Dept 14 Jacek Dirycz SRK Consulting 10750001 OTHER Feed         SRK Consulting 10750001 OTHER Feed         Ag       Al       Ba       Be       Bi       Ca       Cd       Co       Cr       Cu         g/t       g/t

MALVERN	Se	ries	2600	SB.(	OB M	aster	Mode		30 Mai	190	4 1	:21 pm
High U Size	Under %	High Size	Under %	High Size	Under Z	High Size	Under %	High Size	Under %	High Size	Under %	Span 1.63
118 110 102	100 100 100	53.3 49.5	100 99.9 99.8	24.0 22.3 20.7	96.5 95.2 93.4	10.8 10.0 9 31	59.5 55.3	4.84 4.50 4.19	16.8 15.1	2.18 2.03 1.88	0.0	D[4,3] 10.72µm
95.2 88.6 82.4	100 100 100	42.8 39.8 37.0	99.7 99.5 99.4	19.3 17.9 16.7	91.0 88.1 84.6	8.66	46.2 41.2 35.9	3.89 3.62 3.37	11.1 8.8 6.4	1.75	0.0	D[3,2] 7.60µm
76.6 71.2 66.2	100 100 100	34.4 32.0 29.8	99.2 99.0 98.7	15.5 14.4 13.4	80.6 76.3 72.0	6.97 6.48 6.02	30.9 26.5 23.0	3.13 2.91 2.71	4.2 2.5 1.3	1.41 1.31 1.22	0.0	D[v,0.9] 18.74µm
61.6 57.3	100 100	27.7 25.8	98.2 97.5	12.5 11.6	67.8 63.6	5.60 5.21	20.5 18.5	2.52 2.34	0.6 0.2			D[v,0.1] 3.76μm
Source Focal i Present	= length lation	:Sam = = pi	pie 63 mm 1	Beam Lo Obscu Volum	length g. Diff ration le dist	= 2 f. = = 0.3 tribut	.2 mm 3.488 275 ion	Model Volum Sp.S.	indp e Conc A 0.	. = ( 7891	.0457% #²/cc.	D[v,0.5] 9.19µm

2699 pil 1m00429 \*\*ALARMS SET B D \*\* 10750-001/B214-1comp.





2699 pil 1m00429 \*\*ALARMS SET B D \*\* 10758-001/B214-1comp.

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MALVERN	Series 260	0 58.08	Master	Node	30 Mar	1904 1	:21 pm
Particle	diameters	Volume per	centiles		Distribu	ition Momen	ts.
D(4,3)	10.72 µm	D[v,.10]	3.76	Distbn	Mean	Stan.Dev.	Skewness
D(4,2) D(4,1) D(4,0) D(3,2)	9.03 μm 7.64 μm 6.59 μm 7.60 μm	D[V,.20] D[V,.30] D[V,.40] D[V,.50] D[V,.60]	5.51 6.87 7.92 9.19 10.86	Volume Surface Length Number	10.72 7.60 5.47 4.24	6.45 4.87 3.42 2.28	1.66 1.82 2.27 2.86
$ \begin{array}{c}     0(3,1) \\     0(3,0) \\     0(2,1) \\     0(2,0) \\     0(1,0) \end{array} $	6.45 μm 5.61 μm 5.47 μm 4.81 μm 4.24 μm	D[V,.70] D[v,.80] D[v,.90] D[v,.99] Span 1 Unif.	12.94 15.34 18.74 32.35 .63 0.52	Source =	:Sa#F	ble	

2699 pil im00429 \*\*ALARMS SET B D \*\* 10750-001/B214-1comp.

MALVERN	- Se	er les	2600	\$8.0	08 Ma	aster	Node		30 Mai	r 1904	4 1:	38 pm
High Size	Under %	High Size	Under ¥	High Size	Under ¥	High Size	Under %	High Size	Under %	High Size	Under *	Span 1.95
118 110 102	100 99.6	53.3 49.5	91.7 90.0	24.0 22.3	55.7 51.1	10.8	19.9 17.9	4.84	5.8 5.1	2.18	0.0	D[4,3] 25.93µm
95.2 88.6	98.8 98.3	40.1 42.8 39.8	85.9 83.4	19.3 17.9	42.5 38.7	8.66	10.2 14.6 13.1	3.89	4.4 3.6 2.8	1.63	0.0	D[3,2] 14.55µm
76.6	97.1 96.3	34.4 32.0	77.2	15.5 14.4	32.3 29.5	6.97	10.3	3.13	1.1	1.31	0.0	D[v,0.9] 49.43µm
61.6 57.3	94.4 93.1	27.7 25.8	64.9 60.3	12.5 11.6	24.5 22.1	5.60 5.21	7.2	2.52	0.1	1.64	v.v	D[v,0.1] 6.84μm
Source	=	:San	ple	Beam Lo	length og. Diff	= 2 f. = = 0.3	2.2 mm 4.481	Model	indp	× - /	0.02795	D[v,0.5]
Present	catior	i = pi	i i	Volu	ne disi	tribut	cion	Sp.S.	A Û.	4123	₩ <sup>2</sup> /CC.	21.00μm

2699 pil 1m00429 \*\*ALARMS SEI B D \*\* 10750-001/B208-1comp

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## 2699 pil 1m00429 \*\*ALARMS SET B D \*\* 10750-001/B208-1comp

Series 2600 SB.0B

MALVERN

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1:38 pm

Particle	diameters	Volume per	centiles		Distrib	ution Moment	.s.
D(4,3)	25.93 µm	D[v, .10]	6.84	Distbn	Mean	Stan.Dev.	Skewness
D(4,2) D(4,1) D(4,0)	19.43 μm 14.23 μm 10.87 μm	D[v,.20] D[v,.30] D[v,.40] D[v,.50]	10.81 14.58 18.38 21.88	Volume Surface Length	25.93 14.55 7.64	19.05 12.87 7.27	1.69 2.23 3.20
D(3,2) D(3,1) D(3,0)	14.55 μm 10.55 μm 8.13 μm	D[V,.80] D[V,.70] D[V,.80] D[V90]	25.63 30.14 36.60 49.43	NUMDEr	4.84	3.08	4.00
D(2,1) D(2,0)	7.64 µm 6.08 µm	D[v,.99] Span 1	98.25 .95	Source =	:Samp	bie	
6(1,0)	4.84 µm	Unif.	0.61				

Master Mode

30 Mar 1904

2699 pil 1m00429 \*\*ALARMS SET B D \*\* 10750-001/B208-1comp



# 2699 pil ln00429 \*\*ALARMS SET B D \*\* 10750-001/B212-4comp

## 0000014690

MALVERN	Series 260	00 SB.0B	Master	Mode	30 Mar	1904 1	:49 pm
Particle	e diameters	Volume per	centiles		Distrib	ution Momen	ts.
D(4,3)	13.38 µm	D[v,.10]	3.49	Distbn	Mean	Stan.Dev.	Skewness
$ \begin{array}{c} D(4,2) \\ D(4,1) \\ D(4,0) \\ D(3,2) \\ D(3,2) \end{array} $	7.81 μm 6.43 μm 7.37 μm	D [ V , .20 D [ V , .30 D [ V , .40] D [ V , .50 D [ V , .60]	4.74 6.21 7.43 8.97 11.59	Volume Surface Length Number	13.38 7.37 4.84 3.59	13.65 6.66 3.50 2.11	3.42 4.45 4.35 3.54
$\begin{array}{c} D(3,1) \\ D(3,0) \\ D(2,1) \\ D(2,0) \\ D(1,0) \end{array}$	5.97 μm 5.04 μm 4.84 μm 4.17 μm 3.59 μm	D[v,.00 D[v,.80] D[v,.90] D[v,.99] Span 2 Unif.	14.88 18.74 25.62 78.90 .47 0.88	Source =	:Samp	ble	

2699 pil 1m00429 \*\*ALARMS SET B D \*\* 10750-001/B212-4comp



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MAI VERN	Series 2600	\$8.08	Naster Node	23 Mar 1904	12:18 pm
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Particle diameters Volume percentile			entiles	Distribution Moments.						
D(4,3)	25.71 μm	D[V,.10]	5.24	Distbn	Mean	Stan.Dev.	Skewness			
D(4,2) D(4,1) D(4,0) D(3,2)	17.31 μm 12.12 μm 8.82 μm 11.65 μm	D(v,.20) D(v,.30) D(v,.40) D(v,.50) D(v,.60)	7.90 10.91 14.00 17.07 20.92	Volume Surface Length Number	25.71 11.65 5.94 3.41	25.42 12.80 5.82 2.94	1.87 3.78 4.88 4.27			
$ \begin{array}{c} D(3,1) \\ D(3,0) \\ D(2,1) \\ D(2,0) \\ D(1,0) \end{array} $	8.32 μm 6.18 μm 5.94 μm 4.50 μm	D[V,.70] D[V,.80] D[V,.90] D[V,.99] 1 Span 3.6 Unif.	26.02 34.08 66.65 112.27 60	Source =	Sam	ple				

2699 pil 1m00429 \*\*ALARMS SET A B C D \*\* 10750-001. Bag House Dust



23 Mar 1904 12:38 pm

Particle	diameters	Volume percentiles		Distribu	ition Moment	.\$.
U(4,3)	29.66 µm	0[v,.10] 5.28	Distbn	Mean	Stan.Dev.	Skewness
D(4,2) D(4,1) D(4,0) D(3,2)	20.92 μm 13.84 μm 10.04 μm 14.75 μm	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Volume Surtace Length Number	29.66 14.75 6.06 3.83	17.00 14.83 7.26 2.92	0.15 1.32 3.85 7.52
$ \begin{array}{c} 0(3,1) \\ 0(3,0) \\ 0(2,1) \\ 0(2,0) \\ 0(1,0) \end{array} $	9.46 µm 6.99 µm 6.06 µm 4.82 µm	D[v,.70] 39.72 D[v,.80] 45.05 D[v,.90] 51.79 D[v,.99] 66.11 Span 1.55	Source =	:Sam;	ble	
U(1,V)	<b>3.03 μm</b>	0111. 0.47				

2699 pil 1m00429 \*\*ALARMS SET A B C D \*\* 10750-001, B233-P9

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MALVERN	\$(	ries	2600	SB.(	)8 M	aster	Mode		23 Ma	r 190	4 1	:01 pm
High ( Size	Under %	High Size	Under %	High Size	Under %	High Size	Under %	High Size	Under %	High Size	Under %	Span 1.20
118 110 102 95.2 88.6 82.4 76.6 71.2 66.2	100 100 99.9 99.8 99.6 99.6 99.2 98.3 96.4	53.3 49.5 46.1 42.8 39.8 37.0 34.4 32.0 29.8	83.3 77.4 70.9 63.9 57.0 50.3 44.2 38.8 34.3	24.0 22.3 20.7 19.3 17.9 16.7 15.5 14.4 13.4	23.8 20.7 17.8 15.2 13.1 11.7 10.8 10.2 9.7	10.8 10.0 9.31 8.66 8.05 7.49 6.97 6.48 6.02	7.7 6.9 6.3 5.7 5.2 4.8 4.5 4.5 3.9	4.84 4.50 4.19 3.89 3.62 3.37 3.13 2.91 2.71	2.9 2.5 2.1 1.7 1.3 1.0 0.7 0.4 0.2	2.18 2.03 1.88 1.75 1.63 1.51 1.41 1.31 1.22	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	D[4,3] 36.76µm D[3,2] 23.60µm D[v,0.9] 58.52µm
61.6 57.3 Source Focal 1 Present	93.1 88.6 = ength	27.7 25.8 :Sam = = pi	30.4 27.0 ple 63 mm 1	12.5 11.6 Beam Lo Obscu Volum	9.1 8.4 length g. Diff ration le dist	5.60 5.21 = 2 = 0.3 ribut	3.6 3.3 2.2 mm 4.151 3104 ion	2.52 2.34 Model Volum Sp.S.	0.1 0.0 indp indp ie Conc A 0.	; = ( 2543	).1342% m²/cc.	D[v,0.1] 14.03µm D[v,0.5] 36.93µm

2699 pil 1m00429 \*\*ALARMS SET A B C D \*\* 10750-001, C-212-2(168-189')

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MALVERN	Series 260	0 58.08	Master	Mode	23 Mar	1904 1	:01 pm
Particle	diameters	Volume per	centiles		Distribu	ution Moment	ts.
D(4,3)	36.76 µm	D(v,.10)	14.03	Distbn	Mean	Stan.Dev.	Skewness
D(4,2) D(4,1) D(4,0) D(3,2)	29.45 μm 20.44 μm 14.19 μm 23.60 μm	D(V,.20) D(V,.30) D(V,.40) D(V,.50) D(V,.60)	21.91 27.45 32.57 36.93 41.12	Volume Surface Length Number	36.76 23.60 9.84 4.75	16.81 17.62 11.63 4.92	0.12 0.63 2.28 5.48
D(3,1) D(3,0) D(2,1) D(2,0)	15.24 μm 10.33 μm 9.84 μm 6.84 μm	D[v,.70] D[v,.80] D[v,.90] D[v,.99]	45.64 51.09 58.52 75.16	Source =	:San)	ple	
D(1,0)	4.75 µm	Span 1 Unif.	20 0.37				

2699 pil im00429 \*\*ALARMS SET A B C D \*\* 10750-001, C-212-2(168-189')

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2699\_pil 1m00429 \*\*ALARMS SET A B C D \*\* . 10750-001, C-212-2(140-168')

MALVERN Series 2600 SB.0B Master Mode 23 Mar 1904 1:19 pm

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Particle	diameters	Volume percentil	S	Distribu	ition Moment	5.
D(4,3)	38.51 µm	D[v,.10] 10.1	Distbn	Mean	Stan.Dev.	Skewness
D(4,2) D(4,1) D(4,0) D(3,2)	29.11 μm 19.66 μm 13.77 μm 22.00 μm	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Volume Surface Length Number	38.51 22.00 8.96 4.74	21.18 19.06 10.81 4.47	0.53 1.14 2.95 6.07
D(3,1) D(3,0) D(2,1) D(2,0) D(1,0)	14.04 μm 9.78 μm 8.96 μm 6.52 μm 4.74 μm	D[v,.70] 48.3 D[v,.80] 54.8 D[v,.90] 65.5 D[v,.99] 97.4 Span 1.45 Unif. 0.44	Source =	:Samp	ble	

2699 pil 1m00429 \*\*ALARMS SET A B C D \*\* 10750-001, C-212-2(140-168')

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<sup>10750-001,</sup> B235-P13

MALVERN	Series 2600	\$8.08	Master Mode	23 Mar 1904	9:32 am

Particle	diameters	Volume per	centiles		Distribu	tion Moment	s.
D(4,3)	8.93 µm	D[v,.10]	3.63	Distbn	Mean	Stan.Dev.	Skewness
D(4,2) D(4,1) D(4,0) D(3,2)	7.57 μm 6.65 μm 5.93 μm 6.42 μm	D(v,.20) D(v,.30) D(v,.40) D(v,.50) D(v,.60)	4.73 5.87 6.66 7.35 8.09	Volume Surface Length Number	8.93 6.42 5.13 4.22	10.25 4.02 2.58 1.96	7.22 9.45 3.35 2.02
D(3,1) D(3,0) D(2,1) D(2,0)	5.74 μm 5.18 μm 5.13 μm 4.65 μm	D[V,.70] D[V,.80] D[V,.90] D[V,.99] Span 1	9.02 10.40 12.89 75.41	Source =	:Samp	ble	
D(1,0)	4.22 µm	Unif.	0.51				

2699 pil im00429 \*\*ALARMS SET B D \*\* 10750-001, B235-P13

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# Appendix 2: Atterberg Limits

SGS Lakefield Research Limited

Lakefield Research

PSP #: 7-18-8 REV. #: 1.0 DATE: 18 Mar. 04 PAGE: 1 of 6

# PSP# 7-18-8 Modified Atterberg Limits (Liquid Limit, Plastic Limit, and Plasticity Index)

#### 1.0 DERIVATION OF THE METHOD

This method follows the ASTM D 4318 test method.

#### 2.0 **DEFINITIONS**

<u>ETLIS</u>: Environmental Testing Laboratory information station. <u>D.I.</u>: Deionized water. <u>PSP</u>: Project Specific Procedure

#### 3.0 METHOD SUMMARY

The liquid limit is determined by performing trials in which a portion of the sample is spread in a brass cup, divided in two by a grooving tool and allowed to flow together from the shocks caused by repeatedly dropping the cup in a standard mechanical device. The plastic limit is determined by alternately pressing together and rolling into a 3.2mm (1/8-in.) diameter thread a small portion of plastic soil until its water content is reduced to a point at which the thread crumbles and can no longer be pressed together and rolled. The water content at this point is the plastic limit. A calculation is then performed using this data to determine the plasticity index of the sample.

#### 4.0 SCOPE

#### Table 4.1Sample information

Media suitable:	Analytes:
Soils and tailings.	Not applicable.
Optimal sample size (g): 500	Minimum sample size (g): 250

#### 5.0 HEALTH, SAFETY AND ENVIRONMENTAL CONDITIONS

Work with sample in contamination booth. Wear rubber boots, latex or nitrile gloves and full contamination suit with forced air-breathing system when handling samples.

#### 6.0 BASIC PRINCIPLES

To determine the liquid limit, plastic limit and plasticity index of soils.

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PSP #: 7-18-8 REV. #: 1.0 DATE: 18 Mar. 04 PAGE: 2 of 6

### 7.0 SAMPLE REQUIREMENTS AND PREHISTORY

### Table 7.1 Sample requirements and prehistory

Collection information:	None.
Collection concerns:	Sample representation, and sample homogeneity.
Containers to be used:	Any.
Containers to be absolutely avoided:	None.
Sub-samples or dilutions required:	None.
Preservation required (include amount,	Not applicable.
concentrations, when added):	
Temperature requirements for storage:	Drying oven set to 70°C
Holding time (from time of collection to	Not applicable.
completion of analyses):	
Labeling:	LIMS code and MSDS where required.
pH requirements:	None.
Pretreatment:	Pre-wet samples to 10% moisture
Sampling procedures:	Not applicable.
Sampling problems to avoid:	Make sure samples are well mixed
What to do in the case of precipitates:	Not applicable.
Contamination problems:	Highly Toxic samples must be handled with care
Other:	None.

### 8.0 EQUIPMENT AND LABWARE

#### 8.1 Equipment

- 8.1.1 Aluminum weigh boats for moisture determination.
- 8.1.2 Mixing container
- 8.1.3 Spoonula.
- 8.1.4 Liquid limit device, including the brass cup, base, carriage and cam.
- 8.1.5 D.I. squeeze bottle.
- 8.1.6 Balance, capable of reading two decimal places.
- 8.1.7 Drying oven.

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- 8.1.8 Flat grooving tool.
- 8.1.9 No. 40 sieve (425µm).

### 9.0 REAGENTS

Saturated Arsenic solution

#### 10.0 INSTRUMENTATION

#### Table 10.1Instrumentation required

Top loading balance sensitive to two decimal places.

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PSP #: 7-18-8 REV. #: 1.0 DATE: 18 Mar. 04 PAGE: 3 of 6

#### 11.0 PROCEDURE

#### 11.1 Liquid Limit Determination

- 11.1.1 Approximately 150g of dry sample are placed in the mixing container, and 15mL of saturated Arsenic solution added.
- 11.1.2 The sample and 15g/L Arsenic solution are thoroughly mixed, and then small amounts of the wet sample are compacted into the brass cup until the maximum height is the same as the depth of the grooving tool, approximately 1cm.
- 11.1.3 The flat end of the spoonula is used to draw a straight line through the middle of the sample. The grooving tool is repeatedly run through the sample parallel to the line until the brass cup can be seen.
- 11.1.4 Hold the grooving tool perpendicular to the line with the beveled edge forward and run through the sample again to create a v-shaped line.
- 11.1.5 Lift and drop the cup by turning the crank at a rate of approximately 2 drops per second until the two halves of the sample come in contact along a distance of 13mm (1/2-in.).
- 11.1.6 Cut the sample horizontally along each side of the closure, from edge to edge, and remove from the cup in order to determine the moisture content.
- 11.1.7 The number of blows required for the closure and the moisture content data is recorded on the Excel worksheet in Appendix A (F:\Departmt\Envserv\Standard Operating Procedure\Templates\ Atterburg Template.xls).
- 11.1.8 The remaining sample is removed from the brass cup and more dry sample or D.I. is added to adjust the moisture content so that a different number of blows is required to close the groove.
- 11.1.9 A minimum of three points between five and thirty blows is required to plot the graph.

#### 11.2 **Plastic Limit Determination**

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- 11.2.1 After the liquid limit determination is complete saturate 5-10g of sample with D.I. and roll between two hands until the diameter of the tube produced is approximately 3mm.
- 11.2.2 Cut the resultant tube into three equal parts and determine the moisture content on the two end pieces.
- 11.2.3 The remaining piece is rolled between two hands again until the moment of disintegration and then the moisture content is determined on those pieces.
- 11.2.4 All of the data is recorded on the worksheet in 14.2.7.

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PSP #: 7-18-8 REV. #: 1.0 DATE: 18 Mar. 04 PAGE: 4 of 6

### 11.3 Calculations

- 11.3.1 Liquid limit = Moisture Content (dry weight basis, %) \* (Number of Blows / 25)<sup>0.121</sup>
- 11.3.2 Plastic Limit = average of the two moisture contents obtained
- 11.3.3 Plasticity Index = Liquid limit Plastic limit

#### 12.0 MAINTENANCE

#### Table 15.1 List of maintenance procedures and corresponding SOPs

Maintenance Procedure	SOP Number or Other Reference	Frequency	Approx. Time To Complete
Liquid Limit Device	ASTM D4318	Before each use	Problem dependent
Grooving Tool	ASTM D4318	Before each use	Problem dependent

#### 13.0 DECONTAMONATION

Thoroughly rinse all equipment three times with de-ionized water making sure there is no sample left on any piece or in any crack.

#### 14.0 QUALITY CONTROL

When sufficient sample, time and equipment are available a duplicate may be performed.

#### 15.0 WASTE DISPOSAL

All solid samples are discarded in the manner appropriate for the constituents of each particular sample, as determined through other tests.

#### 16.0 REFERENCES

1997 Annual Book of ASTM Standards. "ASTM D 4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils" Vol. 04.08, 1997, pp. 522-532 (Soil and Rock).

SOP 7-17-30 Balances: Calibration and Maintenance, Lakefield Research Limited.

SOP 7-17-16 Drying Ovens: Operation and Maintenance, Lakefield Research Limited.

SOP 7-17-31 Moisture Content Determination, Lakefield Research Limited.

#### 17.0 APPENDIXES

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Appendix A Atterburg Limits Worksheet.

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PSP #: 7-18-8 REV. #: 1.0 DATE: 18 Mar. 04 PAGE: 5 of 6

18.0 <b>REQUIF</b>	RED APPROVALS		
Name	Signature	Date	Title
Steve Jurchisor	n		Author
Brian Graham			Laboratory Supervisor
Liang Liu			Senior Environmental Scientist
Diane Kelly			Quality Control Coordinator
Mike Lord			Manager, Environmental Services

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## CERTIFICATE OF ANALYSIS Modified Atterberg Limits Results

Project No.: 10750-001 Sample I.D.: Bag House Dust Client: SRK Date Complete: 23-Mar-04

LIQUID LIMIT Determination	1	2	3
Tare No.	LL#3	LL#2	LL#1
Tare (g)	2.556	2.552	2.604
Wt. of Wet Soil & Tare (g)	11.417	8.347	10.278
Wt. of Dry Soil & Tare (g)	9.483	6.944	8.371
Wt. of Water (g)	1.934	1.403	1.907
Wt. of Dry Soil (g)	6.927	4.392	5.767
Percent Moisture	27.92	31.94	33.07
Number of Blows	25	15	14
Liquid Limit, LL	27.92	30.03	30.83

<b>PLASTIC LIMIT Determination</b>	1	2	Final Test Results
Tare No.	PL#1	PL#2	Liquid Limit, LL 29.59
Wt. of Tare (g)	2.570	2.562	Plastic Limit, PL 33.79
Wt. of Wet Soil & Tare (g)	5.128	5.308	Natural Water Content, % N/A
Wt. of Dry Soil & Tare (g)	4.476	4.621	Plasticity Index, PI NP
Wt. of Water (g)	0.652	0.687	
Wt. of Dry Soil (g)	1.906	2.059	
Percent Moisture	34.21	33.37	



**Completed By:** 

Steve Jurchison Project Technician Checked By:

Project Manager

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#### **Environmental Services**

## CERTIFICATE OF ANALYSIS Modified Atterberg Limits Results

**Project No.:** 10750-001 **Sample I.D.:** B208-1 Comp.

Client: SRK Date Complete: 30-Mar-04

LIQUID LIMIT Determination	1	3	4
Tare No.	LL#1	LL#3	LL#4
Tare (g)	2.628	2.618	2.600
Wt. of Wet Soil & Tare (g)	21.9	18.56	18.53
Wt. of Dry Soil & Tare (g)	16.99	14.3	14.2
Wt. of Water (g)	4.91	4.26	4.33
Wt. of Dry Soil (g)	14.362	11.682	11.600
Percent Moisture	34.19	36.47	37.33
Number of Blows	34	24	17
Liquid Limit, LL	35.48	36.29	35.63

PLASTIC LIMIT Determination	1	2	Final Test Results
Tare No.	PL#1	PL#2	Liquid Limit, LL 36.33
Wt. of Tare (g)	2.588	2.575	Plastic Limit, PL 30.87
Wt. of Wet Soil & Tare (g)	7.04	5.01	Natural Water Content, % N/A
Wt. of Dry Soil & Tare (g)	6	4.43	Plasticity Index, PI 5.45
Wt. of Water (g)	1.04	0.58	
Wt. of Dry Soil (g)	3.412	1.855	
Percent Moisture	30.48	31.27	]



**Completed By:** 

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Checked By:

Steve Jurchison Project Technician

Project Manager

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## CERTIFICATE OF ANALYSIS Modified Atterberg Limits Results

Project No.: 10750-001

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Sample I.D.: B212-4 Comp.

LIQUID LIMIT Determination	1	2	5
Tare No.	LL#1	LL#2	LL#5
Tare (g)	2.615	2.61	2.582
Wt. of Wet Soil & Tare (g)	18.89	16.41	14.77
Wt. of Dry Soil & Tare (g)	15.18	13.17	11.91
Wt. of Water (g)	3.71	3.24	2.86
Wt. of Dry Soil (g)	12.565	10.56	9.328
Percent Moisture	29.53	30.68	30.66
Number of Blows	35	19 /	16
Liquid Limit, LL	30.75	29.68	29.05

PLASTIC LIMIT Determination	1	2	Final Test Results
Tare No.	PL#1	PL#2	Liquid Limit, LL 31.12
Wt. of Tare (g)	2.575	2.575	Plastic Limit, PL 28.50
Wt. of Wet Soil & Tare (g)	5.63	9.5	Natural Water Content, % N/A
Wt. of Dry Soil & Tare (g)	4.95	7.97	Plasticity Index, PI 2.62
Wt. of Water (g)	0.68	1.53	
Wt. of Dry Soil (g)	2.375	5.395	
Percent Moisture	28.63	28.36	]



**Completed By:** 

Checked By:

Steve Jurchison Project Technician

Project Manager

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## CERTIFICATE OF ANALYSIS Modified Atterberg Limits Results

**Project No.:** 10750-001 **Sample I.D.:** B214-1 Comp.

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### Client: SRK Date Complete: 30-Mar-04

LIQUID LIMIT Determination	1	2	3	4	5
Tare No.	LL#1	LL#2	LL#3	LL#4	LL#5
Tare (g)	2.567	2.576	2.586	2.572	2.569
Wt. of Wet Soil & Tare (g)	19.93	15.71	17.18	15.6	16.92
Wt. of Dry Soil & Tare (g)	15.98	12.54	13.64	12.38	13.35
Wt. of Water (g)	3.95	3.17	3.54	3.22	3.57
Wt. of Dry Soil (g)	13.413	9.964	11.054	9.808	10.781
Percent Moisture	29.45	31.81	32.02	32.83	33.11
Number of Blows	35	28	25	20	18
Liquid Limit, LL	30.67	32.25	32.02	31.96	31.82

PLASTIC LIMIT Determination	1	2	Final Test Results
Tare No.	PL#1	PL#2	Liquid Limit, LL 31.75
Wt. of Tare (g)	2.582	2.587	Plastic Limit, PL 28.91
Wt. of Wet Soil & Tare (g)	5.38	5.54	Natural Water Content, % N/A
Wt. of Dry Soil & Tare (g)	4.76	4.87	Plasticity Index, PI 2.84
Wt. of Water (g)	0.62	0.67	
Wt. of Dry Soil (g)	2.178	2.283	
Percent Moisture	28.47	29.35	



Completed By: \_\_\_\_\_ Checked By: \_\_\_\_\_

Project Technician

Project Manager

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## CERTIFICATE OF ANALYSIS Modified Atterberg Limits Results

**Project No.:** 10750-001 **Sample I.D.:** B233-P9

Client: SRK Date Complete: 23-Mar-04

LIQUID LIMIT Determination	1.	2	3
Tare No.	LL#4	LL#1	LL#2
Tare (g)	2.621	2.61	2.613
Wt. of Wet Soil & Tare (g)	11.832	9.834	10.232
Wt. of Dry Soil & Tare (g)	9.123	7.697	7.964
Wt. of Water (g)	2.709	2.137	2.268
Wt. of Dry Soil (g)	6.502	5.087	5.351
Percent Moisture	41.66	42.01	42.38
Number of Blows	34	29	24
Liquid Limit, LL	43.24	42.77	42.18

PLASTIC LIMIT Determination	1	2	Final Test Results
Tare No.	PL#1	PL#2	Liquid Limit, LL 41.69
Wt. of Tare (g)	2.607	2.624	Plastic Limit, PL 35.29
Wt. of Wet Soil & Tare (g)	6.203	5.29	Natural Water Content, % N/A
Wt. of Dry Soil & Tare (g)	5.200	4.579	Plasticity Index, PI 6.40
Wt. of Water (g)	1.003	0.711	
Wt. of Dry Soil (g)	2.593	1.955	
Percent Moisture	34.21	36.37	



**Completed By:** 

Checked By:

Steve Jurchison Project Technician

**Project Manager** 

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## CERTIFICATE OF ANALYSIS Modified Atterberg Limits Results

**Project No.:** 10750-001 **Sample I.D.:** C212-2 (140-168) Client: SRK Date Complete: 23-Mar-04

LIQUID LIMIT Determination	1	2	3	4
Tare No.	LL#4	LL#3	LL#2	LL#1
Tare (g)	2.597	2.605	2.608	2.61
Wt. of Wet Soil & Tare (g)	12.932	15.31	14.500	13.491
Wt. of Dry Soil & Tare (g)	10.909	12.718	11.922	11.028
Wt. of Water (g)	2.023	2.592	2.578	2.463
Wt. of Dry Soil (g)	8.312	10.113	9.314	8.418
Percent Moisture	24.34	25.63	27.68	29.26
Number of Blows	27	21	15	11
Liquid Limit, LL	24.57	25.10	26.02	26.49

PLASTIC LIMIT Determination	1	2	Final Test Results	
Tare No.			Liquid Limit, LL	25
Wt. of Tare (g)			Plastic Limit, PL	NP
Wt. of Wet Soil & Tare (g)			Natural Water Content, %	N/A
Wt. of Dry Soil & Tare (g)	Non-plastic		Plasticity Index, PI	NP
Wt. of Water (g)				
Wt. of Dry Soil (g)				
Percent Moisture				



**Completed By:** 

Checked By:

Steve Jurchison Project Technician

Project Manager

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P.O. Box 4300, Concession St., Lakefield, ON, KOL 2H0 Phone: (705) 652-2000 Fax: (705) 652-0743

## CERTIFICATE OF ANALYSIS Atterberg Limits Results

**Project No.:** 10750-001 **Sample I.D.:** C212-2 (168-189)

### Client: SRK Date Complete: 23-Mar-04

LIQUID LIMIT Determination	1	2	3	4
Tare No.	LL#1	LL#2	LL#3	LL#4
Tare (g)	2.608	2.596	2.617	2.608
Wt. of Wet Soil & Tare (g)	22.871	15.857	17.701	18.685
Wt. of Dry Soil & Tare (g)	18.604	13.046	14.434	15.07
Wt. of Water (g)	4.267	2.811	3.267	3.615
Wt. of Dry Soil (g)	15.996	10.45	11.817	12.462
Percent Moisture	26.68	26.90	27.65	29.01
Number of Blows	32	28	23	13
Liquid Limit, LL	27.48	27.27	27.37	26.80

<b>PLASTIC LIMIT Determination</b>	1	2	Final Test Results	
Tare No.			Liquid Limit, LL 2	7.70
Wt. of Tare (g)			Plastic Limit, PL	NP
Wt. of Wet Soil & Tare (g)			Natural Water Content, %	N/A
Wt. of Dry Soil & Tare (g)	NON	PLASTIC	Plasticity Index, PI	NP
Wt. of Water (g)				-
Wt. of Dry Soil (g)				
Percent Moisture				



**Completed By:** 

Checked By:

Steve Jurchison Project Technician

**Project Manager** 

# **Appendix 3: Standard Proctor Test**

09/07/2004

	Content (%)	0pt. H <sub>2</sub> O (		941.82	Vol. (cm <sup>3</sup> )		4238	Mold Wt.(g)	
1	Dry Density	Max.		25	Blows/Layer	H	ω	No. of Layers	T
<u> </u>	Wet Density	Max. V		12 in.	Drop		5 lb.	Hammer Wt.	-
	1.527	1.482	1.509	1.508	1.479	1.439	sity (g/cm <sup>3</sup> )	Dry Den	<b></b>
			SUIC	eterminatio	y Density D	Dı			1
	4.59	7.30	5.68	5.39	5.52	7.28	Content (%)	Moisture (	<b></b>
	5.79	0.017	2.6/8	5.299	2.283	2.687	of Water (g)	Wt. c	_

Wt. of Water (g)	Wt. of Dry Soil (g)	Wt. of Tare (g)	Wt. of Tare + Dry Soil (g)	Wt. of Tare + Wet Soil (g)	Tare Number		Wet Density (g/cm <sup>3</sup> )	Weight of Wet Soil (g)	Weight of Mold (g)	Weight of Mold + Wet Soil (g)
5.687	78.11	57.84	135.95	141.64	1	Mois	1.544	1454	4238	5692
5.583	101.177	57.776	158.953	164.536	2	ture Conten	1.561	1470	4238	5708
5.299	98.268	57.922	156.19	161.489	3	ıt Determina	1.589	1497	4238	5735
5.678	99.977	57.687	157.664	163.342	4	ations	1.595	1502	4238	5740
6.017	82.415	57.849	140.264	146.281	5		1.591	1498	4238	5736
5.79	126.074	57.929	184.003	189.793	6		1.597	1504	4238	5742
	Wt. of Water (g) 5.687 5.583 5.299 5.678 6.017 5.79	Wt. of Dry Soil (g)         78.11         101.177         98.268         99.977         82.415         126.074           Wt. of Water (g)         5.687         5.583         5.299         5.678         6.017         5.79	Wt. of Tare (g)         57.84         57.776         57.922         57.687         57.849         57.929           Wt. of Dry Soil (g)         78.11         101.177         98.268         99.977         82.415         126.074           Wt. of Water (g)         5.687         5.583         5.299         5.678         6.017         5.79	Wt. of Tare + Dry Soil (g)         135.95         158.953         156.19         157.664         140.264         184.003           Wt. of Tare (g)         57.84         57.776         57.922         57.687         57.929           Wt. of Dry Soil (g)         78.11         101.177         98.268         99.977         82.415         126.074           Wt. of Water (g)         5.687         5.583         5.299         5.678         6.017         5.79	Wt. of Tare + Wet Soil (g)         141.64         164.536         161.489         163.342         146.281         189.793           Wt. of Tare + Dry Soil (g)         135.95         158.953         156.19         157.664         140.264         184.003           Wt. of Tare (g)         57.84         57.776         57.922         57.687         57.849         57.929           Wt. of Dry Soil (g)         78.11         101.177         98.268         99.977         82.415         126.074           Wt. of Water (g)         5.687         5.583         5.299         5.678         6.017         5.79	Tare Number         1         2         3         4         5         6           Wt. of Tare + Wet Soil (g)         141.64         164.536         161.489         163.342         146.281         189.793           Wt. of Tare + Dry Soil (g)         135.95         158.953         156.19         157.664         140.264         184.003           Wt. of Tare (g)         57.84         57.776         57.922         57.687         57.929           Wt. of Dry Soil (g)         78.11         101.177         98.268         99.977         82.415         126.074           Wt. of Water (g)         5.687         5.583         5.299         5.678         6.017         5.79	Moisture Content Determinations           Tare Number         1         2         3         4         5         6           Wt. of Tare + Wet Soil (g)         141.64         164.536         161.489         163.342         146.281         189.793           Wt. of Tare + Dry Soil (g)         135.95         158.953         156.19         157.664         140.264         184.003           Wt. of Tare (g)         57.84         57.776         57.922         57.687         57.929         57.929           Wt. of Dry Soil (g)         78.11         101.177         98.268         99.977         82.415         126.074           Wt. of Water (g)         5.687         5.583         5.299         5.678         6.017         5.79		Weight of Wet Soil (g)145414701497150214981504Wet Density (g/cm3) $1.544$ $1.561$ $1.589$ $1.595$ $1.591$ $1.597$ Met Density (g/cm3) $1.544$ $1.561$ $1.589$ $1.595$ $1.591$ $1.597$ Tare Number $1$ $2$ $3$ $4$ $5$ $6$ Wt. of Tare + Wet Soil (g) $141.64$ $164.536$ $161.489$ $163.342$ $146.281$ $189.793$ Wt. of Tare + Dry Soil (g) $135.95$ $158.953$ $156.19$ $157.664$ $140.264$ $184.003$ Wt. of Tare (g) $57.84$ $57.776$ $57.922$ $57.687$ $57.849$ $57.929$ Wt. of Dry Soil (g) $78.11$ $101.177$ $98.268$ $99.977$ $82.415$ $126.074$ Wt. of Water (g) $5.687$ $5.583$ $5.299$ $5.678$ $6.017$ $5.79$	

Data Entered By: Steve Jurchison Test Run By: Jack Dirycz Sample could not be evenly mixed

Sample ID: Bag House Dust

Project No.: 10750-001

**Moisture - Density Relationship Results** LAKEFIELD RESEARCH LTD. Appendix 4: Wettability, Capillary Rise, Compaction

SGS Lakefield Research Limited

LR Project No. 10750-001

#### Wettability test

Date March 22,2004 Technologist: Jacek Dirycz

The objective of the Wettability test is to investigate the rate of water Penetration inside the arsenic dust Feed: Bag House Dust

Procedure

Transparent 1 and 3/8" column was fill with arsenic dust to the required in-situ density. Column was placed on the stand. Top of the column was filled with river water. During the test was measured: penetration of water inside the dust, the final solids slump.

#### Parameters, Calculations and Additions

Column D(mm)	31.75	
Volume of 1cmm column	7.91	
Initial weight(g)	378	
Initial height(mm)	580	
Water cm	5.5+7.5	
Water mL	791*13=	102.83
Weight of 1cm dust	6.517241	

Time	weight	height	Wet height	Calc.Moisture	Calc.Moisture	/ol.of wate	r Observation
min	g	mm	cm	of wet sample	in the column	ml	
			1. A.	-	%		
0	378.9	580	0	0.000	0.000	39.55	Initial Reading
1			1	37.767	1.035	35.595	
3			2	37.767	2.050	31.64	
10			3	37.767	3.043	27.685	
20			4	37.767	4.017	23.73	
35			5	32.682	4.017	23.73	
55			5.5	39.832	5.907	15.82	
115			8	37.767	7.724	7.91	
155			8	40.572	8.606	3.955	Added 7.5 cm water= 59.325
155			8	43.135	8.601	63.28	
180			10	40.031	9.466	59.325	
240			11	41.765	11.150	51.415	
1125			13.5	53.891	20.730	0	End test, Total water in the
							sample 98.875 mL

# Wettability Test

- 1) Feed: Bag House dust (dry) from previous test program.
- 2) Set Up: Transparent PVC column 3.17 cm diameter and 58 cm high



- 3) Initial in-situ density of the dust: Target 1100-1200 kg/m<sup>3</sup> Actual packing 820 kg/m<sup>3</sup>
- 4) Hydrostatic pressure was not maintained during the test.



Lakefield Research
LR Project No. 10750-001

Date March 22,2004 Technologist: Jacek Dirycz

#### Capillary test

0

The objective of the Capillary test is to investigate the capillary rise of water inside the arsenic dust Feed: Bag House Dust

#### Procedure

Transparent 1 and 3/8" column was filled with arsenic dust to the required in-situ density. Column was placed inside graduated cylinder which was filled with river water. During the test capillary rise, the final solids slump, and final arsenic in solution was measured.

#### Parameters, Calculations and Additions

Initial weight(g)	344
Initial height(mm)	355
Water mL	400
Water with column	580
Replacement column's Vol.	180

Time	weight	height	Wet height	Vol.of water	Observation
min	g	mm	mm	ml	
0	344	355	0	580	
6			30	560	
12			35	550	
20			50	540	
35			60	520	
55			80	510	
115			100	490	
155			100	490	
180			130	478	
245			145	447	
1125			330	260	
1320	588	350	350	250	

In the end 160ml of water left

# **Capillary Rise Test**

1) Feed: Bag House dust feed (dry) from previous test program.

2) Set Up: Transparent PVC column 3.49 cm diameter



3) Initial in-situ density of the dust: Target

Actual packing

1100-1200 kg/m<sup>3</sup> 1012 kg/m<sup>3</sup>

4)	Res	ults
----	-----	------



Lakefield Research

#### **COMPACTION TESTS**

1. Feed Sample: Bag House dust from last year's test programme.

#### 2. Set up



- 3. Initial Compaction: 5.79 kg dust in 10.3 L or 562 kg/m<sup>3</sup>.
- 4. Initial compaction test Dry dust

Weight (kg) Cum.	Pressure (psi)	Penetration (cm)
0	0	0
0.53	0.09	0.2
1.53	0.26	1.1
4.51	0.74	4.0
9.69	1.59	6.0

#### 5. Freezing (-28°C) for 5 days

#### 6. <u>Water Penetration</u>

Poured 4 L of tap water at room temperature on the frozen dust. Water penetrated the dust immediately, and after 9 minutes all the dust was wet.

## 7. Thawing

 <u>Compaction test on water saturated dust</u> (Added 480 mL of tap water to reach full saturation) Same set up as previously

Weight (kg) Cum.	Pressure (psi) Cum.	Penetration (cm)
0	0	0
0.5	0.08	0.2
1.03	0.17	0.3
2.00	0.33	1.0
5.01	0.82	2.0
10.19	1.67	4.5





**Appendix 5: Sample Receipts** 

	. Lak	efield Research	
•	Sa	umple Receipt $10.39 V_{-0}$	n/
	LIMS #	Project #	
Date 0	3/15/2002 Receipt No.	LR2200788 Initials D.P	
Company	MIRAMAR GIANT MINE	- 1 2 5 A 1 7	J.
Address	YELLOWKNIFE NT	pypty man 2 10	
Postal/Zip	X1A2M1		
Job Description			
Carrier Waybill #	ARMBRO TRANSPORT I AT102699345	NC. Payment Type PREPAID	
Samples	5 DRUMS		
Shipping Weight(kg)	500	Actual Weight(kg)	
	ана. Чар	Sample Prep, Required	
Attention	JOE FERRON	Crush	
Radioactive	N	Puiverize	
Listing/ GEI	HER COUNTER READS (0)	USV/H	

Sanders & Arth

Department PROJECT WORK

## Lakefield Research

	La	kenela Research		
	S	ample Receipt		10750
	LIMS #		Project #	-
Date	03/16/2004 Receipt No.	LR2400713 Initials	D.P	
Company Address	INDIAN & NORTHERN A YELLOWKNIFE NWT	FFAIRS		
Postal/Zip	X1A 2R3			
Job Description				
Carrier Waybill #	MEYERS TRANSPORT T 125083	Payment Type	PREPAID	
Samples	4 PAILS			
Shipping Weight(kg)	35	Actual Weight(kg)		
		Sample Prep. Req	uired	
Attention	JOE FERRON	Crush		
Radioactive	Ν	Pulverize None		

Listing/ Description geiger counter reads .04 usv/h

Department

PROJECT WORK

### Lakefield Research

## Sample Receipt

		LIMS #			Project #
Date	03/23/2004	Receipt No.	LR2400797	Initials	D.P
Company Address	INDIAN & YELLOWI	NORTHERN A KNIFE NWT	FFAIRS		
Postal/Zip Job Description	X1A 2R3				
Carrier Waybill #	MEYERS Q 594300	TRANSPORT	Рау	vment Type	PREPAID
Samples	9 PAILS				
Shipping Weight(kg)	) 72		Actual Weigh	t(kg)	
			Sample	e Prep. Req	uired
Attention	JOE FERI	RON	Cru	ısh	
Radioactive	Ν	Y	Pulver No	rize ne	
Listing/ gei	ger counter re	ads .04 usv/h			

L Description

Department **PROJECT WORK** 

10750-001 High Ausenic